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Publisher's Letter

> "Global electricity consumption is expected to increase from 20,248 TWh to 25,415 TWh"

Increase in electricity demand by China, India and Middle East is the major boost behind global power transformer market growth. Between 2013 and 2020, global electricity consumption is expected to increase from 20,248 TWh to 25,415 TWh and a need to improve access to electricity will see imminent increase in global power transformer market.

For choosing transformer type, the article 'Power Transformer Decision Analysis: Replacement vs Refurbishment' talks about parameters on decision making which requires good understanding of the concept of risk. At the nominal end of life of transformer we may have key decisions to make whether the condition of equipment means that we can effectively refurbish the unit, or does the condition mean that we must replace the unit.

Moreover, a write-up, 'Moisture Management systems in Power Transformers – A need of the hour' insights into how the insulating paper material, being organic will degrade with time, and thereby cause damage to the transformer: the most important and expensive assets in electrical power network.

In technology realm nanorobotics is one of the technology which came into being with the advancement in nanotechnology. Its a technology for creating automatic machines, devices and robots at atomic scale. The write-up 'Nanorobotics: Redefining Future Domain' entails about incredible applications in the field of science because of its nanoscale precision, detection and manufacturing.

Yet an article 'Hybrid capacitor- Battery of future' illustrates that Hybrid capacitor are compact devices and known for stable electrical characteristics at high frequencies. This issue contains topics relevant to the current trends in power sector. We cherish the feedback from our readers, support of our advertisers & subscribers.

Do send in your comments to us at miyer@charypublications.in

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Improving Energy Harvesting and Efficiency to Propagate Automation

> “Energy harvested is stored in a battery or supercapacitor”

Energy is pervading the universe and needs to be harvested, be it lightning energy, renewable energy or sources created by human being. Energy harvesting's role in the technology trends is about the internet of things, and powering the connected devices. Technology providers now offer a wide range of autonomous devices for connected buildings. Harvesting technology can also be applied to wireless sensor networks installed in industrial control and automation environments. Wireless sensor networks have been found to deliver a host of technological and commercial advantages in industrial monitoring, control, and automation applications. Technology is still evolving.

Energy harvesting techniques to powering the networks, thereby making them autonomous, is fast becoming a compelling dynamic. This combination of technologies can address both challenges facing the industrial automation sector: energy efficiency and networked automation. The energy harvesting market is growing every year. The forecasts predict this trend will continue, especially with the emergence of next-generation energy harvesting enabled wireless systems.

Two of the major trends affecting industrial automation sector between now and 2015, according to Frost & Sullivan, are energy efficiency and networked automation. The availability over recent years of small, low cost, wireless sensors that can be reliably connected via a standards-based network has opened up a realm of new applications in areas such as smart buildings and industrial control, among many others. New applications of battery less wireless communications are emerging in many ways, from structural monitoring to management, such as building automation optimizes energy savings and reduces operating costs by lowering total cost of ownership.

The machinery incorporating electric motors is ideal for harvesting or scavenging energy. The primary sources include energy generated from temperature differential, mechanical and kinetic energy - inherent to machinery. No battery requirement is mandatory for larger installations. The cost to monitor, replace and recycle batteries increases with the number of installed nodes.

Generally, the energy harvested is stored in a battery or supercapacitor. The power management device determines when and how the storage device delivers sufficient power to activate the microcontroller to perform the task, for example, to take a measurement or transmit the data captured by the sensor. Having wireless sensor network operating autonomously from the equipment it is monitoring, can also be an advantage. The supercapacitor is the final element to mention in the energy harvesting solution. This energy storage device can be an alternative or complementary to a battery.

Intelligent control of key infrastructures will be required to provide adequate services. These will include automated control of traffic, lighting, energy, transportation systems, and waste disposal. This can only be realized with millions of energy-autonomous sensor nodes, collecting and delivering the necessary data to optimize operations. The importance of energy storage devices in most systems cannot be over-emphasized.

Installing occupancy sensors that turn off lights in vacant rooms can save up to 40 percent on energy and operating costs. This new battery-free environmental awareness benefits business budgets, as well as the natural world. Wireless sensor networks consume lower power than wired equivalents, and when powered by energy harvesting, the savings increase further. However, irrespective of energy source and the application need, power management is essential for autonomous operation.

Gopal Krishna Anand

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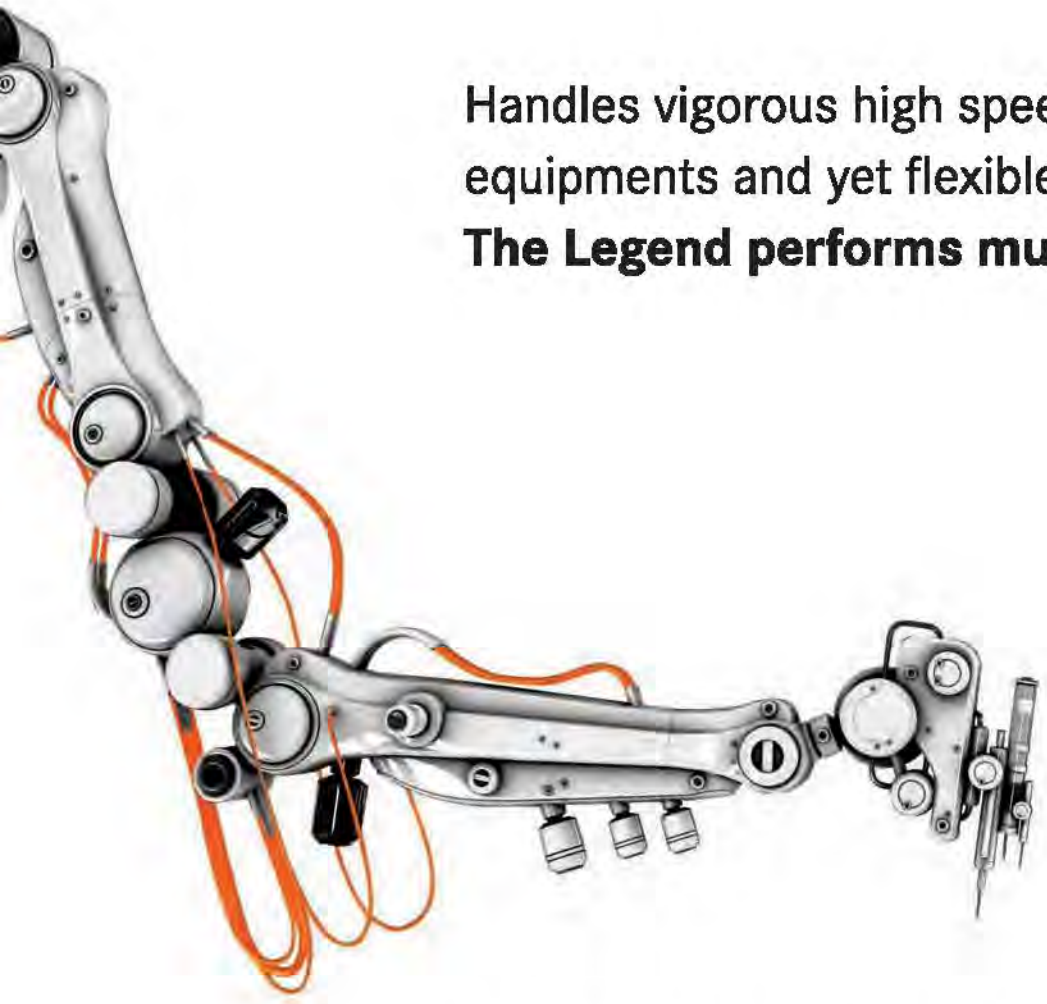

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ACME Solar commissions 25 MW Solar PV Plant in Madhya Pradesh

ACME Solar, one of India's leading solar power producer and a joint venture between ACME Cleantech and the renewable energy arm of French state-run electricity utility Électricité de France S.A. major EDF Energies Nouvelles (EDF EN) and EREN, Luxembourg, announced on the commencement of commercial operations at its 25 megawatts (MW) solar power plant in Khilchipur, Madhya Pradesh, thus increasing its generation capacity to 42.5 MW across a total of three commissioned power plants. "The commissioning of the Khilchipur Solar Power Plant positions ACME Solar as the leader in the field of solar power generation. With partners like EDF EN and EREN, ACME Solar will be at the forefront of serving the nation through higher uptake of renewable energy in the country." said Manoj Kumar Upadhyay, Chairman, ACME Group. The power generated from this solar plant will be evacuated through a 132 KV line linked to project site and supply electricity to the state of Madhya Pradesh under the PPA signed with MP Power Management Company Limited in October 2012. ACME Solar commissioned the solar power project in Madhya Pradesh in record time of 150 days starting from foundation stone laying to electricity generation. With the combination of the expertise of EDF EN as a world leader in the field of renewable energy, experience and expertise in project financing of EREN and the prowess of ACME Solar in developing and structuring solar projects, ACME Solar will be at the forefront of the renewable energy sector in the country. The Solar Power Plant is using Solar PV Technology and has over 1,65,000 Solar PV modules mounted on steel structures, which are erected on concrete foundations. ACME Solar is currently operating 42.5 MW solar power plants in Gujarat, Rajasthan and Madhya Pradesh and is in process of commissioning another 25 MW in Odisha. ■

REC in lieu of excess Electricity Generated from Renewable Energy Sources

Distribution companies are free to purchase renewable energy in excess of the stipulated Renewable Purchase Obligation (RPO). The CERC has received representation from the Gujarat Urja Vikas Nigam that distribution licensees who are purchasing renewable energy over and above their minimum purchase obligation at preferential tariff should be made eligible entity for RECs, in lieu of such excess energy. The Chief Minister, Government of Punjab has also made a similar request. CERC vide Order dated 2 December 2013 has observed that the existing provisions of eligibility in the REC Regulations which is limited to generating companies is adequate at this stage of development of REC market. It may be mentioned that amendment to the Regulations is a quasi-judicial process and the CERC takes a view after following due process of law including public hearing. ■

'Indian Power Stations 2014' inaugurated in New Delhi

Indian Power Stations 2014, the Conference on Power Plants was inaugurated in New Delhi by P.K. Sinha, Secretary, Union Ministry of Power. The theme of the conference is 'Powering Tomorrow Strategize Today'. The Conference is organized by NTPC as an annual event to commemorate the start of power generation from the first 200 MW unit from NTPC-Singrauli in 1982. Sinha expressed his satisfaction on the growth of Power sector in the current year and stressed on the use of latest technologies and new initiatives for improving the performance of the sector. Indian Power Sector is on the threshold of adding large capacity which shall reduce the demands/ supply considerably. In her address Neerja Mathur, Chairperson CEA complemented NTPC for organizing conference for knowledge and experience sharing. She stressed on the need for efficiency, sustainability and energy conservation in the power sector. ■

Mitsubishi Electric hits the Road with sophisticated Factory Automation Tech to Empower Industries

Mitsubishi Electric has set into motion its latest offering in high tech factory automation and switchgear products for India. The 'Empowering Express', a 7-tonne 16 wheeler behemoth is a virtual industrial showroom-on-wheels bristling with technology, fresh from the land of the rising sun. Flagged off at the Maruti Suzuki plant by M. M. Singh, COO, Maruti Suzuki India, the mobile industrial showroom will travel to over 50 cities across the country with stopovers at major industrial hubs. 'Empowering Express' will carry and display a variety of factory automation equipment for managing simple to complex applications across various market segments such as Automotive, Pharmaceutical, Food and Beverage, Textile, Water and Waste Water Treatment, Tunnel Ventilation, Power Distribution in Premium Residential and Commercial Buildings. Mitsubishi Electric India also caters to different customer segments like Packaging, Textiles, Printing, Plastic and Panel builders. Mitsubishi Electric India's endeavour is to come close to the customers, enabling them to have a look and feel of its wide range of products like Programmable Logic Controllers (PLC's), Human Machine Interfaces, (HMI's), Inverters, Variable Frequency Drives (VFD's), Motion Controllers and AC Servos, Robots, Circuit Breakers and Control gear. Masayuki Kamiya, Executive Officer Production, Maruti Suzuki India, present at the occasion inaugurated 'The Empowering Express'. Speaking about the initiative, Shinji Yamabe, MD, Mitsubishi Electric India said "We have decided to take our technology right up to the doorstep of customers. We want them to see and experience first-hand how our technology can help them to cut costs, speed up processes and increase productivity." ■

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EMC components LCL filters for recuperative frequency converter systems

TDK Corporation presents a new series of EPCOS LCL filters (B84143*405) for recuperative frequency converter systems. These high-performance filters consist of a power choke, a capacitor bank with damping resistors and a robust choke. The corresponding filter circuits attenuate the clock frequencies so greatly that the IEC/TS 62578 recommendations for EMI emissions between 9 kHz and 150 kHz to are satisfied. Moreover, in combination with a recuperative frequency converter system, the LCL filters can reduce the line-side harmonics to less than 5%. Recuperative unit can also be operated as a boost converter for higher DC link voltages. The new LCL filters are designed for rated currents of 16 A, 66 A, 200 A, and 400 A at a rated voltage of 520 V. The two smaller versions (16 A and 66 A) are accommodated on a mounting plate for ease of use. Larger versions (200 A & 400 A) consist of two units: a separate storage choke and a mounting plate with power choke and capacitor bank. The filters are designed for clock frequencies of 7 kHz to 16 kHz for feedback module and 4 kHz to 16 kHz for the motor-side frequency converter module. In addition, they are designed for a maximum motor lead length of 150 m or 6 axles and a maximum motor frequency of 100 Hz. Damping resistors integrated in the module prevent the development of natural oscillations. The filters are designed as open modules with convection cooling to protection class IP 00 (corresponding to IEC 60529 2001). Protective covers are available upon request under ordering code B84143Q*R405. Protection class IP 20 is consequently reached. Compared with single power chokes, LCL filters are characterized by a significantly improved reduction of harmonics as well as of the voltage and current distortions with respect to the power line. ■

Solar Power Systems in Government Buildings

MNRE is promoting installation of solar systems in all buildings, depending on the feasibility, willingness of users and availability of funds. Under Off grid and Decentralized Solar Applications Scheme of Jawaharlal Nehru National Solar Mission (JNNSM), the Ministry provides Central Financial Assistance of 30% of the cost of solar systems for installing Solar PV and Thermal Systems at Educational Institutions, Hospitals, Police stations, Community buildings, and buildings for social and community use, etc. For special categories states viz. NE, Sikkim, J&K, Himachal Pradesh and Uttarakhand, remote and difficult areas such as Lakshadweep, Andaman & Nicobar Islands, and districts on India`s international borders the CFA is limited to 60% of the cost of the water heating systems and 90% of the benchmark cost for SPV power projects accessed by only State Nodal Agencies(SNAs) / Solar Energy Corporation of India (SECI). ■

REC Trading Session: February 2014: 117% jump in traded volume over Jan.'14

REC market in February saw some buoyancy as the compliance year 2013-14 comes to an end. The trading session on 26 February, 2014 featured trade of 1,76,107 N-solar and 7,816 Solar RECs. Total trade volume increased by 117% as compared to 84,472 RECs traded last month. In solar segment buy bids of 7,816 RECs and sell bids of 1,14,539 RECs were received and all buy bids were cleared at floor price of Rs 9,300 per REC. In non-solar segment 1,76,107 buy bids and 20,15,377 sell bids were received and all buy bids were cleared at floor price of Rs 1,500 per REC. A total of 751 participants traded at the exchange with 575 participants in non-solar segment and 176 participants in solar segment. On an overall basis, a total of 2122 participants are registered in the REC segment at IEX. ■

Tata Power acquisition of 39.2 MW Wind farm in Gujarat

Tata Power Renewable Energy Limited (TPREL), a 100% subsidiary of Tata Power, one of India's largest integrated power companies, has completed acquisition of 100% shareholding in AES Saurashtra Windfarms Pvt Ltd (ASW), the erstwhile 100% subsidiary of AES Corporation. ASW owns and operates a 39.2 MW wind farm near Dwarka in Jamnagar district of Gujarat. The project which is fully operational since January 2012 has executed a power purchase agreement with GUVNL for sale of the electricity at a tariff of Rs 3.56/kWh for the duration of the project. The project is registered with UNFCCC as a CDM project and is eligible to receive CERs. The project is also registered under the Generation Based Incentive scheme of MNRE. TPREL was selected as the preferred bidder in a process conducted by AES Corporation for sale of its 100% stake in ASW in September 2013 and signed a share purchase agreement for the acquisition on 7th October 2013. With this acquisition, Tata Power's total generation capacity will increase to 8560 MW and its Wind Operational Generation capacity to 437 MW with wind turbines located across five states - Maharashtra, Rajasthan, Gujarat, Tamil Nadu and Karnataka. Anil Sardana, Managing Director, Tata Power, said, "Tata Power endeavours to generate 20-25 % of its total generation capacity from clean energy sources and is proud to have completed this acquisition of the 39.2 MW operational wind farm. The project is a clean energy project, which will enhance and increase the company's clean energy footprint. This is our second acquisition of an operating wind asset and we are in constant look out for similar opportunities in respect of wind and solar plants. This is yet another step towards the Company's commitment to sustainability." ■

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Socomec rolls out First India-made UPS, targets Rs 400 Cr Revenue

Chennai-based Socomec Innovative Power Solutions, 100% wholly owned subsidiary of the France-based €443 million Socomec Group, rolled out its first UPS product Delphys MP Elite from the Gurgaon plant. Socomec invested €3.75 million in India so far and has set ambitious growth plans for upcoming years. It has a strategy to target markets such as industry, building, critical building, infrastructure, renewable energy and OEM, through which it plans to generate Rs 400 crore revenue by Y2016. With the industry segment being a prime focus, the brand has taken an initial step towards the goal, and started producing its existing UPS product Delphys MP Elite, which is well-known for industrial applications in its 5200 square meter plant in Gurgaon, India. The facility has the capacity to produce 500 units annually. Currently, the factory is producing energy efficiency, power control and safety equipment. According to a Frost and Sullivan research report, manufacturing, telecommunication, IT and ITES contribute 34% of the total UPS market revenue. Delphys MP Elite caters to these markets and ensures high quality energy and power protection to critical applications. The product range starts from 80 to 200 kVA and the facility is capable of producing all the ranges. The key features of Delphys MP Elite includes neutral-free IGBT rectifier with sinusoidal absorption, transformer base UPS, several new UPS architecture, high output performances etc. Socomec has total control of the design, manufacture and marketing of its products. It has a strong workforce of 3,200 employees spread over 25 subsidiaries around the world, including 321 employees in India. In India, its offices are spread in 16 locations, serving the length and breadth of the country. ■

BHEL wins order for 206 MW Hydro Electric Project in Punjab

In the face of stiff international competition, Bharat Heavy Electricals Limited (BHEL) secured a prestigious contract for setting up a 206 MW Hydro Electric Project (HEP) in the state of Punjab. Significantly, this is the first major order for electro-mechanical equipment, to be finalised by a Govt. utility company in the current financial year, in the hydro sector. Valued at Rs.3210 Million, the order for setting up of Hydro Generating sets and associated Electro-Mechanical works for the 206 MW Shahpurkandi HEP has been placed on BHEL by Punjab State Power Corporation Limited (PSPCL), as its offer was found techno-economically the best. Notably, the bids for the contract were invited by PSPCL through a Global E-tendering process. With this order, the customer has once again reposed confidence in BHEL's proven technological excellence and capability in executing such hydro projects. ■

WAAREE Group launches online retail venture, enables easy access to Solar Products

WAAREE Group India's premier multi-diverse technology group having forte in multifarious verticals such as Solar Energy, Industrial Valves & Level Gauges and Petroleum Equipment has entered into the retail business at a larger scale with Waamall.in , an online retail division of WAAREE. It is aimed at providing customers an online platform for an effortless experience of purchasing Solar Products that shall include Industrial Retail products, Valves and Level gauges in the near future. Through this platform, WAAREE will be able to offer a large range of its solar products like Solar Mobile charger, Solar Bag, Solar battery charger, Solar camping light and other solar portable products that will now be made available to customers through Waamall.in. ■

Siemens launches best-fit controller for mid-sized DCS market- AS 410 SMART

The Industry Sector of Siemens launched SIMATIC PCS 7 AS 410 SMART - a compact process automation controller for small to mid-sized standard DCS applications. A new addition to the Siemens SIMATIC controller family, it comes with the same hardware ruggedness and proven quality as that of the powerful AS 410 controller. This compact, affordable and easy-to-use controller provides repeatability, meaning once a standard solution is designed, the same can be used for several similar applications as well. This feature not only reduces engineering efforts but also ensures lesser time-to-market. Designed in Germany for round-the-clock industrial applications, AS 410 SMART can withstand harsh temperature conditions, vibration/shock and EMC requirements. It is also equipped with a conformal coating, which is in line with G3 standards, thus making the controller highly robust. With a speed of 450 MHz, this multi-processor system is equipped with 48 MB memory and can be scaled up to 800 Process Objects. Simultaneous management and control of different process tasks at different cycle times is yet another advantage of this high speed controller. Additionally, owing to user friendly and simple configuration, lesser training efforts are required for plant operators and maintenance personnel. AS 410 SMART also provides ease of maintenance to customers as only one controller-spare part needs to be managed. With the addition of AS 410 SMART to the SIMATIC PCS 7 portfolio, Siemens is now well equipped of addressing the different requirements across all Process Automation market segments. ■

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ABB wins power orders worth $160 million in Kuwait, Substations to support infrastructure development

ABB won orders worth about $160 million from the Ministry of Electricity and Water (MEW) to construct substations that will help strengthen the country's power grid and support its growing infrastructure. The orders were booked in the fourth quarter of 2013. Kuwait has crude oil reserves in excess of 104 billion barrels accounting for around 10 percent of global reserves, the fourth largest in the world. As a result, the petroleum industry is the biggest contributor to the national economy, accounting for nearly half of the country's Gross Domestic Product (GDP). The government is making significant investments to enhance its power infrastructure in order to support a planned expansion of crude oil production from the current level of about 2.9 million barrels per day (bpd) to 4 million bpd by 2020. These substations will reinforce the expansion of oil fields in the northern region of Rawdatain, and support Kuwait's long term vision to position it as a regional trading and business hub. "The need to build up reliable and efficient power infrastructure in regions like the Middle East is an important growth driver for ABB" said ABB CEO Ulrich Spiesshofer. "ABB has a proven track record in Kuwait and we are pleased to continue supporting the country's growth and development, combining our global technology and engineering expertise with our strong local presence." "The orders won by ABB are for turnkey projects in Kuwait's north Rawdatain region and include the design, supply, installation and commissioning of two 300/132 kilovolt (kV) gas-insulated switchgear (GIS) substations as well as the extension of three existing 132 kV GIS substations. The projects are scheduled for completion by 2016. ■

Eaton showcases Safety and Energy-Efficient Solutions

Power management company Eaton hosted an Oil & Gas Technology Day at The Leela Ambience Hotel, Gurgaon to showcase its expanded range of electrical, hydraulics and filtration solutions for the Oil & Gas segment. The showcase also included products from the former Cooper Industries, which Eaton acquired in late 2012. The largest in Eaton's 102-year history, the Cooper acquisition has been a transformational milestone that expands the company's market segment reach, strengthens its global geographic footprint and gives Eaton one of the broadest portfolios of electrical products, services and solutions for the Oil & Gas industry. Eaton is engaged in a major strategic initiative to grow its Oil & Gas business in India. The Oil & Gas Technology Day at Gurgaon is part of a strategic initiative that includes a series of events to reach out to customers and EPC contractors, and enable effective interactions across major regions and markets. ■

Schneider Electric introduces StruxureWare

Schneider Electric, announced release of StruxureWare™ for Mining, Minerals and Metals, a suite of applications that optimizes production operations to reduce costs and improve sustainability within operation. This is the newest addition to Schneider Electric's innovative StruxureWare software, the company's platform of integrated software applications designed to help customers maximize business performance and be more efficient and sustainable. The new StruxureWare suite integrates process control, operations management and energy management within the mining, minerals and metals operation to allow customers to gain actionable insight into their entire operation. With ability to manage & analyze data generated in real-time, customers are able to reduce operation costs, waste and increase safety, while monitoring energy usage. ■

Toshiba gets NTPC contract for Super-critical Steam Turbine and Generators supply in Orissa

Toshiba Corporation announced that Toshiba JSW Power Systems Private Ltd. (Toshiba JSW), a Toshiba Group company based in Chennai has been awarded a contract by NTPC Limited, India's largest state-owned energy service provider, for the supply of two 800MW super-critical steam turbine and generator island packages for the Darlipali Super Thermal Power Station in Darlipali, Orissa state. The new steam turbines will enter operation by early 2018. Toshiba JSW will carry out engineering, procurement and construction (EPC) of the complete steam turbine and generator island packages. NTPC's evaluation reflects the high performance and the reliability of Toshiba's supercritical steam turbines and generators, and the company's capabilities in integrating engineering and manufacturing functions. Toshiba can provide customers with competitive EPC solutions, and the company believes it is an acknowledgement of Toshiba's excellent track record for successful completion of challenging projects around the world within contractual schedules. In January 2014, Toshiba Corporation reinforced its thermal power generation business in India by integrating the engineering function of Toshiba India Pvt., Ltd. into Toshiba JSW Turbine and Generator Pvt., Ltd., a manufacturer of turbines and generators based in Chennai, Tamil Nadu state. The company, renamed Toshiba JSW, is positioned to provide full EPC solutions for thermal power plants, and is working to expand its business in India and the surrounding region. Toshiba Group has extensive experience in the manufacture and delivery of supercritical steam turbine and generators in Japan and in overseas. ■

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European Investment Bank and IREDA sign Euro 200 million Agreement

European Investment Bank (EIB) has sanctioned a Line of Credit (LoC) of Euro 200 million to Indian Renewable Energy Development Agency Ltd. (IREDA) to be utilized for financing Renewable Energy and Energy Efficiency projects in India. The total loan period is 20 years. The LoC is secured by a sovereign guarantee from Government of India. Agreement for availing the LoC of Euro 200 million from EIB, was signed by CMD, IREDA and Vice President, EIB in New Delhi today in the presence of Union Minister for New and Renewable Energy. Speaking on this occasion, Magdalena Alvarez Arza, Vice President, EIB said that European Investment Bank started funding Indian project in 1993 and in this period of two decades, India has now become the second largest recipient of EIB fund. Dr. Satish B Agnihotri, Secretary, MNRE said that this LOC of Euro 200 million will facilitate in IREDA's financing of existing and new projects of renewable energy. To tackle the twin problems of widening power deficits and mounting carbon emissions, the Indian Government has set ambitious goals to increasingly displace fossil fuels with renewable sources. The agreement signed today supports the Government of India's focus on a low carbon growth strategy for power generation in India. Developing renewable energy sources not only helps address environmental concerns, but also improves energy security and spurs regional economic development. IREDA is the dedicated financing arm of the Ministry of New and Renewable Energy and has been spearheading the growth of renewable energy in the country. It has cumulatively financed over 2000 projects corresponding to a financial value of about Rs 22,500 crores. IREDA has been raising resources from various bilateral / multilateral agencies as also from domestic sources through both taxable and tax-free bonds. ■

Taiwanese Manufacturers to react carefully & accurately

ITC announced that Taiwanese and Chinese PV products exported to the U.S. have caused substantial damages to the U.S. PV industry. Henceforth, DOC will take over the following administrative processes and announce the anti-subsidy and anti-dumping tariffs by the end of March and mid-June, respectively. EnergyTrend's data shows that Taiwan's cell shipment was around 6.5 GW in 2013, in which the first six largest export countries were China, Japan, Germany, U.S.A., Malaysia, and UK, representing 83% of the total shipment in 2013. Although the shipment to USA only accounted for about 5%, most of the cells exported to China were actually indirectly shipped to the US. From such point of view, demand from the U.S. market truly represented about 50% of Taiwan's total shipment last year. ■

HARTING Han-Eco series offers expanded deployment possibilities

New monoblock inserts for higher contact densities in the Han-Eco® series are expanding deployment possibilities. In addition, the proven Han-Eco "click and mate" snap-in function offers significant handling advantages thanks to tool-less installation. The series comprises robust connector housings made of glass-fiber reinforced high-performance plastics & offers advantages such as weight savings and savings in time during assembly and installation. The new monoblocks E, which have been developed primarily for use in housings from the Han-Eco series, have seen Han-Eco snap-in function retained, i.e. the simple and completely tool-free mounting of the insert. A special feature of the new Han-Eco monoblocks E is that they achieve up to 67% higher contact density compared to Han E standard screw inserts of the same size. ■

Alstom to supply equipment for Shuakhevi hydropower plant in Georgia

Alstom led consortium has been awarded a contract worth around €30 million to equip the 2 x 89.3 MW Shuakhevi Hydropower plant located in Georgia. Alstom's share of the contract is worth around €20 million Euros. Shuakhevi hydro power project is part of one of the largest foreign direct investment projects in Georgia to date. The aim of the project is to supply Georgia as well as Turkey with clean renewable energy to meet the peak electricity demand during winter. The power plant is expected to have an installed capacity of 178.6 MW and is expected to be commissioned in 2016. Alstom's scope of the contract includes the supply and installation of electro-mechanical equipment which consists of 2 vertical Francis turbines of 89.3 MW, spherical type main inlet valves, 2 three-phase vertical shaft generators with salient pole design, 2 three-phase generator step up transformers, 220kV gas insulated switchyard, overhead electric crane and mechanical & electrical balance-of-plant equipments. The main turbines and generators will be manufactured at Alstom's state-of-the-art Vadodara facility in Gujarat - one of the company's largest hydro manufacturing hubs worldwide, while electrical and mechanical balance-of-plant items will be supplied partially from Alstom's sites based in India as well as in Turkey. Jacques Hardelay, Alstom's Hydro business Chief Operating Officer, remarked, Alstom is proud to help Georgia in reducing its carbon footprint through renewable power generation, & will therefore use its technological expertise on this project and will continue to seek new opportunities to challenge the boundaries through technology and innovation. ■

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GE announces Global Wind Turbine Repair Innovation Lab in Albany, New York

GE announced the opening of its Global Wind Turbine Drivetrain Repair Innovation Lab at the site of GE's Power Generation Repair Technology Center in Albany, N.Y. The center marks an investment in GE's presence in the Capital Region and expansion of the local renewable energy team's facilities. The facility is equipped with advanced technologies to support fast development and innovation for repairs to the wind turbine's gearbox and rotor, creating a lab environment to simulate and solve problems that previously had to be worked on more than 100 meters in the air and at remote sites. Technical capabilities of the Innovation Lab include 'Rapid prototyping tools such as 3D printers and computer numerical control machines; Robotic welding and advanced machining tools; Repair of various gearbox models, Turbine generator repair. Andy Holt, GM of global wind projects and services, said, "This is the first facility of its kind dedicated to developing repair technologies and capabilities that reduce the life cycle cost of wind turbines. Albany was an ideal location for the facility with its close proximity to GE's renewable energy headquarters, the GE Energy Learning Center as well as the existing Repair Technologies Center. It is uniquely positioned for collaboration with the field, design engineering, training and product service teams." The Innovation Lab aligns GE with customer needs by helping reduce maintenance and operating costs. GE engineers will have the space and resources to rapidly prototype and develop new technologies to apply to field service repairs. The team at Innovation Lab also will work closely with product engineering to improve serviceability. ■

Largest crop of wind farms under construction; building U.S. industry's momentum

American wind energy industry responded to the extension of the Production Tax Credit in 2013 by starting construction in an unprecedented number of new wind farms, backed by Power Purchase Agreements with electric utilities on a record scale by the close of the year. "These results show the Production Tax Credit continues to be an effective and efficient policy, driving billions of dollars in private investment into our economy, fostering a new U.S. manufacturing sector, and creating economic benefits for communities across America," said AWEA CEO, as American Wind Energy Association released its U.S. Wind Industry Fourth Quarter 2013 Market Report. The record growth for wind energy at the end of 2013 resulted not only from extension of Production Tax Credit but also from investments in technological advancements that have driven down the cost of wind energy by 43% in just four years. ■

Traction Transformer Market worth $1.69 billion by 2018 at CAGR of 7.52%

Global traction transformer revenue market is expected to grow from $1.17 billion in 2013 to $1.69 billion in 2018 at a CAGR of 7.52% from 2013 to 2018. In terms of revenue, the market for traction transformers in electric locomotives is larger as compared to the other rolling stock. The global traction transformer unit shipment market is expected to grow from 6,031 units in 2013 to 8,507 units in 2018 at a CAGR of 7.12% from 2013 to 2018. EMU traction transformers' shipments are the largest, as they account for the most mature market. Traction transformers can be classified into three types · Tap· Changing, Tapped, and Rectifier. In terms of both · revenue and shipments, tapped traction transformers form the biggest market with revenue forecasted to reach $1.51 billion by 2018 at a CAGR of 7.46% from 2013 to 2018, according to market research reports. ■

California Energy Commission updating Appliance Efficiency Enforcement Process

California Energy Commission has begun a public process to ensure that consumers reap maximum economic and environmental benefits of energy efficiency standards for appliances. The Commission held a public workshop to discuss proposed regulations that will establish an administrative enforcement process that helps ensure compliance with appliance efficiency regulations. The California Legislature authorized the Commission to establish a process that assesses monetary penalties not to exceed $2,500 for each violation to those who sell or offer to sell appliances that fail to meet the standards. "Our goal with this rule making is to promote compliance with the state's energy efficiency regulations," said Energy Commissioner Karen Douglas. "Compliance will help to optimize energy savings, protect consumers, and create a level playing field for businesses selling appliances in California."Since 1975, energy efficiency standards for appliances and buildings have saved California ratepayers more than $75 billion in electricity costs, reduced greenhouse gas emissions, and have protected California's environment. "California's appliance efficiency standards have saved consumers billions in energy costs and significantly reduced greenhouse gas emissions," said Energy Commissioner Andrew McAllister. "This rule making process is complementary to our efforts, given that those benefits are fully realized when those who sell appliances in California and those who manufacture appliances for California abide by the standards established." The Energy Commission held a pre·rulemaking public workshop to discuss the proposed regulations and will be taking public comments on the proposed rule making until March 7, 2014. ■

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Moisture Management Systems in Power Transformers – A need of the hour

Power and distribution transformers are the most important and expensive assets in an electrical power network. Compared to other equipment, they are very reliable and require very little maintenance since they have no continuous moving parts. However, the insulating paper material, being organic will degrade with time, and thereby cause damage to the transformer.

- Pradyumna Karnik

Water is a by-product of the decomposition of the long chain hydro-carbon glucose molecules of cellulose that makes up the paper and pressboard insulation. Excessive moisture will saturate the insulation and increase its conductivity.

At higher temperatures vapour or free moisture can develop increasing the high risk of partial discharge and flash-over faults. Moisture has a great influence on the life expectancy and the load carrying capacity of a transformer. Moisture reduces the electrical and mechanical strength of the solid insulation. In general, the mechanical life of the insulation is halved for each doubling of the ppm water content; the rate of thermal deterioration of the paper is directly proportional to its water content.

The design life of power transformers is usually 30 to 35 years. In fact the typical Time to Failure of a large generator transformer (working at constant full load) is 18 to 24 years and a transmission or distribution transformer (working at half load or less) can be 40 to 60 years. The actual life of a transformer is determined by ageing of the cellulosic insulation in the form of paper on conductors and leads, and of pressboard used for inter-turn or intersection spacers. The insulation life is determined by three factors:

- Operating temperature
- Access to oxygen
- Water absorbed in the paper.

As cellulose ages the length of the glucose chain slowly reduces due to chain schism from 1200 molecules to about 200 molecules when it no longer has sufficient mechanical strength to be viable.

Operating temperature

Unless redundancy has been built into the transformer rating at the specification stage, a transformer is always likely to operate at or near the rated value. For every 6.5°C increase in operating temperature the insulation life will halve, based on moisture content in the paper of 0.3% by weight.

The remnant life of the transformer will be reduced whenever it is operating at high temperature. The rate of ageing will be higher (up to 50 times faster at moisture contents of 5% in the paper), and the remnant life will be much reduced.

Oxygen

Ageing is due to chemical reactions between the long-chain glucose molecule of cellulose and oxygen. With no oxygen present there can be no ageing of the paper, but oxygen is always present either as air dissolved in the oil or as water in the oil or paper. Attempts to replace air in the oil by nitrogen or an electro-negative gas have always failed, but a rubber-based membrane has been used with success to prevent direct contact between the oil and the atmosphere.

Unfortunately, the material of the membrane has a lifetime of only 10 to 15 years before is begins to allow air and water vapour to diffuse through it. In addition, water up to 10% of the weight of cellulose is formed by the chemical process of ageing. Fitting a membrane will trap water formed during this process and moisture is locked into the system where it is a catalyst causing more rapid ageing of the insulation.

Water

Under normal conditions oil will dissolve 60 ppm water before it saturates. Cellulose saturates at 10% water content when it is dry and between 12 and 18% water content when it is oil-impregnated. The presence of moisture as a contamination in the oil-paper insulation system will compromise the dielectric strength of the paper and will act as a catalyst for rapid ageing of the insulation system. Moisture can enter the oil-paper system in several ways:

- It can remain absorbed in the insulation if the factory drying process has been inadequate.
- It can enter the transformer during service if the air drying system has not been properly maintained, diffuse through gasket material or enter through cracks in the tank (welding defects).
- It can enter through openings in the tank if the internal insulation has not been correctly protected during site erection operations or during service outages.
- In addition, water is generated internally in the transformer as the paper and pressboard materials age in service. The rate of ageing in service is accelerated by operation at high temperature, by the presence of oxygen as air dissolved in the oil or as water in the paper.

Mitigation to reduce ageing

The traditional means of protecting the insulation system of a transformer from the ingress of water is to fit a silica gel breather. These breathers need to be maintained as often as every two weeks and do not remove moisture generated inside the transformer by ageing of the insulation.

Refrigerated breathers based on Peltier devices are widely used to continuously remove water from oil in the conservator. These devices will slowly remove water from the cellulose insulation but are

ineffective when water in the paper exceeds 2.5% by weight.

Oil filtration plant based on heat and vacuum operations are effective in drying the oil, but as more than 99% of the moisture is absorbed in the paper, it quickly migrates into the oil and the oil remains wet.

Molecular sieve drying devices are connected to circulate the main tank oil over a charge of molecular sieve material; this is a naturally occurring zeolite selected with a 4 Angstrom pore size to match the size of a water molecule. Water is trapped at up to 40% by weight of molecular sieve material through chemical bonding, and can only be removed by a heat and vacuum process to break the energy bonds holding water in the material. Molecular sieve drying devices can be used to slowly remove moisture from the cellulose insulation by removing water from the oil. The movement of water from cellulose to oil takes place at the same rate as the movement of water from oil into the molecular sieve material. High levels of moisture have been removed from the insulation of transformers over a period of weeks and months to reduce the risk of the transformers failing due to electrical surges or through mechanical faults associated with high through-fault currents.

An alternative water management scenario is to fit molecular sieve devices to new transformers, in combination with refrigerated breathers or diaphragm seals. The molecular sieve device absorbs water dissolved in the oil and removes water produced by degradation of the cellulose as it is formed. This combination of devices is effective in maintaining high integrity of the transformer insulation by eliminating the main catalyst for ageing and avoiding a reduction in the dielectric performance of the insulation structure.

Transec – Online Moisture Management System

TRANSEC is an on-line molecular sieve, developed and manufactured in the U.K and now manufactured in Facility if Ravin Group under licence from Transec- U.K.

Transec will continuously remove water from the oil and from the paper insulation in a power transformer while it is fully operational. This on-line process not only reduces ageing, but will improve the dielectric strength of the oil, and increase reliability. Plumbed into the oil 'circuit' of a transformer, the circulation pump will pump the oil across the molecular bed, which, through chemical bond, will attract water particles contained within the oil. By constantly reducing the level of water contained within the oil, water contained within the solid insulation, where over 95% of the water is trapped, will migrate into the oil to maintain the natural water equilibrium. In this way water gradually moves from the solid insulation, to the oil, and then trapped by the molecular sieve.

A 10 micron particulate filter will at the same time remove extraneous matter, such as fibres, which can become ionised, being attracted to areas of high electrical stress and causing a flashover. TRANSEC is designed to be a slow, non-invasive, gradual process, that will by lowering the ppm level of water in the oil, encourage water to migrate from the solid insulation to maintain the natural hydrostatic equilibrium, and hence over a period of time, significantly reduce the water contained within the solid insulation, and therefore reduce the rate of ageing, extending the life of the transformer.

The TRANSEC system has the capacity to remove approximately 10 litres of water from a transformer before saturation, but the rate at which it will adsorb water will depend on many factors, mainly, how much water is available in the oil, and the temperature range through which the transformer will operate. The design flow rate of the pumped oil is nominally 90 litres per hour to give maximum adsorbtion through the molecular bed. The oil temperature does not have to be elevated to give optimum adsorbtion. A single TRANSEC cylinder will adsorb approximately 30% of the weight of the zeolite material giving a theoretical volume of 3.9 litres of water. The rate at which this adsorbtion takes place is dependant on availability of water, temperature, and the % saturation of the cylinders, the process will slow as total saturation is reached. The Isostere graph shows that the adsorbtion performance of the zeolite improves with a reduction of temperature, whereas other dry out devices require elevated temperature to allow effective dry-out. However, we know that the higher the temperature of the transformer, the faster the rate of ageing of the paper insulation material. Typically a CL3AM on a wet (insulation water content 4% by dry weight) hot

Materials & Performance Specification

Product: TRANSEC CL3AM On-line Transformer Drying Unit with Monitoring
Adsorbtion Materials & Performance
Zeolite - Crystalline Aluminoscilicate with binders (CAS-No. 1318-02-1; EINES-No 215-283-8). 3 Anstrom bead size. Non-flammable and bio-degradable. Weight of beads per cylinder - 13 kgs. Oil Volume per cylinder - 12 litres Oil Type - New un-inhibited napthynic to IEC 60296 (3), Adsorbtion capacity of water per cylinder - Maximum 30% of bead weight (3.5 litres – approx 10 to 11 litres total for 3 cylinders per cycle).
Materials in Construction
Cylinders: 304 grade stainless steel all welded construction with quick fit couplers for ease of removal.
Frame: 304 grade stainless steel all welded construction.
Pump: Caned Rotor sealed circulation pump running at average 90l/hr -25°C to 110°C
Pipework: 15mm x 1mm wall Stainless Steel seamless tube with all welded joint construction wherever possible.
Fittings: Stainless Steel ¼ turn ball valves, flow indicator, de-aerator, non return valves etc. Lockable air bleed valve, accessible at ground level on 6mm diam. copper– up to 5 m capillary tube Non-return valve, ½" BSP, brass body construction.
Monitors: Vaisala MMT 162 probes at input and output for SCADA signal for oil temperature and ppm water in oil, with local LCD display. LEM monitor for incoming LV supply and pump integrity.
Installation Typically for CL3AM mounted on transformer:
Materials: 2 x 1.5m length of 15mm stainless steel pipe
2 x Flange Adaptors – 15mm pipe to take off valve flange size. 4 x ½" BSP M x 15mm SS male stud couplings.
3 x ½" BSP M SS hex nipples.
Type Testing: Random unit selected for test once every 12 months. System pressurised to 3 bar for 1 hour at 110°C (pump not running) to prove leak free.
Routine Test: Every production unit. Each individual cylinder is tested under 4 bar pressure prior to TRANSEC unit assembly. Each unit is tested pressurised to 2 bar for 30 minutes at 60°C to prove leak free.

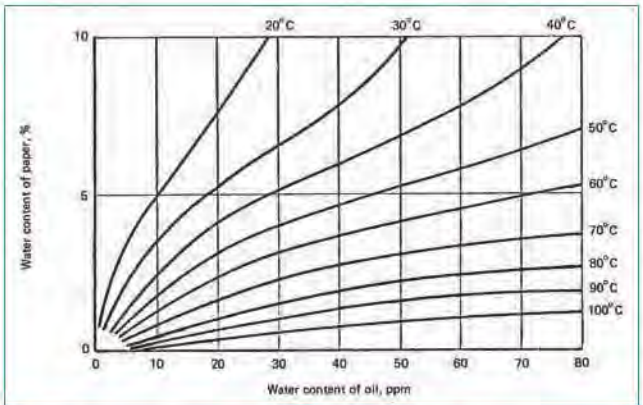

Figure xx Increased rate of ageing of cellulose with water content

transformer operating in a hot humid ambient climate might saturate in 6 to 9 months. A CL3AM on a dry (insulation water content 1% by dry weight) operating at 50° C might take 24 months to saturate. A CL3AM on a brand new transformer (insulation water content 0.3% by dry weight) might take 5 years before saturation. No specific claims for ppm levels in oil are made by TRANSEC, as the reduction of ppm will always depend on the 'wetness' of the transformer, and the dynamic operating conditions. The product is judged on the amount of water that is removed, which is reported to the client when the cylinders are replaced and regenerated.

Regeneration

When the cylinders are found to be saturated they must be replaced. TRANSEC (UK) offers a cylinder exchange where we supply three previously 'regenerated cylinders' for either the client, or TRANSEC to fit in place of the existing ones. This is done by simply using the quick fit couplers on the top and bottom of each cylinder, and removing each cylinder in turn. The couplers self seal, so there is no oil loss. The three replacement cylinders are then fitted and the quick couplers snapped shut. At the same time the particulate filter should also be changed. The 'wet' cylinders removed are then returned to TRANSEC (India), who will carry out the regeneration process. Method statement TR003 must be observed for the cylinder change process. ■

Pradyumna Karnik graduated in Electrical Engineering with Post Graduation in Marketing Management and working with Ravin Cables Ltd as Asst Vice President – High Voltage Business. He has 15 years experience in the cable business.

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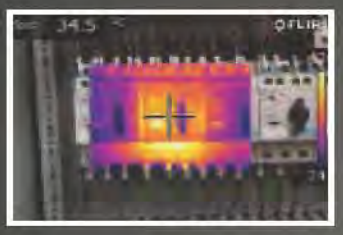

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Preventive Maintenance and Checks on Failure of Transformer

Transformers plays a crucial role in the power system & distribution network and any failure creates disruption of power supply to consumers and the extent of effect depends upon the rating of transformers and area of application. To avoid failure, tests must be performed during preventive maintenance work so that the condition of the transformer can be monitored by trend analysis and verification of any repairs can be checked. Any incipient faults can at this stage be located and repaired before any failures occur.

- Aman Deep

Power transformer is an electric machine with a useful life cycle of 20-25 years. This doesn't mean to say that these cannot be used above this period, in fact, a great part of the electric and industrial fleet is being operated with reliable machines above this time. The really important fact is to know the status and evolution of the transformer to be in conditions to operate it with the maximum security and know if it is appropriate to continue its use, know overload capacity, limit load, refurbish it or either take it out from active service. In service transformers are subjects to thermal, electrical & mechanical stresses as well as stresses of external origin, which arise due to disturbance and also from atmospheric surges. With the further increase in the market competition, it has been observed that the safety margins of the transforms have been brought down to bare minimum, just sufficient to satisfy standard specification and ideal loading conditions. As a result users have been put to constrain of running the plant within the specified capacity throughout the year which cause the more failure risk. To know the actual condition of the transformer, testing and condition monitoring is required. Testing of transformers takes place firstly at the manufacturer's works where the tests should be witnessed by a competent person from the customer side. Here tests are witnessed and test certificates mutually signed by the manufacturer and user. These tests can be Routine test, Type test or any special test desired by the customer as per terms and conditions agreed in purchase order.

Tests must be performed during preventive maintenance work so that the condition of the transformer can be monitored by trend analysis and verification of any repairs can be checked.

Any incipient faults can at this stage be located and repaired before any failures occur. Tests are also performed on the transformer after it has tripped as a result of a fault via the Bucholtz relay, overload relay, restricted earth fault, etc. These tests are to verify the damage, if any, and whether the unit may be safely returned to the services. Tripping of transformer generally occur to various type of fault which may be internal or external. Various types of fault can be classified as : -

Internal faults – Winding Phase to Phase fault, Phase to ground fault, Winding inter-turn fault, tank fault, core insulation failure, shorted lamination etc. External faults – Over load, Under/Over Voltage, Over-fluxing, Under/Over Frequency, external short circuit etc.

Fig. 1: Fire in 12.5 MVA Transformer

This article describes about some tests which can be performed at site and other tests which can be done at vendor works or at any laboratory. After tripping of the transformer, oil sample from the top and bottom sampling valves should be collected and sent to the Laboratory for DGA test. In the mean-time various checks to be carried out on the transformer to check the healthiness of the transformer.

Insulation Resistance (IR)

The purpose of the measurement is to determine the leakage current of the insulation resistance which determines the presence of contamination and moisture. This leakage current is changing with the moisture, impurity contents and temperature of the insulation. Humidity and leakage currents flowing along the outside surfaces of insulators or bushings can also cause false results. Bushings and insulators need to be cleaned off thoroughly before testing. Beside the result of the measurements, the comparison of the periodical measurement gives the information about the condition of the insulation.

Measure the IR between HV to E, LV to E and HV to LV. Lower value of IR could be because of low BDV of oil and improper measurement.

The polarisation index (PI) test is particularly useful as it is an index and therefore the result is not temperature dependant. It is the ratio of the 10 minute insulation resistance value to the 1 minute value. Since the leakage current increases at a faster rate with damaged or contaminated insulation, the polarisation index will be lower for insulation in poor condition. This test provides useful information

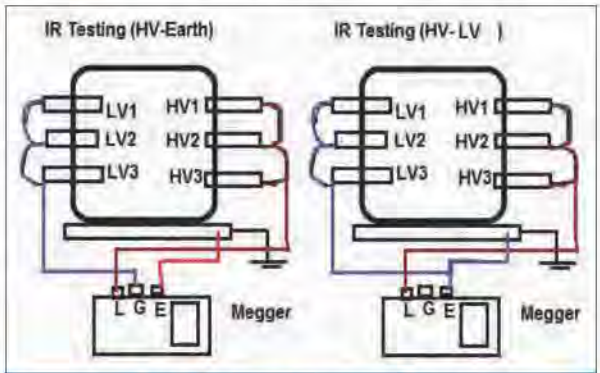

Fig. 2: Insulation Resistance Testing

for trending and evaluating the condition of the insulation (dielectric) system where no previous results are available. Its value should be greater than 1.3. The winding other than under measurement should be properly grounded. Below given Table 1 & Table 2 shows the test results of Healthy and un-healthy transformer respectively.

IR of 3.5 MVA 11/0.433 KV Healthy Transformer			
Terminal	60 sec (MΩ)	600 sec (MΩ)	P.I
HV-E	10800	25400	2.4
LV-E	10300	33900	3.3
HV-LV	18700	41800	2.2

Table 1

IR of 2.5 MVA 11/0.433 KV Un-Healthy Transformer	
Terminals	IR (MΩ)
HV-E	2
LV-E	1500
HV-LV	1000

Table 2

The value given in Table 2 shows the faulty HV winding of the transformer.

Magnetic Balance Test

Magnetic Balance test is used to find the distribution of flux (magnetic), core coil assembly condition and defects in winding (if any). In this method we have to apply turn by turn Voltage between (in Star Connection) phase & neutral and voltage on the other two phases are measured. And in Delta connection we have to apply voltage between two phases and measured between other two phases. Theoretically in star connection the voltage should be 2/3rd and 1/3rd in the other phases when it is applied between UN and WN and it should be ½ when it is applied between VN. Table 3 & 4 shows the result for healthy winding.

HV Side (Delta Connection)		
1U - 1V	1V - 1W	1W - 1U
417.0 (Applied)	401	22
232	419.0 (Applied)	189
20	402	420 (Applied)

Table 3

LV Side (Star Connection)		
2U -2N	2V -2N	2W -2N
238 (Applied)	208	30
121	239 (Applied)	119
38	206	242 (Applied)

Table 4

Turn Ratio Test

The turn ratio test detects short between turns of same coil, incorrect tap-setting, misaligned tap connecting shaft, mis-labeled phase markings and failures in tap changers. This tests is performed with the transformer de-energized and may show the necessity for an internal inspection and removal from the services. In this test three phase voltage is applied on HV side of the transformer (turn by turn on every tap) and voltage measurement is carried out on LV side. The results are analyzed by comparing the test result with factory results or commissioning results. There might be a little variation from the earlier results.

Magnetizing Current

The purpose of this test is to detect poor electrical connections, inter-turn shorts, gross core damage and winding problems. It provides information for mechanical

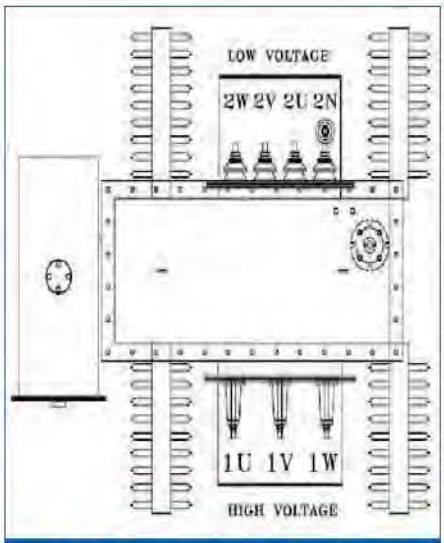

Fig. 3: HV and LV side of Transformer

assessment of transformer. This test generally segregates the faulty phase from the normal phases of the transformer. In this test 415V is applied from HV side while keeping the LV side open. Then magnetizing current is measured in all three phases of HV side. For a healthy transformer this value comes in milli-ampere (mA). This current value exceeds to very high value when there is any inter-turn fault. If a fault develops in the secondary windings, this fault will act as a load across open circuited secondary winding and the faulted windings drawing a current fault current. As a result, the Excitation Current will go up due to the opposing flux created by the fault. Further segregation of fault whether it is in HV or LV winding to be done with resistance measurement. For a 31.5 MVA, 132/11 KV healthy transformer measured value of Magnetizing current are 1.846mA, 1.297mA, 1.677mA between terminal 1U-1V, 1V-1W, 1W-1U respectively on applying 415 V from HV side.

Core to ground Resistance

If an unintentional core ground is suspected then a core insulation resistance test must be performed.

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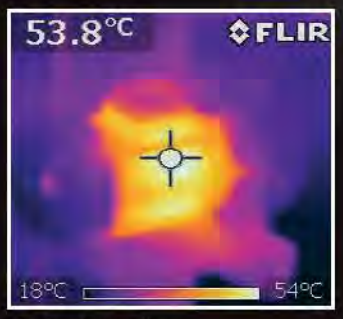
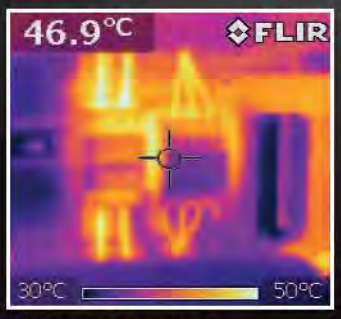


Engine inspection



Overheated connection

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The core is grounded at one location. If an unintentional core ground is formed in another location, circulating currents will flow between the core and ground causing internal heating within the transformer. Dissolved Gas Analysis (DGA) will show the production of combust ethane and or ethylene and possibly methane. The core to ground resistance test can detect if this connection is loose. If the intentional core ground is intact, the resultant resistance should be very low. To do the measurement the intentional core ground connection must be disconnected, an insulation resistance measurement must be done between the now insulated core to ground. This test should produce very high resistance indicating that an un-intentional ground is not present. Normally core to ground resistance should be 1000 MΩ.

In case if it is less than 200 MΩ then it may indicate serious problem.

Short circuit Impendence Test

This test is used to detect the deformation of the windings or core caused by damage, through faults or ground faults.

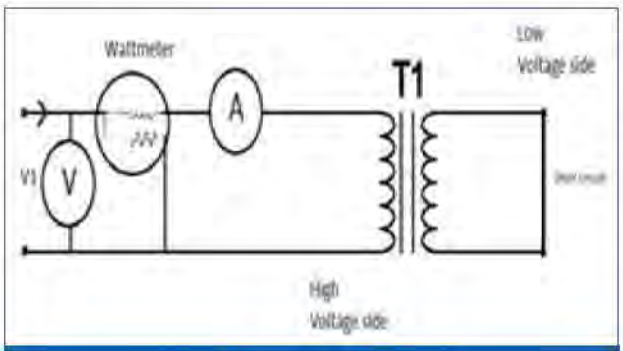

Fig. 4: Short Circuit Test Circuit

In this test three phase 415 V is applied on the HV side of the transformer keeping all the three phase of LV side shorted. Voltage and current is measured at different tap positions. The results are compared among the phases. In case

Fig. 5: Shorted LV side during Short Circuit Testing of 31.5 MVA, 132/11 KV Power Transformer

of variation in a particular phase, then it reveals problem in that particular phase.

Dissolved Gas Analysis (DGA)

In service, transformers are subject to electrical and thermal stresses, which can cause the degradation of the insulating materials. The degradation products are gases, which entirely or partially dissolve in the oil where they are easily detected at the ppm level by dissolved gas analysis. Along with the oil sample quality tests, performing a dissolved gas analysis (DGA) of the insulating oil is useful in evaluating transformer health. DGA allows gases to be extracted from oil and their subsequent chemical decomposition to be determined. Based on variable amount of components identified in the, blend such as N2, O2, CO, CO2, CH4, C2H6, C2H4, C2H2, several diagnostic methods have developed to establish the nature of the incipient failures and the risk it poses to the service reliability of the unit. These gases can be analyzed by Roger's ratio method, IEC-599 methods. The result obtained from DGA must be compared with the previous result to get the better understanding of the transformer health. DGA test should be conducted for a new transformer, which gives a pattern of various gases, which further helps for fault finding at a later stage by considering these results as a reference.

Winding Resistance

Winding resistance can be measured directly using digital micro-ohm meter, which can detect broken conductor strands, loose connections and tap changer contacts. These tests are compared between phases and with the factory tests. Temperature correction factor should be considered during comparison with factory tests. As due to large inductance of the winding, care should be taken during discharging of the circuit. Now days modern instrument discharge the circuit automatically.

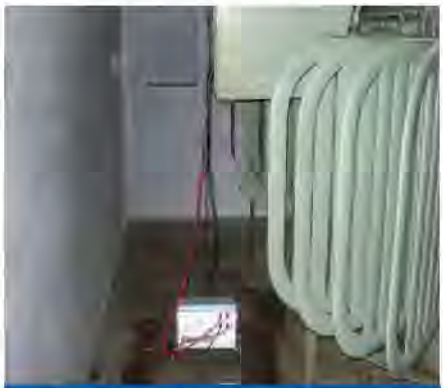

Fig. 6: Winding Resistance Measurement

It should be keep in the mind that if magnetizing current test is required to be conducted that should be done prior the winding resistance test. Because residual magnetism will remain in the core which distort the magnetic current, which can cause the measurement useless. Test results of 2.5 MVA, 11/0.433 KV Distribution Transformer is shown in Table 5,

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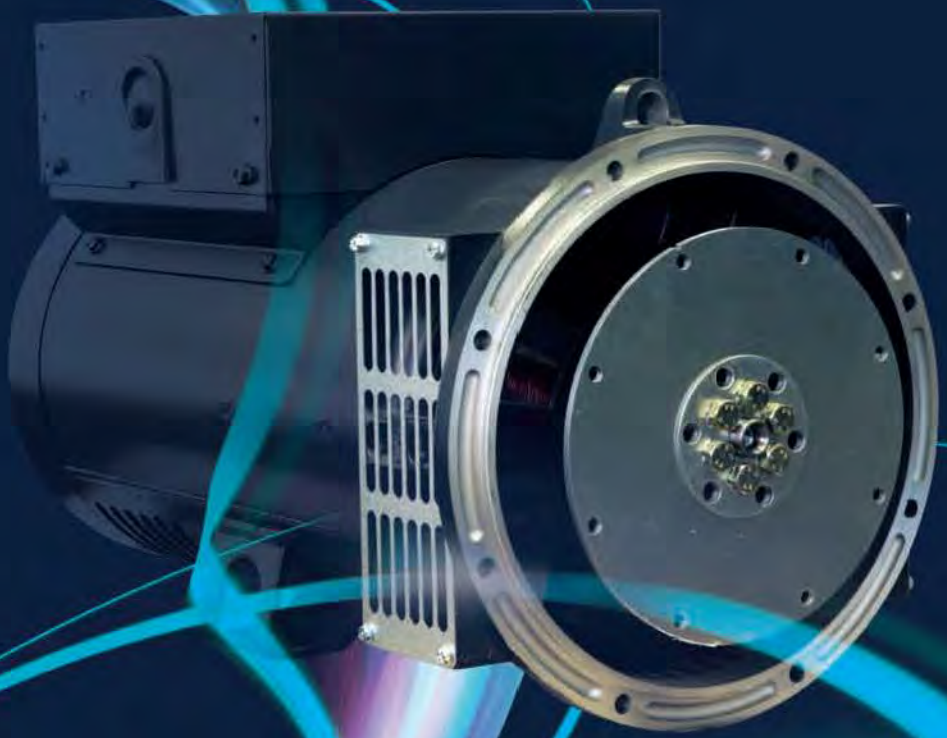

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which shows the abnormality in high voltage winding due to large variation in results. Results were taken at 35 °C with digital micro-ohm meter. Winding resistance at each step should be measured if winding is connected through Tap changer.

Winding Resistance Measurement		
Winding	Connection	Resistance
HV Winding	U1-V1	0.764 Ω
	U1-W1	1.515 Ω
	V1-W1	0.762 Ω
LV Winding	U2-N	1.415 m Ω
	V2-N	1.453 m Ω
	W2-N	1.484 m Ω

Table 5

Tan δ and Capacitance test

This test indicates the state of dryness of the windings and the insulation system as a whole, including bushings, oil and windings. All electrical insulations in power apparatus have a measureable quantity of dielectric loss, irrespective of the condition of the insulation. Proper insulation has low value of losses, while higher losses indicate some problem in the insulation. Normal ageing of any insulation cause losses to increase. On the other hand if the insulation is contaminated with moisture or any other chemical substance then this rate of ageing will be much higher than normal rate. It is very similar to a parallel plate capacitor with the conductor and the neutral being the two plates separated by the insulation material. Tan delta is the tangent of the loss angle between the resistive current (I_R) and the capacitive current (I_C) in the dielectric.

Loss factor is a dimensionless ratio expressed in percent which gives an indication of the condition of insulation. The values obtained for each test are compared to factory test results, commissioning tests and preventive maintenance test results.

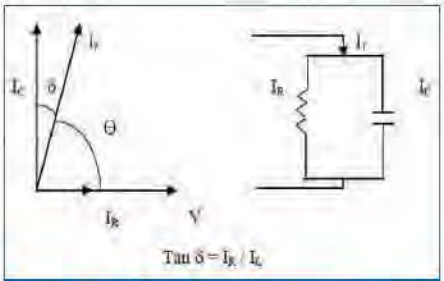


Fig. 7: Test Current Component

Power Transformer Capacitance and Tan δ Measurement			
Measurement	Test Voltage (KV)	Cap. (pF)	Tan δ (%)
HV to Tank	5 KV	7573.1	0.199
	10 KV	7573.1	0.199
LV to Tank	5 KV	12663.0	0.218
	10 KV	12663.0	0.218
HV to LV	5 KV	4154.6	0.130
	10 KV	4154.6	0.130

Table 6

Given Table 6 shows the Tanδ and Capacitance value for 31.5 MVA, 132 / 11 KV healthy Power transformer. In a perfect insulation, the angle would be nearly zero. An increasing angle indicates an increase in the resistive current through the insulation, meaning contamination. The greater the value of angle, the worse the insulation. For a perfect insulation % Tanδ value should be less than 0.5 %.

Breakdown Voltage of Insulating Oil

Transformers utilize oil as a heat transfer medium and a dielectric material, together with cellulose. Breakdown voltage (dielectric strength) is one of the most important parameter of transformer oil. It is measured when the transformer is taken into use and typically monitored by sampling during its operational lifetime and also during some maintenance. It has been reported that breakdown voltage is affected by several factors, such as moisture, particles, acidity, and pressure. Break down voltage is measured by observing at what voltage, sparking starts between two electrodes immerged in the oil, separated by specific gap. Low value of BDV indicates presence of moisture content and conducting substances in the oil. For measuring BDV of transformer oil, portable BDV measuring kit is generally available at site. In this kit, oil is kept in a pot in which one pair of electrodes is fixed with a gap of 2.5 mm (in some kits it is 4mm) between them.

Now slowly rising voltage is applied between the electrodes. Rate of rise of voltage is generally controlled at 2KV/s and observe the voltage at which sparking starts between the electrodes. That means at which voltage Dielectric Strength of transformer oil between the electrodes has been broken down. Average of six reading should be considered as final BDV value. For new transformer oil its value should be greater than 60 KV. Apart from the BDV value of the at site, various other test at laboratory can be performed like Water content, Acidity or Neutralization Number, Interfacial tension, With above mentioned tests we can get the information regarding the type of fault, for further analysis and corrective action transformer manufacturer should be consulted

Fig. 8: BDV Tester

Transformer Failure Trend		
Sr. No	Cause of failure	% of failure
1	Insulation failure	26
2	Manufacturing Problems	24
3	Unknown	16
4	Loose connections	7
5	Overloading	5
6	Improper Maintenance	5
7	Oil contamination	4
8	Line surges	4
9	Fire/explosions	3
10	Lightning	3
11	Floods	2
12	Moisture	1

Table 7

and final action should be taken accordingly. However if we see the trend of various causes of transformer failure as shown in Table 7, it reveals that insulation failure is predominant from the other faults so dielectric tests are the most important tests for accessing healthiness. There are various other offline and online tests such as Infrared Scan, Sonic Fault Detection, Ultrasonic (Acoustic) Contact Fault Detection, Vibration Analysis, Degree of Polymerization, Furan Analysis etc., which can further be used for the complete analysis of health of transformer.

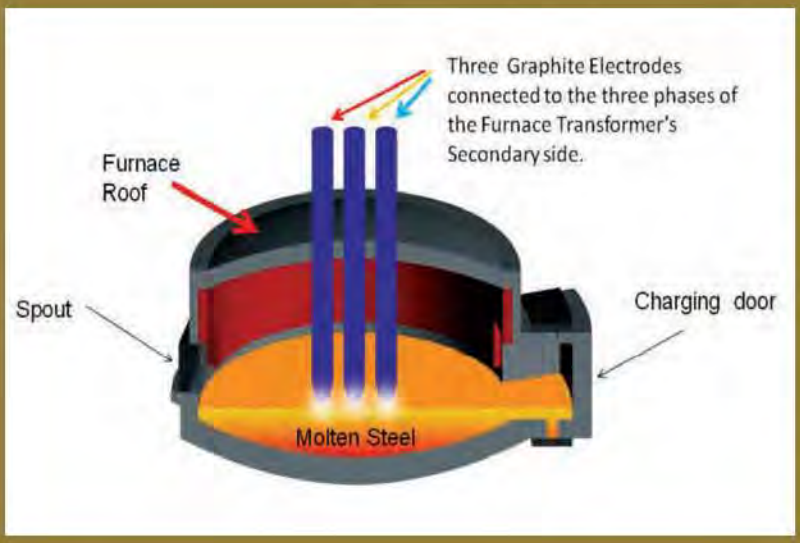
Conclusion

Being an important part of electrical system it plays crucial role in smooth & continuous operation of any sector like industrial, agriculture, commercial, domestic etc. Any breakdown in transformer can stop the functioning of any system, so preventive maintenance of transformer is must. Testing is important aspect of assessment of transformer life and healthiness. From the short planned downtime available it is necessary to perform various tests to have a better understanding of health of transformer. The analysis of root cause of the failure is also important with the help of expertise and transformer manufacturer. Which further enable to take corrective action and can help to prevent the same problem in future. Major failure can be avoided if we have complete preventive maintenance schedule and implementation of the same with regular interval of time. ■

Aman Deep, BTech in Electrical Engineering from Kurukshetra University and MTech from GNDEC, Ludhiana is currently employed with SEL Manufacturing Company Limited. He has also worked with Continental Carbon India Ltd, Johnson Matthey India Limited, Ericson and Vardhman Group in Maintenance and Projects Department.

Eddy Current Heating

'inside the building, housing an Ultra high powered Electric Arc furnace Transformer'



During the early part of 20th. Century Paul Heroult of France developed the first successful Electric Arc Furnace (EAF) which was named after him as " Heroult Furnaces". Since the source of heat in an electric arc furnace is the high intensity of the arc itself, & not the combustion of any fuel, the operation of EAF was considered relatively less polluting, when compared to other types of steel refining furnaces. Thus the Electric Arc Furnace became the preferred route of producing quality steel in which steel scrap is heated & melted by the heat of the electric arcs striking between the furnace electrodes & the metal bath. There are two kinds of Electric arc furnaces: Direct current (DC) and Alternating current (AC).

- C V Govinda Raju

Three Phase AC Electric Arc Furnaces with Graphite electrodes are commonly used in Steel making. We can use 100% scrap in steel making through the EAF steel making route. Capacity of EAF may reach up to 400 tons per single heat & the process through EAF route is considered as energy efficient.

Cycle of steel making

The cycle starts with charging of the furnace with steel scrap. The swing- able roof is placed on the shell & the three electrodes are lowered. Each electrode has its own current & positioning regulators. Furnace transformer is energized thus initiating the current flow through the electrodes & striking of an arc. The electrodes

Fig. 2: Actual Electric Arc Furnace in operation

bore through the scrap thus forming a molten pool of liquid metal. The scrap helps to protect the furnace refractory lining from high intensity arc during meltdown. Power input to the furnace can be increased by increasing the transformer secondary voltage, which in turn increases the arc length. After meltdown, oxygen is injected into the molten pool to oxidize the excess carbon from the metal. Fig. 1 shows the schematic of an Electric Arc furnace & Fig. 2, an actual EAF in operation. Fig. 3 shows Water cooled swung- out roof of an EAF with the three electrodes. Furnaces are further classified as Low, Medium, High, & Ultra High powered, according to the requirement of power to produce one ton of steel (See Fig. 4).

Fig. 3: Water cooled swung out roof of an EAF, showing the three electrodes.

Just as there have been significant changes in the Electrical design & construction of Arc Furnaces in the past several years, there have been equally important developments in the operation of the Arc Furnaces. High powered transformers are the current trends. Most modern furnaces operate at 500 kVA/ton and the trend is towards Ultra high power ranging in between 700 kVA/ ton to 1000 kVA/ton. Developments are in progress to install transformer with 1500 KVA/ton capacity. These developments are leading to

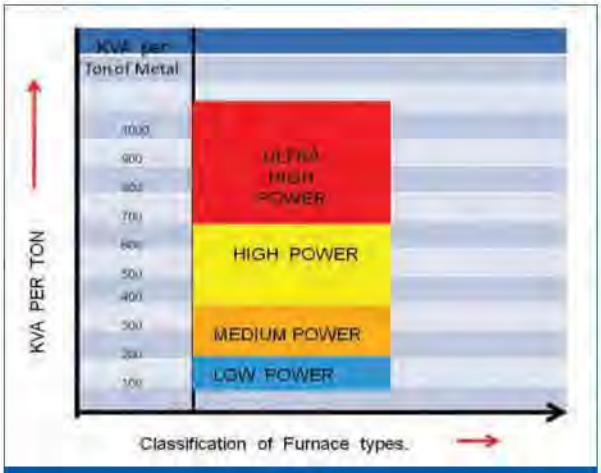


Fig. 4

increasing the productivity in tons per hour. Higher the furnace input power/ton, productivity in tons/ hour goes up. As a result of these developments, the MVA rating of the Furnace transformers are also going up to meet the increased productivity. This means that the Furnace transformer's secondary side currents feeding the furnace electrodes through the water cooled flexible cables are of the range of 75,000 Amps to 100,000 Amps. Naturally the bus bars or bus tubes from the secondary side of the furnace transformers need to be designed to carry such large currents.

Case Study of an Ultra High Power Electric Arc Furnace

These developments led M/s Ispat Industries Ltd. Mumbai, (Presently taken over by Jindal Steel Works) to opt for the latest type of an Ultra high powered "Twin shell arc furnace" designed to have the flexibility,(based on the availability & prices of raw materials), using either solid steel scrap or Sponge Iron or Liquid pig iron from Blast furnace as well as use oxygen blowing through steel, all possibilities built in the design of the Twin shell Furnace. Further the Steel works operator has the benefit of the enhanced flexibility in the use of raw materials as well as in the Steel grades he can produce. Twin shell furnace has the ideal combination of the advantages of an Electric Arc Furnace as well as those of the conventional Converter blowing process in a single production unit (See Fig. 5). This type of combining Converter Blowing process & Arc Furnace melting process is termed as "CONARC" process. As the name itself indicate, a Twin Shell furnace has two identical furnace shells with a single swing- able water cooled roof & an electrode arm. When one shell is using Electricity for melting (i.e EAF operation), the second shell can process liquid pig Iron it steel by oxygen blowing (i.e. Converter operation) & vice versa.

Ispat Industries Ltd., had planned to have two numbers of identical Twin Shell Furnaces each having a capacity of 180 Tons & the contract was concluded with a renowned German equipment

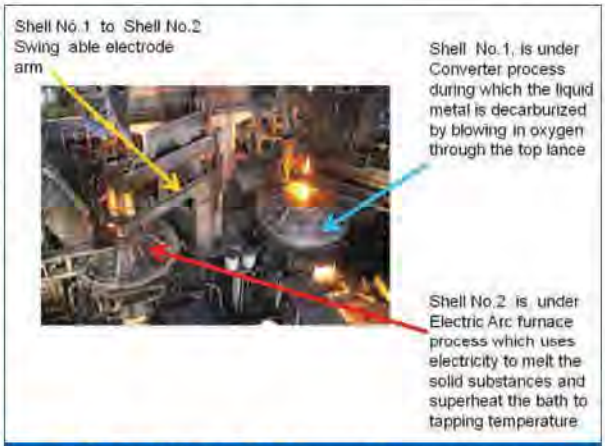


Fig. 5: The 180 t Twin Shell Conarc® furnace in operation

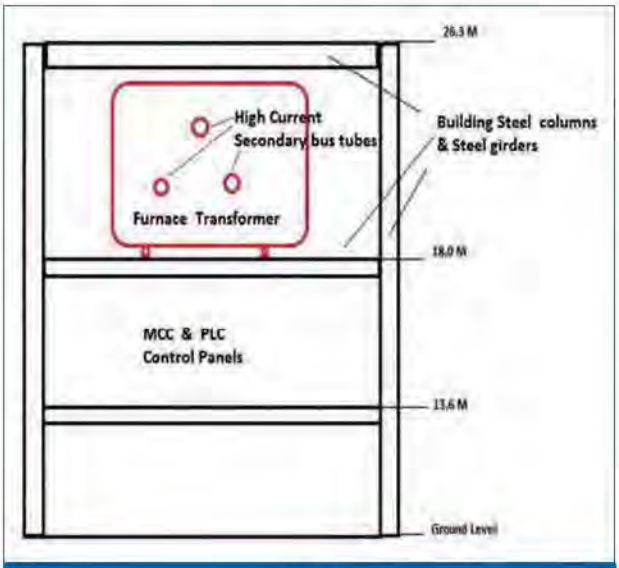


Fig. 6

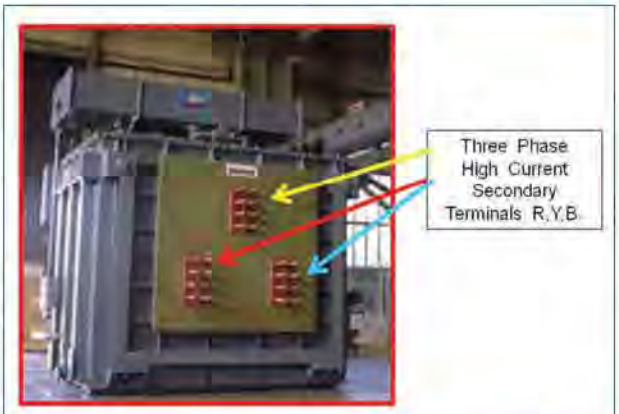


Fig. 7: 137 MVA, Electric Arc Furnace Transformer with LV terminals connected to Furnace Electrodes.

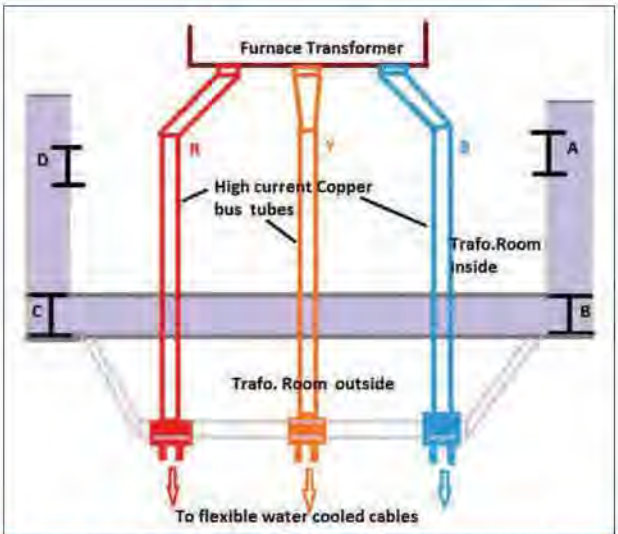


Fig. 8: Sketch showing the plan of the transformer room, Steel columns, high current secondary side bus tubes etc.

supplier in the year 1994. The complete Steel melt shop building was designed & construction supervised by a reputed Indian consultant group. The construction of the entire Arc furnace building was mainly with steel columns & girders, & intermediate walls of RCC construction, as is usually the case with steel plants. The Arc Furnace transformer, weighing 168 Tons (inclusive of oil), was located at a floor level of 18 meters. The floors below the furnace transformer was housing Motor control centres (MCC's), Programmable Logic Controllers (PLC's) etc used for the furnace operation (Fig. 6). The first phase of the Twin shell furnace was commissioned in the year 1998. The furnace was powered by 137MVA capacity Ultra High power transformer, with primary 33 KV and secondary voltage variable from 1400V & downwards. The designed max. current on the Transformer Primary side (33KV side) was 2,393 Amps & on the secondary side was 77,500 Amps. Fig. 7 shows the Furnace transformer with its Secondary terminals. Inside the Furnace transformer room, Circular high current water cooled Copper bus tubes were used to connect the secondary terminals of the furnace transformer and the Water cooled flexible cables feeding the furnace located outside the transformer room wall (See Fig. 8).

Transformer room heating problem

The Phase-1, twin shell furnace was commissioned at Ispat Industries Ltd on 10.4.1998 & there after the transformer loading was gradually raised from 35 MW onwards up to 80/85 MW. As long as the Electric Arc furnace loading was around 50 to 55 MW, there was no appreciable raise in the ambient temperature either inside the transformer room or in the neighbouring rooms. However when the furnace load was gradually increased from 55 MW up to 80/85 MW, tremendous increase in the ambient temperature inside the transformer room, Steel columns (marked A,B,C,D in sketch 8), steel girders supporting the transformer building, RCC walls, transformer room floor, steel girders below the transformer floor etc was observed. As a matter of fact apart from the heating inside the transformer room, the rooms housing the furnace Reactor, Vacuum Circuit breaker (VCB), PLC controls, MCC rooms etc were also seriously affected by the increase in the temperature. The entire construction of the Furnace transformer, VCB room, MCC & PLC rooms etc which were located in different floors, were all having a common steel grid frame work inter connected by Steel columns & girders. The steel column temperatures inside the transformer rooms went up to 139 deg C at a furnace load of 80/85 MW, despite having Stainless Steel reinforcements in the RCC walls inside the transformer room. Here it has to be noted that the equipment supplier had designed the total system for a maximum furnace operating load of 115 MW. With the kind of Eddy Current heating noticed in the transformer room & other switchgear/ Electronic control rooms etc, operation of the Electric Arc

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furnace beyond 55 MW became impossible, let alone operating at the designed capacity of 115 MW. The entire furnace operation became unviable since a major part of the Electrical energy, instead of going for melting operation, was getting wasted in unnecessarily heating up the building columns / girders / walls etc. of the steel plant. The matter was taken up with both the German equipment supplier as well as the Indian consultant who designed & supervised the building construction. The equipment supplier sent a reply saying that they had furnished all the necessary data like heat loading & Magnetic clearances etc required for proper designing of the Furnace transformer room, thus emphasizing that a proper Civil Engg. Consultant should have taken full care to design the transformer room meeting the requirement given by the equipment supplier. They also emphasized that failure to provide adequate air conditioning was one of the reasons for the increase in temperature.

During discussions with the Consultants, the following points emerged out.

- The equipment supplier had furnished the total Heat load inside the Furnace Transformer room as 45KW only.
- Further the Eqpt. Supplier had also furnished the Magnetic clearance required between the High Current Secondary bus tubes & the nearest steel column as 850 mm only.

Based on the above details received, the Consultant had designed proper chilling system to dissipate the heat load of 45KW specified by the equipment supplier. This did not take into consideration of the heat addition due to Eddy Currents which was far higher than 45 KW specified heat load.

Regarding the Magnetic Clearance of 850 mm given by the equipment supplier, the Consultant had provided a clearance of 1500 mm on one side & 1600 mm on the other side from the high current bus tubes to the respective nearest Steel columns. Despite providing more Magnetic clearances than specified by the equipment supplier, the Steel column temperatures were going as high as 139 deg C at an operating power of 80/85 MW itself. At an ambient temperature of 65 deg C inside the transformer room, It was extremely difficult for the persons to stay & monitor the temperature recordings. Frequent failure of Electronic components, Printed Circuit Boards etc installed in the neighbouring rooms, resulted due to the increased ambient Temp.

Failure of the Vacuum Circuit Breaker Controlling the Furnace Transformer

On the primary, 33 KV side of the Furnace transformer, a Vacuum Circuit breaker (VCB) was used for switching ON & OFF of the Furnace, & It had a rating of 2500 Amps. When the ambient temperature inside the transformer room was going as high as 60/65 deg C, the corresponding VCB room ambient temperature was found higher than 45 deg C. On 31.8.98, the Electric Arc Furnace controlling VCB 'flashed over'. The manufacturer had supplied the VCB mounted inside a totally enclosed dust tight switch board. On detailed examination of the failure & checking the permissible current rating at an ambient environment of 45 deg C, the VCB was capable of carrying only 1800 Amps under de-rated condition. But at the time of the failure, the VCB was actually carrying a current of 1950 Amps, which was beyond the permissible rated current at 45 deg C. Thus the VCB had failed prematurely. A spare VCB was installed & in order to reduce the ambient temperature inside the VCB room, two split Air conditioners were installed, one having 16 T & another of 25 T capacity. By commissioning these two air conditioners, the VCB room's ambient temperature came down to 27/28 deg C which was considered OK for the VCB operation.

What is Eddy Current heating

Magnetic field lines form Concentric circles around a cylindrical current-carrying conductor, such as a bus tube. The direction of such a magnetic field can be determined by using the "Right hand grip rule" (see figure 9). The strength of the magnetic field decreases with distance from the conductor. The direction and amplitude of the magnetic field around the conductor depend on the direction and amplitude of the current flowing through it. When the conductor carries DC, the direction and amplitude of the current are constant, so the direction and amplitude of the magnetic field around the conductor are constant. When the conductor carries AC, the

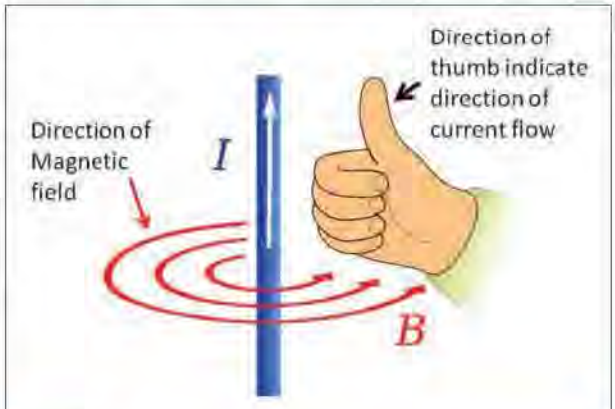

Fig. 9: Fingers point out direction of Magnetic field

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Fig. 10: Image on the left shows the totally enclosed bus duct cover provided on the primary side of a step up transformer, & the image on the right shows the inductive heating around the inspection cover of the bus duct captured from an Infrared camera.

direction of the current is periodically reversing and its amplitude typically changes, so the direction of the magnetic field around the conductor is also periodically reversing and its amplitude is typically changing. If ferrous materials such as steel are positioned within this magnetic field, they can heat up even though they are not part of the circuit. Inductive heating (Eddy Current Heating) can occur on bus supports, cable tray fasteners, and switchgear enclosures. Affected components can become hot enough to cause significant heat damage or even skin burns.

The temperature of the affected component will depend upon the strength of the magnetic field, and the composition and location of the affected component. Inductive heating is derived from the proximal interaction of non-current carrying devices with the magnetic field around energized conductors that are under load. In some cases, the affected components can reach temperatures in excess of several hundred degrees.

Fig. 10 shows the totally enclosed bus duct provided on the primary side of a step up transformer as well as the image captured from an Infrared camera showing the inductive heating around the inspection cover of the bus duct.

From the heating of the Steel columns & Steel girders, it was very clear that the magnetic field around the Furnace Secondary High current bus tubes, were directly hitting the steel columns, girders, steel reinforcements in the RCC walls etc generating a tremendous amount of Inductive heating as a result of insufficient clearance between the high current bus tubes & the building columns / walls etc. As the steel building/ RCC walls were already built to house various equipments on multilevel floors there was no possibility of increasing the required magnetic clearance.

The only other alternative possibility was to provide Non Magnetic shielding by way of Copper or Aluminum sheets to the Steel columns & RCC walls in the vicinity of the High Current Secondary bus tubes. As we did not have any theoretical calculation nor the expertise to calculate & arrive at the correct sizes of the plates, method of fixing etc, & neither the equipment supplier nor the Consultant could provide any concrete solution to this problem (except each blaming the other), we had no other alternative except to contact outside agencies who might have experienced this kind of problem.

Hueber of SMS GHH, Germany, suggested that providing copper shielding between the Columns & the High Current bus tubes will be

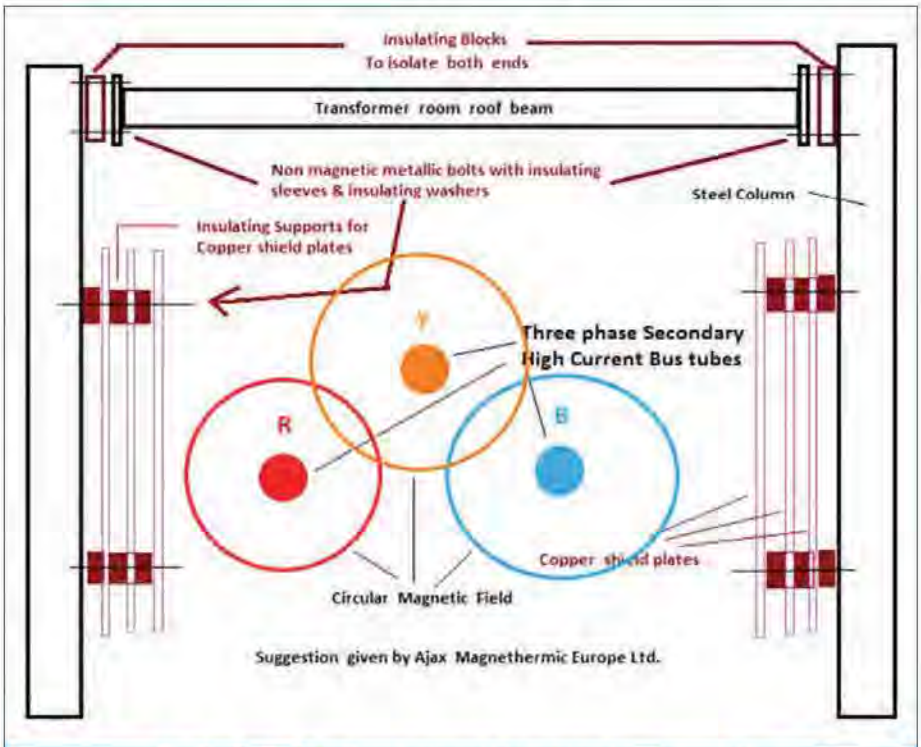

Fig. 11: Width of the Copper plate shall be twice the column width. Air gap between plates = 6mm. Thickness of plate = 6 mm.

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helpful in preventing the Magnetic Field reaching the steel columns. However, he suggested that we should do it by trial & error, giving more layers of Copper plates one behind the other duly insulated with Air Gaps. One vital input he gave was that we should consider a minimum clearance distance of 25 mm for every Kilo amp of current passing through the High Current bus tubes.

Ajax Magnethermic Europe limited, was also of the same opinion that we should try three copper plates, one behind the other with air gap & insulated, non magnetic supports & sent a sketch (See Fig. 11) giving some basic ideas to avoid the effects of stray fields around the high current bus tubes. However they said that this would be a starting point & need some experimentation.

Since both experts had subscribed to our idea of providing non-magnetic shielding to the affected columns, we procured readily available copper plates from the market having the size of 1200 mm X 1200 mm X 6 mm & cut them to 600 mm width pieces (Steel Column flange width was 300 mm).

On a trial basis we mounted three plates, one above the other on a single plane to cover about 3.5 Meters height of the two side columns. With the shielding on a single plane, the steel column temperature came down when compared to unshielded column, however this temperature was still considered high. We added three more parallel plates thus providing a second vertical layer with an air gap. The recorded Steel column temperatures in each case were as follows:

Case 1:

- Temperature without the Copper shield at 80 MW furnace load = 139 deg C
- Temperature without the Copper shield at 65 MW Furnace load = 90 deg C.

Case 2:

- With 6 mm Copper shield in a single plane at 76 MW load = 109 deg C.

Case 3:

- With 2 layers of 6 mm plates as shielding at 80 MW load = 64 deg C
- With 2 layers of 6 mm plates as shielding at 85 MW load = 70 deg C.

With the results of the above trials, it was concluded to add a third layer of Copper shield to bring down the column temperature further. We had also arranged for procurement of stainless steel bolts, insulating sleeves, insulating washers etc to fasten the shielding plates in multi planes. Since the RCC floor in the transformer room RCC below the High current bus tubes were also getting heated abnormally, it was decided to provide a fabricated water cooled Stainless Steel box covering the entire floor as a shield, thus bringing down the temperature. The 'U' shaped high current water cooled flexible cables leading to the Furnace, outside the transformer room were very close to the transformer room wall & the PLC control room wall and this was also heating the exterior walls of the two rooms which also necessitated magnetic shielding. We provided 10 mm thick Aluminum plates on the exterior walls of the transformer room & PLC room with proper insulating supports to cover the entire wall giving ample gap for the free movement of the water cooled flexible cables (See Fig. 12).

As an additional measure large capacity ventilation equipment was provided to the furnace transformer room bringing in fresh air. Since there was no hot air exhaust provision from the transformer

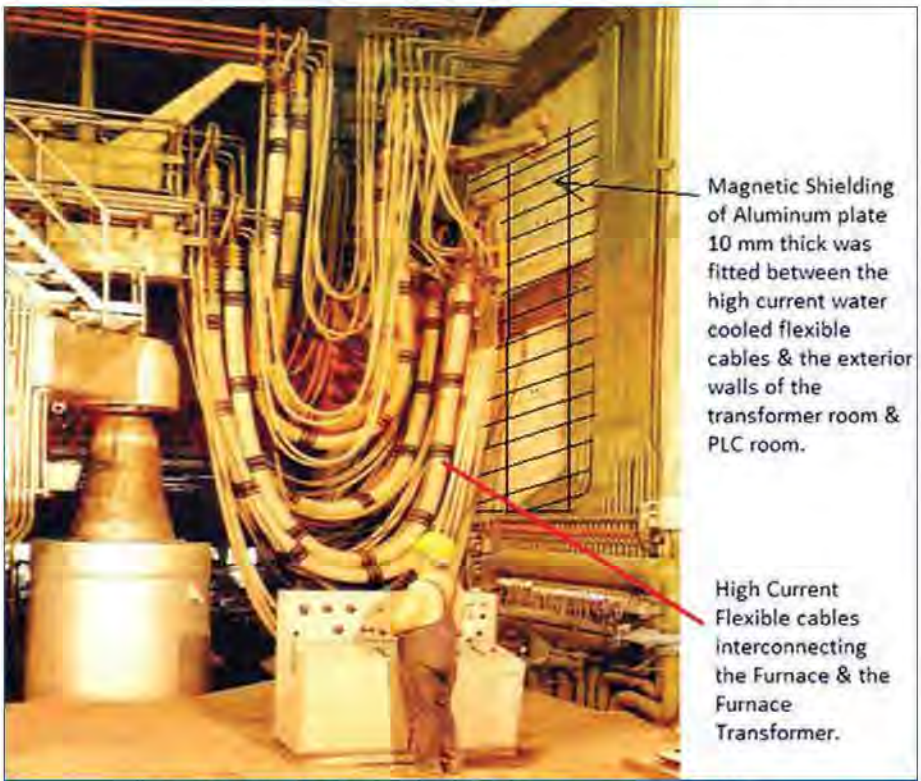

Fig. 12: Width of the Copper plate shall be twice the column width. Air gap between plates = 6mm. Thickness of plate = 6 mm.


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room, an outlet was also provided. With these modifications the heating problem was reduced, however the furnace operation was limited to around 75 / 80 MW as against the deigned capacity of 115 MW.

After we encountered the serious problem of the Eddy Current Heating in Phase - 1 of the project, for Phase-2, the entire design of the steel plant building housing the UHP Furnace Transformer, Reactor room, VCB Room, PLC & MCC rooms etc needed to be revised thoroughly by introducing the following recommendations.

Recommendations & corrective steps to avert Eddy Current heating

- The building housing the Furnace Transformer, particularly area near the High Current Secondary Bus bars, to be constructed using RCC columns only & in no case with Steel Columns. The reinforcement rods used in these RCC columns shall be of Non Magnetic Stainless steel (SS). These SS rods shall have insulating sleeves at all intersection points of vertical & horizontal members & tied together by Nylon twine to prevent rods directly touching each other. No tack welding or binding by metallic wires shall be done while tying up these SS rods. Further none of these SS reinforcement rods shall have any connection or contact with any of the near by columns, girders/beams.
- The entire floor of the transformer room, the side walls of the transformer rooms, walls of the PLC rooms & MCC rooms facing the furnace's High Current water cooled flexible cables shall have similar RCC construction with SS rods as in point -1 above.
- In addition to the above, the external wall of the Furnace transformer room, PLC room, MCC room etc facing the high current water cooled flexible cables, Aluminum sheet of 10 mm thick on insulating supports to be provided to the entire width of the exterior wall, as an anti magnetic shield extending up to 2 meters below the lowest height of the water cooled high current flexible, leaving about 50 mm gap from the surface of the wall. Care should be taken that during furnace operation the high current flexible cables do not touch this shield.
- On the secondary side of the Furnace transformer, a distance of minimum 2000 mm gap to be provided between the RCC columns /RCC walls to the nearest edge of the High current water cooled bus tubes in order to prevent magnetic fields reaching them. This distance of 2000 mm has been calculated considering our case, where the Maximum secondary side furnace current is 77,500 amps and providing 25 mm gap for every kilo ampere (77.5 X 25 = 1937 mm. say 2000 mm).If the Furnace secondary current is higher, this distance will have to be further increased.
- Forced fresh air ventilation of adequate capacity to be provided separately for the Furnace transformer room & the Reactor room.
- Since the Furnace controlling VCB have critical application, they need to be maintained/inspected frequently without interrupting the Furnace productivity. Hence it is suggested that we use Two nos of draw out design VCB's in parallel, thus providing flexibility (i.e. when one VCB is used for furnace operation, the other one can be drawn out for routine inspection/ maintenance).
- Exclusive packaged Air conditioners to be provided to the VCB / PLC rooms.
- The Reactor coil serving the Static VAR compensation equipment connected to the UHP Electric Arc furnace feeder was erected on an RCC foundation block in the open yard at the substation. Normal steel rods & steel wire binding were used by the civil contractor while casting this foundation block. During Arc furnace operation we observed heating of this concrete block & this heating was so intensive, that during rainy season we used to see water falling on the block forming vapour. For phase-2 it was suggested to use only stainless steel rods having insulating sleeves at all intersection points of vertical & horizontal members & tied together by Nylon twine. No steel wire binding or tack welding of SS rods to be done.

This was an unique experience that neither the Equipment supplier nor the Civil design consultant had any exposure on the operation of such UHP furnaces & Ispat Industries Ltd. became the training ground for both of them. The experience derived from this project helped both of them to effect necessary changes in their future projects particularly when the trend of Steel Melting is more & more towards UHP Furnaces. Sharing this experience will also help engineers who deal with high current applications. ■

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Director
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Technical Associates Ltd (TAL), an ISO 9001:2008 company, established in 1969 is one of the India's oldest and reputed manufacturers of Power and Distribution Transformers. TAL has also diversified into Turnkey T&D Projects and is executing several projects for Engineering, Procurement, Construction, Erection and Commissioning of Switchyards and Lines from 11 kV up to 132 kV all over India. The Transformer Division of TAL currently manufactures distribution and power transformers (as per IEC 6076) ranging up to 200 MVA, 220 kV Voltage class out of its both factories at Lucknow (Uttar Pradesh) and Sitarganj (Uttarakhand). TAL is further expanding its product range including Generator Transformers and Auto Transformers up to 315 MVA, 400 kV. In an exclusive interview with **Electrical India, Jitendra K Agarwal** says, we are also planning to upgrade our product range unto 315 MVA, 400 kV class transformers shortly.

What is the scope and scenario of the electrical industry in India?

The scope and scenario of electrical industry is extremely vibrant, as far as the fundamentals are concerned. There can be no question about the fact that there is a tremendous requirement of electrical equipment, products and a great need for power. As a country our per capita power consumption is just about 800 to 900 KW. The developed countries have got about 15000 KW per capita power consumption. So, naturally if you want to bridge the gap and become a developed country, we will have to achieve at least 5-6000 KW per capita power consumption. Therefore if you need to have economic growth you need power and equipment to deliver the power at the doorstep of the consumer.

The problem that we are facing in India today is a little more short term. We have had issues related to policy paralysis, stalled generation projects on one end and high energy losses and poor financial health of the transmission and distribution utilities on the other end, which have all contributed together to the recent slowdown. I still remember it was in the last Elecrama in 2012, that we got to know that Prime

Minister of India has set up a special task force to look at the power related issues for the power producers. It took two years but finally we got to know recently that a lot of issues have been sorted out and power generators are being asked to move ahead. Of course, a lot depends on the upcoming elections, however, having said that, we are confident that whoever comes into power will recognise the importance of power in creating economic growth and he will take adequate measures for the same. We have also seen recently that because of aggressive efforts made by IEEMA, we have also been able to build a lot of consensus and support among the policy makers in important ministries like Heavy Industries and they are now supporting the development of the Electrical industry aggressively. This is further exemplified in the creation and the release of the recent Mission 2020 plan for the Indian electrical industry.

What according to you are the challenges faced by the power industry and what are the ways to overcome it?

As of now there is no single large challenge that we face in the power sector If I purely talk about the electrical equipment manufacturing industry, there is a problem of excess capacity. On account of the ambitious growth targets we have put in place very huge capacity expansions. Almost every company has doubled or tripled its production capacities whereas the order booking has not kept pace with the capacity expansion. I think that is a very significant cause for concern that also leads to issues such as intense competition, price wars, pressures on margins, etc. which are major challenges for the Industry at large. Additionally, we have been facing a severe shortage of skills; we are finding that the skills of the fresh engineers who are entering in the industry are just not appropriate. It is in fact a national challenge that despite having the world's largest and youngest workforce, we are still talking of inadequacy of skills and poor quality of training of new engineers coming into the system. Internationally, the Indian industry faces challenges from cheaper products from China - which may or may not be on account of direct subsidies which Chinese companies receive from their government. Last, but not the least, Indian companies face a perception challenge as well in many global markets where Indian products are not perceived to be of a high quality.

Why do you think that there is a poor perception of Indian products at the global level?

I think, one of the reasons is - historically we were never known as a manufacturing base, neither for our engineering abilities nor the quality of the products that we manufacture. That space was traditionally occupied by the Europeans, and correcting the same will definitely take some time and effort. Secondly, while there has been a lot of improvement over the past 10-15 years, a lot of Indian companies are quite lagging as far as the adoption and inclusion of new technology is concerned. Newer technology can help make production far more efficient, economical and can also significantly improve the quality of the product manufactured - and that is a challenge that many Indian companies need to address immediately.

Can you share about the product ranges that your company caters to the Indian market?

We are manufacturers of transformers for all kind of applications and are in the business for the past 45 years. From small distribution transformers we go up to large power transformers including Extra High Voltage (EHV) transformers. We are also making special transformers like earthing transformers, converter transformers, high efficiency low loss transformers for renewable energy applications, Star rated distribution transformers for distribution networks & railway traction transformers.

Can you tell us what the market structure for the power transformers is?

Power transformers are used by Power transmission companies so we have essentially three main customers for power transformers. We have the central power utilities like Power Grid Corporation, NTPC, then you have State Transmission Companies like KPTCL (Karnataka), MSETCL (Mahrashtra), etc. and then you have EPC contractors who are now executing a lot of power transmission projects. In addition, we also sell Generator Transformers to Power generators who need to step up the electricity produced to feed it into the electricity grid.

Could you inform us about launching of any new products?

We are not launching any new products as such, because we believe in continuous innovation. We keep coming up with newer products in an effort to increase our product range. Last year we started manufacturing Convertor transformers for solar and renewable energy applications along with Traction Power Transformers for railway electrification. We are also planning to upgrade our product range unto 315 MVA, 400 kV class transformers shortly.

Could you share with us some of the projects that you have done so far?

We are regular suppliers of transformers to all the major utilities

in the country. We also work in some overseas markets in Africa and have been executing orders for transformers from some African countries regularly. We are focusing on two key markets, from geographical point of view: South Asia (India, Bangladesh, Nepal & Sub-saharan Africa).

Can you share with us about the quality control of the products?

Maintenance is a very important facet of continued efficient use of any equipment. Just as there is a need for regular maintenance of electrical appliances in your house, similarly electrical equipment in the field also needs constant maintenance including the right kind of protection. The equipment that goes into T&D networks face high levels of stress during operation, and correspondingly this creates a very high need for doing regular preventive maintenance or at least regular checks to ensure optimum use and the long life cycle of the product. This maintenance is usually carried out by the Utility customers and we extend all possible guidance and training wherever required towards ensuring the long term operation of these transformers. As far as the quality control during manufacturing is concerned, this is primarily the responsibility of the manufacturer. We are an ISO 9001: 2000 company. We are also one of the few transformer manufacturers who have NABL accreditation for our transformer test facility. Both of these certifications ensure that we follow well defined and established manufacturing practices with a very high level of checks and balances during the manufacturing and test phase.

How would you like to see your facility updated with latest technology?

We have already put in place a new facility just about 2 years ago which is absolutely state- of- the- art, in fact - it is perhaps one of the most modern transformer manufacturing plants India. Beyond that we are not planning on making any major capacity additions other than making small interventions which are necessary from time to time towards making the manufacturing process for efficient, stringent and increasing the production throughput. As mentioned earlier, we have already established ourselves as manufacturers of 220 kV class of transformers and the next technological leap being planned by us is for going in for manufacture of 400 kV class transformers.

What are your overall plans for the growth of the company?

We are looking at two strategies for growth: product innovation & market diversification - both in terms of market segments as well as geographical expansion. On product innovation I have already mentioned the recent initiatives taken by us in extending our product range to include special transformers as well as transformers unto 400 kV class. Regarding market diversification, three four years back we were completely focusing on domestic utility markets. We are now in the process of changing that where we are moving gradually into the institutional segment, getting approvals from leading Electro-mechanical consultants and increasing the presence of infrastructure companies in our customer list. On geographical expansion we are working at expanding our presence outside India - with South Asia and Sub Saharan Africa being priority markets for us.

What products are you displaying at Elecrama 2014?

At Elecrama, we are showcasing the whole range of our products and services. We are showcasing the state-of-the-art facility that we have created. We are displaying our superior manufacturing & test infrastructure and also showcasing our extensive customer references, details of various transformers manufactured by us as well as the various quality certifications that we have received as a company.

What are your anticipations from the business visitors?

We have gotten a good response from overseas visitors - people who are looking at sourcing transformers and electrical equipment from India.

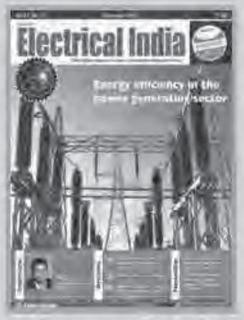
We have also met with a lot of people who were not our existing customers and hope to serve them as our customers in the future. So we are very bullish & aggressive and hope that we will be able to convert the extensive discussions into actual business.

Where would you envision your company in the next two years?

At presently we are a 200 crore company. At the end of two years we are hoping that we should be able to reach at least Rs 300 to 350 crores in turnover. Also presently 5% of revenue comes from exports and I want to see us generating at least 15% of the revenue from exports in two years. That is the target we have set for ourselves.

We further want to establish ourself in the EHV market where we are recent entrants. We have also been recently approved by prestigious customers such as Power Grid Corporation & NTPC for supply of the transformers and we wish to build upon this further.

In 2016 we would want TAL to be known as the preferred supplier of transformers amongst all our customers. ■



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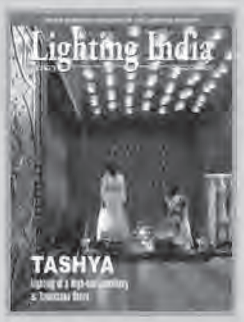

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Hybrid Capacitor

- Battery of future

Battery is conventional energy storage device and is a persistent problem in many electrical systems. Maintenance, life and low terminal voltage are the main issues with battery. Cost, weight and volume are also critical issues in many applications. In recent years many types of batteries have come in the market which has partially addressed the issues like maintenance etc. A combination of battery and supercapacitor is an innovative solution to existing battery system. However such solution is not eliminating the need of battery. Development of hybrid capacitors has given the hopes that, in near future battery can be eliminated in most of the portable systems.

- N P Mahulkar & Dr P B Karandikar

Capacitors may seem simple enough, but specifying them has actually grown more complex in recent years. The universe of capacitors has expanded greatly over the past few years, in large part because of capacitor designs that take advantage of developments in conductive polymers, metal oxides, carbon materials, dielectric materials and electrolytes. These advanced capacitors sometimes use conductive polymers to form the entire electrolyte or the conductive polymers can be used in conjunction with a liquid electrolyte in a design known as a hybrid capacitor. Either way, these polymer-based capacitors offer a performance edge over conventional electrolytic and ceramic capacitors. However, at the end what matters are its reliability,safety, life cycle, cost, stability, longevity and electrical characteristics. Origin of hybrid capacitor can be traced back to B. E. Conway's experimental work on electrochemical capacitors.First supercapacitor for military applications is developed by Pinnacle Research Institute and later by Maxwell technologies for power applications. In 1994 David Evans developed "Electrolytic-Hybrid Electrochemical Capacitor" by combining electrode of electrolytic capacitor with electrode of electrochemical capacitor. Recent developments of hybrid capacitors were pioneered by FDK; they have combined an electrostatic carbon electrode with a lithium-ion electrochemical electrode. But their high costs limited its use to specific military applications.

Construction

Energy storage in electric double-layer capacitor is due to interface between high surface area electrode and an electrolyte solution. Double layer capacitors are characterized by their long life cycle, and high power density than batteries. However, energy density of electric double-layer capacitor obtained at present is smaller as compared with batteries and therefore limits its wide spread use. To obtain a device that shows large energy density, high power density and stable performance, hybrid capacitor is developed. The main components of hybrid capacitor are two electrodes, electrolyte and the separator. Electrode materials used for hybrid capacitor should have characteristics like high porosity, high conductivity, high surface area, and resistance to oxidation or reduction. Carbon materials have been particularly popular owing to their large surface area and porous nature. Generally supercapacitor consists of two electrodes immersed in electrolyte solution.

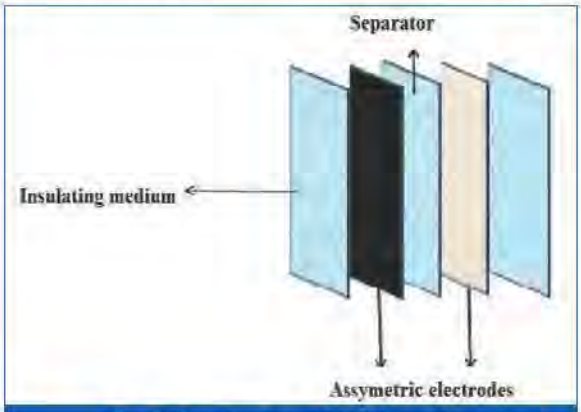


Fig. 1: Construction of hybrid capacitor

The electrodes are separated by insulating medium called separator. The purpose of separators in supercapacitor is to provide physically separation between electrodes in order to prevent short circuit. It is very thin and porous material to minimize internal resistance. Furthermore, separators should be chemically inert so that they can maintain conductivity and stability of electrolytes. Nowaday's polyethylene is used as separator due to low cost and high porosity. Difference between supercapacitor and hybrid capacitor can be found in construction of electrodes.

Hybrid capacitors are asymmetric, while supercapacitors are symmetric in nature. In hybrid capacitor one electrode is of activated carbon or carbon derived carbon and other electrode is of composite material which is combination of activated carbon with metal oxide. Figure 1 shows typical construction of hybrid capacitor.

Materials for Electrodes

Electrochemical energy storage devices employ two types of electrodes that create difference in the energy storage. Energy storage in one electrode is by means of chemical reactions with electrolyte which occurs during charging or discharging known as faradaic electrode. The other one stores charge without chemical reactions and is called non-faradaic.

Faradaic electrodes have much higher energy density but limited due to electrolyte operating voltage, repeatability, and life. Non-faradaic energy storage is a physical charge storage mechanism that suffers none of those problems.

The capacitance of non-faradaic electrodes is proportional to electrode surface area. Hybrid capacitor combines non-faradaic electrode of double-layer capacitor and an electrode with a faradaic electrode of pseudo capacitors in compatible electrolyte to form cells.

Hybrid capacitors are asymmetric in nature, thus correct polarity must be observed before applying voltage. The asymmetric nature of hybrid

capacitor provides higher energy density as compared to an equivalent electrolytic capacitor. In such asymmetric systems the pseudocapacitve electrode with their high capacitance value provides high energy density while the double layer electrode enables high power density.

Therefore hybrid capacitor has higher specific capacitance as well as higher specific energy than double layer and pseudocapacitors. Composite electrodes are found to be most efficient material for hybrid capacitors and are constructed by mixing carbon-based material with metal oxides like manganese oxides, ruthenium dioxide, vanadium pentoxide or conducting polymers. Manganese oxide has shown appealing results for energy storage applications in supercapacitors due to its low cost, non-toxicity, and abundance availability. Thus, these composite electrodes results in much higher capacitances than either symmetric carbon or symmetric metal oxide or polymer-based electrodes. In addition to composite material, nano materials like carbon nano tubes with high conductivity provided a new source of material in supercapacitor and hybrid capacitor.

Battery electrodes can also be used for development of hybrid capacitors, such electrodes not only influence in material development but also together with carbon offers high energy and power density.

Some scientists proposed graphene instead of activated carbon or graphene–polymer composites and graphene–metal oxides for hybrid capacitor. Graphene is a form of carbon and with its environmentally nature became new alternative due to its two dimensional structure, and high electrical conductivity.

Electrolytes for hybrid capacitor

Electrolytes are conductive solutions which consist of solvent and dissolved chemicals that dissociate into positive and negative ions. The more ions the electrolyte contains better will be its conductivity. In hybrid capacitors electrolytes act as a conductive medium between the two electrodes. The electrolyte determines the capacitor's operating voltage, temperature range, internal resistance and capacitance. Depending upon voltage limit electrolytes are categorized as follows.

Aqueous

Dilute sulfuric acid, potassium hydroxide, sodium perchlorate, potassium sulphate, lithium perchlorate, lithium hexafluoride, potassium sulphate, potassium chloride are some examples of aqueous electrolytes. Aqueous electrolytes have high conductivity, voltage withstand limit of 2 to 2.2 V per cell and a relatively low operating temperature range.

Organic

Organic electrolytes are also known as non-aqueouselectrolytes. Organic electrolytes with organic solvents such as acetonitrile, propylene carbonate, and diethyl carbonate are more expensive than aqueous electrolytes, but they have a higher voltage withstand limit of typically 3 to 4 V per cell with higher temperature range. Organic electrolyte suffers from drawbacks of the lower electrical conductivity which in further results in lower power density.

Ionic electrolytes are green electrolytes which are ionic conductors, non-volatile in nature and stable at high temperatures. Ionic electrolytes are composed of organic anions which enable them to increase voltage range. Ionic electrolytes have high voltage range up to 6 V. Despite such properties ionic electrolytes are not commercially viable due to high cost. Aqueous, non-aqueous and ionic electrolytes are in liquid forms and they suffer from leakage problems.

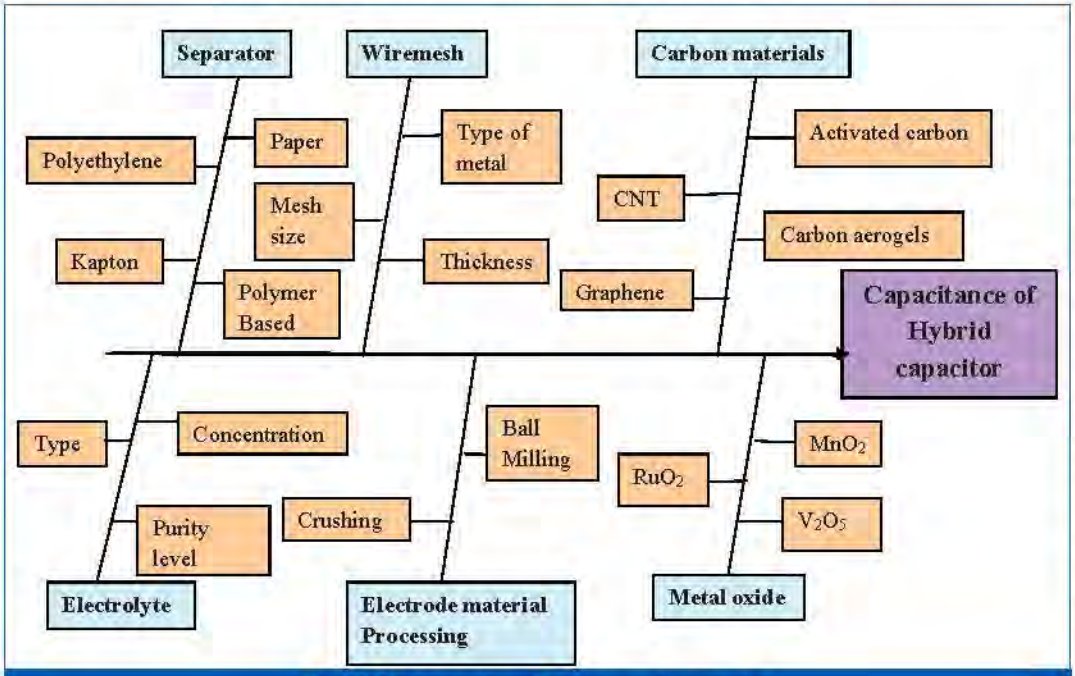
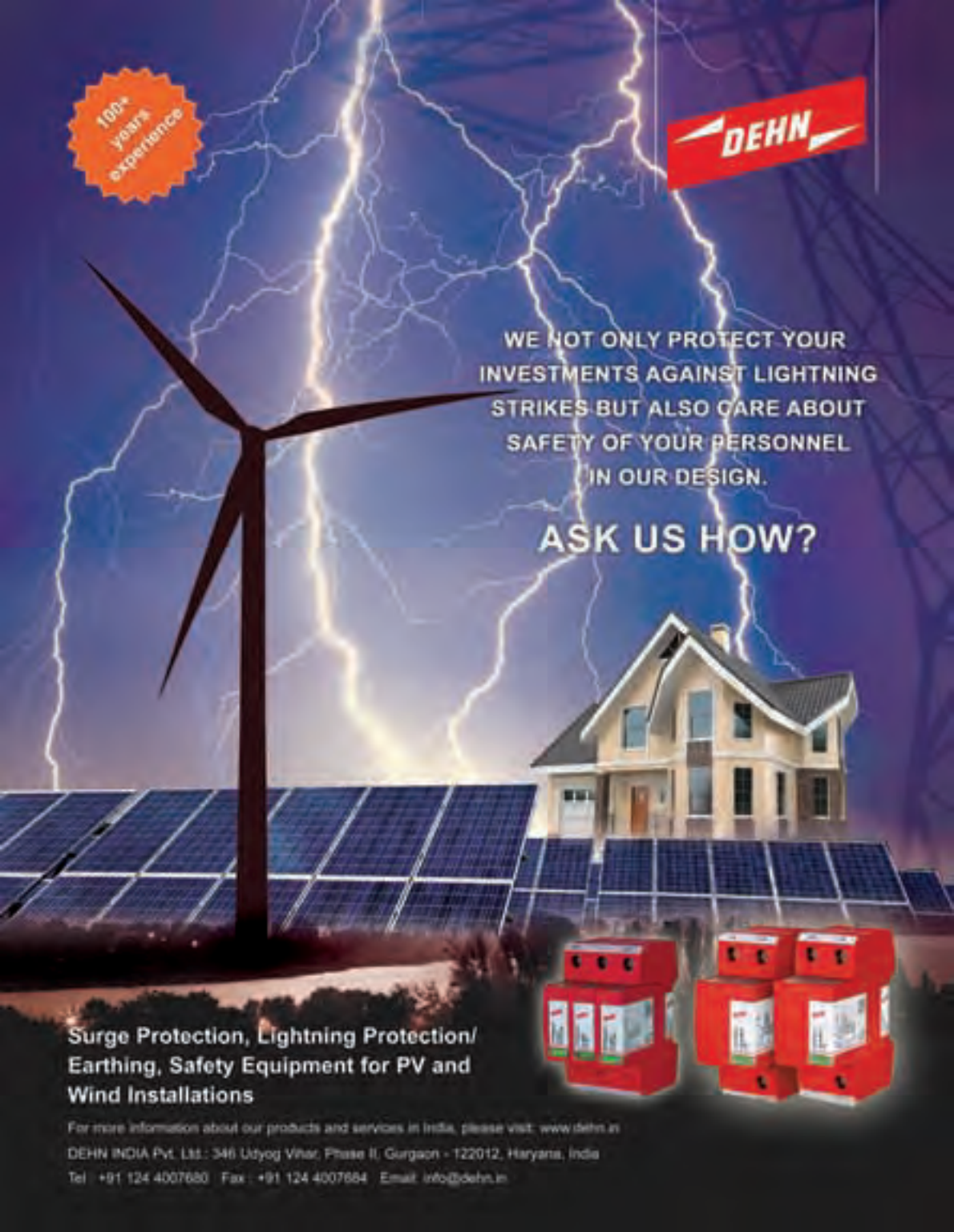


Fig. 2: Main parameters affecting capacitance value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Hybrid capacitor using gel type electrolytes have been proposed by some researchers.

Gel type electrolytes can be obtained by solidification process in which electrolyte is prepared by mixing of nano powders with ionic liquid. Hybrid capacitor developed using gel electrolytes have shown improvement in performance with less or no leakage problems. Figure 2 provides electrode-electrolyte parameters that affect capacitance value of hybrid capacitor.

Comparison between supercapacitor and hybrid capacitor

The main difference between supercapacitor and hybrid capacitor can be found in construction of electrodes. These arrangements of electrodes results in higher capacitance and energy density. Table 1 showing comparison of symmetric and asymmetric capacitors.

Advantage of hybrid capacitors

- Flexible structure is possible with hybrid capacitors.
- High power density than conventional capacitor.
- Can be charged and discharged number of times; discharge in several minutes and charged in seconds to minutes which is faster than batteries.
- Do not release any thermal heat during discharge and contains no hazardous materials like batteries therefore safer in nature.
- No danger of overcharging; when fully charged it simply stops accepting a charge and reversing polarity will not cause fire or explosion
- High operating temperature range.

Limitations of hybrid capacitors

- Low cell voltages
- Self-discharge rate is higher than that of an electrochemical battery.
- High cost mainly due to electrode materials.

Comparison with battery and electrolytic capacitors

The battery particularly the lithium-ion battery was dominating energy storage device for long period. Lithium-ion batteries are used for both electronic as well as automobile applications. With large usage lithium-ion batteries replace nickel metal hydride and lead acid batteries. Supercapacitors may replace lithium-ion batteries and electrolytic capacitors,thus provide new device for energy storage applications. With advent of time hybrid capacitor are developed which after extensive studies and research are on the way of replacing supercapacitor.

Specific energy storage in hybrid capacitor is given by,

$$E = CV2/2,$$

Where C-Specific capacitance in farad per gram

V- Applied voltage.

Hybrid capacitors are manufactured by very few companies in the world. They are similar to lithium-ion batteries, but they retain superior life cycle as compared to batteries. Lithium ion batteries store energy electrochemically. During discharge lithium ion travels from the high-energy anode material to the low-energy cathode material and during charging back to the high-energy anode. The charge and discharge process in batteries is a slow which creates physical and chemical changes in electrodes that result in low power density and limited life. Hybrid capacitor has different storage mechanism. These capacitors store charge at the surface of the electrodes instead of within the electrodes as that of batteries. Hybrid capacitor can be charged quickly, leading to a very high power density than battery and does not lose their storage capabilities with time.

Theoretically, hybrid capacitor can be charge or discharge millions of time without loss of energy storage capability. The main limiting factor of hybrid capacitor is their low energy density, i.e. the amount of energy hybrid capacitors can store per unit weight is very small when compared with batteries. Additionally, the cost of hybrid capacitor exceeds the cost of battery due to high cost of materials. However, recent advances in materials and material production methods may soon bridge the energy density gap for some commercial applications. Electrochemical reactions are very slow and are subjected to limitations imposed by the electrolytes whose conductivity depends on temperature. This explains the generally poor performance of batteries at low temperatures and their low specific

Parameter	Supercapacitor	Hybrid Capacitor
Capacitance	0.1 to 470 F	300 to 3300 F
Charge/discharge cycles	105 to 106	104 to 105
Temperature	−20 to +700C	−20 to +700C
Energy density	1.5 to 3.9 Wh/kg	10 to 15 Wh/kg
Power density	2 to 10 kW/kg	3 to 14 kW/kg
Self-discharge time	Weeks	Month
Life time	5 to 10 years	5 to 10 years
Efficiency	95 %	90 %

Table. 1: Comparison of symmetric and asymmetric type capacitor

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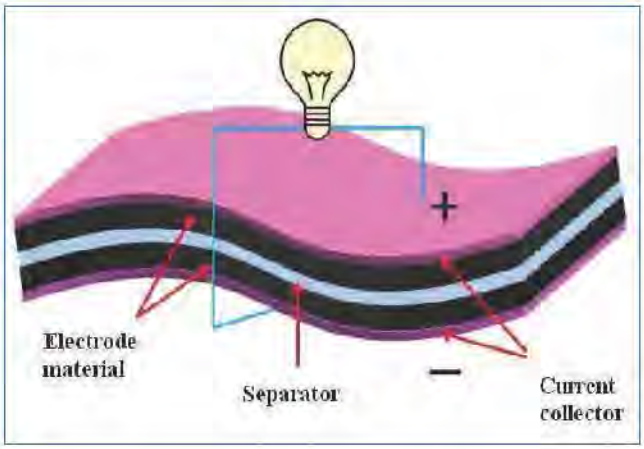

power compared to capacitors at different temperature.

Use of electronics in industries has created an increasing demand of capacitor. Such applications have different operating conditions which are not suitable for conventional capacitor. Development of supercapacitor and hybrid capacitor with higher voltage ratings has provided solution for such applications. Considering huge demand for applications continuous technical improvements are going on in the field of hybrid capacitor to make it an attractive alternative to supercapacitor and conventional capacitor. Life cycle, reliability, cost, material for electrodes and electrolytes are some factors that are also considered in improvement process. These hybrids are compact devices and known for stable electrical characteristics at high frequencies, therefore used for applications like computer servers, backup devices and networking gear.

Applications

Hybrid capacitors have more power density but less energy storage as compared to lithium ion batteries. The hybrid capacitor offers an enhanced capability of energy storage, providing power to applications more quickly and efficiently. For automotive applications, hybrid capacitors can be used for short-term back-up power for starting, horns, music systems and power windows. For power windows or door locks, in the event of an emergency, the hybrid capacitor can provide power to unlock the doors or lower the windows when the rest of the electrical system has been compromised. Computing system can also get benefited by hybrid capacitors. When disconnecting the battery, the computer loses power. If hybrid capacitor is used, the computer will retain its power. This can be performed many times due to its long life cycle.

Safety issues in electrochemical devices

Safety issues are very concern in electrolytic capacitors, which are mainly due to short circuit and partial discharge. The problem arises when electrical or mechanical stresses create defects and abnormalities in the dielectric of capacitor. Failure of electrolytic capacitors occurs due to drying up of their liquid electrolyte in response to increase in temperature and long on times.

In addition to drying of electrolytes, leakage is another problem which is being faced by electrochemical devices such as batteries, supercapacitors and hybrid capacitors. This problem can be solved by use of gel electrolytes. Hybrid capacitor are ecofriendly, they do not produce any harmful chemicals or compound as that of batteries. Fire due to sparking occurs at the terminal of battery, this aspect needs to be addressed in packaging of cells. Such incidents are unknown in supercapacitors and hybrid capacitor.

Conclusions

After studying hybrid capacitor and considering various parameters, it is found that reliability and performance of hybrid capacitor can be increased with the use of various metal oxides, graphene and activated carbon. Hybrid capacitor has high energy density than normal capacitor and supercapacitor but lower than battery. Hybrid capacitor shows better performance than battery in case of power density, hence bridges the gap between batteries, conventional capacitor and supercapacitor. Research work at leading laboratories and capacitor manufacturing industries is trying to improve this energy density. In automobiles supercapacitors are used in combination with the batteries. In future hybrid capacitor with high power density and moderately high energy density in combination with batteries will replace it in automobiles as well as military applications. ■

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One of the main objectives of earthing electrical systems is to establish a common reference potential for the power supply system, building structure, plant steelwork, electrical conduits, cable ladders & trays and the instrumentation system. To achieve this objective, a suitable low resistance connection to earth is desirable. However, this is often difficult to achieve & depends on a number of factors:

- Soil resistivity
- Stratification
- Size and type of electrode used
- Depth to which the electrode is buried
- Moisture and chemical content of the soil.

We shall discuss here on soil resistivity.

Soil resistivity is a measure of how much the soil resists the flow of electricity. Its value is used to design the grounding system in an electrical substation or for lightning conductors. It is also necessary for design of grounding (earthing) electrodes for high-voltage direct current (HVDC) transmission system. In HVDC system, one method is to use only one conductor and the return path is though the earth. This system is called "single wire earth return" power transmission system. Here, the earth is used as the path of conduction from the end consumers back to the transmission station.

Theory of Soil Resistivity

Resistance is that property of a conductor which opposes electric current flow when a voltage is applied across the two ends. Its unit of measure is the Ohm (Ω) and the commonly used symbol is R. Resistance is the ratio of the applied voltage (V) to the resulting current flow

Measurement of Soil Resistivity

Measurement of soil resistivity is the single most critical factor for designing grounding system for a substation or a power plant. It involves safety of people working in these premises. It also determines the corrosiveness of soil. The SI unit of resistivity is Ohm-meter (Ωm). But most often Ohm-centimeter (Ω-cm) is also used.

- Mayadhar Swain

(I) as defined by the well known linear equation from Ohm's law:

$V = I \times R$

Where,

V is potential difference across the conductor (volts)

I is current flowing through the conductor (amperes)

R is resistance of the conductor (ohms)

"Good conductors" are those with a low resistance. "Bad conductors" are those with a high resistance. "Very bad conductors" are usually called insulators.

The Resistance of a conductor depends on the atomic structure of the material or its resistivity, which is that property of a material that measures its ability to conduct electricity. A material with a low resistivity will behave as a "good conductor" and one with a high resistivity will behave as a "bad conductor". The commonly used symbol for resistivity is ρ (Greek symbol rho).

The resistance (R) of a conductor can be derived from the resistivity as:

$$R = \frac{\rho L}{A}$$

Where,

ρ is resistivity of the conductor material (Ω-m)

L is length of the conductor (m)

A is cross sectional area (m^2).

Resistivity is also sometimes referred to as "Specific Resistance" because, from the above formula, resistivity (Ω-m) is the resistance between the opposite faces of a cube of material with a side dimension of 1 meter.

Consequently, soil resistivity is the measure of the resistance between the opposite sides of a cube of soil with a side dimension of 1 meter.

Soil Resistivity and Soil Corrosion

Soil resistivity is a function of soil moisture & the concentrations of ionic soluble salts. Hence, it is considered to be one of the driving factors in determining the corrosiveness of soil. Generally, the lower the resistivity, the higher will be the corrosion as indicated in Table 1.

Soil resistivity (ohm- cm)	Corrosion Rating
> 20,000	Essentially non-corrosive
10,000 to 20,000	Mildly corrosive
5,000 to 10,000	Moderately corrosive
3, 000 to 5,000	Corrosive
1,000 to 3,000	Highly corrosive
<1,000	Extremely corrosive

Table 1: Corrosion ratings based on soil resistivity

Factors Affecting Soil Resistivity

Factors affecting soil resistivity are:

- Moisture
- Dissolved salt in water
- Temperature
- Seasonal variation
- Artificial treatment
- Type of soil

Effect of Water or Type of Soil

Soil resistivity generally decreases with increasing water content and the concentration of ionic species. Sandy soils are high up on the resistivity scale and therefore considered the least corrosive. Clay soils, especially those contaminated with saline water are on the opposite end of the spectrum. Table 2 shows how typical values alter with changes in soil.

Type of Soil or Water	Typical Resistivity Wm	Usual Limit Ωm
Sea Water	2	0.1 to 10
Clay	40	8 to 70
Ground well & spring water	50	10 to 150
Clay & sand mixtures	100	4 to 300
Shale, slates, sandstone etc	120	10 to 100
Peat, loam & mud	150	5 to 250
Lake & brook water	250	100 to 400
Sand	2000	200 to 3000
Moraine gravel	3000	40 to 10000
Ridge gravel	15000	3000 to 30000
Solid granite	25000	10000 to 50000
Ice	100000	10000 to 100000

Table 2: Resistivity values for several types of soils and water

Temperature (Centigrade)	Soil resistivity (Wm)
20	72
10	99
0 (water)	138
0 (ice)	300
-5	790
-15	3300

Table 3: Effect of Temperature on Soil Resistivity for sandy loam with moisture content of about 15%

Effect of Temperature

An increase in temperature decreases the resistivity. This can be explained from the following two facts:

- Water present in soil mostly determines the resistivity.
- An increase in temperature markedly decreases the resistivity of water.

Effect of temperature on soil resistivity is shown in Table 3.

When water in the soil freezes, the resistivity jumps appreciably. Ice has a high resistivity. The resistivity continues to increase as temperatures go below freezing point.

Effect of Moisture

Presence of moisture decreases the resistivity of the soil as shown in Table 4.

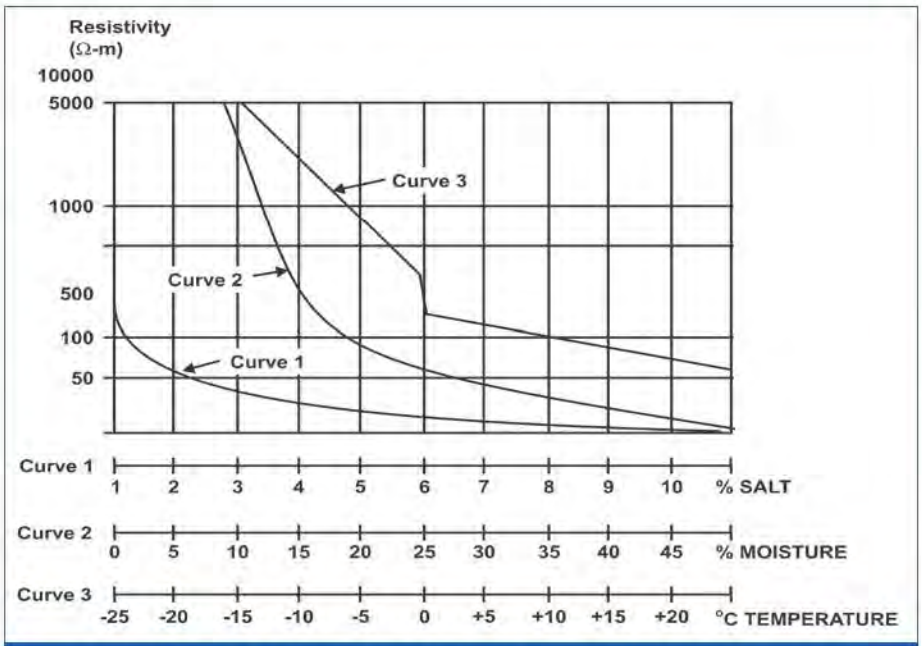
	Typical resistivity Ωm	
Moisture % by weight	Clay mixed with sand	Silica based sand
0	10000000	-
2.5	1 500	3 000000
5	430	50 000
10	185	2 100
15	105	630
20	63	290
30	42	-

Table 4: Effect of Moisture on Soil Resistivity

Effects of moisture, temperature, and salt upon soil resistivity are shown in the graph below.

Measurement of Soil Resistivity

Soil resistivity measurements are most often conducted using the Wenner four-pin method and a soil resistance meter. The Wenner method requires the use of four metal probes or electrodes, driven into the ground along a straight line, equidistant from each other, as shown in the following Figure. Soil resistivity is a simple function derived from the voltage drop between the center pair of pins, with



Effects of moisture, temperature, and salt upon soil resistivity

current flowing between the two outside pins.

An alternating current form the soil resistance meter causes current to flow through the soil, between pains C1 and C2. The voltage or potential is then measured between pins P1 and P2. The meter then registers a resistance reading. Resistivity of the soil is calculated from the instrument reading, according to the following formula:

$p = 2 \pi AR$

Where:

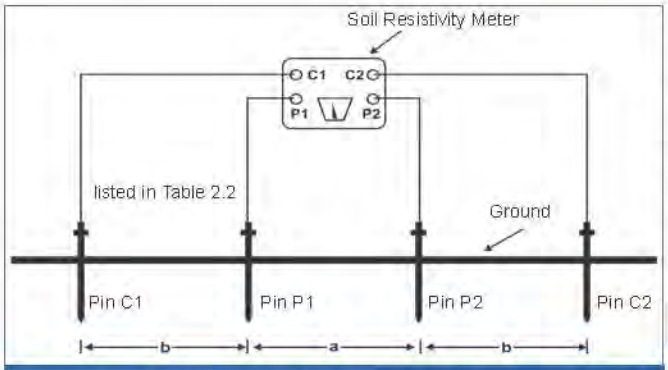
p is the soil resistivity (ohm-centimeters)

A is the distance between probes (centimeters)

R is the soil resistance (ohms), instrument reading.

The resistivity values obtained represent the average resistivity of the soil to a depth equal to the pin spacing. Resistance measurements are typically performed to a depth equal to that of the buried system (pipeline) being evaluated. Typical probe spacing is in increments of 0.8 m (2.5ft).

While making four-pin resistivity measurements, if the line of pins is closely parallel to a bare underground pipeline or other metallic structure, the presence of the bare metal may cause



Wenner four pin soil resistivity test set-up

the indicated soil resistivity values to be lower than it actually is. Because in that case a portion of the test current will flow along the metallic structure rather than through the soil. Hence measurements along a line closely parallel to pipelines should be avoided.

Improving Soil Resistivity

Low soil resistivity is to some extent tied to an electrolytic mechanism with such characteristics as chemical composition, soil ionization, homogenous grain size and even distribution, playing a large determinant due to the effect on the retention of soil moisture and packing density in contact with the electrode.

If suitable electrical resistance cannot be simply and economically attained by the installation of a standard earth grid, an application of earth enhancing compound will assist.

Obtaining a satisfactory earth resistance has always been a problem in areas of poor soil conductivity. Most national and international 'Lightning Protection' codes require an earth resistance of 10 ohms or less to be provided for a lightning protection installation. For electrical substation it is 1 ohm or less.

The laying of copper grids, tapes and rods alone may not always provide the desired result. Even if copper materials are used and the specified resistance level is achieved, seasonal fluctuations in soil moisture can cause variations in the resistance level. In dry periods it is possible for the earth resistance to rise above the installed level. This variation in earth resistance can affect the integrity of the entire lightning protection or electrical system.

If suitable electrical resistance cannot be simply and economically attained by the installation of a standard earth grid, an application of earth enhancing compound will assist. Such compounds consist of chemical solutions of good electrical conductivity which, when mixed with water and poured into the earthing grid and surrounding soil become a gelatinous mass, forming an integral part of the overall earthing system. Field tests have shown dramatic improvement in earth resistance when such compounds are added to high resistivity soils such as shale or silica. Erico supplies two such compounds; Earth Gel and GEM. Earth Gel comes in kit form and comprises of two 5 kg parts consisting of a copper solution in one and a complex mixture of chemicals which assists in the "gelling" stage, in the other. Of particular advantage with the compounds is that it will not wash or leach away like many other resistance improving mixtures. This obviates the need to reduce the area with time.


Soil resistivity measurement meters

Conclusion

It is well known that the resistance of an earth electrode is heavily influenced by the resistivity of the soil in which it is driven and as such, soil resistivity measurements are an important parameter when designing earthing installations. As the earthing system is related to safety of personnel and equipment, precise measurement of soil resistivity should be done. Soil resistivity is a very variable quantity. If we want to know what the value is at a given location and at a given time of year, the only safe way is to measure it. Knowledge of the soil resistivity at the intended site, and how this varies with parameters such as moisture content, temperature and depth, provides a valuable insight into how the desired earth resistance value can be achieved and maintained over the life of the installation with the minimum cost and effort. ■

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Difference between Bonding, Grounding and Earthing

One of the most misunderstood and confused concept is difference between Bonding, Grounding and Earthing. Bonding is more clear word compare to Grounding and Earthing but there is a micro difference between Grounding and Earthing.

- Jignesh Parmar

Earthing and Grounding are actually different terms for expressing the same concept. Ground or earth in a mains electrical wiring system is a conductor that provides a low impedance path to the earth to prevent hazardous voltages from appearing on equipment. Earthing is more commonly used in Britain, European and most of the commonwealth countries standards (IEC, IS), while Grounding is the word used in North American standards (NEC, IEEE, ANSI, UL).

We understand that Earthing and Grounding are necessary and have an idea how to do it but we don't have crystal clear concept for that. We need to understand that there are

really two separate things we are doing for same purpose that we call Grounding or Earthing.

The Earthing is to reference our electrical source to earth (usually via connection to some kind of rod driven into the earth or some other metal that has direct contact with the earth).

The grounded circuits of machines need to have an effective return path from the machines to the power source in order to function properly (Here by Neutral Circuit).

In addition, non-current-carrying metallic components in a System, such as equipment cabinets, enclosures, and structural steel, need to be electrically interconnected and earthed properly so voltage potential cannot exist between them. However, troubles can arise when terms like "bonding," "grounding," and "earthing" are interchanged or confused in certain situations.

In TN Type Power Distribution System, in US NEC (and possibly other) usage: Equipment is earthed to pass fault current and to trip the protective device without electrifying the device enclosure. Neutral is the current return path for phase. These Earthing conductor and Neutral conductor are connected together and earthed at the distribution panel and also at the street, but the intent is that no current flow on earthed ground, except during momentary fault conditions. Here we may say that Earthing and grounding are nearly same by practice.

But In the TT Type Power Distribution System (In India) Neutral is only earthed (here it is actually called Grounding) at distribution source (at distribution transformer) and Four wires (Neutral and Three Phase) are distributed to consumer. While at consumer side all electrical equipments body are connected and earthed at consumer premises (here it is called Earthing). Consumer has no any permission to mix Neutral with earth at his premises here earthing and grounding is the different by practice.

But in both above case Earthing and Grounding are used for the same Purpose. Let's try to understand this terminology one by one.

Bonding

Bonding is simply the act of joining two electrical conductors together. These may be two wires, a wire and a pipe, or these may be two Equipments.

Bonding has to be done by connecting all the metal parts that are not supposed to be carrying current during normal operations to bringing them to the same electrical potential.

Bonding ensures that these two things which are bonded will be at the same electrical potential. That means we would not get electricity building up in one equipment or between two different equipment. No current flow can take place between two bonded bodies because they have the same potential.

Bonding, itself, does not protect anything. However, if one of those boxes is earthed there can be no electrical energy build-up. If the grounded box is bonded to the other box, the other box is also at zero electrical potential.

It protects equipment & Person by reducing current flow between pieces of equipment at different potentials.

The primary reason for bonding is personnel safety, so someone touching two pieces of equipment at the same time does not receive a shock by becoming the path of equalization if they happen to be at different potentials.

The Second reason has to do with what happens if Phase conductor may be touched to an external metal part. The bonding helps to create a low impedance path back to the source. This will force a large current to flow, which in turn will cause the breaker to trip. In other words, bonding is there to allow a breaker to trip and thereby to terminate a fault.

Bonding to electrical earth is used extensively to ensure that all conductors (person, surface and product) are at the same electrical potential. When all conductors are at the same potential no discharge can occur.

Earthing

Earthing means connecting the dead part (it means the part which does not carries current under normal condition) to the earth for example electrical equipment's frames, enclosures, supports etc.

The purpose of earthing is to minimize risk of receiving an electric shock if touching metal parts when a fault is present. Generally green wire is used for this as a nomenclature.

Under fault conditions the non-current carrying metal parts of an electrical installation such as frames, enclosures, supports, fencing etc. may attain high potential with respect to ground so that any person or stray animal touching these or approaching these will be subjected to potential difference which may result in the flow of a current through the body of the person or the animal of such a value as may prove fatal.

To avoid this, non-current carrying metal parts of the electrical system are connected to the general mass of earth by means of an earthing system comprising of earth conductors to conduct the fault currents safely to the ground.

Earthing has been accomplished through bonding of a metallic system to earth. It is normally achieved by inserting ground rods or other electrodes deep inside earth.

Earthing is to ensure safety or Protection of electrical equipment and Human by discharging the electrical energy to the earth.

Grounding

Grounding means connecting the live part (it means the part which carries current under normal condition) to the earth for example neutral of power transformer.

Grounding is done for the protections of power system equipment and to provide an effective return path from the machine to the power source. For example grounding of neutral point of a star connected transformer.

Grounding refers the current carrying part of the system such as neutral (of the transformer or generator).

Because of lightning, line surges or unintentional contact with other high voltage lines, dangerously high voltages can develop in the electrical distribution system wires. Grounding provides a safe, alternate path around the electrical system of your house thus minimizing damage from such occurrences.

Generally Black wire is used for this as a nomenclature.

All electrical/electronic circuits (AC & DC) need a reference potential (zero volts) which is called ground in order to make possible the current flow from generator to load. Ground is May or May not be earthed. In Electrical Power distribution, it is either earthed at distribution Point or at Consumer end but it is not earthed in Automobile(for instance all vehicles' electrical circuits have ground connected to the chassis and metallic body that are insulated from earth through tires). There may exist a neutral to ground voltage due to voltage drop in the wiring, thus neutral does not necessarily have to be at ground potential.

In a properly balanced system, the phase currents balance each other, so that the total neutral current is also zero. For individual systems, this is not completely possible, but we strive to come close in aggregate. This balancing allows maximum efficiency of the distribution transformer's secondary winding

Micro Difference between earthing & Grounding

There is no major difference between earthing and Grounding, both means "Connecting an electrical circuit or device to the Earth". This serves various purposes like to drain away unwanted currents, to provide a reference voltage for circuits needing one, to lead lightning away from delicate equipment. Even though there is a micro difference between grounding & earthing.

Difference in Terminology: In USA term Grounding is used but in UK term Earthing is used.

Balancing the Load Vs Safety: Ground is a source for unwanted currents and also as a return path for main current some times. While earthing is done not for return path but only for protection of delicate equipments. It is an alternate low resistance path for current.

When we take out the neutral for a three phase unbalanced connection and send it to ground, it is called grounding. Grounding is done to balance unbalanced load. While earthing is used between the equipment and earth pit so as to avoid electrical shock and equipment damage.

Equipment Protection vs Human Safety: Earthing is to protect the circuit elements whenever high voltage is passed by thunders or by any other sources while Grounding is the common point in the circuit to maintain the voltage levels.

Earth is used for the safety of the human body in fault conditions while Grounding (As neutral earth) is used for the protection of equipments.

Earthing is a preventive measure while Grounding is just a return path.

The ground conductor provides a return path for fault current when a phase conductor accidentally comes in contact with a grounded object. This is a safety feature of the wiring system and we would never expect to see grounding conductor current flow during normal operation.

Do not Ground the Neutral Second time When It is grounded either at Distribution Transformer or at Main service Panel of Consumer end.

Grounding act as neutral. But neutral cannot act as ground.

System Zero Potential Vs Circuit Zero Potential: Earthing and Grounding both is refer to zero potential but the system connected to zero potential is differ than Equipment connected to zero potential .If a neutral point of a generator or transformer is connected to zero potential then it is known as grounding. At the same time if the body of the transformer or generator is connected to zero potential then it is known as earthing.

The term "Earthing means that the circuit is physically connected to the ground and it is Zero Volt Potential to the Ground (Earth) but in case of "Grounding" the circuit is not physically connected to ground, but its potential is zero (where the currents are algebraically zero) with respect to other point, which is also known as "Virtual Grounding."

Earth having zero potential whereas neutral may have some potential. That means neutral does not always have zero potential with respect to ground. In earthing we have Zero Volt potential references to the earth while in grounding we have local Zero Volt potential

reference to circuit. When we connect two different Power circuits in power distribution system, we want to have the same Zero Volt reference so we connect them and grounds together. This common reference might be different from the earth potential.

Illegal Practice of Interchange: Purpose of Grounding wire and earthing wire

Neutral wire in grid connections is mandatory for safety. Imagine a person from 4th floor in a building uses plumbing or Earth wire (which is earthed in the basement at Basement) as neutral to power his lights. Another Person from 2nd floor has a normal setup and uses neutral for the same purpose. Neutral wire is also earthed at the ground level (as per USA practice Neutral is Grounded (earthed) at Building and as per Indian Practice it is Grounded (earthed) at Distribution Transformer). However, ground wire (Neutral wire) has a much lower electrical resistance than plumbing (Earthing) which results in a difference of electrical potential (i.e. voltage) between them. This voltage is quite a hazard for anyone touching a water tap as it may have several tens of volts.

The second issue is legality. Using ground wire instead of neutral makes you an energy thief as the meter uses only the Phase and neutral for recording your energy consumption. Many Consumers make energy theft by using Earthing wire as a Neutral wire in an Energy meter.

Conclusion

Ground is a source for unwanted currents and also as a return path for main current. While earthing is done not for return path but only for protection of delicate equipments. It is an alternate low resistance path for current. Earth is used for the safety of the human body in fault conditions while Grounding (As neutral earth) is used for the protection of equipments. ■

Jignesh Parmar BE (Electrical) from Gujarat University has more than 11 years experience in Power Transmission-Power Distribution-Electrical energy theft detection-Electrical Maintenance-Electrical Projects (Planning-Designing-coordination-Execution). He is Presently associate with one of the leading business group as a Assistant Manager at Ahmedabad. He is Freelancer Programmer of Advance Excel and design useful Excel Sheets of Electrical Engineering as per IS, NEC, IEC, IEEE codes. He has published numbers of technical papers in various journals. He is regular technical Blogger.

"Focusing on the innovation & technology with continuous upgradation"

Jitendra K Agarwal
Director
Genus Power Infrastructures Limited

Genus Power Infrastructure limited, an ISO 9001 & 14001 certified and public limited company is an integral part of the US $400 million Kailash Group. Genus has three business divisions offering highly innovative and sustainable solutions to the power sector. Its Metering Solution Division provides a complete range of Electricity Meters; Power Back-Up Systems and Solar Solutions Division offers a wide range of UPS & Inverters and the Engineering Construction and Contracts undertakes Turnkey Power projects. Its top-notch R&D Center is recognized by the Ministry of Science and Technology, Govt. of India. In an exclusive interview with **Electrical India, Jitendra K Agarwal** says, we are in the process of building up one more factory of appx 2 Lakh Sq ft at Ramchandrapura, Jaipur.

What according to you is the scenario of the power sector in India?

Power sector in India is going through a phase which is both good and bad. Bad because the economic slowdown has affected the power sector too. This sector is also going through a tough time like other sectors with discoms/ utilities delaying payments to manufacturers like us on one hand while USD appreciation making cost of the goods more on the other hand. There is a liquidity crisis in the market. At the same time Good in the sense that energy is at the foundation of infrastructure development and that's why I feel its crucial for energy sector to grow. There is no escape to it. Power infrastructure plays a crucial role by improving the standards of living. In the coming time, we are looking at lot of thing to happen in the infra and power infrastructure in the country. And there has been lot of talks on not only at the state level but also at the national and central government level. Everybody is realizing and talking about the importance of the energy, and how it is going to be the main contributor to the overall growth of the country. So I see a fantastic future for the country provided the government has the true zeal to take it in the right direction.

What challenges are faced by the power sector in India and how would overcome it?

One of the major challenges is the financial health of the distribution companies. The financial health of the companies is really bad because of the mindless subsidies and the T&D losses. On the electricity price front, there is and always be lot of political pressure on the distribution companies. Unfortunately energy is going to be a political subject which political parties can never leave out from their agenda and will be there forever! There is also an uncertainty in the financial restructuring of state discoms initiative. So the only way to come out of this situation is to improve the efficiency of electricity distribution. I strongly believe; it is possible and one of the biggest example of this is the success of Delhi distribution companies.

There was a T&D loss of 65% approx. in Delhi when Tata Power and Reliance took over Delhi discoms, and from 65% it has now come down to 11% approx.. today which is phenomenal. As a company I feel very proud that we got an award from Tata Power in 2009 for being a close partner in helping them reduce the T&D losses through use of our meters. So, there is a clear cut story of success in front of us. While increase of energy efficiency is possible in urban areas, where the focus of discoms is more, rural areas will remain neglected and subsidized and that is where I propose a Social Security fund to take care of the interests of the discoms in subsidizing power in the rural areas. This will be a social fund to take care of electricity price subsidiary similar to employment, food etc that are there are being talked about.

What all activities of the company do you look after?

I am an MBA by education, positioned as Director-Marketing of the company focusing more on the business development, and my primary responsibility is marketing and sales. However being from the promoter family, I am also part of the core team engaged in Vision formulation, growth strategies, diversifications, new product development, advance technologies and organizational development,

What product ranges does Genus provide to the Indian market?

We are a one-stop shop for complete range of electronic meters in the country. We are pioneers in the single and three phase domestic electronic meters since the year 1996. Today, Genus has the largest installed base of electronic meters in India with more than 2.8 crore electronic meters working satisfactorily in the field. Our government recognized Research & Development Centre with more than 200 hundred engineers is instrumental to our success. We also provide complete range of power back up systems and solar solutions offering a wide range of UPS and Inverters such as Home UPS, Static UPS, High Capacity Inverters, Online UPS, Solar Inverters, Solar Power Conditioning Units, Batteries and Solar Power Packages. We undertake turnkey power projects such as Sub Station erection upto 420 kV, laying up of transmission and distribution lines, Rural Electrification, Switchyard, Network Refurbishment etc.

We have been focusing on the innovation & technology with continuous upgradation of manufacturing facilities. We would like to be called as a competitive solution provider. Our uniqueness is having a complete forward and backward integration in the manufacturing of our products. We maintain a stringent quality control and to have close monitoring on the cost, we have expanded our manufacturing facilities to tax free zones. We have more than 50 molding machines, six high precision automated SMT lines, NABL accredited test lab, automatic Test Benches and all kinds of quality and reliability testing is done in house only. This is our core strength; technology at right price, we don't call it cheap, neither do we call it expensive but at a right price. That is the success mantra of Genus.

Could you share with us the plans you have for updation of state-of-the-art facility with the latest equipment?

As I said we focus on innovation and technology and without advanced manufacturing facilities it is not possible to provide the solutions we offer at the right price. We have state of the art manufacturing plants: three plants in Haridwar and two in Jaipur, where we undertake constant upgradation of existing manufacturing facilities and implementation of lean manufacturing techniques. It is a continuous process. We are in the process of building up one more factory of appx 2 Lakh Sq ft at Ramchandrapura, Jaipur which will be most modern integrated plant, with emphasis on energy saving features.

Could you provide some information on the major metering projects that you have done so far?

One of the very prestigious projects that we are doing right now is that of BESCOM. It consists of 20,000 installations of DT METERS with complete product being supplied by us along with remote meter reading through GSM and GPRS technology. We will provide the meter reading data for next 5 years including the billing data. We are very proud to say that we would be the only meter manufacturing company in the country to go to one of the North-

East states, and do the supply, installation and commissioning of 23,000 electronic pre-payment meters of our own. We are also the first company in the country probably to the best of my knowledge who truly do smart metering installations in the utility. CESC is the first utility which got smart meters from us. Initially they did a POC of 20 meters, now they have taken 750 meters from us and it is truly turning out to be one of its kind covering smart metering domain.

Could you detail about Rural Electrification projects undertaken by you?

Genus's business is divided in three divisions, Electronic Metering Division which we call Metering Division, Power Back-up Division, wherein we offer power back-up solutions in the form of UPS, Inverters, Batteries and Solar solutions of wide capacity. The third division is Engineering Construction and Contracts division which we call ECC division wherein we undertake projects in power sector. Our ECC division in engaged in Rural Electrification projects of more than 1 million BPL connections under RGGVY scheme in our six years of ECC existence. At present we have taken a big RAPDRP project of distribution in Uttaranchal and many more such projects in some other states of India are on the verge of completion.

Are you planning to launch any new product; can you mention some of the newly launched products?

New Product Development is our lifeline. There is a continuous development happening in Genus, either in the form of increased features in the existing products or altogether new products. Genus lives on innovation, technology and new product development. We have recently launched Smart Grid Meters to enable deployment of smart grid projects in India, Net Meters, DIN RAIL Prepayment Meter, Gas Meter, Solar Power Conditioning Units and MPPT based Solar Charge Controller under solar solutions.

What products are you displaying at ELECRAMA 2014?

We are showcasing complete range of electronic metering from residential to prepayment to smart meters alongwith communication capabilities. I would like to particularly mention products such as Pole mounted Smart Group Metering Solution, live functioning of Smart Street Light system, Class 0.2 Rack mounted ABT Meter, Live display of Data from BESCOM project under exhibit, that have evoked great curiosity and response from Indian visitors while visitors from ASEAN and African countries showed keen interest in our Prepayment Meters under display. Our Gas Meter with prepayment option also draws attention from even general public. Under power back-up, we are displaying our power backup products like inverters, UPS, battery and Solar Solutions. We are moving into solar solution that is something new which we started few months back and the response both from local and overseas visitors received here makes us believe that there is tremendous scope in solar. We already have inverters, solar power conditioning unit, own batteries, MTPT charge control and hence easy for us to diversify into solar solution offerings. We are outsourcing Solar Panels right now but soon will be manufacturing solar panels too in one of new facilities.

Do you have any collaboration with any other company? Do share highlights about the channel partners?

The pride of Genus is that we have not bought technology from anybody. Everything is developed in India and designed by we Indians and we are very proud of it. For Power back up and Solar Solutions, we have channel partners across the country. When it comes to the electronic energy meters, it is sold to the utilities. We have more than 100 people in sales and have more than 15 offices across the country ensuring prompt services to the utilities and end consumers across the country.

Can you tell us what all plans do you have for the overall growth of the company?

For the overall development of the company I would again say it is a continuous process. We are now aiming for becoming an international player, be part of Smart Grid development in the country in a big way and expanding ourselves into solar solutions. Recently, we have purchased big land in Haridwar and setting up one more manufacturing unit of batteries thereby enhancing our capacity with backward integration for batteries In meters, we are enhancing production capacity of our high end meters such as DT Meters, prepayment meters, smart meters etc.

How was the experience at Elecrama 2014?

It is very good except for the infrastructure of Bangalore which I will call it very sad such as traffic jams, distance from one place to other etc. Otherwise the place is very good to exhibit, there is a very good response and the global presence is on high note.

The best response has come from African, Asian and Middle East market. I am very glad that we as Genus have got very good response and that is what makes me see and hope a very bright future for the electrical industry. ■

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Power Transformer Decision Analysis:
Replacement vs Refurbishment

Power transformers exist to provide a safe and economical means of transferring electrical power around the grid system. They are generally high capital items, with a long lead time on delivery, requiring much planning and thought for their procurement, operation and eventual end of life. It is at the nominal end of life of a transformer that we may have a key decision to make: does the condition of the equipment mean that we can effectively refurbish the unit, or does the condition mean that we must replace the unit?

- Kenneth Elkinson, Tony McGrail

The difference in approach may be significant in terms of investment and subsequent reliability of the power transformer installed. The decision is affected by a range of parameters, including: maintenance history, the applicability of online condition monitoring, refurbishment, or replacement cost. Each of these inputs is affected by financial considerations as well as practicality. For instance, it may be more cost effective and likely to succeed if a refurbishment takes place at a manufacturing facility. There also exists the possibility that a change in probability of failure after an asset is refurbished will affect the decision.

Decision Making

There are several parameters associated with a replacement or refurbishment decision – starting with the immediate financial costs of different approaches (replace or refurbish) and then adding in the factors:

- Likelihood of failure of a unit after installation
- Operational costs associated with each activity
- Business interruption expense
- Fines or penalties associated with loss of service
- Transport costs associated with removal and reinstallation
- Environmental or safety issues associated with decision.

It is not possible to completely and comprehensively address every context in any single analysis – but we can expand our understanding through multiple and dependent analyses. We will address some of these issues as illustrations; more complex analysis, depending on context, can be built from simpler analyses. An example may be the situation where penalty costs associated with unavailability of a power transformer override other financial considerations and an energized spare is the appropriate short term response (1).

Risk Analysis

To comprehend the decision making process, we need to have a good understanding of the concept of risk. Risk is the combination of the likelihood of an event and the consequence of that event; these are usually given in terms of:

- The probability an event will occur in a given time frame or period, say 5 years
- The total costs of that event in dollars, or some appropriate measure

With large assets, such as power transformers, it is not easy to identify the probability of failure; and the costs associated with the failure may be contingent on network configuration at the time, and the mode of failure (tank rupture leading to fire and oil spillage likely being more costly than a bushing failure with no fire and no oil spillage). Failure rates must be estimated for power transformers, and may vary with design, role, size and location of the unit.

Costs	Dollars
New unit	$1,000,000
Refurbishment	$650,000
Replacement for new unit	$1,000,000
Replacement of refurbished unit	$1,000,000

Table. 1: Example Costs of Refurbishment & Replacement

Simple Decision Tree

In theory, the decision to replace or refurbish is a simple financial analysis:

Probabilities	%
Failure of new unit	1%
Failure of refurbished unit	5%

Table. 2: Probability of Events

- What are the costs of a replacement unit?
- What are the chances a replacement unit will fail?
- What are the costs of refurbishing a unit?
- What are the chances a refurbished unit will fail?
- What will it cost for a replacement unit in case either a replacement or a refurbished unit fails?

We can summarize exemplar costs and probabilities in two tables – the values are purely indicative:

It can be seen that we have set costs for replacement of both a new

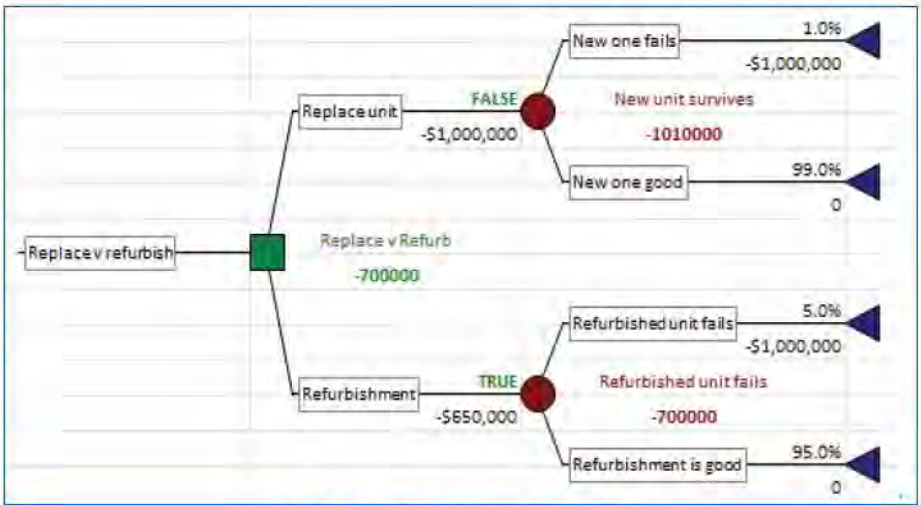

Fig. 1: Straightforward Decision Tree

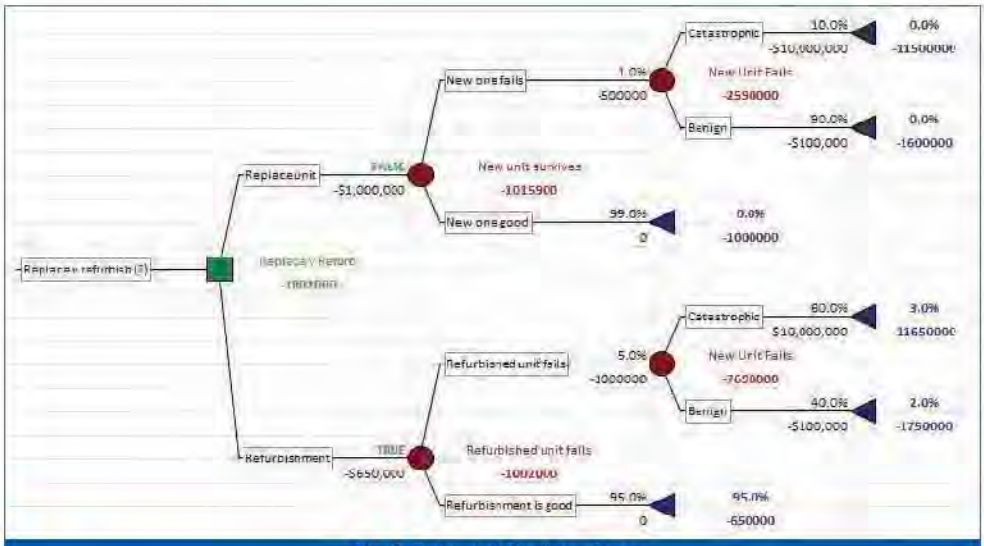

Fig. 2: Extended Decision Tree

unit which subsequently fails and a refurbished unit which subsequently fails to be the same: this is not necessarily the case, but the values here are for illustration.

A simple decision tree can summarize the data and also identify the optimal decision, as in Figure 1.

The decision is summarized on the left; the first two branches identify the two options: replace or refurbish. For each branch there are two sub-branches representing the subsequent failure or survival of the unit. Costs and percentages associated with each branch are given – note the sum of probabilities for events in each sub-branch must add to 100%.

In this version of a decision tree program (2) the decision branch which provides the lowest 'expected

It may be that the new unit comes with a new fire suppression system and extended condition monitoring, reducing the likelihood of catastrophic failure - or is built to new manufacturing standards. But in this case, with these figures, we still find a refurbished unit is the optimal decision.

Finally, we add some variation based on the refurbishment being found, while at the refurbishing facility, to be impossible, as per Figure 3 – while the work is in progress, say, further damage is found and the unit must be scrapped. We add a 5% chance that such a situation may occur. This is the extra 'chance' node on the decision tree at the bottom of the figure – this means, in this case, that we will have to obtain a new unit!

The analysis in Figure 3 adds a small chance that we have a problem with the planned refurbishment which was not visible in the field when the initial decision was made. This, however, means that the preferred option – the "True" option, is to immediately replace the unit. Even the addition of a small, but realistic, chance that a refurbishment is not possible now tips the optimal decision to a replacement.

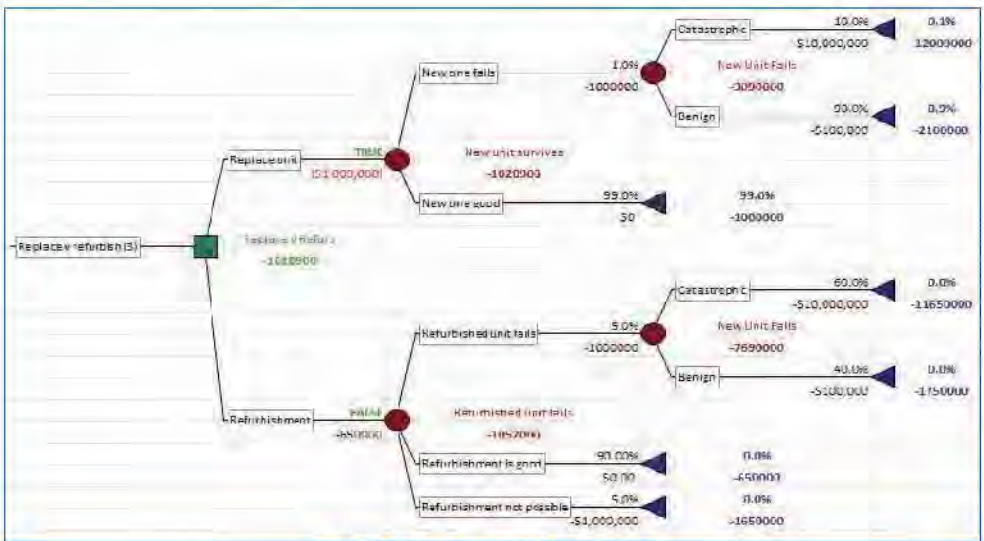

Fig. 3: Further Extended Decision Tree

Discussion

As can be seen from the examples presented, the replace/repair decision is very sensitive to variables analyzed. It is also very sensitive to the percent probabilities used – which will be estimates based on industry expectations or historic values. However, it should be noted that some probabilities are contingent probabilities and are even more difficult to ascertain. It is worth noting that a decision tree tool, such as the one used here, allows for addition of Monte Carlo simulations to allow for probability distributions and far more complex analyses.

Analysis may become quite complex quite quickly – we have found that it is usually best to start with a small model

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which works well rather than a large model which doesn't work. Development of more complex models is easier to then pursue. Finally, it is the nature of spreadsheets that numbers can be changed and decision outcomes altered as a result. It is important not to try and 'fix' the numbers to reflect a particular, desired, outcome.

Conclusion

Replacement/refurbishment decisions are complex and highly context dependent- including analysis of costs, probabilities and contingent probabilities. Decision tree analysis of replace/refurbishment decisions can be very sensitive to estimated quantities, with outcomes varying in what may be surprising ways. It is important to keep in mind that the use of this tool is as an aid to decision making and understanding of the business context, rather than replacing the need for decision making and understanding. ■

Kenneth R Elkinson, P.E., has Bachelor of Science in Electrical Engineering degree from the University of Massachusetts at Lowell. He held a number of positions at Doble Engineering, and is now Apparatus Analytics Engineer. Previously, Kenneth worked with National Grid in the US as a Substation Engineer. He is a licensed Professional Engineer in the state of Massachusetts.

Tony McGrail is Doble Engineering Company's Solutions Director for Asset Management and Monitoring Technology, providing condition, criticality and risk analysis for utility companies. Previously he was with National Grid in UK and the US; he has been both a substation equipment specialist, with a focus on power transformers, circuit breakers and integrated condition monitoring, and has also taken on the role of substation Asset Manager and Distribution System Asset Manager, identifying risks and opportunities for investment in an ageing infrastructure. Tony is a Fellow of IET, Immediate Past Chairman of IET Council, a member of IEEE, ASTM, CIGRE and the IAM, is currently on the executive committee of Doble Client Committee on Asset and Maintenance Management. He is a US delegate to ISO 55000 Standard Development Working Group, Chair of the IEEE Asset Management Working Group, and a contributor to SFRA & other standards. His initial degree was in Physics, supplemented by an MS and a PhD in EE and an MBA. He is an Adjunct Professor at Worcester Polytechnic Institute, MA, leading courses in Power Systems Analysis and Distribution Fundamentals. Tony presents at power industry events around the globe, including the IEEE PES and T&D Conferences, EuroDoble Colloquia, Doble Life of a Transformer Seminars.

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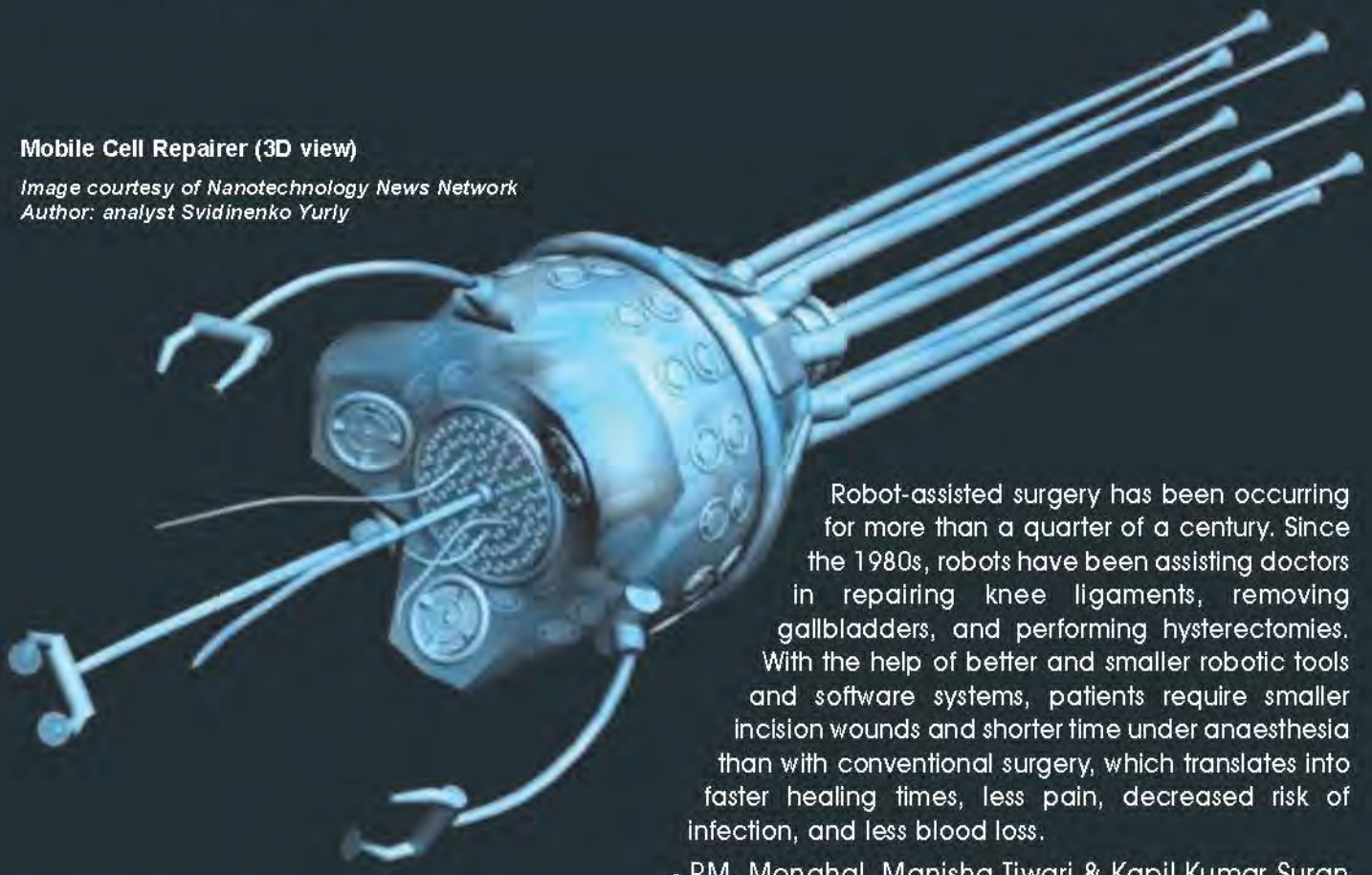

Mobile Cell Repairer (3D view)

Image courtesy of Nanotechnology News Network
Author: analyst Svidinenko Yurly

Robot-assisted surgery has been occurring for more than a quarter of a century. Since the 1980s, robots have been assisting doctors in repairing knee ligaments, removing gallbladders, and performing hysterectomies. With the help of better and smaller robotic tools and software systems, patients require smaller incision wounds and shorter time under anaesthesia than with conventional surgery, which translates into faster healing times, less pain, decreased risk of infection, and less blood loss.

- P.M. Menghal, Manisha Tiwari & Kapil Kumar Suran

Nanorobotics

Redefining Future Domain

Beyond making surgery safer and more accurate, robots are increasing the number of people with access to top medical care. In remote surgery, or telesurgery, a doctor controls a robot that works on a patient—even if that patient is thousands of miles away. Moreover, in the event of a bio-terrorist attack or an epidemic, immune robotic medical personnel may be the best solution to contain and cure infected individuals. In military medical care, remote surgery can help provide soldiers with medical care more quickly than under current conditions. Modified tanks could house remote operating rooms. These tanks could accompany soldiers into battlefields. Soldiers often lose their limbs or even their lives because it simply takes too much time until they reach a medic or hospital. With Telesurgery, a medic could perform a life-saving operation on a remote injured soldier. Moreover, fewer medics would be required in the field, since a single medic could perform surgeries on soldiers from geographically disparate platoons.

Nanorobotics is one of the technology which came into being with the advancement in nanotechnology. Its a technology for creating automatic machines, respondent devices and robots at the atomic scale of 10-9 nanometers. Nanorobotics is one of the major discipline of largest and most complex engineering and designing nanorobots. Nanorobots are constructed with the molecular components ranging from 0.1 to 10 micrometers and with the help of nanorobotics ninety nine percent human like non biological robot can be constructed. At present nanorobotics has emerging applications in the field of medicine and technology.

History

Known as nanorobot pioneer, Cavalcanti is the medical nanorobotics inventor for the practical hardware architecture of nanorobots, which was integrated as a model based on nanobioelectronics for applications in environmental monitoring, brain aneurysm, diabetes, cancer and cardiology. His advanced prototype provided a suitable integrated circuit approach, using an effective wireless platform for energy supply with cell phones and satellite, to enable the commercial implementation of nanorobots with long distance teleoperation and data transfer for health care, drug delivery, and laparoscopic nanosurgery.

The nanorobot genius work has an impact on current nanorobotics history, providing with the first nanorobot a legacy for coming generations. The history of the nanorobotics as an integrated circuit for medicine is highlighted as an advanced CMOS nanoelectronics device. The practical experimental nanorobot invention comprises an engineered based prototyping device with applied approach using manufacturing methodologies with current and emerging technology trends.

Thought of Nanorobotics

Nanorobotics deals with the controlled manipulation of objects with nanometer-scale dimensions.

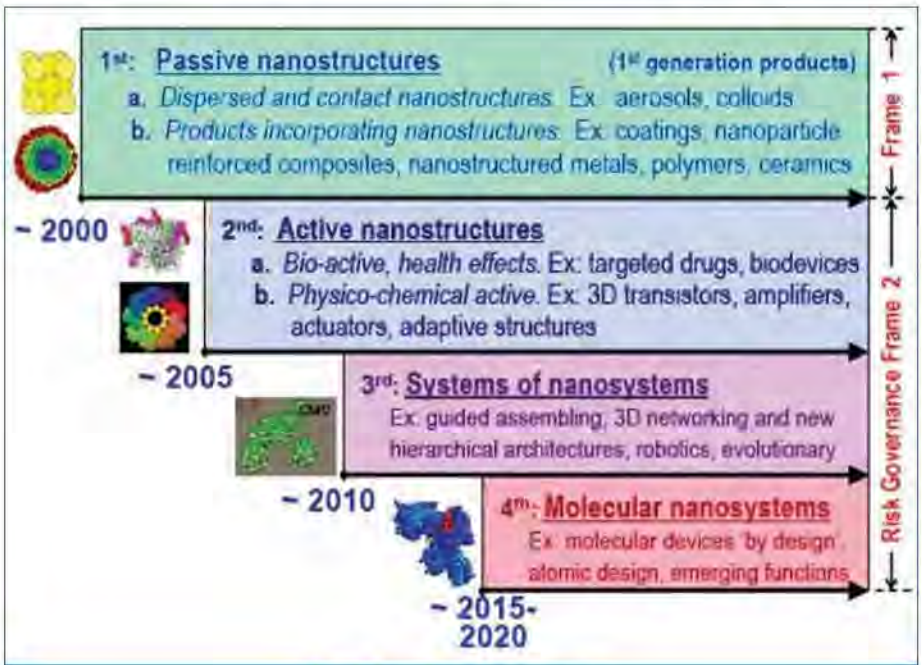

Fig. 1: Transition of nanosystems

As an atom has a diameter of a few Ångstroms (1 Å = 0.1 nm = 10-10 m), and a molecule´s size is a few nanometers. Nanorobotics is concerned with interactions with atomic- and molecular-sized objects, and is sometimes called molecular robotics. The fact that enormous amounts of information can be carried in an exceedingly small space, because in the tiniest cell, all of the information for the organization of a complex creature such as humans can be stored. Many of the cells are very tiny, but they are very active; they manufacture various substances, they walk around, they wiggle; and they do all kinds of marvellous things - all on a very small scale. Also, they store information. This thought lead to the launching of nanorobotics. Medical nanotechnology is often expected to utilize nanorobots injected into the patient to perform their treatment on a cellular level. Instead, medical nanorobots may be manufactured in carefully controlled nanofactories in which nanoscale.

Nanorobotics Theory

Since nanorobots would be microscopic in size, it would probably be necessary for very large numbers of them to work together to perform microscopic and macroscopic tasks. These nanorobot swarms, both those incapable of replication (as in utility fog) and those capable of unconstrained replication in the natural environment (as in grey goo and its less common variants), are found in many science fiction stories.

The most detailed theoretical discussion of nanorobotics, including specific design issues such as sensing, power communication, navigation, manipulation, locomotion, and onboard computation, has been presented in the medical context of nanomedicine

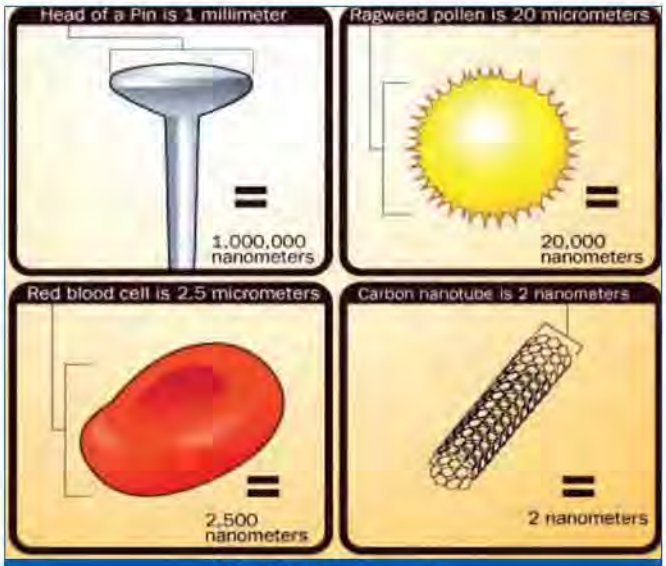

Fig. 2: Defining nanosize


Fig. 3: Artificial Limb for an Amputee

by Robert Freitas. Some of these discussions remain at the level of unbuildable generality and do not approach the level of detailed engineering.

Nanorobotic Technology

Nanorobotics, an emerging field in medicine which states that nanorobots travel inside our bodies, digging for information, finding defects or delivering drugs. Basically, we may observe two distinct kind of nanorobot utilization. One is nanorobots for the surgery intervention, and the other is nanorobot to monitor patients' body. For the first case, a most suitable approach is the tele-operation of nanorobots as valuable tools for biomedical engineering problems. Hence, for example surgery experts guiding a minimally invasive medical procedure.

For cases such as monitoring the human body, the nanorobots are expected to follow a defined set of specified activation rules for triggers of designed behaviors. In such case the nanorobot is designed to be able to interact with the 3D human body environment, in order to fulfil programmed tasks. The nanorobots require specific controls, sensors and actuators, basically in accordance with each kind of biomedical application. Sensors may be wireless ultra fast, super sensitive, and non-invasive and may use chemical, electronic or photonic based detection.

Nanorobotics is the technology of creating a robot or a robotic device on a microscopic scale using nanotechnology. Nanotechnology engineers the building of nanorobots ranging in size from 0.1-10 micrometers. The nanorobot is constructed of molecular components and as of today the artificial non-biological nanorobots remains a hypothetical concept.


Fig. 4: These nanogears were made by attaching benzene molecules (outer white blobs) to the outsides of carbon nanotubes (inner gray rings). By courtesy of Great Images in NASA

How Nanorobotics Works?

Nanorobotics plays vital role in the development of efficient robots. It uses nano components and there objects to build the structure of robots. Its nano nature allows scientists and engineers to engineer the mimic of human beings. Most complex parts of robots can be constructed well with the help of nanorobotics. The devices which are created with the help of nanorobotics is known as hypothetical devices, names such as nanobots, nanoids, nanites or nanomites are also used to explain themachines by nanorobotics. Nanorobotics permits robots for precision and interactions of different function with nano scale objects, all the robots with nanoscaling are operated at nanoscale resolution. Each part and component of a robot from infra structure chip to external body is configured at atomic scale. Although nanorootics makes structure of the robot complex but it facilitate the device with extra ordinary intelligence and efficiency.

Approaches

- Biochip: The joint use of nanoelectronics, photolithography, and new biomaterials provides a

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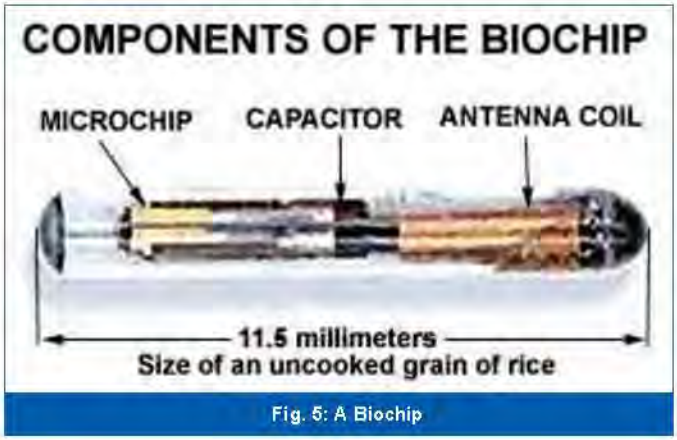

Fig. 5: A Biochip


Fig. 6: A DNA nanorobot that can track down leukemia Cells and kill them on sight

possible approach to manufacturing nanorobots for common medical applications, such as for surgical instrumentation, diagnosis and drug delivery. This method for manufacturing on nanotechnology scale is currently in use in the electronics industry. So, practical nanorobots should be integrated as nanoelectronics devices, which will allow tele-operation and advanced capabilities for medical instrumentation.

- Nubots: Nubot is an abbreviation for "nucleic acid robots". Nubots are synthetic robotics devices at the nanoscale. Representative nubots include the several DNA walkers reported by Nadrian Seeman's group at NYU, Niles Pierce's group at Caltech, John Reif's group at Duke University, Chengde Mao's group at Purdue, and Andrew Turberfield's group at the University of Oxford.
- Positional nanoassembly: Nanofactory Collaboration, founded by Robert Freitas and Ralph Merkle in 2000 and involving 23 researchers from 10 organizations and 4 countries, focuses on developing a practical research agenda specifically aimed at developing positionally-controlled diamond mechanosynthesis and a diamondoid nanofactory that would have the capability of building diamondoid medical nanorobots.
- Bacteria based: This approach proposes the use of biological microorganisms, like the bacterium Escherichia coli. Thus the model uses a flagellum for propulsion purposes. The use of electromagnetic fields are normally applied to control the motion of this kind of biological integrated device.

Future Aspects

Nanorobotics has incredible applications in the field of science and technology. With the assistance of this diverse technology, world is now able to see and utilize the instruments which were never seen before. Some of the most famous nanorobotics instruments and applications are given herein.

- Atomic force microscope: Atomic scope microscope is on the instrument which could be considered as nanorobotic instrument. It is configured and manipulated at nanoscale and also used to vie the particle of an element or material at the smallest level. In the field of medical sciences atomic scope microscope is used to diagnose the cancer and the fatal bacteria.
- Nano macro/microscale robots: Nano macro and micro sale robots can move with the nanoscale precision and can detect and scan the objects and obstacles in the way at completely without leaving a single particle. Nanotechnology delivered excellent applications such as microscopic robots that automatically gathers the other devices or travel inside the


Fig. 7: Robots of the future could operate at the nano-scale level, cleaning arteries or building computer components

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human body to transfer drugs or do microsurgery. These robots are so fast that they can shake the most viscous fluids just in matter of seconds.

- Toxicity detectors: Another useful application is the detection of toxic chemicals and the measurement of concentrated substances in the envoirnment. these detectors will be very useful and beneficial for the chemists in order to manage and reduce the toxicity of chemicals.
- Single molecule car: Recently, another demonstration of nanorobotics is the single molecule car which has nano infrastructure. This car is developed by chemical process and have buckyball wheels. It is configured by controlling the temperature in the air and also by positioning the scanning tunnel microscope.

Conclusion

In Future medical nanotechnology has been posed as a possible method to use to inject nanorobots into a patient in the need of cellular level treatment. Conceptual discussions of nanorobotics include specific design issues that relate to navigation, sensing, manipulation, power communication, on board computation and locomotion.

Even though all aspects of the nanotechnology is in a conceptual status presently, the projected concepts continue to be developed. The manufacturing concept of positional diamondoid molecular would be the technology of nanoscale manufacturing which in turn enables the construction of diamondoid nanofactories. The diamondoid concept is to manufacture molecular machines and products made of diamond. Diamondoid materials include, of course, diamonds, covalent solid that is similar to diamond in chemical inertness and strength properties. Four technical capabilities will have to be achieved first — Nanomechanical Design, Programmable Positional Assembly, Diamond Mechanosynthesis and Massively Parallel Positional Assembly. ■

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Rated asymmetrical making current	52.5kA
Rated operating sequence of Circuit Breaker	O-3min-CO-3min-CO
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Mechanical operating sequence LBS(C-O) M2	5000
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Manufacturer	JYOTI Ltd
Tested samples/items	Three-pole AC Medium-Voltage SF6 gas-insulated metal-enclosed switchgear (RMU) consisting of three functional units (two ring units with a load-break switch and one feeder unit with earthing switches and a vacuum circuit breaker for grounded and ungrounded neutral system for indoor application
Tests carried out	Basic short-circuit test-duties Single-phase fault test Single-phase double earth fault tests Three-phase mainly active load current switching tests Three-phase closed-loop distribution circuit current switching tests Three-phase cable-charging current switching tests Three-phase line-charging current switching tests Three-phase short-circuit making tests Earth fault breaking current tests Cable-charging breaking current tests under earth fault conditions Short circuit making tests
Standards/Specifications	IEC 62271-200 (2011) IEC 62271-100 (2012) IEC 62271-103 (2011) IEC 62271-102 (2003)
Tests date	from November 28, 2012 to December 13,2012

The results reported in this document relate only to the tested samples/items.
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Prepared	PMV - Ghezzi Giuseppe
Verified	PSV - Garolfi Dario, PMV - Magistris Paolo
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CESI S.p.A.

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Jyoti Ltd.
Water • Power • Progress

"Manufacture and supply all voltage range of shunt reactors shortly"

Dr Katsutoshi Toda
Chairman & Managing Director
Toshiba Transmission & Distribution Systems (India) Pvt Ltd

Toshiba Transmission & Distribution Systems group is a world leader in the supply of integrated solutions for energy Transmission & Distribution. Their systems effectively control T&D in order to deliver reliable electricity from Power Plants to Factories, Transportation Systems and even our Homes. Toshiba has developed its superior technology and has a history of high product quality in this market throughout the course of more than 100 years, manufacturing its first transformer in 1894 and its first switchgear in 1902. Toshiba Corporation, Japan has acquired the businesses of Power Transformers, Distribution Transformers & Switchgear from Vijai Electricals Limited, Rudraram Works, Hyderabad, Andhra Pradesh, India in December 2013 and thus formed Toshiba Transmission & Distribution Systems (India) Pvt Ltd (TTDI). In an exclusive interview with **Electrical India, Dr Katsutoshi Toda** says, Toshiba will position TTDI, the new company as a core production base for expanding its T&D business.

What is the scope of transmission and distribution sector in India?

Due to the economical slow down in India, investment in T&D sector is not very positive for the past few years. The power demand is growing rapidly in India. So I believe this sector is promising in India from the long term point of view because space for the investment on T&D sector is still huge. Electric power supply per person in India is very small, as compared to China it is only 1/3rd, and so naturally it will increase much more in the future. For the growth of national economy and for the development of national infrastructure, decision making by the government is vital in all the countries. I am sure that the central and state governments will take appropriate decisions and lead the electrical industry in the proper direction in order to meet the continuous growing power demand in India.

India has planned to add an additional 88425 MW during the 12th five year plan up to March 2017 which is the highest so far in

India. The power ministry projects that the power demand will be 400000 MW by 2022 and 800000 MW by 2032 in India. All the above points predict very bright scope for transmission and distribution sector in India in the future.

Could you share details about product range of your company and about the plans you have for updation of latest technology in the manufacturing facility?

Toshiba will position TTDI, the new company as a core production base for expanding its T&D business in India and the global market. At present we are the leading manufacturer of amorphous core transformer and CRGO core manufacturer in India.

We will extend power transformers up to 765kV. We will also manufacture and supply all voltage range of shunt reactors shortly. Product range of switchgears will be enhanced adding new range of medium voltage and extra high voltage switchgear products.

On the medium voltage, we are planning to add Solid Insulated Switchgears and vacuum interrupters up to 84kV. We will add Ring main units up to 36kV and compact substations.

On the high voltage, we will introduce new range switchgears from 132kV up until 800kV to the product line. Further more, we expect Gas Insulated Switchgear (GIS) to become much more popular in India. Toshiba's state-of-art GIS technology will be a strong portfolio of TTDI. We will also add Surge arrestors up to 765kV and its component technologies.

Thus TTDI covers full range of voltages of both transformers and switchgears. TTDI will also enter other growing markets in India, including power electronics systems, such as high voltage direct current (HVDC) power transmission and static VAR compensators for high voltage networks (SVC), and railway power supply systems.

Where would you envision your company in the next five years?

Toshiba has established TTDI, in India by acquiring the distribution transformer, power transformer and switchgear businesses of Vijai Electricals which entails the designing, manufacturing technologies, sales channels, and employees etc., Toshiba will integrate our state-of-the-art design and manufacturing technologies for T&D systems.

Toshiba will position TTDI, the new company as a core production base for expanding its T&D business in India and the global market, alongside its other bases in Japan, China, Brazil, Russia, Italy and Southeast Asia. Toshiba will add high-voltage power transformers, new range of medium voltage switchgears, medium and high voltage vacuum interrupters up to 84kV, and extra high-voltage switchgears for GIS and AIS, Medium and high voltage surge arrestors etc., as well as increase the manufacturing capacity especially for high-voltage switchgears. We are also going to position TTDI as a global supply center for products, sub assemblies and components to various Toshiba manufacturing facilities around the world.

How are you planning to position Toshiba in Indian and global market?

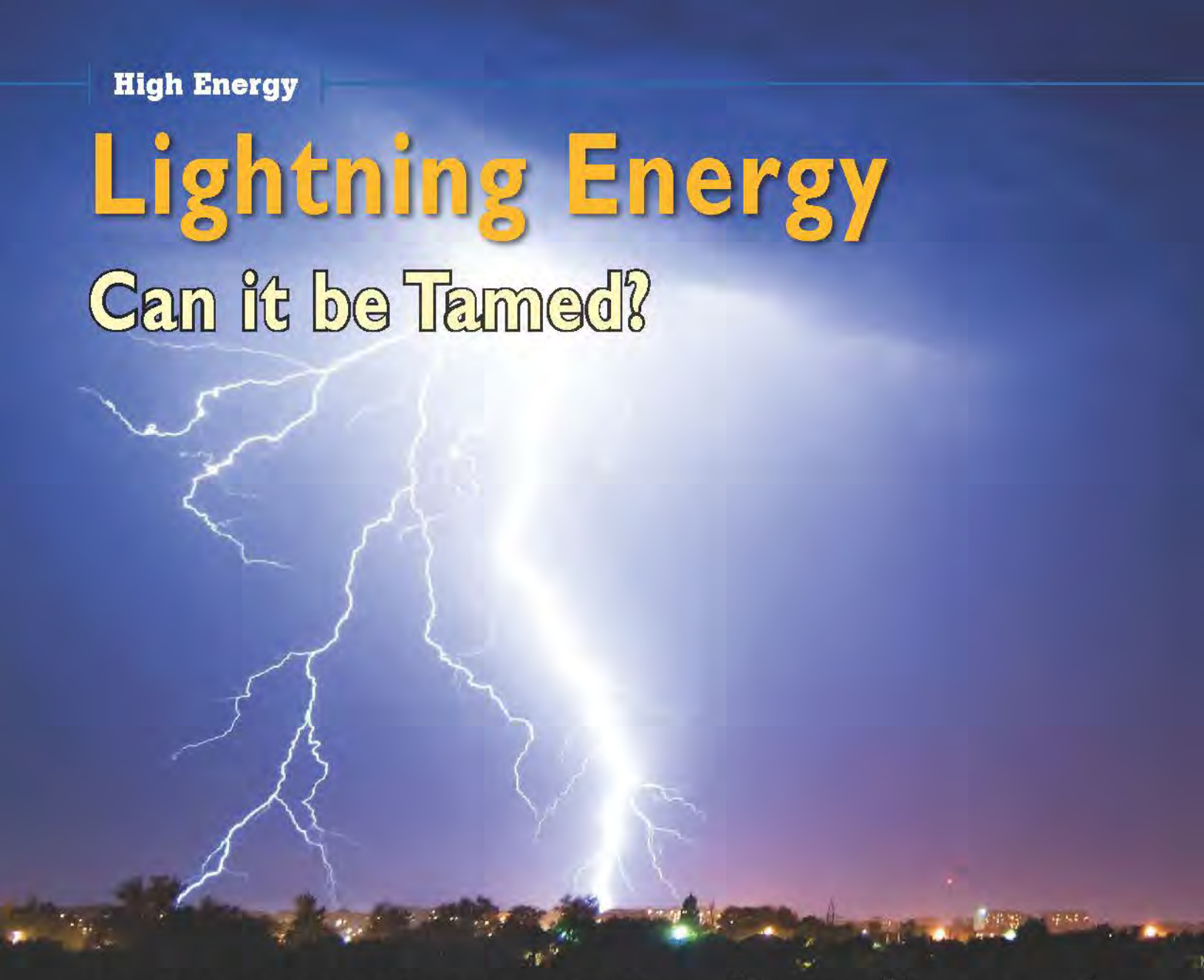
Toshiba will position TTDI, the new company as a core production base for expanding its T&D business in India and the global market. Toshiba has a long history for T&D business in India. With the acquired local manufacturing capability, Toshiba will have additional strength in T&D business in India and expand the business volumes. We believe that Toshiba (TTDI) can increase the market share by manufacturing and supplying customer focussed world class products and services as mentioned above with Japanese quality from the local factory. The knowledge base of Toshiba and the manufacturing capabilities of India will hugely benefit Toshiba in a big way. Also the delivery time will considerably come down reducing the cost of freight and duties giving us the marketing edge.

How advantageous was Elecrama show for you especially since it was held in Bangalore this time?

ELECRAMA is a gateway for opportunity to inform the customers in India and abroad that Toshiba has launched its global manufacturing hub in Hyderabad. It has provided the right platform to communicate that world class range of medium, high voltage products Toshiba is introducing in India. The customers were very keen to know the range of Toshiba products that planned to be manufactured in India and we have received overwhelming response through ELECRAMA 2014. ■

Lightning Energy

Can it be Tamed?



I landed in Kashebere village in Democratic Republic of Congo as a part of United Nations. This village is a beautiful village at an altitude of 2000 meters above mean sea level and is near to the equator. On an average there are eight to nine months of a rainy season in one year and hence it is densely forested. A particular day has generally all seasons and temperature variations.

- Major Prashant S Borde

Morning is covered with thick fog (visibility five meters only) then it opens up and day becomes dry and hot taking temperatures to 35 degrees. After 1 pm the white clouds start forming up which generally change their shades to gray by 3 pm. By 4 pm the thundering and lightning starts, and is followed by rainfall for duration of one to two hours. The nights become very cold and chilly dropping the temperatures to 8 degrees. The daily timetable may change but without changing in pattern.

As a curious electrical engineer, it was both fascinating and the best available natural laboratory for me to study the effects such as

thundering and lightning. I could relate the theories put with reference to Lightning engineering with that of practical observations. This article highlights on the relations established as per the observations with respect to heavy energy transfers done by water vapour molecules in the form of lightning and thundering.

Debatable statements (and some myths) relating to lightning that I had heard before I had related them with observations are as under.

- It falls on highest elevated point.
- The lightning conductor can protect the area.
- The water vapour form in ions and aligns such that there is charge concentration of the order of Mega Volts and beyond.
- The positive and negative charges attract and break the air causing visual lightning and audible thundering.
- The molecules of water vapour loose energy to form water droplets which is mainly responsible for tornadoes, wind storms, hurricanes, lightning and thundering.
- Carbon dioxide is responsible for lightning.
- Lightning is attracted by Copper and we should not wear rings while lightning.
- Most of the time lightning travel in the direction of Earth as it is oppositely charged.
- Lightning is accompanied by thunder.
- Lightning happen when heavy winds collides the layered clouds.
- Piezoelectric effect forms in a cloud.
- The lightning travels from cloud to ground in a straight path of minimum distance.

However with the practical observations and calculations I could get different results. We shall discuss them one by one.

Observations

I observed that this effect takes place irrespective of day or night. This effect also takes place in presence or without heavy winds. Both lightning and thundering may occur jointly or without. I had noticed that only one of these effects is also produced in isolation. The frequency of inter cloud lightning was more than that of cloud to ground. The lightning caused damages at certain points even though these ground features were lower in elevation with reference to installed two lightning conductors. All the waves did not reach the ground. They did not travel in straight line but were generally noticed travelling in mesh and branched manner. The sparks branched sometimes and even joined back. The intensity of light was not uniform in the entire length of spark. Few of the branches of spark also travelled in upward direction i.e. away from gravitation. The sparks kept on forming in an intermittent pattern. Their path was seldom repeated. The sparks travelled from one point and travelled to another point in a curved linear direction at varying speeds. Lightning happened in clouds irrespective of the fact that they were stationary or moving or colliding. The thunder sound source was also noticed to be travelling in linear fashion or else it was only instantaneous. Electromagnetic effects on electronic circuitry and shock waves were largely observed. It resulted in temporary rise in voltage in electric lines. Lightning happened only when there were black clouds present. There was no effect of this lightning and thundering in white clouds even when these both types are formed due to water vapour. Lightning did not happen in fog.

Theory and Calculations

Water chemically known as H20 has a molar mass of 18.0152833 gms/ mol and maximum saturation at 30 degrees which is 30 gms/ m3. Taking 6.023 x 1023 molecules per mole of water vapour in $1m^3$ is 1.003x 1024 have 2 hydrogen atoms. If all of them were to become H+ ions it would be 2.006x1024. The ionization energy of

all these hydrogen atoms would be around 4.36 x 106 Joules. For the volume of 1 km by 1 km by 100 meters it would be theoretically 4.36 x1014 Joules. The heat of vaporization is theoretically 2.27x106 and for this volume of water vapour at the max density would be 3.78x1011 Joules. We can read through the figures and notice that even if complete heat of condensation (or vaporization) is converted in the ionization of Hydrogen, it would not be sufficient.

Moreover due to entropy large amount of heat released during the process of condensation is transformed in heavy winds. Some of the above mentioned assumed statements become debatable with this theoretical calculation. Hence the question arises what is it that increases the potential of water vapour and how? Next we see that dielectric breakdown capacity of air is 33 KV/cm and with humidity it decreases considerably. The breakdown term means that an insulator becomes a conductor for the duration of applied high voltage above its breakdown capacity. For various elements such as wood it is still lower. Another factor is the geometry of the terrain. For 1m distance the breakdown potential is approximately 3.3 MV. Now when we see naturally the distances (100 meters and beyond) between the theoretical of highest point of elevation may not hold good always as there would be a stream of dense vapour present which would have lesser breakdown capacity. It is possible that lightning produces has voltages less than GV but more than few MV. In this point of debate we see that the lightning conductor may only give passage to the spark but due to uneven water vapour content the air may not breakdown as we always hope. The wire mesh form increase the probability of receiving lightning bolts but are more costly.

Till now no one has found the actual reasons for the lightning. But on observing hundreds of times, I have few important findings and hypothetical answers to our questions.

The breakdown term means that an insulator becomes a conductor for the duration of applied high voltage above its breakdown capacity. For various elements such as wood it is still lower.

We know that the term voltage means the ratio of charge to capacitance which also means electromotive force. The hydrogen atom has different energy bands. Here we are going to apply some of our experimental observations. Firstly the water vapour absorbs infrared radiations. They also absorb ultra violet and cosmic radiations. I would like to add in this that water vapour also absorb visible range radiations. It is because we have seen that some of the clouds are dark. Next we know that there is one electron in the H atom which is paired with one valence of Oxygen atom in water for more stability. Thirdly we are aware that there is intermolecular affinity of various molecules of water. Fourthly and most importantly the physical chemistry of the water molecule is responsible for the huge energy transfer in our Earth. On these known facts we are going to discuss three theories that may help in understanding the lightning and thundering effects. These theories are interrelated for some of the statements mentioned in them.

Detonation wave theory

The term detonation means a violent release of energy caused by a reaction. This detonation takes place in a wave form. This implies that one water vapour molecule, when releasing energy actuates the neighbouring water vapour molecule to release the energy. It was observed that the energy released is not a big explosion but a progressing wave in some unknown direction. When a molecule keeps on adding the energy it becomes unstable beyond a particular limit. This molecule releases the energy in form of photons and electromagnetic waves. The energy released in form of photons strike the other neighbouring molecule having the next maximum energy level and transferring the energy to that molecule, thus making it going in temporary unstable state. This extra charged molecule also releases energy by emitting photons and electromagnetic waves. The wave continues till the time that the photons released do not find suitable water vapour molecule having suitable high energy. The availability of the suitable water vapour molecule in the proximity decides the further direction of spark.

Energy distribution and stabilization theory

We know that as per Energy Band theory, the electron moves around the nucleus in an elliptical (or circular) orbit at a distance such that it remains

stable. But, we have not found, what happens with the energy levels when the water molecule absorbs different types of radiation. This theory states that a water vapour molecule does require some energy to reach the saturation before going into liquid or solid stage. This is done by proportional absorption of infrared, ultraviolet, visible and cosmic radiations. Water vapour molecule after reaching a particular density starts having feeble affinity towards each other. Once the energy levels have reached the saturation and the molecule are likely to become unstable (meaning electron leaving away from nucleus of H+ ion that has only one proton). The electron jumps to lower energy level releasing high amount of energy in a very short period of time. In some cases if this does not happen, then the electron may forcibly go away from the Hydrogen atom leaving only charged proton. Hence having a situation wherein electrons and charged particles are floating in space. These may be for a very short duration of time but may initiate the energy levels of other molecules.

Nuclear reaction theory

There is high possibility that the H+ ions (protons) may collide with each other in the presence of cosmic radiations or may get fused in heavier atoms such as Carbon, Oxygen or Nitrogen making it temporarily unstable. This would release instantaneous energy. The Japanese team of scientists had already reported that gamma radiations were also observed before the bolt of lightning in July 2013. These radiations would increase the energy levels up to the saturation limits and actuate the energy emission.

Conclusion

Nature has its own unexplained mysteries. The effects of lighting and thunder are one of the biggest mysteries for engineers. The experiments and practical observations may help us in understanding and probable taming this energy source. What challenges lay ahead of us are to make an engineering approach and control this magical source of tremendous energy for the development of mankind. ■

Major Prashant S Borde is an officer of Indian Army and presently located at Democratic Republic of Congo in United Nations Peace Keeping Mission. He is BTech in Electrical Engineering from College of Military Engineering, Pune.

Harmonics - A Power Quality Problem

Power Quality is defined by any problem manifested in voltage, current or frequency deviations that results in failure or malfunctioning of customer sites or equipments.

- Haren Shah

Bureau of Energy Efficiency (BEE) play key role in creation of professionally qualified energy managers and auditors with expertise in energy management, project management, financing and implementation of energy efficiency projects as well as policy analysis. It is a law to force firms to make more profit and not an Act to control and monitor Energy Consumption of Industry. Under the BEE's PAT Scheme (Perform, Achieves & Trade) for Eight Industrial Sectors like Aluminum, Cement, Chlor – Alkali, Fertilisers, Iron & Steel, Pulp & Paper, Textile and Thermal Power Plants, it is mandated to compulsorily improve their energy efficiency by adopting all the available measures including replacement of their old equipments with new and energy efficient equipments.

For quality performance of various power system devices it is necessary to understand the problems due to harmonics deeply and take further remedial measures for improvement and better performance.

Harmonics – A Power Quality Problem

- The power quality may defined as any problem manifested in Voltage, Current or Frequency deviations that results in failure or misoperation of customer sites or equipments.
- Harmonics, voltage flicker, voltage regulation, voltage sag, voltage swell and transients usually characterize the quality of electric power.
- Harmonics is one of the major factors due to which none of these conditions are fulfilled in practice.
- The presence of harmonics distorts the waveform shape of voltage and current increases the current level and changes power factor of supply, which In turn creates so many disturbances.

Sources or Causes of Harmonics

- Rapid use of energy conservation devices in both domestic sectors and industrial sectors such as electronics chokes for tube lights, electronics energy controllers for the motors and electronic fan regulators etc. also inject harmonics substantially.
- Large use of the shunt capacitors to improve power factor and stability has significant influence on harmonic level. Related to the supply system converters and traction are the major causes of generation of harmonics.
- More use of solid state power converters for industrial furnaces for mini steel and non-ferrous metal plants, use of thryistors for locomotives, extensive use of single phase electronic loads in domestic sectors are causes of harmonic generation.
- A growing power quality concern is harmonics distortion that is caused by the non - linearity of customer loads.

Impacts of Harmonics on various Equipment

- **Transformers:** The Primary effect of power system harmonics on transformers is the additional heat generated by the losses caused by the harmonics content of the load current. Magnetic loss increases due to higher frequency level of harmonic current. Copper loss increases in winding due to third harmonic current present with load current. Also copper loss increases in the delta connected transformer windings due to extra circulating zero sequence currents.
- **Rotating Machines:** An increase in motor, generators, turbine operating temperature will cause reduction of the rotating machine's operating life. Extra audible noise is produced during the operation due to the difference between the time harmonic frequencies. Also harmonics cause variation of mechanical resonance speed of adjustable speed drives, which may do damage due to amplification of the pulsating torques.
- **Capacitor:** The effect of the Harmonic component is to cause extra power loss due to decrease of impedance by increasing frequency; which in turn increases the temperature level and shortens the life by early equipment failure. Also it increases the dielectric stress inside the capacitors.
- **Circuit Breakers:** The harmonic distortion of the current can affect the interruption capability of the circuit breakers and thermal magnetic

breakers. The extra heat due to losses for frequencies above the fundamental raises the temperature of the thermal device, which in turn may reduce the trip point of the circuit breaker.

- **Measuring Meters:** Wattmeter and watt-hour meter, Electronic Energy meter shows error from the frequency characteristic of the voltage and current waves affected by harmonics. Linearity of the meters can be degraded when the power factor is low or waveforms have large crest factor caused by the Harmonics. Absolute average responding meters calibrated in RMS and peak responding meters give erroneous result under the presence of harmonic distortion.
- **AC/ DC Drives:** Voltage surges due to harmonics can damage the power diodes connected at the input of an AC variable frequency drive. Under sustained over voltage and under voltage condition the equipment may be shut down. Input voltage waveform containing harmonics may have multiple zero crossing, which may change the firing angle of the thyristors.

- **Conductors:** There are two mechanism is which harmonic currents can cause heating in Conductors that is greater than for the RMS value of the current. The first mechanism is due to current redistribution within the conductor and includes the skin effect and the Proximity effect. The second mechanism causes abnormally high current that is due to excessive third harmonic current in the neutral conductor.
- **Cables:** Harmonics cause extra heating which in turn causes a degradation of dielectric, production of cable jacket both inits dielectric role & its mechanical protection role, reduction of life span due to oxidation and a possible overall reduction of maximum operating capacity of the cable.
- **Computer Networks, Control Room, SCADA:** Presence of Harmonics effects can cause nuisance tripping of sensitive loads. Some Computer controlled loads are sensitive to voltage distortion. Data acquisition through SCADA system may get effected due to power disturbance like voltage sag, swell, transient events, and presence of harmonics
- **Protective Relays:** Waveform distortion does affect the performance of protective relays and may cause relays to operate improperly, or not to operate when required as in ground Relays due to zero sequence third harmonics and dual input relays by the phase relationship between the respective input harmonics. Changes of operating points operating torque and time of static relays may happen due to distortion of waveform, which in turn causes improper high speed operation of difference relays.

Controls & Remedies for Harmonics

- Limit harmonic current injection from nonlinear loads Transformer connections can be employed to reduce harmonics in three phase system using parallel delta-delta and wye delta transformers to yield net 12-pulse operation or delta connected transformers to block triple harmonics.
- The Harmonic distortion in adjustable speed drives can be controlled will within IEEE 519-1992 limits by drive design modification, switching from 6 pulses to higher pulses converters, connection of series reactor.
- Modify system frequency response to avoided adverse interaction with harmonic currents. This can be done by

With the move towards deregulation within the Power utility industry, customers are demanding superior power quality and reliability of supply. Many utilities have responded to the needs of their customers by establishing power quality divisions.

feeder sectionalizing adding or removing capacitor banks adding shunt filters or adding reactors to detune the system away from harmful resonances.

- Applying Harmonic like Filter harmonic current at the loads or on the system with shunt filters or try to block the harmonic currents produced by the loads. There are number of devices to this. Their selection is largely dependant on the nature of the problems encountered. Solution can be as simple as an in-line reactor (i.e. a choke) as in the PWM based adjustable speed drive applications or complex as designed active filter.
- In the Reactor (i.e. Choke) as in the PWM based adjustable speed drive applications or complex as designed active filter.
- Monitoring problem manifested in V, I, Hz. Data acquisition is the primary step for both the situations. The requirement is the data on the current and voltage distortion both as it exists.
- For quality performance of various power system devices it is necessary to understand the problems deeply and requires further remedial measures for improvement and better performance.
- So for quality performance of various power System devices it is necessary to understand the problems deeply and requires further remedial measures for improvement and better performance. Data acquisition is the primary step for both the situations.

Planning & Designing for Harmonic Suppression

- With the move towards deregulation within the Power utility industry, customers are demanding superior power quality and reliability of supply. Many utilities have responded to the needs of their customers by establishing power quality divisions within their marketing departments.
- Analyzing the spectra and knowing the size of systems planned, different solutions can be deduced and incorporated in the design that will lessen the disturbances or possibly eliminate them entirely.
- Providing solution to power quality problems, cost plays a major role. Hence it is always necessary to find cost effective solution to resolve Power Quality issues to minimize equipment downtime and loss of production by using handy and easy to use instruments for monitoring, measuring and recording all necessary values in three phase like TRU-RMS value, voltage, current, frequency, apparent & reactive power, energy, power factor, phase angle and above all harmonic analysis with transients events.

MECO "POWER & HARMONICS ANALYZER – Model 5850" is a state of art versatile instrument using micro controller technology, ideal to carry out vigilance checks, surveys, audits and periodic visits for checking at industrial and consumers end. The measurements can be done on Live loads. It does analysis for 1 & 3 Phase Quality power system. Large Dot Matrix LCD Display with Backlight of 35 Parameters in screen to monitor Energy, Active Power, Apparent Power & Reactive Power, Power Factor, Energy, TRU RMS Value, AC Current, and Average & Maximum Demand with Programmable Time Interval, CTR & PTR. Displays Harmonics upto the 99th Order, THD with Waveform &Peak value. Has inbuilt memory of 512K for 17000 records & Optical Isolated RS-232 ~ USB Interface with users friendly software with facility to retrieve power data & harmonics on meter screen at site. Available with Clamp on CT having Multiple Range of 1/10/100A or 10/100/1000A or 300/3000A & 120/1200A (Flexible CTs) as per application.

Objective

Objective of it is to provide steady state harmonic limits that are reasonable to both electric utilities & the users.

- The power provider should limit Harmonic voltage since they have control over the system impedance.
- The users should limit Harmonic Currents, since they have control over loads.
- Both parties share the responsibilities for holding harmonic levels in check. ■

Haren Shah
Senior Marketing Executive
Meco Instruments Pvt Ltd
Navi Mumbai.

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Software Implementation and its challenges in the Electrical Industry

Choosing a good software is a very important task. But implementing it is a much bigger and trickier affair. Though a lot of companies invest time and money in the first part, i.e. choosing a solution, they fail in the second part to successfully implement the solution. On account of this, we keep hearing about a lot of paid but unused solutions.

This leaves a very bad taste both with the buyer as well as the solution provider. It also takes away the confidence level with other prospective buyers and eventually results in getting back to the error prone manual methods.

So, where and what is the problem?

The success of a product is usually defined by ease of use, speed of implementation and how quickly it can be flavoured to meet the specific demands of each user group. Problems are plenty for both the user as well as the developer to keep up with each other with respect to features. Most of the times the user wants everything at one click of a button and everything to be perfect in one go.

However they fail to understand that for this to happen, a lot of time has to be invested for preparing the back end intelligent data. This one critical part, if not understood well, will result in a failure, which is in most of the cases. This extends the implementation cycle to a great length and beyond a point, the implementation is shelved. Moreover, no one has the quality time to spend on building this critical mass.

Many a time it is the ownership of this task which is the problem. "I don't have time to do this"is a very common reaction when the implementation of a solution is taken along with normal day to day activity.

Probable solutions

As a software solutions company we have faced all these problems and more. However, by educating the buyer on what needs to be done to achieve success in implementation, we have been able to turn around a lot of implementations to go live. Some of the important factors which are helping us in converting implementations to go live are:

Phasing out the implementation milestones

First and foremost, identify the implementation mile stones. If this is done correctly, the transition from a chaotic situation to a totally automated situation happens seamlessly. Dividing the overall requirement to phases and successfully delivering each phase gives a lot of confidence to the user.

Recognizing a core team

Next, identify a core group of experienced users who will spend quality time with the implementation team. These experienced users can create a template or a standard or a process for all others to follow. This time investment will always be justified in the long run.

Targeting standardized product offerings

Any company which is in business for some time would have repeatedly done the same kind of job for different customers. These offerings can be usually be standardized based on a logic and can be made searchable. These standards can be used as starting points to create new projects. Minor changes to these standards or templates can be handled at the individual project level. Let us look at how the concept works with a case study.

Case Study

The following is a case study of how a solution was implemented on AutoCAD along with an add-on solution in a reputed electrical panel manufacturing company. This solution is running successfully since the last 5 years.

Product	Low Voltage Switchboards
Base software	AutoCAD
Add-on	Speed
Core team	2 engineers from the Design department

Step 1 – Creating the knowledge bank

All the different types of feeders

were recognized. A total of about 1500 different feeders were created, which included Incomers, Bus-couplers, DOL, RDOL, Star Delta and Outgoing feeders with several different ratings each.

All these combinations were done for three reputed switchgear manufacturers viz., Schneider, ABB & Siemens.

Based on the switchgear size, the compartment sizing was also decided. The door arrangement, door cut-out and internal arrangement drawings were also created for the above standards. The Bill of Materials for all these combinations were created and assigned.

Step 2 – Using these feeders in the project

When a new project started, the users would search the knowledge bank and choose the feeders closest to the requirement on hand. Once the feeder was imported to the project, any specific changes would be done to these feeders. These feeders were then used to create the GA, SLD and the BOM.

Step 3 – Linking with the ERP

Once the final approval happened, the BOM would be moved to the ERP solution for the other departments to get into action.

Milestones achieved with this implementation

- Time reduction of about 80% in generation of GA, SLD and BOM
- Error reduced drastically due to the standard representation by every user
- Automatic BOM calculation reduced errors in calculating components
- Transfer of BOM to ERP resulted in seamless integration with purchase and planning group.

Conclusion

Implementing automation projects are definitely possible and within a very reasonable time. This can happen provided there is a proper understanding on what can be achieved and what can be the goal to achieve. Today a variety of solutions and solution providers are available to do many things. It is only the mind-set of the user as well as the solution provider in understanding each other to achieve a common goal will play an important role in the success of any such projects. ■

Courtesy: M. V. Keerthi Bhanu, DeltaCADD Solutions Pvt Ltd Bangalore, Karnataka.

Use of Prime Vs Non-Prime CRGO in Transformers

"Effects thereof on Power Sector"

B. Lal
Director General
Indian Transformer Manufacturers Association (ITMA)
Ghaziabad

Cold-Rolled Grain-Oriented Silicon Electrical Steel (CRGO) used as core material for the manufacture of transformers, is not manufactured in India and transformer industry is totally dependent on the import of this main raw material from 15 foreign mills located in USA, Japan, UK, Korea, France, Germany, Russia, Poland & China. The production capacity of these mills is about 25 to 30 lakhs tones per year which meets the requirement of Indian Industry of about 2.5 lakhs to 3 lakhs tones per year. At present 50% or even more non-prime CRGO material is imported due to free trade policy of Government of India which is being used for manufacture of transformers in India.

Prime CRGO ensures superior technical parameters with respect to losses, efficiency, low magnetizing current low in rush current, reduced magneto-restriction phenomenon and less carbon emission and has passed all the tests in the Mills producing the material as per the standards laid down by the country of its origin while the non-prime CRGO is the one declared defective, second, scrap or rejected or already used and removed from the old transformers which shall result in inferior technical parameters besides higher losses, carbon emission, bigger size of core, tank, oil quantity and additional copper winding and noise pollution etc.

There is very strong lobby created by some steel traders with some lamination processors primarily due to the cost differential between the prime CRGO and non-prime CRGO which is as much as 300% cheaper than the prime material. The steel traders have been making huge profits since CRGO was decontrolled from DGTD and was put under open general license and this practice/ system is being operated by them for the last 3 to 4 decades and thus have amassed ill-gotten wealth simply by importing non-prime material and selling to the manufacturers of Transformer in India. In case they import prime material the profit margin will not be more than 5 to 10% which they are not satisfied with.

It is very well known that ITMA had been consistently struggling with all relevant authorities like, MOP, CEA, MOS, MOCA, BIS of Government of India for the last ten years, so that non-prime material, in any form is not allowed to be imported. During these years numerous meetings were held at all levels and as a result original first Quality Control Order was issued on 9th September 2008, which was extended at the behest of some vested interests and consequentially the CRGO item was omitted from the order vide S.O.No. 308(E) dated 9th February 2010 of MoS. Thereafter ITMA made continuous efforts with all relevant authorities and ultimately second Quality Control Order dated 12th March 2012 was issued which has since been extended twice and has now become effective for implementation w.e.f. 1st October 2013.

Finding no other alternative the same negative forces who had got deleted/omitted the item CRGO in February 2010 order had been working tirelessly to see that the second quality control order dated 12th March 2012 also meets with the same fate. In this connection it is being contended that by use of non-prime CRGO, the efficiency of the transformer is not affected and thus it should be freely allowed to be imported for manufacture of transformers in India. This concept is utterly misleading as all over the world efforts are going on to improve the transformer efficiency resulting in energy savings besides significant environmental improvement in reduction of carbon

footprints. Small increase in efficiency say 0.5% of the distribution transformers in India would result in annual saving of 4 to 5 Billion KWh together with reduced carbon emission (C02) of 4 Million Tons per year.

Bureau of Energy Efficiency (BEE) under its Star & labelling Programme has also come out with five categories of transformer as star 1, star 2, star 3, star 4 and star 5 with gradations in respect of total losses. Star 5 is the most energy efficient having very less losses. Improvement in core material technology is a continuous process and new grades of very low losses are being developed which will further increase the efficiency of transformer by reducing the losses and thus will help in huge reduction of C02 emission.

Besides Bureau of Energy Efficiency (BEE) has been able to achieve energy savings during the initial year 2011 to the extent of 54.918 MU with corresponding avoided Generation Capacity of 12.35 MW, when S & L programme notification was brought in to force since January 2010 for Distribution Transformers (as per BEE's report for the year 2011). ITMA and BEE undertook awareness programme of Energy Saving vigorously at various States/Regions, which is still being carried out till date. It is possible that during the year 2012 the energy saving of 120 MU could have avoided generation capacity of about 20 MW (estimated).

It is also given to understand that claims are being made by the same lobby that non-prime/used material (CRGO) can be used in manufacturing of transformers since it is a non-ageing and does not lose its properties/characteristics even after rendering service for a period of 25 to 30 years. Such concept rather a mind set is absolutely untenable as CRGO is a silicon electrical steel which is insulated for formation of the transformer magnetic core. The insulation is subjected to electrical, mechanical and thermal stresses during the course of service period of the Transformers. These stresses impair the lamination (CRGO) resulting in hotspots, increased losses, burnt spots and fusion of core thus formation of gases thereby causing failure of transformer. Even during repair of transformer affected Lamination and winding have to be changed. It is pertinent to bring out that the transformer manufactured with non-prime material have 4 to 5 years of life span against 25 to 30 years of transformers manufactured with prime material. Such premature failure of transformer put additional maintenance cost and prolonged outages affecting industrial production and other vital services to the consumers entailing very poor financial health of discoms and attracting criticism from public at large.

It is too well known that 99% of transformers are purchased by the utilities/discoms, who always specify the use of only prime material with relevant documentation from the raw material manufacturing mills etc., in their specifications. But due to unexplainable reasons the use of non-prime material find its way in the manufacturing of the transformers which are installed in the country's distribution network to supply power to the end users. It appears that the modus operandi is to get one or two transformers tested as per the requirement / specifications of the utilities / discoms by using the prime material, whereas balance supply is managed with non- prime material only.

The transformers manufactured out of non prime material are sold as new transformers as per the specification of the purchaser, which is factually incorrect. It would be proper that the transformers manufactured with non-prime material should be branded as transformer manufactured with non-prime material. This aspect will be more clear from the following analogy.

"CRGO core is actually the heart of transformer without which, it cannot be functional. It is akin to a brand new car having reconditioned engine offered for sale at show room price."

As stated above, there are only 15 mills in the world manufacturing CRGO steel and supplying the material to Indian market and out of which 13 have already got themselves registered with BIS for certification as per IS:3024 and balance two are in process of registration, thus the apprehension of cartelization being professed by the foreign mills is ruled out and there would be fair competition due to registration of 13 foreign mills.

Despite the fact that the Quality Control Order dated 12th March 2012 has come into force w.e.f 1st October 2013, some of the importers are still managing to get the non-prime CRGO material cleared at Kolkata/ Mumbai ports which fact has already come in to the notice of Ministry of Steel, Government of India and some action is underway to plug the loop-hole in order to stop this menace of rampant corruption going on unabated for many years.

Under the present ambiance surcharged for anti corruption, it is high time when dubious means adopted by some unscrupulous elements for import of NON-PRIME CRGO MATERIAL for their selfish ends are stopped forthwith so that the accumulated T & D losses of Power Sector which are reportedly more than 2 lakhs crores are curtailed to some extent. ■

Elmeasure India Pvt Ltd

ElMeasure India is a fast growing technology leader in the field of energy management. ElMeasure offers a powerful, latest technology based, cost effective, user friendly complete solution for Energy Management to help industries, commercial establishments and major power users to reduce wastages and minimize power losses. The Return of Investment is typically less than 12 months and user can have recurring profits. Elmeasure India Pvt. Ltd. was promoted in 2004 by a young team of entrepreneurs with collective experience of more than a decade in the field of energy management. ElMeasure has its Head Quarters at Bangalore and state of the art manufacturing facilities at Bangalore, Coimbatore and Dehradun. Its philosophy of commitment to the operational excellence in terms of quick response, faster deliveries, deep customer relationship and cost effective products and solutions has helped the company to gain the confidence of thousands of customers in India and Overseas. Committed and talented workforce and value based management will ensure that it remains a preferred brand in the industry. Today, ElMeasure is uniquely positioned to serve the needs of every customer. The company's innovative and entrepreneurial spirit coupled with gravity, depth and breadth of its knowledge and relationships, assures customers that they have chosen the right partner to help them succeed. ElMeasure has the corporate mission of meeting the social responsibility to contribute to build a strong nation.

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- Wind turbines and solar energy

AC Capacitors Range

- Self-healing MKP up to 1 $kVAC_{RMS}$
- 1-phase and 3-phase

Recommendations: IEC 60831, IS 13340, and customer specifications

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Retrofit Led Highbay from Venture

Venture Lighting India introduced a retrofit LED HIGH BAY as a direct replacement of traditional High bay with thermal conductive Bio-Polymer plastic heat sink for better reliability and longer life. Advantage with Bio-Polymer heat sink is 40% lighter weight and 94% more heat radiation than aluminum heat sink (of same design and size).

Features:

Direct Replacement of traditional High Bay, Innovative design with thermal conductive bio plastic, High intensity of illumination Ignite quickly, no noise, without mercury, UV, IR radiation, Electric wave and radio interference resistant, smart, portable, easy to install, cost effective solution, High Power Factor (> 0.9), ROHS compliant, IP 65 Protection.

Applications:

Factory, warehouse, supermarket, assembly shop floor, areas which need illumination from High Bay. ■

For further details contact:

marketing@vlindia.com

Oil-immersed Distribution Transformer (11&33 KV) by CEEG

The company can design and manufacture oil immersed transformer with voltage up to 220KV and capacity up to 100MVA according to IEC standard, this series of oil immersed transformer have following features: low loss, low temperature rise and low partial discharge, high reliability, core lifting free, no leakage. **Safety:** This product adopts integrated insulation structure according to IEC60076/14; 7-stage temperature control technology. **Advanced insulation temperature control technique:** special insulation material is used in hot-spot of the winding and transformer body. **Liquid flow loop temperature control technique:** to control the temperature of the top liquid and liquid near the hot-spot of winding; to control the transformer temperature under overload condition. **Iron Core temperature control technique:** to control the temperature of insulation parts. **Sealing temperature control technique:** To control the sealing type transformer would be working well under the temperature limitation. **Sub-assembly temperature control technique:** to select subassembly according to the temperature limitation .Short-circuit temperature control technique. ■

Website:

www.ceeg.cn

Static Single Phase Plc Meter by Shenzhen Techrise Electronics Co Ltd

DDSI876 Static Single Phase PLC Meter is designed to realize automatic meter reading via low voltage line. The product has features of advanced PLC technology, stable operation and accuracy measurement. It is an ideal product for AMR system and applied for residential customers. It complies with IEC 62053-21, IEC 62056-21.

Features: Records active energy for latest three months, reverse energy measured as forward energy Energy frozen; monthly freeze for 3 months on first day of each month. Day freeze for latest seven days at 24:00 Real time calendar timing and broadcast time calibration, Communication; can be programmed or data collected through remotely infrared or PLC communication LCD display with 6 integers and 1 decimal, **Indication:** impulse signal light and power off indication light indication, **Optional:** Switch on/off through PLC or remote infrared communication order. ■

Website:

www.trj-china.com

STS 5000

Multifunction Test System for CT, VT and Power Transformer Capacitance and Tan Delta Diagnostic System

ISA brings the ultimate product of its range, STS 5000, the multifunction substation maintenance & commissioning test system for current, voltage and power transformers. STS 5000 with the optional module TD 5000 is also an accurate and reliable capacitance and tan delta diagnostic system.

STS 5000 main features are:

It is fully automatic; **primary injection testing capabilities:** up to 800 A or up to 3000 A, with the optional module BUX 3000; variable output frequency: 15 - 500 Hz; power dissipation factor test with the optional module TD 5000 (voltage up to 12 kV); 2000 V AC high-pot test; large graphic display; advanced Test & Data Management Software for test set control, results storage and analysis; USB interface and Ethernet interface for PC connection; it is compact and lightweight;

Patent pending technology for capacitance and Tan Delta measurement

STS 5000 features can be enhanced by the following OPTIONAL MODULES:

The high voltage (HV) generator TD 5000 performs the measurement of the tan Delta, capacitance and power factor of any device, at the frequency of the mains or in a wide frequency range. The Circuit Switch option STCS performs the automatic measurement of PT's transformer ratios, of the winding resistances and of the short-circuit inductances, testing also the operation of the Load or no-Load Tap Changer. The extremely high current BUX 3000 option performs high current tests, with currents up to 3000 A. The oil tester STOIL tests the dielectric oil of a power transformer. ■

For further details contact:
isa@isatest.com

SOFCT by Skippers Electricals Ltd.

SKIPPER Oil Filled Current Transformers have been used in diverse environments and have delivered outstanding performance consistently. The transformers are compliant with rigid standards of international quality and meets the highest standards of safety and environment stipulations. They are ISO9001-2000 certified. They are used to transform high voltage line current to a low standard value current. The live tank-type current transformers are designed for optimum performance. The testing of the skipper oil filled current transformers is tested under very strict conditions for their performance, reliability and durability at international testing labs such as ERDA and CRPI (India). The current transformers are type tested for their ability to endure short circuit situations. The quality control is carried out at each stage of production. The product is checked for several times before it proceeds to succeeding stage. The Quality Assurance Department monitors all quality control documents and carries out its own additional inspection at strategic points during the production process. ■

Website:
www.skipperseil.com

Recent Trends in Use of High capacity Cast Resin Dry Type Power Transformers

Over a decade Cast Resin Distribution Transformers or Dry Type Transformers generally called of capacity upto 2500 KVA with voltage levels upto 33 KV are being used, mainly in multi storied buildings. In addition these are also used in IT Industries, Hospitals, Malls and in Various Industries and ESCOMS etc., installing these Transformers inside the multi storied buildings has given better aesthetic to the building. These Transformers are also found to be maintenance free and it can be placed closer to the load center as these Transformers are fire retardant which is quite successful in most of the major cities.

Today similar type of Transformers with higher capacity are being explored in the range upto 25 MVA capacity generally called POWER TRANSFORMERS. These Transformers are envisaged especially in the large Grid substations, multistoried complex / buildings for better aesthetic of building and utilizing the existing floor space of the building. The substations again are placed near to the load center.

But there is a limitation in using such transformers all these years in terms of voltage class as this is restricted upto 33 KV voltage class only as there are no insulations or resins have been developed so far in the world although some experimenting is going on at 66 KV voltage levels. In addition the power transformer also needs On Load Tap Changer (OLTC) to have constant voltage levels at the secondary side as voltage fluctuations are high in

Sl. No.	Oil Type Transformer	Cast Resin Dry Type Transformer
1	Hygroscopic	Non Hygroscopic: Complete Embedding of Winding in Resin prevents penetration of moisture into winding and breakdown by ionization. No further Drying is required prior to commissioning.
2	Inflammable	Non Inflammable: Insulation system used makes Cast Resin Transformers self-extinguishing, which eliminates the need of costly fire extinguishing systems.
3	Low Short Circuit Strength	High Short Circuit Strength: Cast Resin Windings have highest possible strength levels for generated electrodynamic short circuit forces.
4	Low Impulse Strength	High Impulse Strength: Resin after casting act as interturn & inter winding insulation to enhance the impulse strength of transformer.
5	High Losses	Low Losses: In view of lower copper losses the transformer is more efficient when working at optimum & higher loading conditions, thus making the transformer more cost effective over a period of time.
6	Low Life Cycle	High Life Cycle: Owing to negligible ageing of insulation the life of these transformers is considered to be higher as compared to 20/25 Years of oil filled transformers
7	High Maintenance	Low Maintenance: Except occassional dust cleaning no maintenance is required
8	High Cost Installation	Low Cost Installation: Possibility of installing these transformers closer to load centers reduces cost of LT Cabling & soak pits.
9	large Space	Space Saving: The size of these transformers is less compared to oil filled transformers

Brief Comparison Table of Oil Filled vs Cast Resin Transformer

India. Here again some limitation in providing the OLTC on the primary side as these is no manufacturer available in India. We have to depend only upon overseas manufacturers. Today the vacuum technology is available in the world for the Tap Change changers unlike vacuum bottles used in switch gears. These On Load Tap changers have very long contact life compared to the normal contact type tap changers specially designed for the tap changers due to frequent switchings. Today manufacturers in Germany and China are manufacturing such Vacuum Type On Load tap changers upto a capacity of 500A. These tap changers can be used easily upto 25 MVA Transformer capacity.

Although Cast Resin Power transformer capacity upto 20 to 25 MVA are used in China and Europe but still these are still not very popular. India is looking at using such Technology.

A grid substation in New Delhi by DISCOM under the green initiative program has implemented in using 20 MVA, 33 KV Cast Resin Transformers on a trial basis. Hopefully once this is successful many more such grid substations are seen in India in future. ■

18 MW Solar Park from SunEdison India enables Tamil Nadu Businesses to reap Financial Benefits of Utility-Scale Solar

SunEdison, a leading solar technology manufacturer and provider of solar energy services, announced that it has commenced full-time operations at its 18 MW Tirunelveli solar power plant in Tamil Nadu. The park is designed to help commercial and industrial businesses easily own a solar park. SunEdison relied on its global experience to select a site, obtain permits, design and build a unique solar park that allows businesses to procure as much solar electricity as they desire without having to become solar experts. Due to the 2012 Accelerated Depreciation Benefit for Solar tax law and competitively priced solar power through the Open Access program, which allows developers to sell Renewable Energy Credits, businesses investing in the Tirunelveli Solar Park can expect rapid return on their investment. The Accelerated Depreciation Benefit allows businesses in India to receive 100% depreciation on solar assets in the first year after purchase. Businesses that purchase part of the Tirunelveli Solar Park can expect payback of their equity investment as a tax credit within the first year. Power generated by their portion of Tirunelveli Solar Park will be fed into the local electricity grid to offset their electricity bills. The Tirunelveli Solar Park locks in electricity pricing for 25 years, protecting owners from the rising costs of fossil fuel generated electricity. SunEdison is offering a secure, turnkey solution based on the knowledge the company has amassed interconnecting 1.4 GW (gigawatts) and operating 1.9 GW of solar worldwide. ■

Index to Advertisers

Air Core Coil Winding Machine

The very simple looking bobbin less Air Core Coil usually requires a huge deal of operations to attain the configuration. Although the coil is compact, the precision of Winding Assembly is very crucial. This module for Air Core Coil Winding designed by ELECTROMECH, has been the ultimate solution to perform the task without any manual interruptions. The stand alone type of Machine supports the various sequences of activities, in order to achieve very precise, high productive winding operations. The operations include Wire Straightening, Enamel Scraping START Lead Bending, Winding, END Lead Bending, Cutting, Ejection and Collection of Coils. The ergonomically designed structure of the machine is highly space conscious and is accomodable in all winding setups. The machine is feasible for wire diameters from 0.9 mm to 3.2 mm for winding width up to 40 mm and maximum of 3 layers. ■

For further details contact:
electromech@dataone.in

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TAURUS POWERTRONICS-Tower Footing Earth Impedance Measurement Instrument (TFR)

TFR is one of the innovative products from Taurus. It is a high frequency earth tester (25 KHz) which measures the footing impedance of the transmission towers. This works on principle of three peg/fall of potential method which is widely accepted method of earth impedance measurement. It measures the individual tower's earthing value so as to measure the effectiveness of the particular tower's capability to ground the surge currents, leakage currents and the lightning strike. It is the ONLY system in the market capable of testing ground Impedance of individual tower legs, without disconnecting the overhead ground wire – this alone is a huge time and money saver, not to mention a major safety improvement. This high frequency earth tester is used to measure the power system's ability to discharge transient energy in to ground whilst minimizing earth potential rise, ensuring the equipment and personnel are safe from any danger. It is one of the important factors in determining the effectiveness of a lightning or surge protection system. This overcomes the disadvantages in conventional earth testers which measures complete grid resistance (because of parallel path from many towers). Also it overcomes the difficulty that conventional earth testers cannot measure Impedance which is the major cause for transient tripping.

It has a wide measurement range (0to 2k ohms) and is immune to power frequency interference and its harmonics. The instrument is designed to operate in a highly induced environment and to give highly stable, reliable, repeatable readings with its strong capability of noise & leakage current/ voltage suppression. ■

For further details contact:
info@tauruspowertronics.com

Parker Hannifin offers New AC10 series of VFD to machine builders

Parker Hannifin India launched their new series of AC variable frequency drive, the AC10Micro Drive. AC10 is a simple, reliable and extremely versatile drive providing economical solution to every-day motor control applications requiring speed or torque control and are available in the power range of 0.2 kW to 15 kW. Offering extremely compact dimensions and features normally only associated with higher specification drives, AC10 provides an optimised solution for OEM machine builders and process industry users, seeking a simple cost-effective drive without any compromise in performance. The many functional benefits such as auto-tuning sensor less vector mode, built-in PLC functionality, multiple V/f etc are available as standard which makes the device beyond simple V/Hz motor control. Some of the features are that the product is built- in PID controller and also is built in brake chopper; it has advanced fault diagnostics along with automatic voltage regulation; it is available in compact size. Some of the benefits are that it is quick and easy set - up for process; no extra cost, panel space is saved; it has better and precise dynamic torque control; it is also easy to set-up for most applications; safe to work in very harsh environment. The new AC10 Drive will be available from the state of the art Parker India modern manufacturing facility at mahindra world city near Chennai and will also be available through nationwide network of sales offices, ATCs (system integrators) and Parker Stores.

Applications

The typical applications for AC10 include conveyors, centrifuges, fans, mixers, packaging machines and textile machines etc. ■

For further details contact:
sales.augindia@parker.com

LCD Power Meter: ND20

ND20 (meter of network parameters) is distinguished by high measurement accuracy, legible backlight LCD display and an attractive price in relation to offered measuring functions. Design of ND20 meter, available functions and communication possibilities is ideal tool to control and monitor energy quality parameters & energy consumption in all industry branches, public utilities or in public service buildings.

Features of the ND20 meter:

- Measurement of: Power network parameters in 2,3 or 4-wire balanced and unbalanced systems; Harmonics of voltages & currents; THD factors for currents & voltage
- Indications considering values of programmed ratios,
- Profile of 15, 30, 60-minutes power (9000 measurements),
- Watt-hour meter for the selected harmonic, providing information about loss costs in connection with harmonic occurrence; Backlit LCD 3.5 screen; Protection grade from the frontal side: IP65; Digital transmission to the master system through the RS-485 interface (MODBUS).
- Configurable analog, alarm and pulse outputs (energy). ■

For further details contact:
info@rishabh.co.in

IT 51: 5kV Digital Insulation Tester from Motwane

Motwane introduces yet another revolutionary product IT 51 in the 5 kV Insulation Testing and becoming a strong player in the DC Insulation tester market. With introduction of the highly successful 5 kV Diagnostic Insulation Tester 5KPI two years back, Motwane has launched a series of High performance & high precision Digital Insulation Testers and is marching towards leadership in the DC Insulation market The all new IT 51 is a microproceesor based compact and robust 5 kV Digital Insulation Tester with PI and Spot Insulation facility. It is ideal for Power Distribution & Transmission Companies, HT Motor mfgrs, Large EPC Contractors, Transformer testing, Switchgears, CT, PT and Insulator testing. The advanced features of PI help to undertake predictive maintenances of Electrical installations. It automatically performs Polarization Index test and helps to get the job done, quickly and safely. IT 51 comes with various distinctive features like Insulation resistance up to 1 TΩ, covering large set of applications. It has a wide selectable voltage range of 250/500/1000V/ 2500/5000 VDC so as to fulfill different set of applications of Telecom, Power, Oil & Gas, Motors, Railways and Electrical Contractor sectors. It has an inbuilt Volt meter which is capable to measure AC/DC voltage up to 600 V. Hence no need to carry extra multimeter. The IT 51 is equipped with two programmable timers settable from 0 Sec to 99 Sec. The robust ABS housing and other safety features like live circuit detection, automatic discharge of capacitive load after insulation resistance test, accessories in accordance to IEC 61010-31, CE & CAT IV compliance, ensures the Safety of the User as well as Electrical installations. The equipment is powered by a powerful internal rechargeable battery and is provided with additional AC mains provision for battery charging thus keeping the recurring costs under control. The Insulation Tester is completely advanced in features & is equally complying to all high grade safety standards such as IP 54 which protects it from ingress of dust and water, CAT IV 600V which protects it from voltage transients up to 8KV, IEC 61010-1/EN61010-1 / VDE0411-1 to ensure safety, EN 61326 provides protection from EMI & contamination degree II. ■

For further details contact:
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A New Generation of Cable Fault Systems. NOW ARRIVED.

sebaKMT CENTRIX VAN

A unique test van concept design to deliver accurate prelocations and pinpointing cable fault systems.

- Central Control of all test Van systems for LV and HV cables from 2kV upto 80 kV
- Arc reflection prelocation upto 80kV

Portable Cable Fault Location Systems

SFX 32

One Button Operation: Simple portable fault locating system with surge generator.

- Measures all DC-Testing, Prelocating, Burning (Fault Conditioning), Pinpointing upto 32 kv

SPG 40

Mobile and multi functional system for testing prelocation and pinpointing in low and medium voltage networks.

- Insulation Testing upto 5000 V
- DC Testing upto 40 kV

EZ THUMP

Smallest and lightest IP 54 rated weighed 12kg only.

- For fast Pre-location and Pinpointing in one small unit
- Available as 4kV or 12 kV version

MFM 10

Easy automated sheath fault location unit with bipolar measuring voltage.

- IP 54 rated
- Voltage upto + - 10 kV DC
- High Current of upto 750 mA

Reliable for over 60 years:

Sebakmt is a Leading German manufacturer of Cable Fault Location testing equipments, with diagnosis and cable fault solutions in areas of Power Networks, Water Networks, Line & Object Location, Communication Networks and TV Inspection of sewers. It is a 61 year old company with unique range of products to support reliable and economic operations of its customers.

To read more on cable testing abstracts and application notes Log on to www.sebaKMT.com/en/products/power networks/application-notes

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■ Cable Testing ■ Diagnostic ■ Power Quality ■ Cable & Phase Identification ■ Sheath Testing ■ Earth Fault Location ■ Overhead Line Testing

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