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# R&D Efforts of CPRI: Sustenance of Technologies and Focus on Challenges for the Future

*With its state-of-the-art infrastructure and expertise, CPRI has made significant contributions to the power sector in the country for improved planning, operation and control of power systems. Besides in-house R&D, CPRI also undertakes sponsored research projects from manufacturers and other agencies in different areas of specialization in Power Engineering. CPRI has completed 50 years of dedicated service to the Indian power sector. With a humble beginning in the year 1960, CPRI has grown from strength to strength and today it has a major role to play in all the ambitious plans, projects, schemes of Ministry of Power, Government of India. CPRI under the guidance, support and encouragement of Ministry of Power, will forge ahead to serve the Indian Power Sector in a big way. CPRI also looks forward to work in close cooperation with the Indian Power Industry and the Academia for achieving the economic growth and prosperity of the country.*

## 1.0 BACKGROUND

Central Power Research Institute (CPRI) is the hub of Indian Power Sector encompassing major activities including R&D, Testing and Certification, and Consultancy. Set up in the year 1960 by the Government of India, it functions as a center for applied research in electrical power engineering, assisting the electrical industry in product development and quality assurance. CPRI also serves as an independent authority for testing and certification of power equipment. CPRI's governing body includes eminent professionals from industries and utilities, prestigious academic and research institutions and the government. It employs over 200 highly qualified and experienced engineers and scientists besides other supporting staff.

Indian Power Sector is opening up new opportunities for innovations with the introduction of reforms, economic globalization and liberalization policy of the government. The power system planners have given utmost importance to energy sector since beginning, and there has been a manifold increase in installed generation capacity and transmission networks. With increase in system expansion, stability and security problems have become challenging. It is of vital importance to focus our attention now on ways and means to build expertise within the country to find solutions for the problems existing in the system and also for the problems that may arise in the future. Research, in phased manner, is needed to bridge the knowledge and technology gaps, more so due to changes in technology happening at a more profound and faster pace in the new millennium.

Power Sector, being highly technology intensive, Research and Development (R&D) plays a

200 kA COAXIAL CAGE TYPE HIGH CURRENT SHUNT

major role in the developmental plans, especially when Technology upgradation is considered for strengthening the power sector. The forces driving change in Indian Power scenario are large gap between Generation and demand, complex growth of Indian Power networks, Liberalization policy of the Government, Power sector reforms. This is the guiding factor for developing a strong base for R&D.

### 1.1 Research and Development

With its state-of-the-art infrastructure and expertise, CPRI has made significant contributions to the power sector in the country for improved planning, operation and control of power systems. Besides in-house R&D, CPRI also undertakes sponsored research projects from manufacturers and other agencies in different areas of specialization in Power Engineering.

The Power Sector in India is characterized by multi-dimensional complexity. Many organizations are carrying out research in different areas of power and energy. Hence, there is a need to make Research programmes optimal and result-oriented with the available resources. In CPRI, presently, there are three Research schemes: namely (1) RC of CPRI, (2) Research Scheme on Power (RSoP) and (3) R&D under National Perspective Plan of Ministry of Power. All the three schemes are funded by the Ministry of Power, Government of India, but each one of them have different out-lays, objectives, duration, purpose and perspective for the Indian Power Sector.

WATER PUMPING WINDMILL 1985

#### 1.1.1 Research scheme on power

The Research Scheme on Power popularly known as RSoP, was initiated by Ministry of Power, Government of India, in 1961. The scheme is being administered by CPRI since 2001. The scheme basically aims to provide funds for carrying out need-based research in power sector including solving of operational problems encountered in the power system.

#### 1.1.2 Relevance of RSoP in Indian power sector

Over the years, the RSoP has evolved as a key instrument to deal with the operational and local-specific issues of state-level power utilities. In many of these initiatives, the R&D element is comparatively less. Consequently, the average investment in any RSoP project is not much. Nonetheless, it has kept the innovative spirit alive at the utility level in its efforts to find out local-specific solution.

### 2.0 CPRI R&D (RC)

Divisions and Units of the Institute take up Research Projects under the Research Contingency fund provided by Ministry of Power, Government of India. Total Outlay for five-year plan period: ₹ 14.80 crores during the 11th five-year plan.

These Projects help in augmentation of Research and testing facilities, improvements in new techniques in testing/diagnostic methods, product/process improvements product standardization, etc.

TESTING OF 630 kVA HIGH TEMPERATURE SUPERCONDUCTOR TRANSFORMER DEVELOPED BYT EMCO LTD.

Applied research at CPRI aims at solving day-to-day problem, of Power Sector. In addition, the Research investigations at CPRI also target new technologies for indigenization, concept proving, technologies for pilot plant demonstration and techno-economic feasibility and Technology Transfer. Product evaluation and certification also broadly fall under this category, since it often leads to innovative Research ultimately ending up in novel manufacturing processes and products for the Indian Industry.

R&D at CPRI focuses on problems relating to maintenance and remaining life assessment which are of direct relevance to Power Plants. In addition, CPRI addresses system studies for quality assurance, efficiency and reliability which have direct bearing to the Distribution systems in India. The research problems relating to Transformers, Switchgear, Tower Design, Material Technology, High-Voltage engineering have the Transmission sector. In recent years, a number of Projects have been initiated in the RC, RSoP and NPP schemes on New and Renewable Energy. Under this category, some of the typical problems of Wind, solar and biomass have been initiated.

### 2.1 Advantages of RC Projects

The R&D of CPRI is customer and market-driven. It has the objective of meeting the requirements of the Power sector in Product development, Product evaluation and quality assurance and reliability. The infrastructure development through RC adds immense value to the activities of CPRI in terms of addition of new equipments and systems, adoption of new and latest technologies for product evaluation and certification. Some of the Research projects are also designed to understand serious field problems and to provide solutions to such problems. The problems of RLA have been of tremendous help to the state electricity boards and private distribution companies for routine and regular maintenance in the thrust areas of thermal and hydro generation. The problems of Distribution sector have been addressed and the benefits have accrued in adoption and upgradation of new technologies.

Thus, the biggest and most significant contribution of R&D in CPRI is the integration of Research efforts in India through proactive participation and collaborative efforts with Industry, Academics and Research Institutions. CPRI has the unique distinction of being the largest R&D Institution in India catering to the specific needs of the Power sector, since PSUs and Private Power Industry have focused on their own R&D linked with their commercial interests. The efforts of CPRI as a National Centre of Excellence in Power Engineering need impetus by way of strengthening of Man Power and funding. CPRI has taken lead role in R&D of Power sector and the outcome of R&D efforts has helped the Power sector to consolidate and progress over the years.

## 3.0 COLLABORATIVE R&D

### 3.1 National Perspective Plan R&D

#### 3.1.1 Networking with Academic Institutions and Centre of Excellence

Multi-disciplinary applied research at EPRI, USA, is being pursued in a collaborative approach involving academia, industry and utility. EPRI executes projects by contracting through its consortium. A similar approach will be adopted in executing the projects at CPRI.

With ever-increasing development in technological advances and competitiveness, no single organization can afford to possess the requisite expertise. Research today requires multidisciplinary approaches, thus necessitating pooling of expertise. Thus, opening up of 'Collaborative Research' schemes is on win-win logic.

The basic philosophy of collaborative research centers on:

- Taking up multi-disciplinary research
- Partnership basis
- Participation of utilities, industry and academia

### 3.1.2 Major thrust areas for research

The rapid growth of power industry in India has opened up challenging opportunities for innovation and creation not only in technical areas but also in the area of operational management. At the same time, it has brought a lot of challenges to power engineers and researchers to handle bulk power transmission from remote areas, security problems for the grids and environmental issues.

The system planning and operation are mainly concerning major thrust areas, such as: Generation, Transmission, Distribution, New and Renewable, Materials Technology and Energy Efficiency. For reliable and secure operation of the system, and to be in phase with the technological developments, research in these areas is required in a phased manner. New and challenging areas for research are discussed as follows:

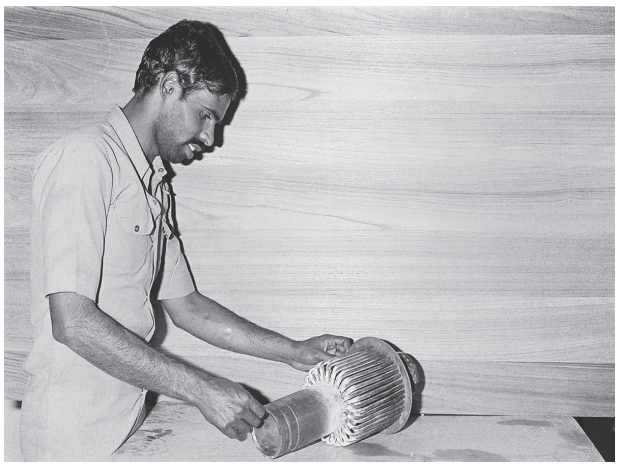
(a) In **Generation**, important aspects that need special attention is on improving the performance of existing thermal power plants, solving problems related to diagnostic measures for condition monitoring of equipment, improving the plant availability, reliability, efficiency and safety, beneficiation of coal and fly ash utilization. It is also essential to adopt new technologies, such as: Supercritical boilers for power generation, Green technology approaches to thermal generation and Gasification of solid and liquid fuels for power generation. The major problems for the low efficiencies in steam turbine are due to aerodynamic and secondary losses due to inadequate blade profiles (geometry) and other clearances of the last-stage blades. The other problems are erosion of blades, deposition on blades, breaking of blades, leakages from condenser, feed water heaters, valves, manhole gaskets, etc.

(b) The **Hydropower** base available in the country has grown commensurate with the requirements so far and has been geared to take up all types of hydro-electric power developments. For obtaining high reliability operation of the forthcoming large hydro electric power projects, it is essential to keep pace with the technological development and improvements taking place in the developed countries. Also, considering the problems of silt erosion damages, which are typical for Indian conditions, corrosion, etc. in the


CPRI ENERGY METER 1991

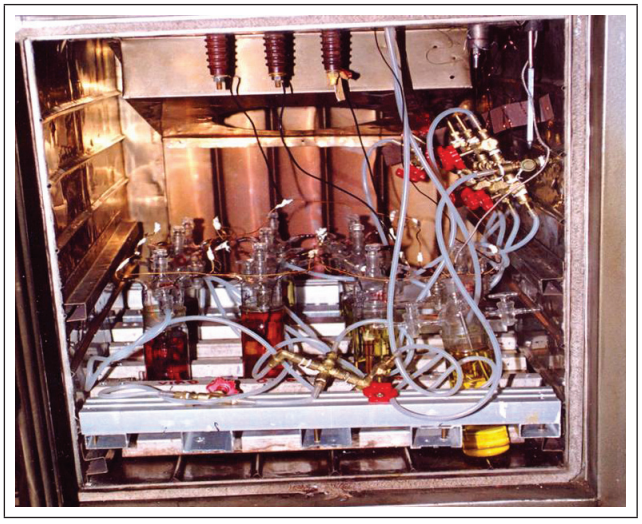
existing hydropower stations, the required technology development in hydropower sector needs a big thrust.

(c) The **Transmission** system requires adequate and timely investment and also efficient and coordinated action to develop a robust and integrated system. The Indian Power System is growing steadily. Network expansion should be planned and implemented, keeping in view the anticipated transmission needs of the country. To match the growing demand, transmission system is also expanding with an over lay of 765 kV AC lines on existing 400 kV System, high-capacity long-distance HVDC system, high-capacity long-distance HVAC system, adoption of FACTS devices, such as TCSC wherever feasible on 400 kV and 220 kV lines, etc. With the formation of regional grid and interregional ties to form ultimately the National Grid, the Power System is becoming more and more complex. Side-by-side with this growth, requirement of high security and reliable operation of large generating plants with EHV and UHV transmission network assumes tremendous importance in maintaining Power System Stability for a better grid management.



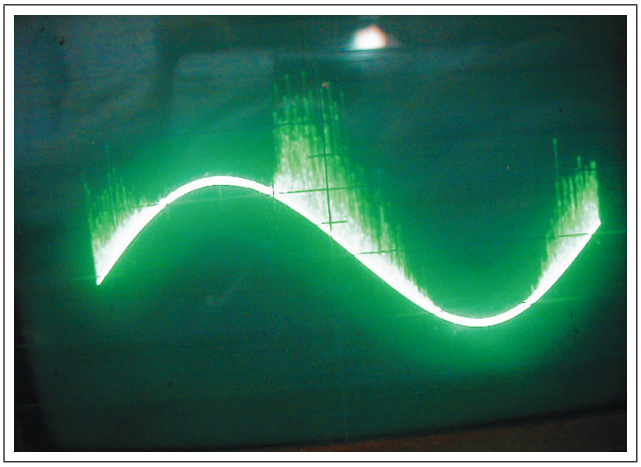
CPRI STIRLING ENGINE 1995

The severe cascading blackouts that have been seen in many parts of the world highlight the vulnerability of large AC systems. Instances of grid failure due to pollution flashover have come to notice



on 400 kV single circuit lines during fog conditions, inadequate reactive power support, voltage instability, power swings, etc. A firewall preventing the spread of such disturbances can be accomplished using measures to avoid voltage instability, relay coordination, design transmission line insulators suitable for varied environmental and pollution conditions, adopting FACTS controls, HVDC connections, which make an important contribution in controlling power transmission, safe-guarding stability and containing disturbances. Technologies such as FACTS and HVDC transmission have played a crucial role in alleviating transmission system constraints.

(d) **Distribution** system needs a careful attention in the areas such as reduction in losses, metering, distribution automation, planning, harmonic pollution, custom power devices, demand-side management, etc. High-Voltage Distribution System is an effective method for reduction of technical losses and improved voltage profile. Encourage LT/HT ratio keeping in view techno-economic considerations. Application of IT has great potential in reducing technical and commercial losses. Integrated resource planning and demand side management also needs special attention and implementation. Substantial efforts are required for capacity building, so that the present day Distribution system would be transformed into a modern day distribution system, namely Smart grid.



Smart grid represents a vision for a digital upgrade of Power Distribution system to both optimize current operation as well as open up new avenues for alternative energy production.

Design and development of High Temperature Superconducting transformers, and compact transformers in distribution systems need careful attention and applied research in this area in a phased manner is proposed.

(e) **New and Renewable Energy Sources**

Technologies related to Wind, Biomass, Solar, Geo thermal, Fuel Cells are identified under this thrust area. Research focus is on grid connectivity of large wind mills, self-healing wind connected micro grids, distributed generation and large use of ethanol for energy products. Development of micro and mini grids and larger penetration of renewable energy are important areas for research.

(f) **Energy Efficiency**

A considerable amount of energy can be saved through energy efficiency and demand side management measures. Periodic energy audits have to be made for power intensive industries under the Energy Conservation Act. Emphasis on standards and labeling of appliances needs to be given priority. Thus, topics that require careful attention are:

(i) Demand-Side Management

(ii) Standards and Labeling

(iii) Load Management.

Also, an attempt to design and develop energy storage devices for applications is an emerging area in power sector. Energy storage technologies that have been developed or are under development for electric power applications include pumped hydropower, compressed air energy storage, batteries, super capacitors, flywheels and superconducting magnetic energy storage. Design, Development, Testing and Evaluation of Short-Term and Long-Term Response of Energy Storage Devices are important aspects.

At a discrete level, flywheel energy storage modules offer unique performance characteristics suitable for many applications. It is technically feasible to combine the best feature of high-speed flywheel energy storage with proven developments in high-power electronics.

Energy storage technologies, such as Redox Flow Batteries, have a large role to play in the electricity grid of the future. There is a need for development of novel storage technologies to meet requirements associated with (i) the effective production and delivery of electric power, (ii) the provision of secure, high-quality power at end-user sites and (iii) support of renewable and distributed energy resources.

### 3.2 Achievements and Future plan

A number of Research projects have been successfully completed by CPRI during the last five decades. These projects have been identified with specific objectives of the thrust areas of Power Engineering, and it gives an idea about the capability and depth of knowledge of CPRI Engineers and Scientists in identifying problems and evolving solutions to them.

Even under the RSoP scheme, every effort is made to identify Research Problems of relevance and importance to the present day needs of the Power Sector. The involvement of utilities and Academia has been the salient feature of RSoP.

Some of the best R&D efforts have emerged from State Power Utilities because their long standing experience in field-related problems and their association with CPRI laboratories have together lead to achievements under normal circumstances which would not have been achieved by individual institutions or Research Organizations. Thus, RSoP has fostered new relationships, networking and collaboration in R&D of Power Sector involving Power Utilities, Academia and Research Institutes.

Another milestone achieved by CPRI in its endeavor to take R&D in Power Sector is by the involvement of India's leading Educational Institutions of North East in the RSoP projects. In addition, CPRI has also encouraged other Research Organizations in development of new materials and has encouraged Research in the emerging area of Renewables. CPRI has given importance to knowledge dissemination and to facilitate easy access to the Indian Industry about R&D outputs researchers are also encouraged to publish their Research outputs. Further, the Library and Information Center is being strengthened to share and access the wealth of knowledge that is presently available in the world.

## 4.0 PUBLICATIONS OF RESEARCH

The Institute has developed a wealth of expertise in research and development for power sector, and information has been disseminated by way of participation and presentation of technical in journals/seminars/conferences/workshops and in training programs.

## 5.0 PATENTS

The Institute has undertaken many R&D programmes of relevance to the power sector and has developed many products and processes which are novel in nature. Over the years, the institute has patented its inventions.

The research work at CPRI has resulted in several patents.

### 5.1 Commercialization of Patents

The institute has commercialized the know-how on a non-exclusive basis to the industry. The details of the commercialized patents are available on the website.

## 6.0 CONCLUSIONS

CPRI has completed 50 years of dedicated service to the Indian power sector. With a humble beginning in the year 1960, CPRI has grown from strength to strength and today it has a major role to play in all the ambitious plans, projects, schemes of Ministry of Power, Government of India.

CPRI under the guidance, support and encouragement of Ministry of Power, will forge ahead to serve the Indian Power Sector in a big way. CPRI also looks forward to work in close cooperation with the Indian Power Industry and the Academia for achieving the economic growth and prosperity of the country.

## ACKNOWLEDGMENT

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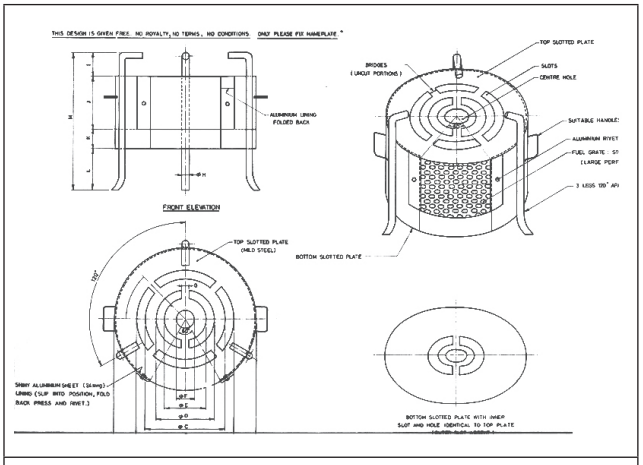


CPRI DESIGN WOOD BURNING STOVE

in preparation of this paper are thankfully acknowledged.

Major thrust for R&D in CPRI was provided by the dynamic leadership of Dr. M. Ramamoorty during the period 1985–1994. His initiative and drive provided the much needed impetus for R&D in CPRI. Shri N. Murugesan, Director General, CPRI has set the tone for CPRI to play a bigger role in R&D of Power sector during the 12th plan. This is reflected in the number of Research projects that are presently on-going in CPRI under Plan R&D and RSoP schemes.

## ANNEX 1: PROJECTS

LIST OF SOME IMPORTANT R&D PROJECTS COMPLETED

| Sl. No. | Research Projects |
|---|---|
| 1. | Acoustic emission technique for online condition monitoring of power transformers |
| 2. | Surface deposition and composite impregnation techniques using complex carbides for enhanced wear life of components |
| 3. | Assessment of Life Expectancy of Polymeric Insulators |
| 4. | Development of New techniques for primary measurements in Thermal power stations |
| 5. | Advanced Technique to study the influence of residual stress on the structural integrity of the plant components |
| 6. | Synthesis, characterization and use of Nitrogen hector cycles for curing flame retardant properties of halogenated and non-halogenated system |
| 7. | A Mobile facility for field Evaluation of Accuracy of Current Transformers and Losses of distribution Transformers |
| 8. | Design & Development of interrupting Chamber |
| 9. | Development of Data acquisition Software for 8 channel High speed Digital Storage Oscilloscope |
| 10. | Improvements in lightning impulse voltage measuring system for lower test voltages |
| 11. | Design and fabrication of non contact type travel recorders for analysis of circuit breaker characteristics |
| 12. | Development of instrumentation system for corona power loss measurement in experimental line |
| 13. | Three phase prepaid energy meter - Laboratory Model |
| 14. | Time Synchronizing Unit (TSU) |
| 15. | Thermo-Plastic lined fuse carrier for drop out fuse |
| 16. | Development of accelerated ageing test procedure for RTV coated insulator |

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| 17. | Development of diagnostic tool - Acoustic technique for partial discharge in HV capacitors and transformers |
| 18. | Development of Marble waste - products, Bricks, Mosaic tiles, Bath tub, Sinks, etc. |
| 19. | Automation in relay testing facility for thermal and mechanical durability test |
| 20. | Development of sensors for primary measurements in Thermal Power stations |
| 21. | Biological effects of magnetic fields |
| 22. | Development of Polymeric insulating material for outdoor insulator application |
| 23. | Investigation of suitable data collection protocol for the liberalized energy market |
| 24. | Performance evaluation of communication technologies for automatic remote meter reading |
| 25. | Design, fabrication and development of drop out type expulsion fuse phase-II |
| 26. | Nano composites for flame retardant applications – Exploratory Study |
| 27. | Studies on thermoplastic elastomers for halogen free, fire retardant low smoke cable compounds |
| 28. | Insulation diagnosis by high voltage spectroscopy |

## LIST OF COMPLETED RC PROJECTS DURING 2007 – 2010

| S. No. | Title of the Project |
|---|---|
| 1 | Condition Assessment of complex geometry Power Plant components by Ultrasonic TOFD technique. |
| 2 | Study of dynamic performance of relays using Real Time Power System Simulator |
| 3 | To study the effect of corrosive sulphur on transformer components |
| 4 | Dielectric Diagnosis of HV rotating machine insulation based on structural changes of the insulation due to ageing |
| 5 | Showcasing of Energy Conservation measures in an office building – CPRI HO |
| 6 | Establishment of electromagnetic method of stress assessment to benchmark structural soundness in turbine and other plant components |
| 7 | Evaluation of shunt reactor current switching capability of MV vacuum circuit breaker |
| 8 | Study on enhancement of capability of conducting capacitor current switching tests on 245 kV Circuit breaker from Voltage factor of 1.2–1.4 |
| 9 | Microzonation for Power Projects |
| 10 | Building up Research Infrastructure (CCAR) |
| 11 | End-of-life Estimation of RTV coated insulators under pollution conditions |
| 12 | Development of polymer nano composite for electrical Devices |
| 13 | Effects of Harmonic influence on Energy meters |
| 14 | Damage tolerance of cenosphere based coatings and composites in plant condition |
| 15 | Study of the combustion characteristics of Indian coals in Oxy-fuel combustion environment through experimental and Numerical methodologies |

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| 16 | Polymer ceramic composites with high dielectric constant for electrical application |
| 17 | Study on integration issues of Multi-in-feed HVDC systems into one AC system |
| 18 | Evaluation of gassing characteristics, sulphur levels and Electro-static charging tendencies of transformers oils |

## LIST OF ONGOING RC PROJECTS – 2010

| S. No. | Title of the project |
|---|---|
| 1 | Development of high Strength composite core materials for O/H line transmission conductors' applications |
| 2 | Assessment and Mapping of corrosion in boiler tube components |
| 3 | Design and Development and fabrication of co-axial shunt for measurement of short circuit currents up to 200 kA rms of one second |
| 4 | Power Line Communication (PLC) for Power Sector Applications (both LV & MV) |
| 5 | Seismic Qualification of Transformers |
| 6 | Development of tracking wheel test facility and evaluation of polymeric insulators |
| 7 | Study of GPS synchronized End-to-End testing of Distance protection scheme and evolving field test methodology |
| 8 | White LED – Technology assessment |
| 9 | Polymer Composite Sections For Compact Transmission Line Towers |
| 10 | Study of smart grids and impact of renewable integration. |
| 11 | Development of miniature specimen test techniques and advanced NDE approach for damage assessment of in-service high temperature power plant components |
| 12 | Design and testing of HV electrode for EHV/UHV system equipment |
| 13 | Design and development and validation of test suites for IEC 62056 (DLMS/COSEM) compliant energy meters |
| 14 | Development of high performance polymeric components based on PEEK & PC for power sector applications |
| 15 | Conversion of Transformer Heat Losses into Useful Electrical Energy |
| 16 | Development of High resolution Impulse Recorder for High impulse Voltage and Current measurements |
| 17 | Technology for design and development – Engineering of HTS power apparatus HTS transformer and superconducting fault current limiter |

## LIST OF RESEARCH PROJECTS OF CPRI TAKEN UP DURING THE YEAR 2011–2012

| S. No. | Title of the project |
|---|---|
| 1 | Design and Development of transmission line tower using Square and Rectangular hollow sections and its environmental impact |
| 2 | Vibration and shock qualification of Energy meters and relays |

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| 3 | Seismic qualification of substation equipment's |
| 4 | Low loss giant dielectric Nano-ceramics |
| 5 | Impact of blended coal firing on the power plant performance-Experiments and numerical studies |
| 6 | Investigation of the combined effect of cavitation and silt erosion behavior of hydro turbine steels and coatings: Experimental and numerical methods |
| 7 | Assessment and Erosion Resistance of Coal Burner tip materials and improvement of erosion life through CFD modeling |
| 8 | Design and Development of GTO based fault current limiter for MV distribution network and Dynamic behavioral analysis under various fault conditions |
| 9 | Design of external insulation from the point of view of pollution |
| 10 | Wide area measurement based power system security of a state transmission grid |
| 11 | Detection and localization of impending faults in MV Power Cable System employing Partial Discharge techniques |
| 12 | Localizations of Multiple Defects in Transformer Insulation by Acoustic Emission Technique. |
| 13 | Design, development and fabrication of High Voltage/High frequency Static discharge device. |
| 14 | Improved Reliability assessment in the power distribution system |
| 15 | Centralized literature compilation for Research activities of CPRI and Up gradation DL and KMS |
| 16 | Development and Validation of Software for Calculation of Parameters of Digitally Recorded Standard Lightning - Impulse Voltages with Overshoot and Oscillations |

## LIST OF ONGOING RSOP PROJECTS

| Sl. No. | Title of the project | Investigating agency |
|---|---|---|
| 1 | Study on performance of reclaimed oil in distribution transformer oil and reclaimed oil in power transformer | TNEB |
| 2 | Study on Furanic Compounds in Transformer Oil | TNEB |
| 3 | Feasibility study on "Midget Transformers" in 11 kV/433 V Network – I-phase | TNEB |
| 4 | Performance Analysis and Trading of Wind Power Generation in Emerging Power system | IIT, Kanpur |
| 5 | Development of appropriate algorithms for efficient management of Energy Control Centers | Dayananda Sagar College of Engineering, Bangalore |
| 6 | Stabilization of AC/DC Network with unified power Flow Controller | Banaras Hindu University-IT, Varanasi |
| 7 | Optimal placement of Sectionalizing switches and distributed generation resources for Improving service Reliability in power distribution system | IIT, Roorkee |
| 8 | Condition monitoring of Generators in Power Stations using On-line Partial Discharge measurements and Off-line Tan Delta measurements | TNEB |
| 9 | Analysis of Subsynchronous Resonance and Design of controllers for Ramagundam – Kadapa TCSC | SRSCM. Chennai |

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| 10 | Evaluation of efficacy and long term performance of locally available clays of Kerala as an encasement In earthing systems in high soil resistivity areas | KSEB |
| 11 | Design and development of a FPGA based Adaptive Distance Relay for Flexible AC-Transmission Systems | Inst. of Tech. Edu. & Res. SOA. Univ. Bhubaneswar |
| 12 | Wide area measurement and control for improving observeability and stability of power systems | IIT, Kanpur |
| 13 | Performance evaluation of a new device for electricity production | IIT, Delhi |

## LIST OF RSOP PROJECTS IN PROGRESS FROM THE YEAR 2011

| Sl. No. | Title of the Project | Organization |
|---|---|---|
| 1 | Development of remote energy metering system towards the estimation of zonal energy consumption with AMR | Department of Applied Physics University of Calcutta |
| 2 | Pollution Assessment in selected sites of Getco Grid | ERDA |
| 3 | Corrosion survey of metallic and reinforced concrete structures in power stations | ERDA |
| 4 | Study of Power Quality problems and Counter Measures in present Power systems using Power Electronic Devices | NIT, Rourkela |
| 5 | Design and development of a DSP based controller for small hydro and wind power generator | Department of Electrical Engineering, IIT Roorkee 247667 |
| 6 | Application of intelligent control to hybrid wind diesel-solar power system | NIT, Hazratbal, Srinagar 190006, Kashmir |
| 7 | Investigation on the operation and control of multiple distributed generation sources in micro grid (Phase-I and Phase-II) | Dept. of Electrical & Electronics Engineering, NITK Suratkal, Mangalore 575025 |

## LIST OF NEW RSOP PROJECTS IN INITIAL STAGES OF IMPLEMENTATION

| Sl. No. | Title of the project | Organization |
|---|---|---|
| 1. | Diagnostic study on partial discharge activity in cryogenic insulation structure by multi sensor system | Dept. of Electrical Engg. IIT, Madras, Chennai-600036 |
| 2. | Development of Graphene based super capacitors for energy storage and frequency regulation in smart power grid | Centre for materials for Electronics Technology, Thrissur – 680 771, Kerala |
| 3 | Development of high performance polycarbonate ABS nano composites for EMI shielding application | TERI, Bangalore |
| 4 | Development of Glass Fiber Reinforced Polymer Nano Composite Rods for High Voltage Insulators | Dr. Siddaramaiah and Dr. N.M. Renukappa, JC College of Engineering, Mysore |
| 5 | Development of Nanostructured Material Compositions for Next Generation Solar Cell | Dr. Mitali Saha, Dr. S.K. Das, NIT, Agartala |

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|---|---|---|
| 6 | High temperature superconducting energy storage technique for use in distributed generation system (Fly wheel energy storage system) | Siddaganga institute of technology, Tumkur |
| 7 | Design and Development of Anti-islanding protection relay for Distributed Generations | Prof. S.R. Samantaray, IIT, Bhubaneswar |
| 8 | Improved operation of Distribution Networks Incorporating Load Models | Prof. S.P. Singh, Dr. D. Singh BHU IT, Varanasi |
| 9 | Design of a 25 k, we pressurized circulating fluidized bed unit | Prof. P. Mahanta, Department of Mechanical Engineering, IIT, Guwahati |
| 10 | Documentation of Results and benefits Research carried out under MOP sponsored RSoP since inception from 1961 onwards undertaken by CBIP | CBIP, New Delhi |
| 11 | Creation of Data Bank of power sector Specialists in the country and Prepare new software package for easy access and search | CBIP, New Delhi |
| 12 | Study of Metallurgical Aspects of Nitronic Steel for Underwater Part Applications | Dr. Ashok Sharma, Dept. of Metallurgical Materials Engineering, MNIT, Jaipur |

## LIST OF NPP PROJECTS NEARING COMPLETION

| Sl. No. | Title of the Project | Implementing Organization |
|---|---|---|
| 1 | Development of Silt Erosion Resistant Material for Turbines of Hydro generators | NML, Jamshedpur |
| 2 | National Effort to develop Technology for Custom Power Devices | C-DAC, Trivandrum |
| 3 | National Effort to develop Technology for Custom Power Devices | BHEL, Hyderabad |
| 4 | Development of Superconducting Transformers | EMCO, Thane |

## LIST OF NPP PROJECTS IN PROGRESS

| S. No. | Title of the Project | Implementing Organization |
|---|---|---|
| 1 | Development of Silt Erosion Resistant Nano-composite Coatings by Physical Vapor Deposition for Hydro Turbine Components | IIT, Roorkee |
| 2 | Tunneling in water charge zones under high hydro static pressure | NHPC |
| 3 | Design and development of High Temperature Superconducting (HTS) Fault Current Limiter (FCL) | Crompton Greaves |
| 4 | Development of Dynamic Voltage Restorer (DVR) based voltage source stabilizers for process industry | C-DAC CIT TNEB |
| 5 | Improvement in reliability, safety and long term performance of power and converter transformers through improvements in quality of transformer oil | CPRI |
| 6 | A study on Stability and Reliability of the power system with large penetration of wind power | CPRI |

## ANNEX 2: PUBLICATIONS

| Papers Published in | 2006–07 | 2007–08 | 2008–09 | 2009–10 | 2010–11 |
|---|---|---|---|---|---|
| Journals (National) | 12 | 1 | 5 | 27 | 19 |
| Seminar/Workshop/Conference (National) | 46 | 41 | 20 | 21 | 97 |
| Journals-International | 16 | 6 | 35 | 31 | 04 |
| Seminar/Workshop/Conference (International) | 13 | 37 | 28 | 28 | 21 |
| Total | 87 | 85 | 88 | 107 | 141 |

## ANNEX 3: LIST OF PATENTS

PATENTS AWARDED

| Sl. No. | Application title | Award year and patent number |
|---|---|---|
| 01 | Lightning Arrester Field Test Kit | 1970 |
| 02 | Field Oriented Control of Synchronous Motor for Variable Speed Operation | 1994 (172072) |
| 03 | Fluidised Beta Multi-Fuel Updraft Biomass Gasifier | 1999 (179425) |
| 04 | New Aluminium Conductors for Coastal Application | 1999 (179042) |
| 05 | Hand Held Capacitance Detector | 1999 (181132) |
| 06 | Spherical Electrode AC Digital Field Strength Meter | 1999 (181110) |
| 07 | Development of Latent Accelerator Based on Metal Chelates for Faster Curing of Epoxy Resin System | 2000 (181043) |
| 08 | Zirconia Based Ceramic Spray Powder for Plasma | 1999 (181225) |
| 09 | Synthesis of Capacitor Liquid Dielectric from Rapeseed Oil | 2000 (182271) |
| 10 | Fly Ash Based Ceramic Floor Tiles | 1999 |
| 11 | Fly Ash Based Ceramic Wall Tiles | 1999 |
| 12 | Fly Ash Based Acid Resistant Brick /Tiles | 1999 |
| 13 | Condensate Depression Monitor | 198941 (2006) |
| 14 | Card Operated Pre-Paid Energy Meter using Novel Card Reading Technique | 198927 (2006) |
| 15 | Development of Digital Techniques for Measurement of Resistive Leakage Current in Zinc Oxide Arrester | 201476 (2006) |
| 16 | Flame Retardant Low Smoke Compound Based on PVC for Cable Application | 201478 (2006) |
| 17 | Stabilized Zirconia Plasma Sprayable Powder and Industrial Process for its Manufacture | 229939 (2009) |
| 18 | A Flame Retardant Composition for Cable Applications | 234791 (2009) |

| | | |
|---|---|---|
| 19 | An Apparatus and a Method for Optimum Extraction of Dissolved Gas in Mineral / Synthetic Oil | 236822 (2009) |
| 20 | An Apparatus for Flow Simulation for Measurement of Pulverized Particle Mass Flow | 240681 (2010) |
| 21 | Radio Based Centralized Control System for Electrical Loads | 247111 (28.3.2011) |
| 22 | Time Synchronizing Unit for Continuously monitoring electrical Substations | 251180 (29.2.2012) |

## PATENT APPLICATIONS UNDER PROCESS

| Sl. No. | Patents | Patent application no | Filing month and year |
|---|---|---|---|
| 1 | A Standalone Stored Time Based Electrical Load Controller | 486/MAS/2003 | June 2003 |
| 2 | Thermal Barrier Coatings from Naturally Occurring Zircon Sand | 1389/CHE/2004 | April 2004 |
| 3 | PVC based FRLS material using sulfate glass composition for cable insulation and sheathing applications | 366/CHE/05 | April 2005 |
| 4 | Device for Measuring Internal Diameter/Dimensions of Hollow Cylindrical Spherical Shells | 605/CHE/2005 | May 2005 |
| 5 | Thermal Barrier Coatings from Fly Ash Derived Cenospheres | 208/CHE/2006 | Feb 2006 |
| 6 | Composition for Polymeric High Voltage Insulators for Outdoor Applications | 209/CHE/2006 | 8.2.2006 |
| 7 | A Device for Carrying out Inspection Inside a Shaft Rotor Bore | 1482/CHE/2006 | 21.08.2006 |
| 8 | Nitrogen Hetero Cycle as an Accelerator for Curing of Epoxy Resin System | 1896/CHE/2006 | 12.10.2006 |
| 9 | A System for Measuring Thermal Energy Gained by a Water Storage Tank | 1437/CHE/2006 | 14.8.2006 |
| 10 | Intelligent Air Conditioner Controller | 626/Kol/2008 | 28.3.2008 |
| 11 | Hot Blended Waste Particulate Fillers with Inorganic Catalyzed Disperse Phase | 651/KOL/2008 | 31.3.2008 |
| 12 | Multilayer Nanomullite – Alumina Coatings for Wear and Erosion Resistance Applications | 652/KOL/2008 | 31.3.2008 |
| 13 | Silica Rich Soil Nutrient Support Material Obtained Through Dry Ash Beneficiation | 567/KOL/2009 | 31.3.2009 |
| 14 | Ash Micro-Spheres Based Thermal Insulation Refractory | 568/KOL/2009 | 31.3.2009 |
| 15 | A natural convection cryogenic cooling system for a superconducting Transformer | 2750/MUM/2009 | 27.11.2009 |
| 16 | An inspection method for characterization of surface breaking inclined crack based on Ultrasonic Time of Flight Diffraction | 102/KOL/2010 | 3.2.2010 |

| | | | |
|---|---|---|---|
| 17 | An apparatus and a process for optimizing performance of a heat exchanger system | 364/KOL/2010 | 31.3.2010 |
| 18 | Marble dust as a filler material for manufacture of Polymer Composites | 455/KOL/2011 | 31.3.2011 |
| 19 | Beneficiated Fly Ash Cenospheres as a Resource Material for Manufacture of Polymer Composites | 456/KOL/2011 | 31.3.2011 |
| 20 | A modular rod type resistive superconductor fault current limiter equipment and assembly | 3024/MUM/2011 | 25.10.2011 |
| 21 | A modular plate type resistive superconductor fault current limiter equipment and assembly | 3025/MUM/2011 | 25.10.2011 |
| 22 | Nano-filled polymer based high performance novel thermo plastic composite material for dielectric applications | 365/KOL/2012 | 30.03.2012 |
| 23 | Nano-laddered sorbent type material for transformer oil reclamation | 376/KOL/2012 | 02.04.2012 |
| 24 | High velocity jet type erosion test rig to grade and evaluate silt erosion coatings used in hydro power plants | 377/KOL/2012 | 02.04.2012 |
| 25 | A high temperature secondary pre-heating system to determine the combustion reactivity of pulverized fuel particles in drop tube furnace | 378/KOL/2012 | 02.04.2012 |
| 26 | A robotic crawler system operable under LFET to conduct automated corrosion mapping of boiler water wall tubes | 379/KOL/2012 | 02.04.2012 |
| 27 | An improved process for optimally configurating and operating shunt reactor bank to test LV capacitors | 380/KOL/2012 | 02.04.2012 |
| 28 | An improved water/nitrogen dual cooled probe system for collecting burnt sample particles at various elevations inside drop tube furnace | 381/KOL/2012 | 02.04.2012 |
| 29 | An apparatus and method to monitor inlet and exit Parametric conditions of steam in a thermal heating system to achieve optimal efficiency | 382/KOL/2012 | 02.04.2012 |
| 30 | An apparatus for on-line measuring of operating efficiency of deep well or bore well-motors in-situ | 383/KOL/2012 | 02.04.2012 |

## PATENTS APPLIED FOR RESEARCH OUTCOME OF NPP PROJECTS

| Sl. No. | Patents | Year |
|---|---|---|
| 1 | M/s EMCO Transformers, Thane have jointly applied for patent with CPRI for: T research work carried out jointly 'A natural convection cryogenic cooling system for superconductor transformer'. No: 2750/MUM/2009 as a part of the NPP project on "Development of High Temperature Superconducting (HTS) 630 kVA Distribution Transformers for application in Distribution System" | 2010 |

| | | |
|---|---|---|
| 2 | M/s Crompton Greaves have jointly applied for patent for "A modular plate type resistive superconductor fault current limiter equipment and assembly" for the developments undertaken in their NPP project on "Design and development of High Temperature Superconducting (HTS) Fault Current Limiter (FCL)" | 2011 |
| 3 | M/s Crompton Greaves have jointly applied for patent with CPRI for "A modular rod type resistive superconductor fault current limiter equipment and assembly" for the developments undertaken in their NPP project on "Design and development of High Temperature Superconducting (HTS) Fault Current Limiter (FCL)" | 2011 |

PATENTS COMMERCIALIZED

| Sl. No. | Patents |
|---|---|
| 1 | Formulation of composition for non-halogen flame-retardant low smoke compound for cable application |
| 2 | Novel extraction apparatus for dissolved gases in mineral oil and synthetic oil |
| 3 | PVC based FRLS material using sulfate glass composition for cable insulation and sheathing applications |
| 4 | Hand held capacitance detector |
| 5 | Spherical electrode AC digital field strength meter Synthesis of capacitor liquid dielectric from rapeseed oil |
| 6 | Fly Ash based ceramic floor tiles |
| 7 | Fly Ash based ceramic wall tiles |
| 8 | Fly Ash based acid resistant brick/tiles |
| 9 | Flame retardant low smoke compound based on PVC for cable application |

## ANNEX 4: TECHNOLOGY TRANSFER AT CPRI

TECHNOLOGY TRANSFER AT CPRI

**(a) Valued Added Products from Fly Ash**

| Sl. No. | Licensees of CPRI know-how | Year |
|---|---|---|
| 1 | Ravi Fly Ash Products (P) Ltd. | May 1992 |
| 2 | Supreme Shelters and Chemical (P) Ltd., Vijaywada | May 1992 |
| 3 | Titanium Equipment and Anode Maufacturing Co Ltd., Madras | May 1992 |
| 4 | Environment and Pollution Control, HSEB Panipat | March 1993 |

**(B) Reclamation of used Transformer Oil**

| Sl. No. | Licensees of CPRI know-how | Year |
|---|---|---|
| 1 | GP, CPT C. Kalidas, Secundrabad | July 1992 |
| 2 | ESVEE IND, Bangalore | March 1994 |

**(C) Semi-Conducting Compound**

| Sl. No. | Licensees of CPRI know–how | Year |
|---|---|---|
| 1 | Plasti Colors, Ahmedabad | July 1992 |

**(D) Mrso (Synthesis of Capacitor Dielectric from Rape Seed Oil)**

| Sl. No. | Licensees of CPRI know -how | Year |
|---|---|---|
| 1 | Meher Capacitors, Bangalore | 1992 |

**(E) Epoxy Novolak Resin**

| Sl. No. | Licensees of CPRI know-how | Year |
|---|---|---|
| 1 | SVS Bushings, Madras | |
| 2 | Guardian Plasticobe (P) Ltd, Calcutta | Aug 1995 |

**(F) Electronic Ballast**

| Sl. No. | Licensees of CPRI know-how | Year |
|---|---|---|
| 1 | BPL Systems & Proj Ltd., Bangalore | March 1992 |
| 2 | Tummala Electronics (P) Ltd., Bangalore | March 1992 |
| 3 | Hitech Systems, Bangalore | Sept 1991 |
| 4 | Apex Systems, Bangalore | Sept 1991 |
| 5 | ESVEE Industries, Bangalore | Sept 1991 |
| 6 | GSR Electronics, Bangalore | Oct 1991 |
| 7 | Alphen Housen Elect (P) Ltd, Bangalore | Oct 1991 |
| 8 | Athveyonix, Bangalore | Oct 1991 |
| 9 | Sreeplex, Tumkur | Nov 1991 |
| 10 | Nitin Electronics, Bangalore | Nov 1991 |
| 11 | AVR Electronics, Mysore | Apr 1992 |

| | | |
|---|---|---|
| 12 | Gangotri Electronic, Bangalore | May 1992 |
| 13 | J.P. Sawoo, Calcutta | May 1992 |
| 14 | Mridul Electro Solar Sys., Nagpur | May 1992 |
| 15 | Protech, Nasik | June 1992 |
| 16 | SuneetAprotech, New Delhi | June 1992 |
| 17 | Magnewin Magnetics, Sangli | July 1992 |
| 18 | Shanta Elect Industries, Bangalore | Oct 1991 |
| 19 | G.G. Electronics, Bangalore (NRDC) | June 1993 |
| 20 | H.H. Elecronics, Bangalore | Dec 1991 |
| 21 | Sameer Electronics, Karnal (Punjab) | Oct 1994 |
| 22 | Abhinandan Elctronics, Bangalore | Dec 1994 |
| 23 | Krisaro Electronics, Tiruchinapalli | Apr 1996 |
| 24 | Kerala Women Entrepreneur DevCor, Thiruvananthapuram | July 1997 |

**(G) Live Line Detector**

| Sl. No. | Licensees of CPRI know-how | Year |
|---|---|---|
| 1 | Empower Control Systems, Bangalore | Nov 1993 |

**(H) Static Bypass Switch**

| Sl. No. | Licensees of CPRI know-how | Year |
|---|---|---|
| 1 | Micro Systems, Bangalore | Feb 1993 |

**(I) Automatic Power Factor Controller**

| Sl. No. | Licensees of CPRI know-how | Year |
|---|---|---|
| 1 | ARCS | Jan 1996 |

**(J) Trivector Meter**

| Sl. No. | Licensees of CPRI know-how | Year |
|---|---|---|
| 1 | M/S BHEL | |
| 2 | M/S English Electric Co. Ltd., Madras | Sept 1991 |
| 3 | Indain Mocasses Co. Ltd., Bangalore | Aug 1991 |

**(K) Dist Plan (S/W Package)**

| Sl. No. | Licensees of CPRI know-how | Year |
|---|---|---|
| 1 | M/S IIT, Kanpur | June 1994 |

**(L) Spherical Electrode Digital Meter**

| Sl. No. | Licensees of CPRI know-how | Year |
|---|---|---|
| 1 | M/S Green Dot Enterprises, Bangalore | Aug1994 |

**(M) Solar Photovoltaic Lanteen**

| Sl. No. | Licensees of CPRI know-how | Year |
|---|---|---|
| 1 | M/S KCP Solar Industry, Salem Bangalore | July 1995 |

**(N) Single and Three Phase Digital Energy Meters**

| Sl. No. | Licensees of CPRI know-how | Year |
|---|---|---|
| 1 | AVR & Co. Ltd., Hyderabad | Aug 1991 |
| 2 | Apex Telecom Technologies (P) Ltd., Hyderabad | April 1992 |
| 3 | Titan Technocrats (P) Ltd., Secundrabad | Sept 1992 |

**(O) Power Line Harminic Analyser**

| Sl. No. | Licensees of CPRI know-how | Year |
|---|---|---|
| 1 | Jaya Sales International (42 k) | March 1994 |

**(P) Cadet**

| Sl. No. | Licensees of CPRI know-how | Year |
|---|---|---|
| 1 | Lotus Power Gear (P) Ltd., Bangalore | July 1992 |

**(Q) Cable Fault Locator**

| Sl. No. | Licensees of CPRI know-how | Year |
|---|---|---|
| 1 | Electrons Devices, Kapur (CPRI Share 42 k) | Oct 1992 |

**(R) Solid Particle Erosion Testing Apparatus**

| Sl. No. | Licensees of CPRI know-how | Year |
|---|---|---|
| 1 | DUCOM, Bangalore | March 1997 |

**(S) 1-ϕ Energy Meter and 3-ϕ Digital Energy Meter**

| Sl. No. | Licensees of CPRI know-how | Year |
|---|---|---|
| 1 | Seahorse Industries, Thiruchirapalli | March 1999 |
| 2 | Accurate Meters Ltd, New Delhi | April 1999 |

**(T) 1-ϕ Digital Energy Meter**

| Sl. No. | Licensees of CPRI know-how | Year |
|---|---|---|
| 1 | BBS Electronics (P) Ltd., Bangalore | March 1999 |
| 2 | WELLWIN Industry Ltd, Chennai | July 2001 |
| 3 | Auto Meter Alliance Ltd, Noida | January 2003 |

**(U) 12 kV Load Break Switch**

| Sl. No. | Licensees of CPRI know-how |
|---|---|
| 1 | G.K. Electricals, Bhopal |

**(V) Technology Transferred to Outside Agencies**

| Sl. No. | Technology Transferred |
|---|---|
| 1. | The Centre for Ash Utilization Technologies and Environment Conservation (CASHUTEC), Established at Raichur Thermal Power Station |
| 2. | Technology of Multiple Gas Extraction Apparatus was transferred to M/s. Dakshin labs, Bangalore |
| 3. | Transfer of know-how for transformer oil acidity value testing kit to M/s Foresight Automation, Bangalore. |
| 4. | Know-how transfer of Pre-paid Cad operated Energy Meter to M/s Autometers Alliance, Noida. |
| 5. | Technical know-how of single phase static energy meter has been transferred to M/s. Autometers Alliance Ltd. Noida |
| 6. | Ground Mat design software was procured by Maharashtra State Electricity Board, Mumbai and Tamil Nadu Electricity Board, Chennai |

## PRODUCTS/PROCESS/SOFTWARE DEVELOPMENT

| Sl. No. | Product/Process/Software Development |
|---|---|
| 1. | PVC based FRLS compound has been developed and is available for commercial production |
| 2. | Support to indigenization in Indian Space Research Programme (LSPC, ISRO, Mahendragiri) |
| 3. | PVC based FRLS compound has been developed and is available for commercial production |
| 4. | The R&D efforts which have resulted in development of products and processes during the year are:<br>✖ Time Synchronizing Unit (TSU)<br>✖ Thermo-Plastic lined fuse carrier for drop out fuse<br>✖ Development of diagnostic tool - Acoustic technique to partial discharge in HV capacitors and transformers<br>✖ Development of Marble waste - products, Bricks, Mosaic tiles, Bath tub, Sinks, etc. |


FUTURE GENERATION OF PROFESSIONALS