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ISA Delhi Section

International Society of Automation

ISA Delhi Section

POWAT – 2013

Automation – For Sustainable Development

12th & 13th April 2013
(Friday - Saturday)

at **Hotel Hyatt Regency**
Bhikaji Cama Place, New Delhi

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POWER AUTOMATION TECHNOLOGY EVENT
(Conference and Exhibition)


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Chairman & Managing Director

एनटीपीसी लिमिटेड
(भारत सरकार का उद्यम)
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Message

I am glad to note the efforts being put up by International Society of Automation (Delhi) Section in organizing the fourth Power Automation Technology Event - 2013 (POWAT). Such a focused and sustained campaign dedicated to Power Automation Technology domain is required to accelerate the technological transformation of the power industry in India.

Indian market, is luring national and international players who have the expertise to take up the Automation technology to the next level. A unceasing exertion is required by the Industry players users to scrutinize the need for efficiency, safety, innovations and above all sustainability through such technology platforms. In view of the opportunities for the engineering professionals, this knowledge sharing event, I am sure, would add a lot of value to all the participants.

With the Nuclear and Renewable power technology likely to increase their share in the future power scenario, it is apt that the POWAT-2013 is addressing these areas among the technical papers. It is also noteworthy that through such seminars, ISA Delhi Section has striven to facilitate establishing of global benchmarks in power generation in India in terms of both reliability and cost competitiveness.

I wish the event a grand success. I also wish ISA Delhi Section members and all the participants in this event a productive time ahead.

(Arup Roy Choudhury)

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पी. सुधाकर
P. Sudhakar
कार्यकारी अध्यक्ष एवं प्रबंध निदेशक
Acting Chairman & Managing Director

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April 9, 2013

MESSAGE

I am very pleased to learn that yet again this year ISA Delhi Section is organising their Power Automation Technology event POWAT-2013 on the 12th and 13th April 2013 focussing on Automation Technology for Sustainable Development in both Conventional and Non-Conventional Power Generation.

I am sure this event will provide an opportunity to the Indian power sector automation experts to get exposed to the national and global developments and an opportunity to share experiences in implementing the latest state-of-the-art solutions.

I am aware that ISA Delhi Section believes that the engagement of various stakeholders including end users, designers and technology providers would go a long way in implementing automation solutions that are best equipped to handle the complex challenges in this domain.

I wish ISA Delhi Section all the best in their endeavours.

(P. SUDHAKAR)
Acting Chairman & Managing Director

ए. के. झा
निदेशक (तकनीकी)

A. K. Jha
Director (Technical)

एन टी पी सी लिमिटेड
(भारत सरकार का उद्यम)
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I am pleased to be associated with the efforts of International Society of Automation (ISA), Delhi Section in its efforts to organise this focused knowledge sharing event for the automation professionals of the power sector.

The power sector in this country is going through a challenging time and all stake holders have to innovate and rise to the occasion to leverage sustainable growth through proper management of existing assets and judicious implementation of business expansion schemes. The current scenario, therefore calls for increased use of innovative automation, for sustainable growth by operating the machines as close to the design limits as possible.

To meet the challenge of sustainable development, increased contribution through renewable sources are the need of the hour. Renewable energy has its own challenges and therefore needs a different approach to automation solutions.

I am happy to note that a large cross section of national and international experts shall be presenting papers and discussing implementation experiences for automation solutions across the broad spectrum of power generation such as thermal, nuclear and renewable energy.

I do sincerely hope that the learnings shared in this two day conference will be of practical value to the participating delegates and power sector in general will get immensely benefited.

I wish the conference grand success.

(A.K. JHA)

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Message from Director General CPRI

I am glad to know that the ISA Delhi Section programme POWAT-2013 is being held for the fourth consequtive year. Knowledge sharing and continuous engagement of technology leaders is the key to developing succesful performers in any industry. I congratulate the organisers for putting together such an event which provides a vibrant platform to all stakeholders to engage each other in better appreciating the challenges of automation in the Indian Power Sector.

It is heartening to note that ISA(D) POWAT-2013 is focussing on the key issues of concern in the Indian Power Sector including the emerging area of renewable energy as well. I am happy to note the excellent support from the Power Industry majors and the Government for this event. The Department of Science & Technology has shown the way for cooperation between technology developers and the Industry by supporting this meet.

I wish the event a grand success and hope that all participants will be enriched through their engagement during these two days of knowledge exchange.

N MURUGESAN
DIR. GENERAL CPRI

न्यूक्लियर पावर कॉर्पोरेशन ऑफ इंडिया लिमिटेड
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K. Jagannath
Executive Director (E&I)

MESSAGE

I am glad to know that international society of Automation –Delhi section is organising Power Automation Technology (POWAT) conference 2013 during 12-13 April at Delhi with the theme "Automation for Sustainable Development".

For sustainable growth of Indian economy power industry needs growth through all its sectors. In order to meet the huge energy demand, we should explore all sources of energy. NPCIL is rapidly augmenting the generation capacity by constructing several Nuclear Power Plants to contribute in this national endeavour.

Automation plays a key role in efficient and safe management of plants. Indian industry has supported its evolution from earlier relay based controls to latest state of art software based controls. POWAT provides a common platform where all stakeholders viz user, R&D organisation, industry and consultants interact to improve automation.

I wish the POWAT 2013 all success in this objective.

K. Jagannath
(K. Jagannath)

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कार्यकारी निदेशक (अभियांत्रिकी)

A. K. GUPTA
Executive Director (Engg.)

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भारत सरकार का उद्यम
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नोएडा कार्यालय / NOIDA OFFICE

April 10, 2013.

I am pleased with the efforts put in by ISA Delhi Team in organising POWAT-2013, the Power automation show, focusing on the automation solutions for the power industry. Continuation of such efforts to bring out technical papers on the Power Segment's automation evolution each year and to present it to the stakeholders in the Industry is praiseworthy.

The power sector has been under tremendous pressure on various fronts. The existing assets are under tremendous pressure to perform under wide fluctuating conditions due to fuel scarcity and quality. Grid integration of new renewable plants also poses substantial challenges. This poses substantial challenges on existing control and automation systems.

It is, therefore, important that such technology oriented and focused seminars like this are able to create significant contributions for the benefit of the fraternity. I am quite confident that through this conference, specific challenges and issues of modern day power generation, transmission and distribution would be addressed and it will also showcase the trends in the technology related to Power Plant Automation, Optimization, Safety & Protection, Retrofitting & Upgrades with respect to Instrumentation and Controls.

This two days conference is very appropriately timed by the ISA Delhi Section. I am sure that this platform will be satiating the needs of all the participants from the Power Industry.

I wish ISA Delhi Section all the very best for a successful event ahead.

(A.K. Gupta)

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TATA

Debabrata Guha
Chief - Corporate Engineering

Message

Automation – For Sustainable Development for Power Automation Technology POWAT is the most apt and timely event being organized by ISA Delhi, dedicated to advancing sustainable, energy efficient and futuristic technologies.

With Automation taking big leaps in technology, it is time now for the Energy Producers and Distributors to take advantage of the latest success stories in the domain of Control & Automation. Now more than ever before, industrial enterprises and utilities rely on their control systems to improve their reliability and efficiency. As POWAT 2013 is covering the technology papers from both Conventional as well as Renewable Power spectrum along with Panel Discussions, I feel very confident that all the participants will reap the benefits on this unique business and knowledge-sharing platform for the sustainable energy industry.

I extend my best of wishes to ISA Delhi Section for making this event successful and I am sure that POWAT will stake its claim in the energy mix of the future.

Debabrata Guha
Executive Vice President & Chief,
Corporate Engineering, Tata Power

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ISA District 14

<u>Message from ISA District Vice President – District 14</u>

Due to continuous changes in the field automation technology, the need of the hour for the champions of the industry is to get impartial and unbiased information, which in turn would enable them to take the right decisions and make their organization, more profitable without compromising the quality or safety and protect the environment.

It is also worthwhile to mention that sustained development cannot be a one sided endeavor and in this context "The International Society of Automation" (ISA) with its decades of experience and strong network of professionals worldwide, constantly strives to address these challenges. This endeavor is clearly reflected by ISA-Delhi section, as they spearhead the "Power Automation" event every year, which is laudable and this will be the fourth year of its glory. POWAT 2013 is absolutely crucial in the context of the current Indian power scenario and I am confident that POWAT 2013 will address these critical issues through seminars, presentations and deliberations.

I am privileged to be a part in an organization, which not only enlightens, but also empowers. I am extremely pleased to be part of this wonderful event and wish ISA – Delhi section members and participants to make the most of out of this event. I wish ISA-Delhi Section "All the very best for POWAT 2013" to be a Grand Success.

V.P. Raman
ISA District Vice President (District 14)

From the Desk Of President ISA(D)

Mankind's quest for progress has led to a rapid depletion of fossil energy sources and questions of sustainability has driven manking to seek better efficiencies in all industrial processes to sustain competitive growth and development. This has led to increased dependence on Automation Technologies in every industrial activity. Automation will continue to play a key role in the Indian Power Sector, facilitating our quest for being truly world-class across the entire energy value chain.

In the present scenario, the work of automation professionals is critically important to ensure sustainable management of our energy resources through optimum utilisation and higher efficiencies.

The International Society of Automation (ISA) provides leadership, education and promotes development of standards for leveraging optimum automation for ensuring operational excellence. ISA Delhi Section with more than 350 members, has been actively promoting various programmes to facilitate "knowledge building through knowledge sharing" - in keeping pace with the rapidly evolving automation technology and business needs.

I am confident that the mission of the ISA (D) POWAT to "Engage all stake holders of power sector in adopting the latest instrumentation and automation standards, there-by achieving safe, reliable, efficient and enviroment friendly power availability in country" will be further strengthened through this event POWAT 2013.

I take this opportunity to extend my sincere gratitude to all industry leaders, dignitaries, sponsors, members & volunteers who have been kind enough to support this event .

I do hope and wish that POWAT 2013 will make an enriching impact on all the participants for all times to come.

PRASENJIT PAL
Hon. President
ISA Delhi Section

Message

I am privileged to inform that Power Sector Automation technology event for 2013 (POWAT-2013) organized by ISA Delhi Section is being held in New Delhi on 12th and 13th April, 2013. The theme of this year's POWAT 2013 is Automation for Sustainable Development.

The power is the most important input for our national growth and development.
Meeting the energy challenge is of fundamental importance to our economic growth targets and its efforts to raise its level of human development. The broad vision behind the energy policy is to reliably meet the demand for energy services of all sectors at competitive prices. The demand must be met through safe, clean and convenient forms of energy at the least cost in a technically efficient, economically viable and environmentally sustainable manner.
In order to our future requirement, we need to go for rapid capacity addition using all the possible energy options including coal, hydro, nuclear, and renewable resources. It is praiseworthy to note that the use of automated system has many folds in power sector. This ensures reliable and quality power. With increased automation, we have increased availability, reliability, safety, and stability of the assets of the power plants. At the same time, we need to give more emphasis on issues like cyber security. I am glad to inform that this is being dealt in the conference.

It is a good opportunity for the Control and Instrumentation Engineers to attend this conference to enhance the technical expertise as ISA gives a common platform to all the stake holders for sharing the knowledge and expertise.

Before, I conclude, I sincerely thanks to all sponsors, contributors of the Technical papers and to all members of organizing committee who despite huge workloads at their respective organization have worked very hard to make this event successful.

S Bhattacharyya

(SOUMITRA BHATTACHARYYA)
Convenor (POWAT-2013)

Message from Honorary Secretary ISA Delhi Section

Efforts are currently underway to define a set of Sustainable Development measures for every industry specially the power sector. As we debate these goals with respect to the sustainable technologies, we are facing the underlying aliments of sustenance in the quality and quantity of automation domain in India. It is the time to ensure that the efforts to improve the industrial automation scenario are more than just the stopgap measures – that they enable the struggling automation fraternity in face of dire threats to increasethe strength of the technology and technologists needed to lead the automation sector in industry.

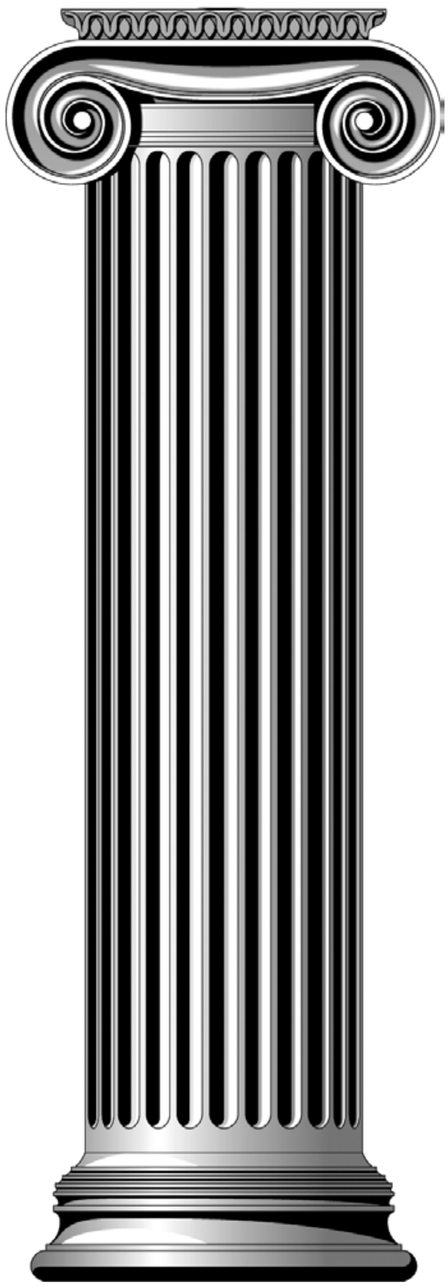
“Automation” is there in each one of our life and it has only one objective and that is to make our lives easy. For almost a decade now ISA in India has been able to provide a structural framework that is striving to bring greater clarity on the aspects of Automation that we cannot afford to ignore. While ensuring that all what ISA doescontributes to the larger objective of making the life easy for the automation society in the country by strengthening the drive to create and operate innovations.

If we picture such a society as an edifice, the ideals of knowledge exchange and engagement of technology leaders are the key pillars that hold it up, while the foundation on which these rests is to push the automation industry to the performance leadership in India. With more specialization fewer people have good grasp of the bigger system as a whole. ISA Delhi Section has constantly attempted to address such issues through many seminars, exhibitions and workshops including the one for Power Automation Technology domain titled POWAT which is now being organized for the fourth time with a theme of “Automation – for Sustainable Development” so that Indian power industry can develop a vision of being world class by retaining the leadership through the management of Innovation, R&D, Technology and Talent.

Upholding this POWAT 2013 event, I take this opportunity to express my sincere gratitude towards all the Guests of Honour, Senior Dignitaries, Delegates, Sponsors and above all, the ‘behind-the-scene’ working members & executive committee members of ISA Delhi Section.

Ashish Manchanda
(Honorary Secretary – ISA-D)

ISA Delhi Section



The International Society of Automation (ISA)

Founded in 1945, the International Society of Automation (ISA) is a leading, global, nonprofit organization that is setting the standard for automation by helping over 30,000 worldwide members and other professionals to meet, interact and share their knowledge. Based in Research Triangle Park, North Carolina, ISA is organised into 14 districts and hundreds of sections across the world. The South East Asia region is designated as District-14 and within this district, the Delhi Section is an active organization drawing members from the entire spectrum of automation industry across Power, Oil & Gas, Metallurgy, Chemicals & Fertilizers including the Engineering fraternity from Consultants, EPC Contractors, Automation Component Suppliers & Equipment Manufacturers, System Integrators and many other industries.

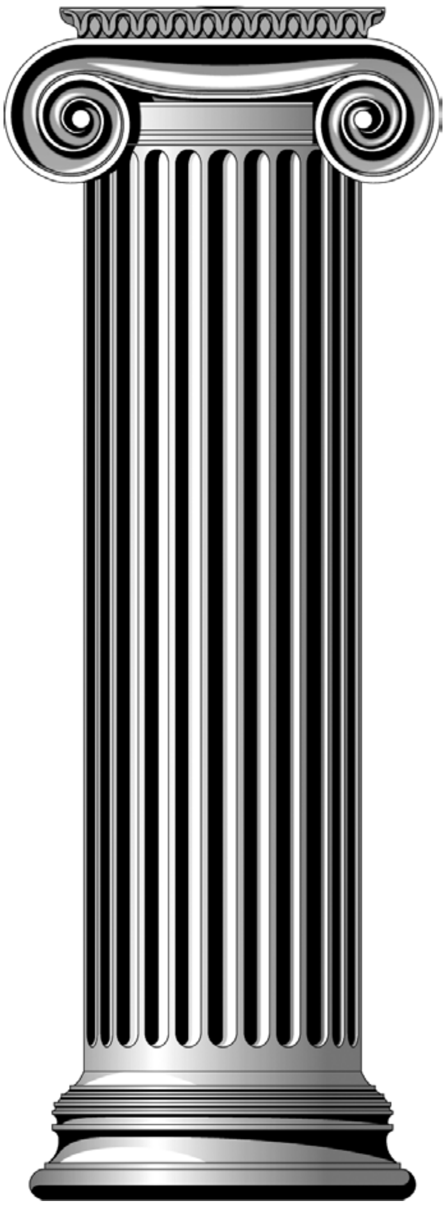
ISA has been involved in promoting emerging technologies across the globe by a variety of ways such as:

- Developing and updating standards for existing & evolving technologies in automation related fields ;
- Publication of Text-books, hand-books, journals, proceedings etc. on a wide array of automation related subjects from primary field sensors to integrated automation and management systems for various kinds of plants & processes;
- Facilitating Interface & interaction with other agencies like IEC, IEEE, EPRI, ASME and others to develop and maintain automation related standards with regular updating, keeping pace with the march of technology in various fields;
- Organising Training, Seminars/Workshops, Webinars and Exhibitions
- Carrying out certification programs for technicians, engineers and senior professionals.
- Recognizing the talented and the dedicated professionals in the field of Automation through various honours and awards
- Interaction with Student members, formation of student section and annual scholarships, competitions etc. are many interesting student programs of the ISA.

The ISA Delhi Section - ISA(D)

ISA Delhi Section had been formed almost a decade back and has progressed well since then with a membership of more than 350 and growing. ISA Delhi Section had taken many initiatives in the past including organizing two exhibitions ISA (D) EXPO' 05 & '07, a large number of seminars and workshops on emerging technologies. Regular Monthly technical exchanges on diverse topics are organised for the benefit of all members of ISA(D), thereby increasing the knowledgebase & technical capabilities of members.

ISA Delhi Section



ISA Delhi Section has taken quite a few initiatives in the recent past to better address the need for knowledge sharing among industry specific groups of Automation Engineers. Notably, within the overall ambit of ISA(D), two industry specific interest groups have already been created, one for the Power Industry namely Power Automation Technology group(or POWAT) and one for the Oil & Gas Industry called Petroleum & Natural Gas Industries Automation Domain(PNID).

ISA(D) Power Industry Automation Technology Group (POWAT)

POWAT is an initiative taken by ISA-Delhi section to provide a common platform to all stakeholders of the Power Sector Automation community including End Users, Power Equipment suppliers, Automation Equipment & Component suppliers, System Integrators, Consultants, R&D establishments, Academicians, Independent Experts and Students for sharing of knowledge and experiences. The purpose of this forum is to enable learning from peers and industry experts and their experiences in the field of Power sector automation, so as to promote sustainable development of power sector automation solutions.

The vision of the ISA (D) - POWAT is :

"Take the Automation in the Indian Power Sector to global heights and acquire numero-uno position."

The mission of the ISA (D) – POWAT is :

"Engage all stake holders of power sector in adopting the latest instrumentation and automation standards, there-by achieving safe, reliable, efficient and environment friendly power availability in country.''

To realize the above vision and to execute the mission, the various long term and short term activities being carried out by ISA(D) - POWAT are :

Enable knowledge sharing among power sector automation fraternity including utilities companies, consultants, equipment manufacturers, turnkey suppliers and academicians.

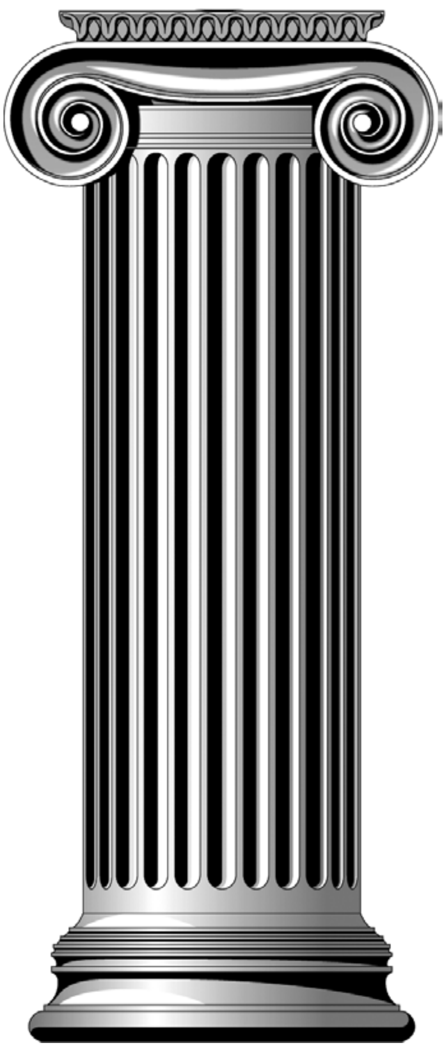
Facilitate through integrated automation, the realization of world class power plants in India with green, clean and lean visualization, there-by establishing global benchmarks in power generation in terms of reliable & quality power, at a competitive cost.

Provide an opportunity for Indian power sector automation experts to get an exposure to the global developments in automation and there by providing an opportunity to seek & implement latest state-of-the-art solutions best adapted for India Specific conditions.

Provide an interface for the automation fraternity with the policy markers and regulators

ISA Delhi Section has deep convictions that the engagement and

ISA Delhi Section



involvement of various stake holders including technology providers and developers would certainly help in achieving the roadmap for implementing automation solutions for power sectors that are equipped to handle the complex challenges of modern era.

After the resounding success of POWID-INDIA-2009 organized in Delhi on 24-25 April-2009, POWID-INDIA 2010 organised in Mumbai on 28-29 May 2010 and POWAT-2012 on 13-14 January 2012 in New Delhi, ISA Delhi Section Proudly announces the largest focused Power Sector Automation Show, POWAT-2013 on 12-13 April 2013 at Hotel Hyatt Regency, Bhikaji Cama Place, New Delhi.

The last three POWER automation events were held under the able patronage of topmost Power leadership of India. The event was attended by very senior level power automation professionals from all segments of power sector. On an average over 300 delegates had attended these shows each year representing around 90 organizations.

This two day conference and exhibition seeks to engage all stakeholders & players in the field of Power Sector Automation. The Symposium intends to engage automation experts from Thermal Power, Nuclear Power, Hydro Power, Renewable Energy, Transmission & Distribution, Automation Component Providers & Equipment Manufacturers, System Integrators, Consultants, R&D Organisations, Academicians and others for an invigorating exchange of knowledge on Business, policy and Technology trends. We attempt to bring on stage, the key technology issues before a well represented audience from the full spectrum of the Indian Power sector.

It is our Endeavour to develop a technology road map through continual efforts and various programs of POWAT, so that Indian power industry can develop a vision of being world class, by retaining the leadership through the management of Innovation, R&D, technology and talent. This calls for the involvement of not only the Technocrats, Scientists, Academicians, IT and Management professionals, but also the senior policy and decision makers and doyens of industry to influence future course of power industry in India. Over and above, it also necessitates the continuous engagements of leaders and stalwarts, not only from the fields of Automation and IT but also from diversified disciplines like Project Management, Finance, Power Generation, Transmission, Distribution, Administration, Macro Planning, Manufacturing, Environment Planning/ Engineering, Government, Quality Management and host of other domains, sectors and divisions. This is meant to be a continuing endeavor for pushing the power industry to the forefront of technology and performance leadership.

This power packed, two days program with event theme as “Automation – For Sustainable Development” is being planned to satiate the ever-increasing demand of knowledge sharing among automation professionals of Power industry.

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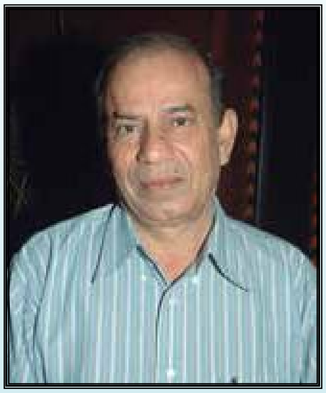

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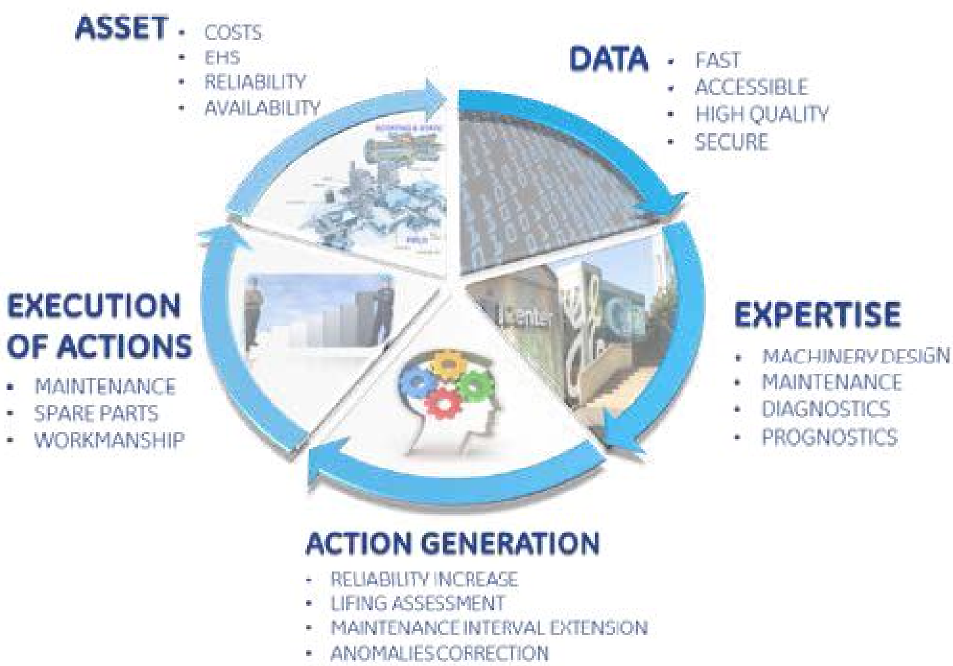

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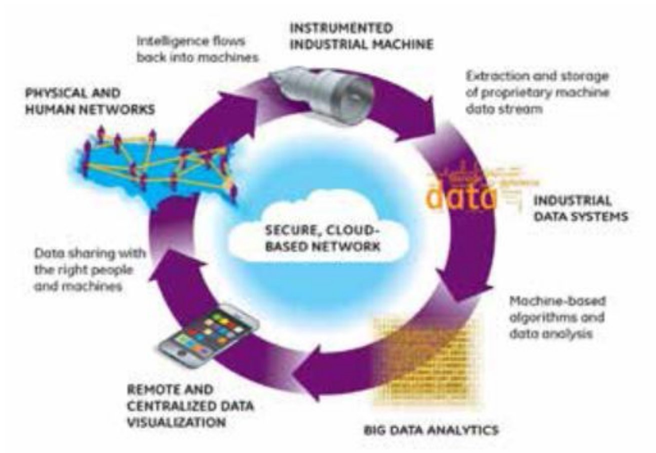

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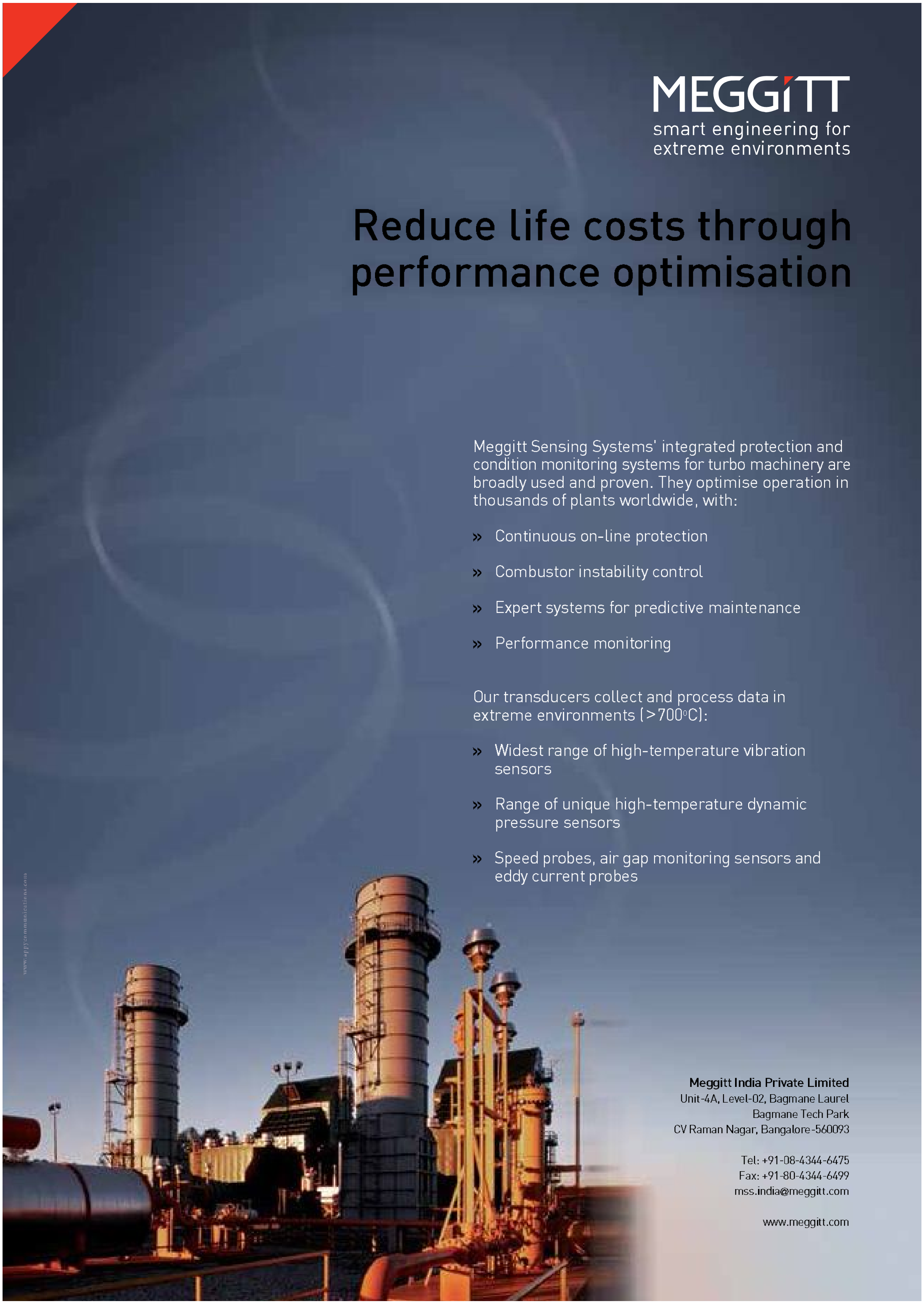
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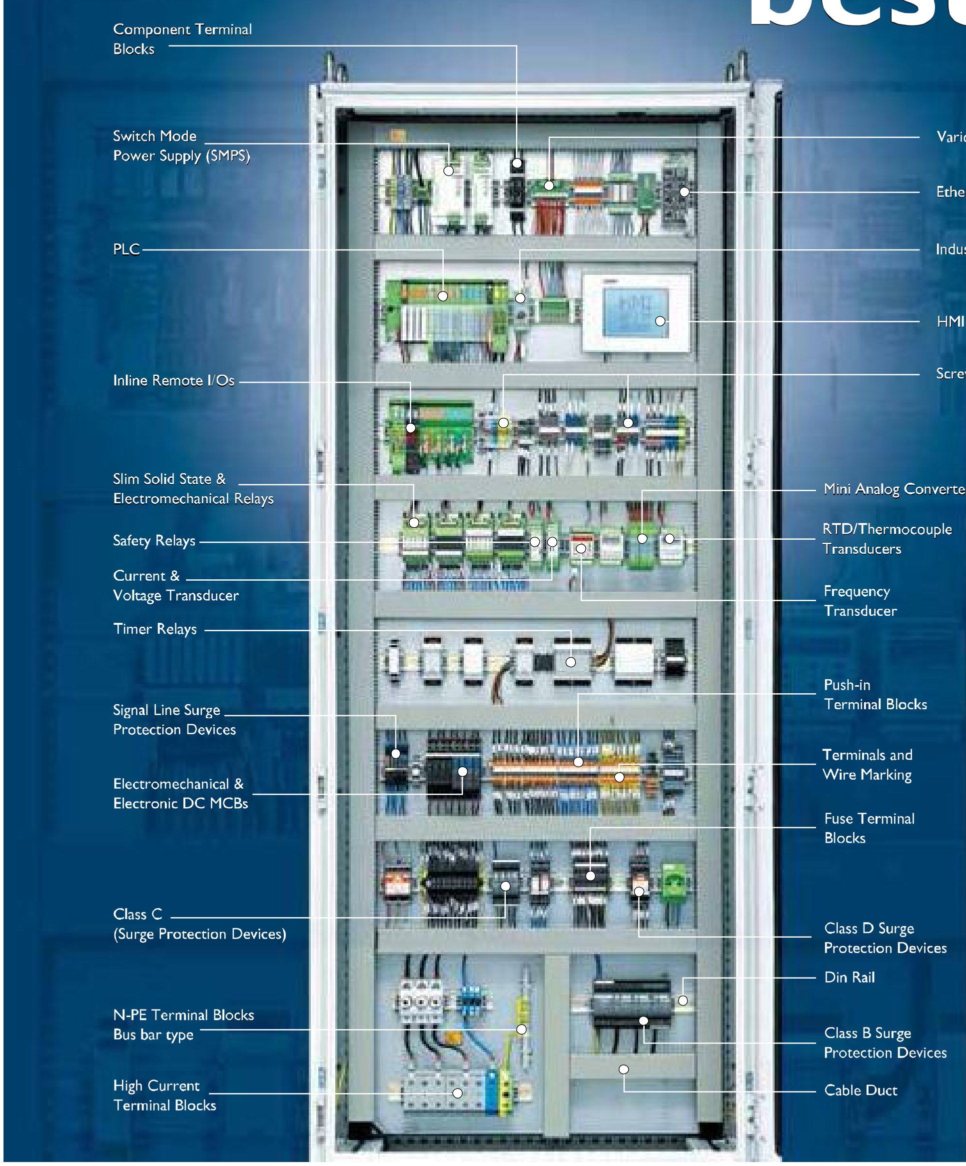

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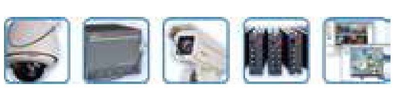

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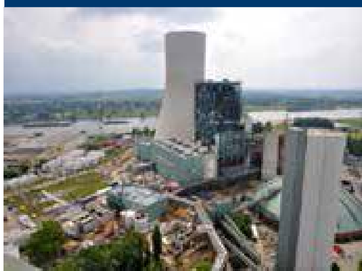

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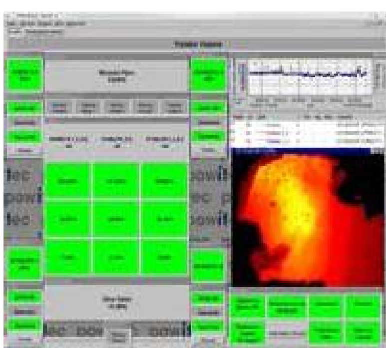

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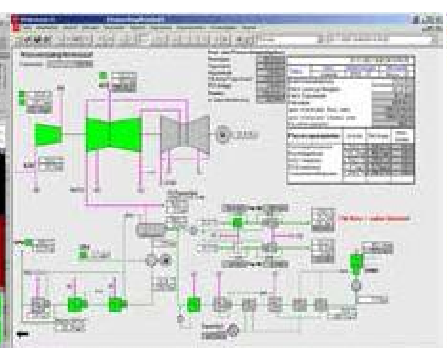

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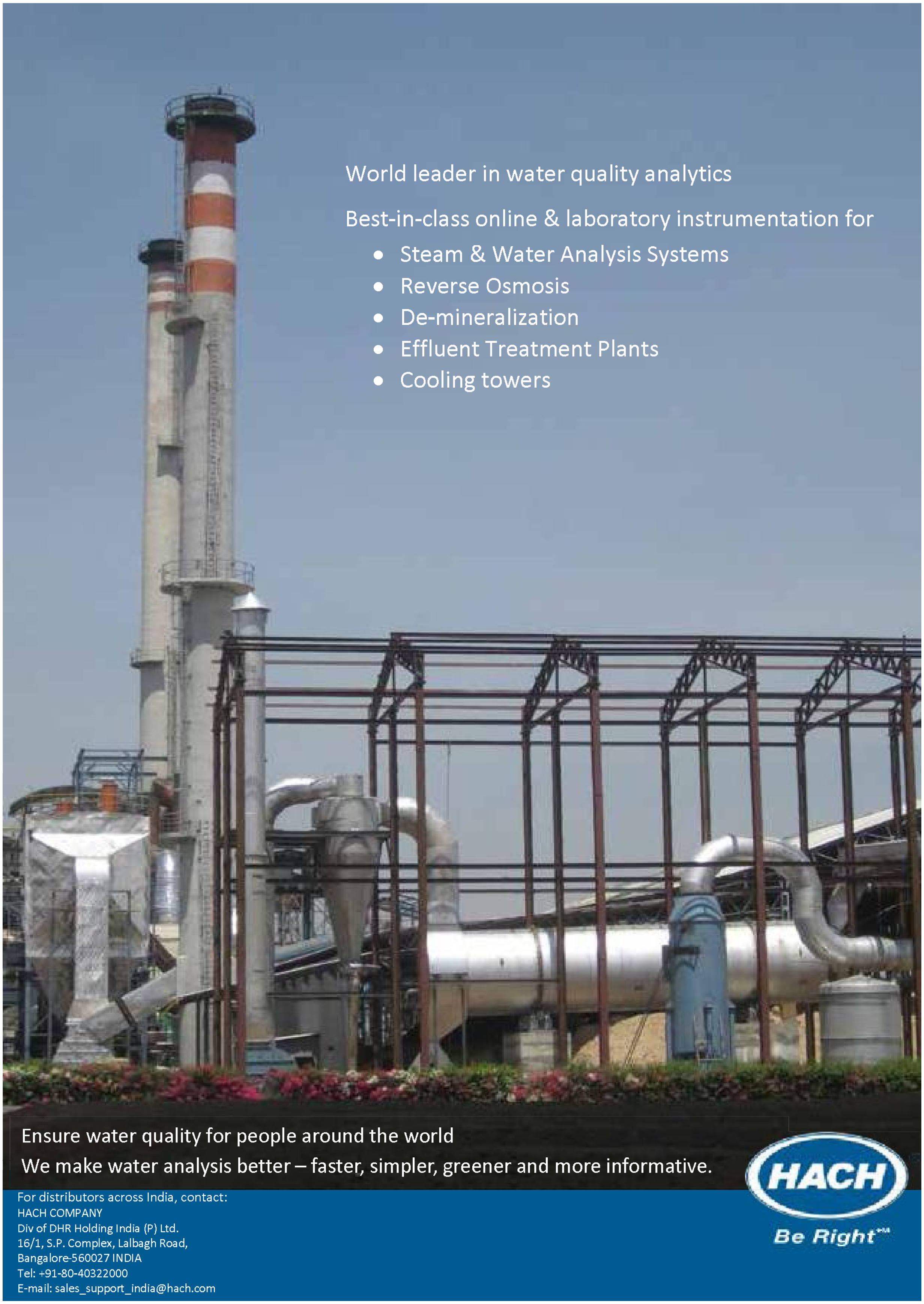
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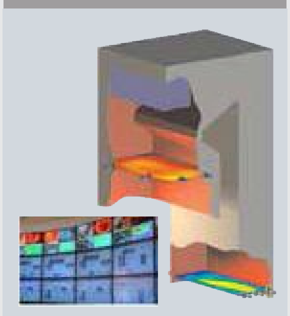

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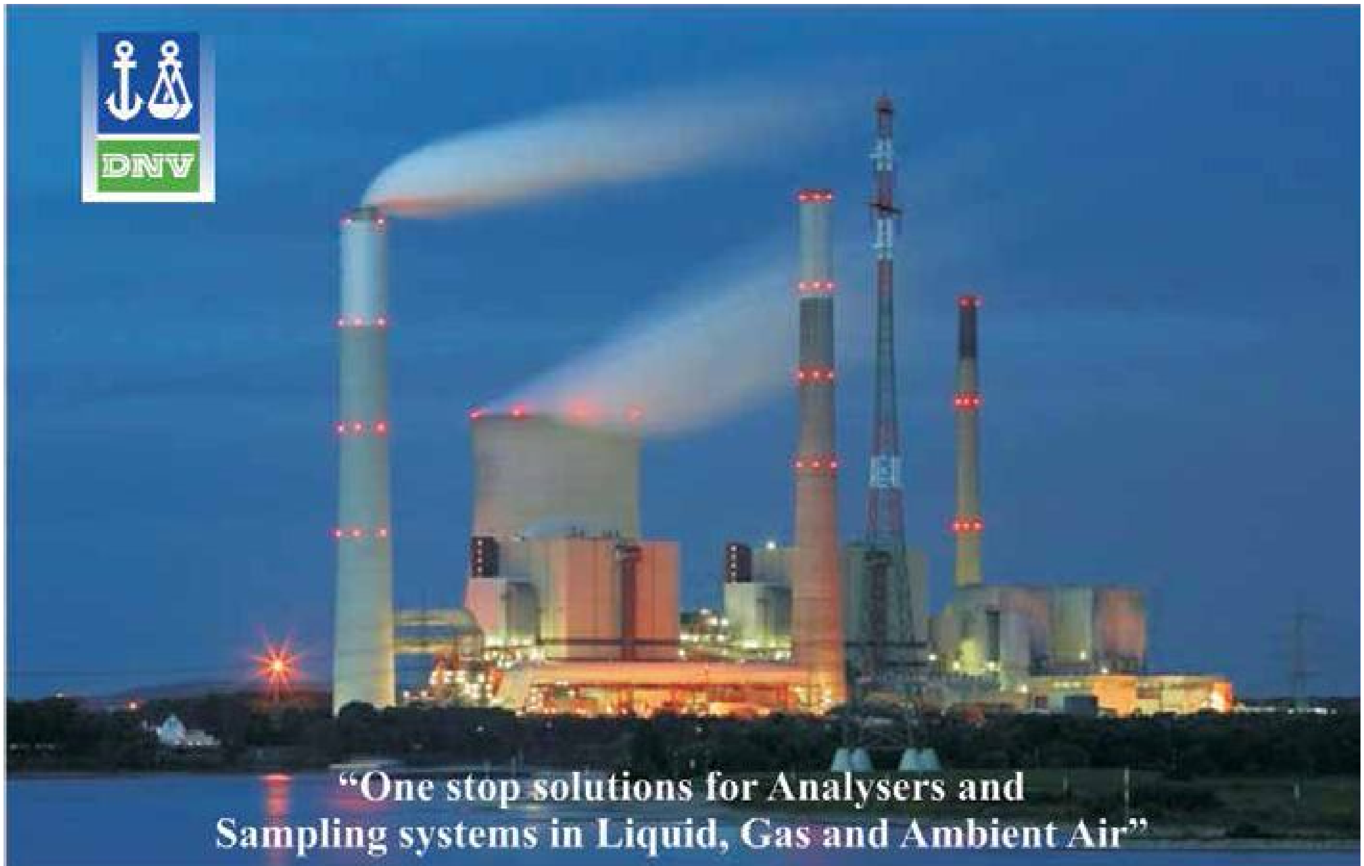

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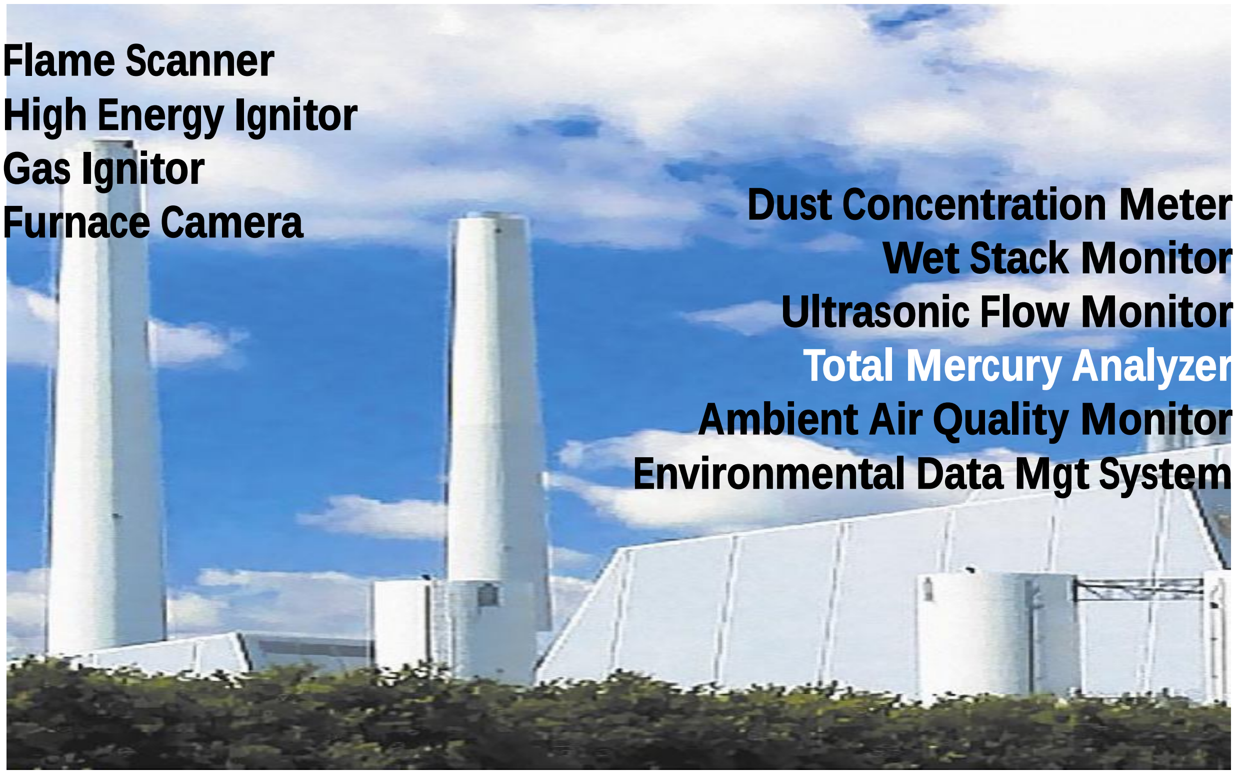

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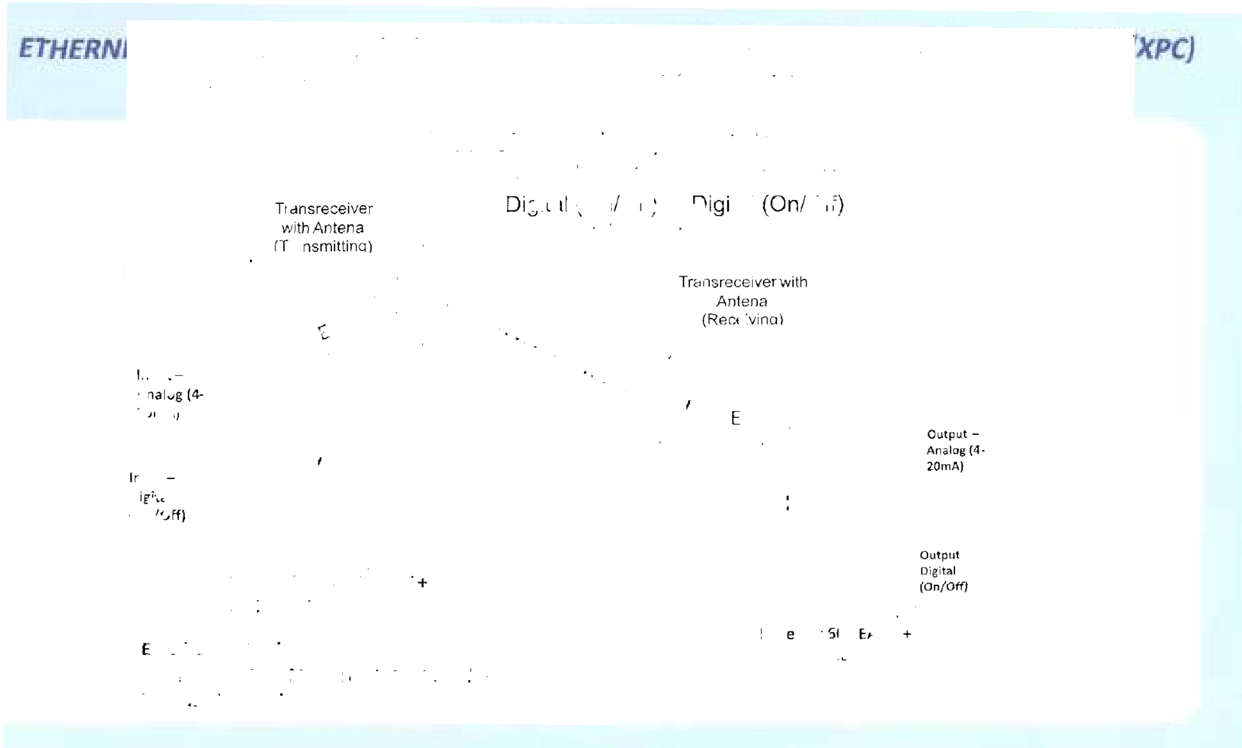

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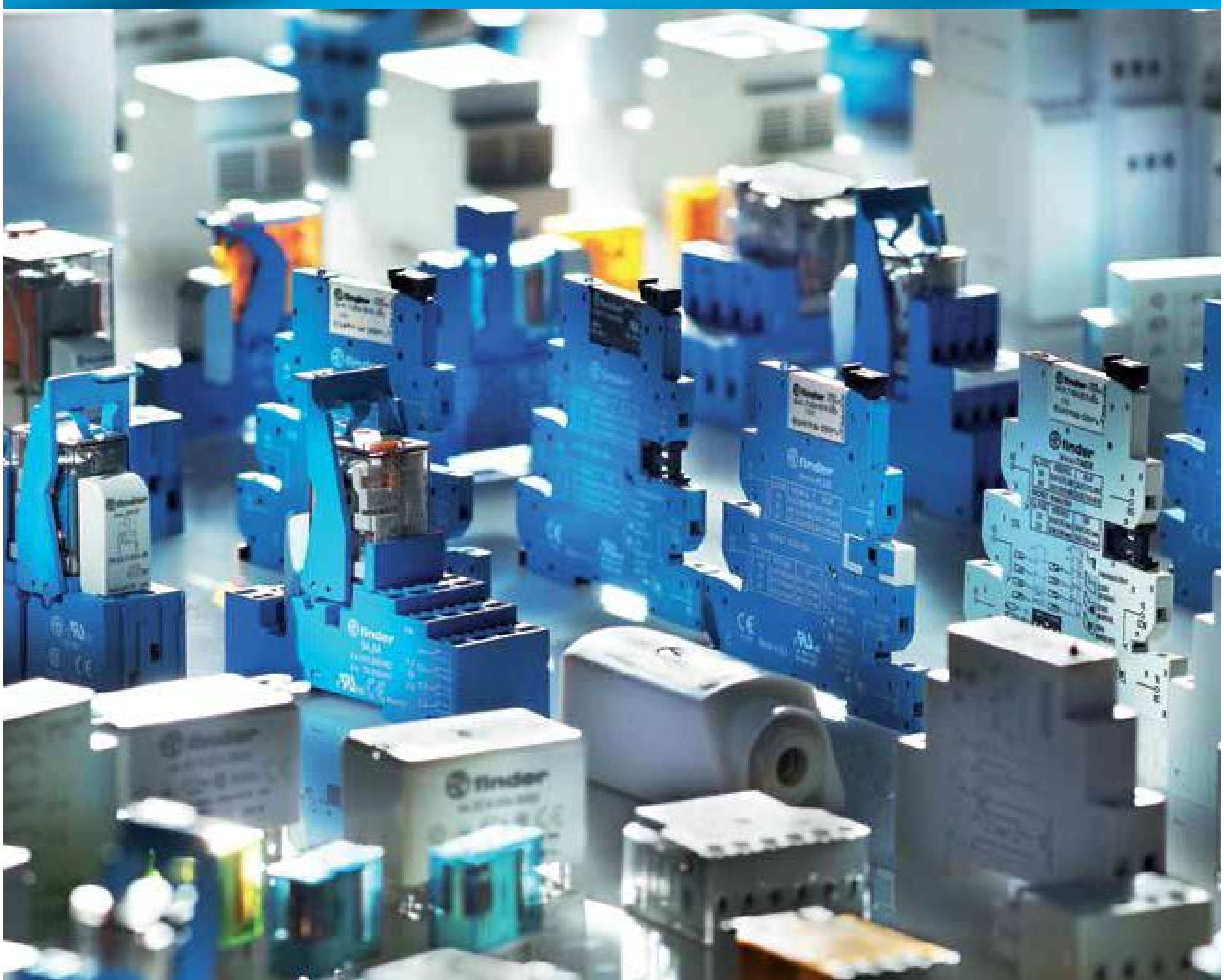

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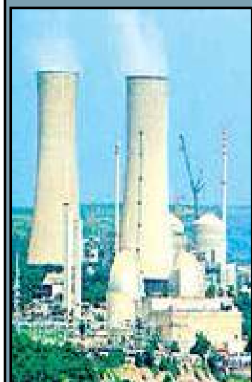

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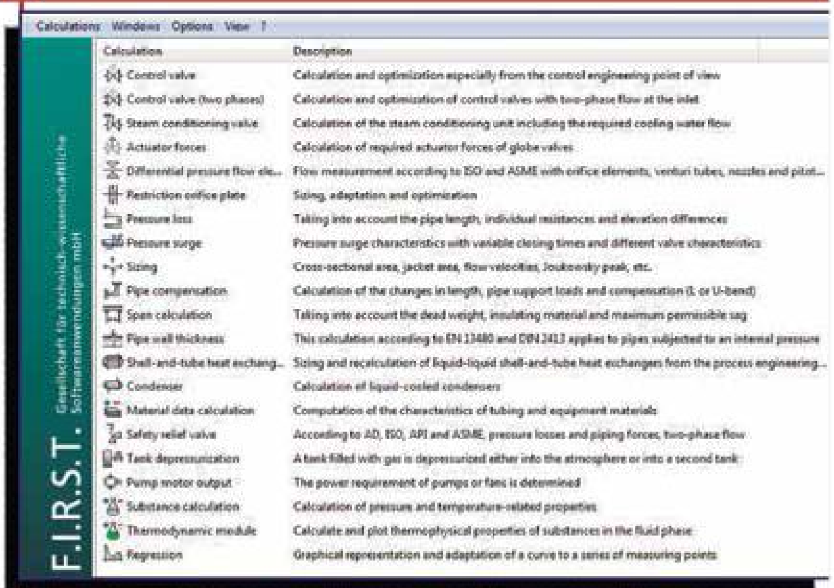

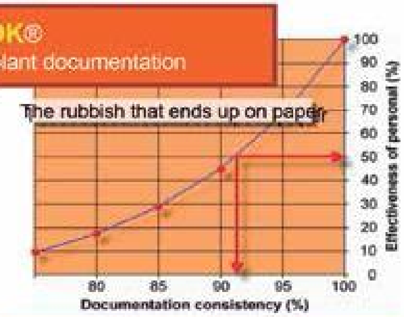

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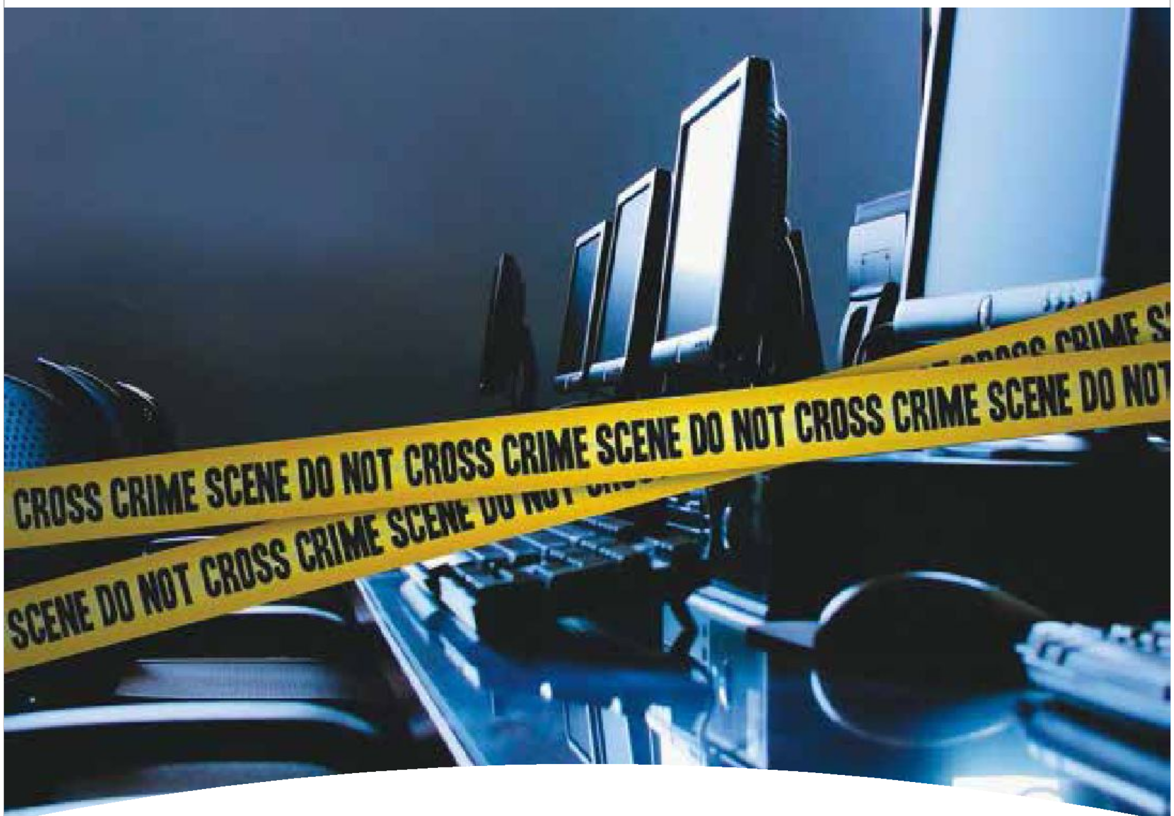

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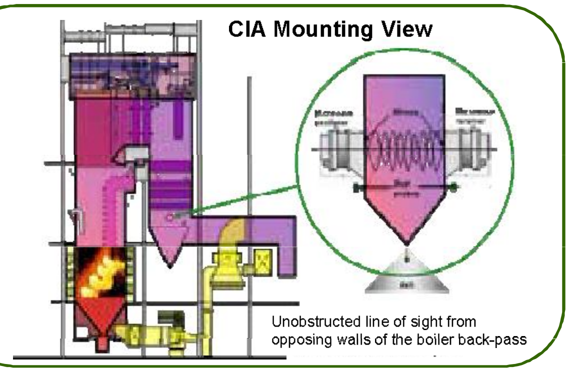

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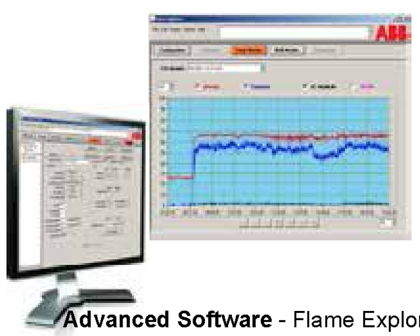

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POWAT - 2013

Programme Details

Date - 12th & 13th April 2013 (Friday - Saturday)

at Hotel **Hyatt Regency,** Bhikaji Cama Place, New Delhi

DAY-1	12-Apr-13	
Time	**From**	**To**
Registration	**8.30 AM**	**9.15 AM**
Inauguration Session	**9.30 AM**	**10.30 AM**
Arrival of Chief Guest **Sh. Arup Roy Choudhury** CMD, NTPC		
Welcome of Dignitaries by Bouquet		
Lamp Lighting		
Welcome address by ISA-D President		
Adress By Guest of Honour **Sh. N Murugesan,** DG, CPRI, Banglore		
Address by Guest of Honour & Chief Patron **Sh. A K Jha,** Director-Techincal, NTPC Limited		
Address by Guest of Honour & Key Note Speaker **Sh. P Sudhakar,** CMD ECIL		
Address by Guest of Honour **Sh. R N Nayak,** CMD PGCIL*		
Address by Chief Guest **Sh. Arup Roy Choudhury** CMD, NTPC		
Release of Souvenir by Chief Guest		
Vote of Thanks by Convener-ISA-D POWAT		
Inauguration of Exhibition by Chief Guest and Dignitories (confirmation awaited)*		
Tea Break	**10.30 AM**	**11.00 AM**
Session-1 "Invited Papers - Power Spectrum"	**11.30 AM**	**12.45 PM**
Session Chair: Mr. N Murugesan, Director General, CPRI	Session Co-Chair: Mr. D K Jain, CEO, NSL Power	
Invited Paper on Automation in Power Generation (Thermal)	Mr. D Guha, Sr. Execiutive Vice President & Head of Engg	Tata Power
Invited Paper on Automation in Solar Power Generation	Mr. Sidharth Ghoshal, Director Business Development	Areva Solar
Invited Paper on Automation in Nuclear Power Generation	"Mr. M Bharath Kumar, Associate Director (C&I,R&D and Simulator)"	NPCIL

Invited Paper on Solar Power generation	Dr. Tariq Alam,CEO	PL Delta Technologies
Networking Lunch Break	**12.45 PM**	**1.45 PM**
Session-2 "Innovative Technologies across Power Industries"	**2.00 PM**	**3.30 PM**
Session Chair: Mrs. Arundhati Bhattacharya, GM & HOD PE C&I, NTPC	Session Co-Chair: Mr. S Bhatnagar, GM & HOD C&I, BHEL PEM	
A New Technology for Bunker/Silo USA Inc.,Storage Weight and Level Measurement – ™	Kennan M. Yilmaz Ravinder Goyal	Strain Systems (EIP Enviro India)
Temperature imbalance and fluctuations due to difficult fuels - Diagnosis,	Prof. Dr. Hans Paul Drescher	Bonnenberg + Drescher, Aldenhoven, Germany
Innovation in Generator Condition Monitoring	Mr. Yvan Jacquat	MC-Monitoring
Real Time Process Improvement and Diagnostic for a Thermal Power Plant with Optimization & Expert Systems	Mr. Abhishek Kumar, Mr. Himanshu Pant, Mr. J S Chandhok	NTPC NETRA
Remote Monitoring & Diagnostics Solutions	Mr. Ramji Vasudevan/ Mr. Prashant Kapadia	GE
Networking Tea Break	**3.30 PM**	**4.00 PM**
Session-3 " Technical Solutions to Power Sector Challenges"	**4.15 PM**	**5.45 PM**
Session Chair: Mr. Ajit Kumar, ED (BD), NTPC	Session Co-Chair: Dr. Tariq Alam, CEO, PL Delta Technologies	
Solar Simulator (Plant Optimisation)	Mr. V S Sharma	Steag India
Intelligent combustion optimisation as reaction to changing pulverised fuel properties - A case study	Dr. Peter Deescow	Steag Germany
Substation Automation System Essentials India Pvt. Ltd.	Mr. Vaibhav Tare	FLUOR Daniel
Analysis of Power System failure at IFFCO-Aonla and subsequent measures to enhance reliability–A Case Study	Mr. A K Bhaduri	IFFCO
New Technology in Vibration Monitoring - A case study	Mr. Mukesh Vyas	FORBES MARSHALL
Networking Dinner	**7.00 PM**	
Day-2	**13-Apr-13**	
Session-4 - "Automation /Technologies in Nuclear Power Plants"	**9:30 AM**	**11:00 AM**
Session Chair: Mr. M Bharath Kumar, Associate Director (C&I,R&D and Simulator)	**Session Co-Chair: Mr. Rajiv Gupta, DGM Instrumentation, Engineers India Llimited**	
Design of an Electromagnetically Shielded Electronics cabinet for Indian NPPS	Mr. Virendrakumar Wankhede, Mr. Neeraj Agrawal, Mr. Anand Behre	NPCIL, Mumbai

Environmental Qualification of Instruments for use in Nuclear Power Plant	Mr. Neeraj Agrawal, Mr. Anand Behre	NPCIL, Mumbai
Independent Verification and Validation of Pre-Developed Computer Based Digital I&C Systems	Mr. Harish Rajput	NPCIL, Mumbai
Operating Experiences with Programmable Logic Controller (PLC) Systems in Indian Nuclear Power Plants.	Mr. Vinay Soni, A.V Ughade, Mr. K K Chandra, Mr. C P Shrivastwa	NPCIL, Mumbai
System Reliability Estimation and Updation	Mr. Lalit Kumar Singh, Mr. Ajita Srivastava, Mr. S K Goswami, Mr. Agilandaeswari K., Mr. M Bharath Kumar.	NPCIL, Mumbai
Networking Tea Break	**11:00 AM**	**11:30 AM**
Session-5 "Automation in Thermal Power Plants "	**11:45 AM**	**1:15 PM**
Session Chair: Mr. Pankaj Bhartiya, GM-CENPEEP, NTPC	**Session Co-Chair: Mr. V P Raman, DVP, ISA District-14**	
Unifying Security and Safety communication over IP Infrastructure	Mr. Tom-Andre Tarlebo	Zenitel
Small, High-sensitivity simpler single beam, New Series, Infrared Gas Analyzers for wide range of applications	Mr. Sanjeev Kumar Gupta	Analyser Instrument Co. Pvt. Ltd., Kota
Real Time Measurement of Carbon in Fly Ash for Coal Fired Boilers in Power Plants.	Mr. Anup Shukla	ABB Limited
Predictive Emissions Monitoring Systems (PEMS): A Novel and Cost-Effective Method for Continuous Compliance Monitoring of Source Emissions	Mr. Thomas Eisenmann	DURAG, Germany
Defence in Depth: A multilayered approach to cyber security of IACS(Industrial Automation and Control System)	Mr. R Sararangapani	NTPC NOIDA
Networking Lunch Break	1:15 PM	2:15 PM
Panel Discussion on Cyber-Security In the context of Plant DCS Controls	2:40 PM	4:00 PM
Panel Chairman: Mr. S. C. Pandey, ED (NC), NTPC	Panel Co-Chairman: Mr. Nandkumar, MD, Chemtrol	
Cyber Security for Automation Systems in the Power Industry and Global Best Practices	Mr. Sarosh Muncherji, Sr. Security Consultant Industrial IT Solutions,	Honeywell Process Solutions
Mr. Amitava Biswas Country Head – Honeywell Process Solutions		
Mr. Shreesha Chandra Sr. VP, Yokogawa Limited		
Panel Facilitator: Mr. R Sarangapani, NTPC		
Honours and Awards	**4:00 PM**	**4:30 PM**
Networking Tea Break	**4:30 PM**	**5:00 PM**

Invited Papers

CONTROL & INSTRUMENTATION – USER'S PERSPECTIVE FROM DECADE OF PROGRESS TO ERA OF NEW POSSIBILITIES

Debabrata Guha
Executive Vice President & Chief,
Corporate Engineering, Tata Power

Ashok Kumar Panda
Head, Control & instrumentation,
Core Technology & Diagnostics, Tata Power

Abstract

Universally acknowledged is the fact that the leading stations of the world including Indian power plants could not have con¬sistently achieved high levels of overall plant performance without significant contribution by the I&C systems. Technology opportunities have undergone a significant evolution over the last few years, creating many innovative openings for the implementation of increasingly complex control systems for industrial applications.

This paper will briefly review the successes and changes brought about in control and instrumentation field over the last decade and how the technologies have grown and significantly expanded in capability over the time. We will then review the current 'state-of-the-art' and discuss where these new technologies will lead in the future.

Identified in this paper are the some areas of opportunities for process improvement, which can be offered by the continued expansion of processor power and speed, enterprise-wide data visualization, the incorporation of sophisticated embedded intelligence for on-line process optimization.

Keywords: Industrial Control System, DCS, Model Predictive Control, Control Loop, Simulator

1.0 Introduction

Control & automation systems form the bed-rock of the power domain in terms of reliability, availability, stability, safety and maintainability. The role of automation is becoming more and more important with the rapidly changing production schedules, varying fuel qualities and tightening environmental requirements. In sum, the current operational environment is far more sophisticated than at any time before, yet we've just barely scratched the surface of automation system capabilities.

Over the past decade, automation platforms have progressed from proprietary to industry standard hardware and software and to totally integrated systems with almost unlimited connectivity. Along with the inherent flexibility of the modern DCS platform, is the vastly increased computing power of controllers that offers a host of enhancements which have altered the nature and expectations of plant operations. Traditional functions such as process trending, alarming, logging and historical data collections have become not only easier to accomplish, but easier to share beyond the control room, making the DCS an integral part of the corporate IT infrastructure.

Advanced technology tools possess very human-like heuristic algorithms that can sift through mountains of data and piece together the bits to create useful information that may give a generating company a competitive edge in the power market. Future success depends on continuum of collecting data, developing information from that data, extracting knowledge from the information, and then developing the wisdom necessary to operate a plant, a system of plants, or a complete enterprise in the most economical way.

'Smart' applications involving fuzzy, Neuro etc seek to continuously track actual plant operating conditions, learn as they accumulate experience, and then adjust process set points to optimize production based on a defined goal.

Let us introspect the existing practices, current philosophies being adopted and explore for leveraging the platform to an era of possibilities, may be paradigm shift.

2.0 Advanced Control Concepts

Increased emphasis on more environmentally friendly, efficient, and safe processes has led to focus optimization efforts across plants. This calls for higher and higher levels of efficiency in the management of the operating units in order to fulfill a number of requirements. Among them, the most important are:

- The optimization of the steady state operating conditions according to precisely quantified economic criteria
- Possibility to operate with flexibility over the whole operating range with high rates of load variations,
- Efficient dynamic control strategies explicitly coping with the constraints imposed by technological limits and by environmental restrictions.

Minimizing the boiler and turbine losses during transients, reducing thermal stress, and attaining smooth and stable control actions are the other requirements that have to be attained in order to increase the maneuverability and the economic operation of power plant.

Conventional proportional-integral derivative (PID) controllers give acceptable regulation performance in most standard operating conditions. But highly interacting control requirements, nonlinear process dynamics with exposure to continuous disturbances limits the performance of PID controllers.

Though neural networks, fuzzy logic and other knowledge-based expert systems, used for specific optimization functions such as emissions, unit heat rate and boiler fireside cleaning, but have not been used for the most part, to regulatory role. These advanced concepts need to be slowly pushed through for the next generation of power plant supervisory and regulatory controls. The beauty of today's DCS platform is that advanced control applications are embedded in the system, using the same engineering environment, configuration database, and controller platform for unprecedented availability, robustness and ease of use. No additional software interfaces, data mapping are required to implement the advanced control concepts.

Let us take an example of superheater steam generation process - a multivariable, multistage, and nonlinear process. Due to the energy balance, the gain coefficient of the attemperation process depends on boiler load (steam flow), which makes the process itself non-linear. The phenomenon of slow heat exchange in the superheater tubes, signifies the large time constants associated with the process. With all these dynamics, the steam temperature must be maintained as high as possible in order to achieve highest efficiency; on the other hand, the creep-resistance of the superheater tubes must not be exceeded. This makes SH steam temp control a challenging task for the automation engineers.

In another example of HP Bypass control valve, the downstream temp does not represent what happens in the valve/pipe itself because of damping effect of the pipe, the wall thickness of the thermo well. It may be the case when the downstream temperature (as measured) swings by 5 degree, temp inside the valve/pipe might swing about 50 degree with large gradients. This causes the severe thermal stress to the valve internals leading to a lifetime reduction of valves and piping.

In all such applications, advanced control strategy like model predictive control (MPC), State variable with observer, Artificial Intelligence based control can follow the dynamics of the attemperation and heat exchange processes.

3.0 Alarm Management

At first glance, it seems logical that adding alarms would promote plant safety by quickly bringing potential issues to the attention of operators. With today's distributed control systems, it is possible to quickly and cost-effectively add alarms that would not have been practical in the past. Additionally, alarms tend to be constantly added in different stages of the project but rarely deleted. In fact, the mindset "if it costs nothing, why not alarm it?" becomes an easy trap to fall into.

Flexibility and economy features combined with near-zero engineering effort have contributed to the proliferation and the heightened risk for alarm floods and nuisance alarms, with consequential adverse effect on process efficiency, equipment protection, environmental incident and personnel safety.

According to the Engineering Equipment and Materials Users' Association (EEMUA), "The purpose of an alarm system is to direct the operator's attention towards plant conditions requiring timely assessment or action." If a signal needs to be collected historically, or has some diagnostic value but does not satisfy the litmus test of requiring operator action, then it may be treated as an "alert."

The following guidelines (as per EEMUA, ISA 18.2 standards) may be adopted for an effective alarm management system.

- Suppression of redundant alarms - In case of redundant tripping inputs (2V3 logic), an alarm should be active only when two out of the three inputs are active or output of 2V3 logic high.
- Eclipsing Logic - to address multiple alarms generated from one process measurement. e.g. Vessel level high alarm may be masked by the actuation of high-high level alarm.
- Blocking of alarms from an out-of-service plant/ equipment (e.g. Low-flow on a pump)
- Suppression of major event alarm to reduce alarm floods during periods of drastic increase of alarm traffic. (During a plant trip condition, several failsafe actions automatically initiated, no need of alarming the events for operator action).
- Rationalization of all multiple alarms initiated directly to the root cause.
- Transient alarms associated with load changes are revised or eliminated.
- Grouping of Multiple process alarms from the same plant area
- Blocking of Downstream (child) alarms (such as switchboard protection alarms)
- Only a select few to be designated as "high" or "critical," thereby truly differentiating from lower-priority alarms. Using a three-level system, alarms should be distributed so that 80% are low priority, 15% are medium priority, and only 5% are high priority. Each level of priority should have its own unique audible tone and unique graphic color. The color should not be repeated for use in any other function on the control system graphics.

To make alarm management system more effective, root cause analysis tree may also be envisaged so that all the alarms can be traced back to the root cause with presentation of prioritized set of courses to the operator for recovery options. Operator is free to act on the advice or use his own judgment.

An effective alarm management implementation is dynamic and hence, alarm best practices and the application of a continuous improvement rationale are central to this important activity.

4.0 Unattended and Reduced Attendance Control Room

In 1995, Stanwell Power Station in Queensland, Australia won an international award for unique operating arrangement "unattended operation" as normal practice.

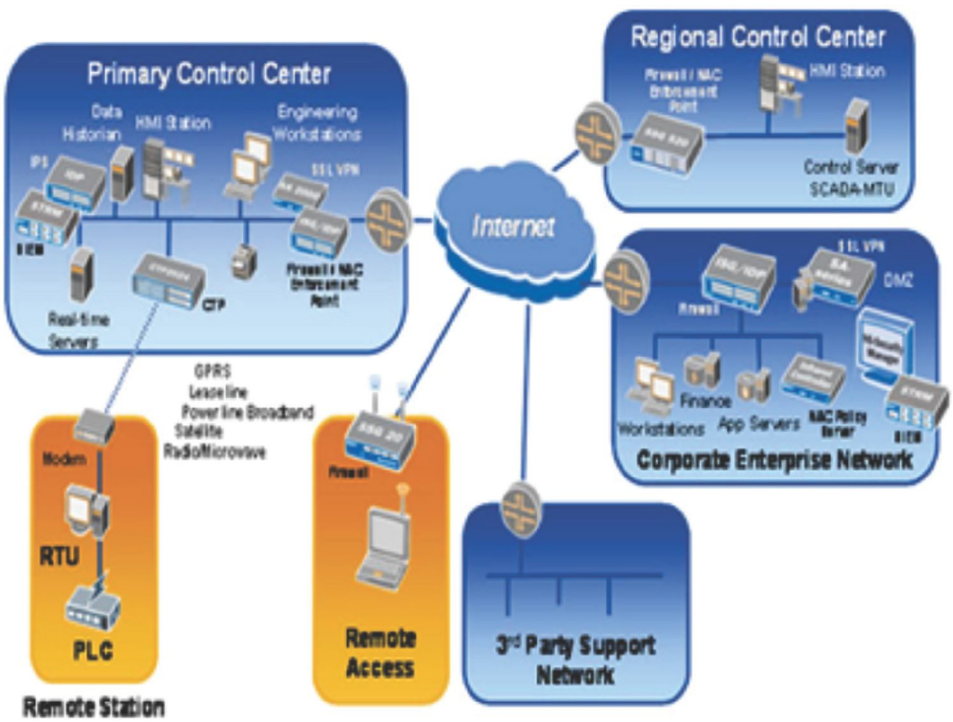
Many recent utility green field power projects have incorporated plant automation, with the goal of reducing the number of operators. Options to accomplish this goal range from centralizing the supervision of common plant functions to establishing fully unattended control rooms monitored by roving operators. A pocket pager or tablet device is carried by the roving operator to receive any significant alarms and advice. Operator recall alarms and lights are located around the plant and are activated if physical presence in the control room is required. The level of plant protection is automatically raised in unattended mode until an operator returns to the control room.

From a physical perspective, the control room is unattended, but from a supervisory perspective, the operator (together with the protection system) remains in effective control of the unit and is at all times able to receive alarm information.

"Reduced attendance" operation - one operator supervising two or more units - defines operator actions largely as responses and interventions, rather than as (the more traditional) monitoring, control, and protection.

The essential design principle is to include single-pushbutton cold, warm and hot startup to full load, advanced modulating control design, highly responsive plant performance, high-reliability control and protection, advanced alarm management, unit islanding etc that will achieve the desired operational regime. A raised level of self-protection is ensured by safety integrity level (SIL) analysis. If other actions - additional load holds, unit runbacks, rundowns, and automatic starting of additional plant equipment - can avoid a unit trip, these should also be taken by the control system.

5.0 Ensuring the Cyber security of Plant Industrial Control Systems



With the introduction of IT based Control Systems, efficiency, reliability and operational flexibility of control system have increased manifold. At the same time, the increased connectivity of control system network to corporate networks has led to an increasing risk of exposure to cyber space & thus to cyber attacks

Risk also extends to smart grid technologies, which are introducing millions of new, intelligent components to the electric grid, those enable two-way wired and wireless communications. These devices communicate in much more advanced ways than was possible in the past. – Today, flexibility enables an array of new functionalities and applications but introduces new potential vulnerabilities.

To date, 225 nos. of control system cyber incidents have been documented globally in electric power, water/ wastewater, chemicals, pipelines, manufacturing, transportation, and other major infrastructures. Impacts of these events range from trivial to significant environmental discharges to significant equipment damage to major electric outages to deaths. In 2012 alone, attacks against the energy sector comprised over 40% of all incidents reported by ICS-CERT. Many of these incidents targeted information pertaining to the ICS/ SCADA environment, including data that could facilitate remote access and unauthorized operations."

The triad of confidentiality, integrity, and availability (CIA) effectively defines the attributes needed for securing systems. In the IT domain, cyber attacks often focus on the acquisition of proprietary information - confidentiality is the most important attribute, which usually dictates encryption requirement. However, in the Industrial control system (ICS) domain, cyber attacks tend to focus on the destabilization of assets. Moreover, most control system cyber incidents are unintentional and often occur because of a lack of effective message integrity and/or appropriate ICS security policies. Consequently, integrity and availability are much more important than confidentiality in ICSs

Certain guidelines must be adhered to maintain the ICS more secured than they are today.

- To develop and implement baseline security policies for maintaining up-to-date antivirus definitions, managing system patching, and governing the use of removable media. (such as the use of only write-once media such as CDs or DVDs, Disablement of USB ports etc). A good backup procedure should incorporate best practices to ensure that malicious content is not spread or inadvertently introduced, especially in critical control environments.
- The normal disconnect is that I&C professionals design industrial control system network but don't understand much IT products and its cyber security implications. Further, responsibility for the integrity of control system network tends to be splintered among various roles. In order to enforce network security, a set of security policies and procedures must be developed by a team of I&C and IT engineers specific for the control system, network and then to implement a system of periodic comprehensive security audit by a certified auditor for vulnerability, penetration testing and other security parameters. This policy to be followed by the vendor during the tenure of the Contract & by O&M thereafter.
- Security features need to be strengthened and more elaborated in the specification stage itself e.g. Firewalls with Intrusion prevention system (IPS) features etc. It is necessary to involve IT expert at the review stage as well as during the FAT of the DCS system for testing from security angle.
- The hardware, software, and firmware that affect cyber security are to be identified in any formal system diagrams or supplier documentation and to establish a living configuration management/ configuration control program that includes the ICS as well as cyber security-specific software (for example, patch versions), hardware (such as network interface cards), and firmware. Make the equipment suppliers and contractors, partners in securing our systems.

ICSs were never viewed to operate in a secure environment, nor are they often considered susceptible to cyber security threats. However, recent cyber security failures have proven these assumptions wrong. The bottom line is that to Change the culture so that security is considered in the same context as performance and safety and to mandate effective cyber security requirements not as a mere compliance exercise.

6.0 Control Loop Performance Monitoring (CLPM) software

Poorly performing controls can cause operational difficulties - increased heat rate, accelerated equipment wear, increased emissions, slower load ramp rates, reduced generation capacity, steam temperature excursions, and unit trips following upsets.

Plants may cycle through daily load changes; have different burners in service and burn coal of varying quality. Control loops may respond differently under different operating conditions – may be stable at full load but oscillate at low load. It would be helpful if loop performance-monitoring applications evaluate the control loops and provide a more targeted corrective action for process control engineers.

The main functions expected from several control loop performance-monitoring (CLPM) software products, commercially available now are as below.

- Assessing loop performance automatically and to identify poorly performing ones.
- Prioritizing bad actors - provides a prioritized list of poorly performing loops based on the criticality.
- Diagnosing control problems- not only indicates which loops have poor performance, but also attempts to give a diagnosis of why the performance is poor.
- Providing guidance on problem resolution- provide steps for validating the diagnosis and resolving the problem.
- Maintaining performance and tuning history - maintain history related to several aspects of

control loop performance and controller tuning settings. These settings can be trended over time to see the effect of tuning changes on loop performance. It is helpful to see at what point in time the tuning settings were changed, what the old values were, what they were changed to, and what effect the changes had on loop performance, loop stability, and standard deviation in error.

CLPM software can be very much useful to less-experienced process control engineers by helping them differentiate between good and poor loop performance and diagnosing the causes. It greatly reduces the overall commissioning cycle time and simplifies the tuning of the complex and critical control loops.

7.0 Power Plant Simulator

Training simulators have practically become a necessity in today's power producing industries for the operators, engineers and plant management in how to best operate the facilities.

Training simulators are used to meet a number of needs:

- Validation of process equipment design, equipment sizing & Control strategy; Process operability analysis; early identification of design problems to avoid costly corrections.
- Investigation of process and operational changes is simplified - engineering staff can investigate the heat rate and life expenditure effects of changes like adding a bypass valve or damper or changing the startup procedure.
- Plant operators can operate a virtual plant, using controls and interfaces that are the same as in the actual plant with actual plant responses and results. This reduces initial startup problems dramatically, and shortens duration for new plant or control system upgrades.
- Since actual plant malfunctions may occur very infrequently, the simulator provides a method by which the operators can be trained to be ready for a multitude of possible malfunctions to which they would not otherwise be exposed. Serious plant equipment damage is often avoided when operators are properly trained with simulated malfunctions.
- Simulators help to ensure uniform operation of the plant, leading to consistent and efficient operating procedures followed by all operators. This is a very important factor in both economic and safety considerations.
- Control engineers can experiment control design changes and implement new control schemes before they are implemented in a "live" plant situation, thus eliminating unforeseen problems and facilitating a smoother integration of new control schemes.
- Simulator is used to uncover any control system configuration issue, hidden "logic errors" that might lead to subsequent unit trips, equipment damage etc. These errors only reveal themselves when certain operational sequences are performed and all of the control system pieces are integrated with real world timing.

The latest DCS simulator technology provides a "virtual controller" PC-based environment that can be easily coupled to a range of low- to high-fidelity simulation process models. It is now possible to create a 'virtual' simulator where the actual DCS application software can reside on a desk-top PC, with one PC able to emulate up to 20 DCS controllers. This allows the simulator to be easier and less expensive to maintain, creating a far more flexible and valuable asset.

The quantum of instrumentation, control logic and interlocks involved in today's power plants is quite enormous and complexity varies further for supercritical, USC and A-USC power plants. The major benefit of this simulator is to enable operators to learn the "dynamics of the plant" and validate the process control logics and evaluate possibility of de-bottlenecking in the existing plant or even before the plant is commissioned.

Building operator confidence is the key to being well prepared for smooth operation and to support faster commissioning. The Simulator provides the control system with its final touch – putting it through what can be thought of as a "dynamic" FAT, testing the control system just as the operator would use it. In addition to dynamic tuning, this testing also uncovers

8.0 Community of Experts

Automation systems are now “network enabled” and fast becoming communications channels that transmit the real-time data to automation supplier’s center of excellence and to the experts around the world. The computers may be at a power plant, but the expertise and software will inevitably be located elsewhere. Providing the right information to the right person at the right time for informed decision-making saves time and thereby improves operational efficiency. Performance-enhancing products and services can be provided through the portal to increase efficiency and minimize downtime, so that the operating costs can be reduced by optimizing all the plant’s processes as a whole rather than piecemeal.

This way, a community of experts — operators, maintenance engineers, management, engineering consultants, Original equipment manufacturers — can collaborate towards the common objectives: targeted quality, maximum production, minimum environmental impact, and minimum costs. This is the forum to share & post details of experiences, meet as we travel; talk as we face issues; etc. The automation system then becomes a platform that runs or interfaces with many different application programs obtained from the “community.” Clearly, bullet-proof tools for information security, notification management, messaging, and application integration are required.

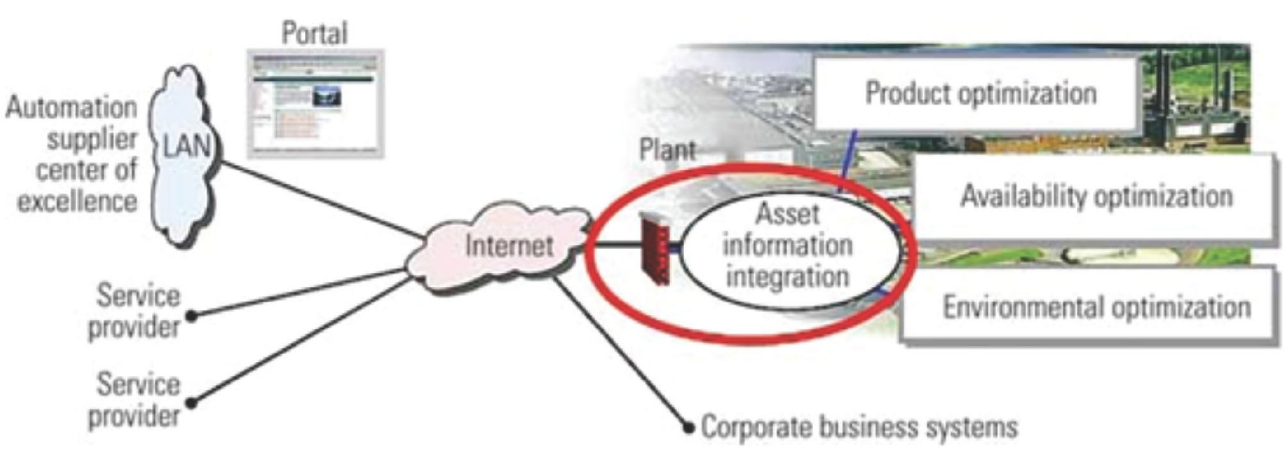
In short, automation systems of the future will further improve plant reliability by leveraging communities of expertise with advanced, open information technology tools and hardware. Why can’t we establish centers of excellence so that an organization behaving as a community is engaged to solve short-term problems and to develop evolving procedures for optimizing performance?

9.0 CONCLUSION:

The future of power plant operation will be about squeezing the last drop of performance from existing power generating assets. Our challenge as an industry today is to continue to develop and implement the right technology tools that will push us a little further along this data-information-knowledge-wisdom continuum.

Power generation is generally perceived a very conservative industry when it comes to accepting new technology. This stance is justified by the critical nature of the product that must be supplied instantly, continuously, and with very high reliability. However, simply relying only on fully mature technology, as is our habit, may result in a significant lost opportunity to modernize the power generation infrastructure. Several new technology concepts are matured enough that promise to improve the process and cost of delivering electricity.

Both, Indian utility power stations and C&I manufacturers have to effectively plan and gear up so that this the advanced technology concepts could be quickly absorbed and ap¬plied to power industry more extensively.



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Mr. Debabrata Guha, is a First Class First Electrical graduate from Bengal Engineering College, Shibpur in 1977. He has joined The Tata Power Co. Ltd. in October 2011, as Chief of Corporate Engineering with responsibilities of engineering of Power plants, Transmission and Quality Assurance. He has an overall working experience of over 34 years in various companies.

Mr. Guha has 14 years experience with Reliance and headed the Engineering and QA function. He was involved with detailed engineering, erection and commissioning of Refinery and Ultra mega power project. He was also involved with Engineering and implementation of Distribution projects including Network Planning, Automation, SCADA.

He had worked with NTPC for 19 years having detailed knowledge in engineering of coal and gas based thermal power plants. He joined NTPC as a engineering Executive Trainee and had been awarded the Gold medal for the best Executive trainee.

Ashok Kumar Panda is First Class (Honours) graduate in Electronics and Telecommunication Engineering from NIT, Silchar and a post graduate (Silver Medallist) from IIT, Delhi. He joined Tata Power in 2012 as Head, Control & Instrumentation, Core Technology & Diagnostics.

Earlier, he was working in Lanco EPC division as HOD, C&I engineering for last 4 years and had been dealing the C&I engineering of thermal, combined cycle and solar power projects.

He had joined NTPC in 1991 as EET and had worked in areas of O&M, Engineering and had been involved in several optimization projects.

C&I SYSTEMS FOR NUCLEAR POWER PLANT

By
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Indian Nuclear Power Plants (NPP) are operating Safely and Competitively. Automation in NPP enhances the reliability of plant control and safety systems. The automation of the C&I in our NPPs is done to a large extent through an integrated plant-wide approach. Plant relies on C&I systems for protection, control and monitoring. In addition the C&I systems in NPP shall include provisions for in-service testing and maintenance tasks. The life cycle of C&I Systems comprises defining the requirements, design, product development, Installation, commissioning and operation. The C&I also addresses the outage support, operator training, enhancements, and upgrades throughout the life cycle of our plants. We minimize total plant life-cycle costs and disruptions through proper maintenance and support strategies specific to each plant's long-term needs. C&I automation at NPCIL balances analog / Hardwired system maintenance and enhancements with phased digital system upgrades.

C&I systems for nuclear power plants are important not only as means for executing control logic but also as means for providing a human-machine interface for operators. NPCIL is continuously striving to develop such systems for the fusion of human and machine.

In nuclear power plants it is essential to understand what is happening in the plant as a whole at all times. To achieve this with a minimum of difficulty, plant operation and monitoring data is amassed and compiled in a central control room. The interface provided between the equipment and operators is essentially screen based with soft controls. Additionally, to ensure sufficiently good acknowledgment and response time in emergency situations, the system is equipped with dedicated hard switches, indicators and recorders exclusively for the following purposes.

(1) Essential alarms

(2) Controls for Safe Shutdown

(3) Recording relevant parameters

The C&I systems provided in NPCIL plants use that both commercial and custom built technology satisfying the reliability requirements demands of the equipment. The operator work stations are designed based on the commercially available computers and the control computers through embedded systems with custom built technology.

This paper discusses the intricacies in the implementation of the C&I systems for the NPPs.

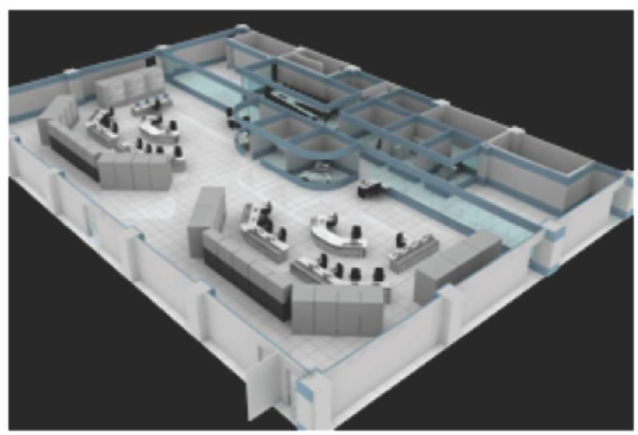

Fig 1: Typical MCR for 700 MWe NPP

M. Bharath Kumar
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Innovative

TEMPERATURE IMBLANCE AND FLUCTUATIONS DUE TO DIFFICULT FUELS - DIAGNOSIS, COUNTER MEASURES

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KEYWORDS

Difficult fuels, radiation influence, imbalances of temperatures, acoustic gas temperature measurement, combustion diagnosis and optimization

INTRODUCTION

The fire in a furnace often develops an unknown life of its own. This applies in particular in boilers with difficult fuels, mainly hard coal, lignite or waste. Varying fuel qualities and/or modification of the boiler operation makes a safe and economical operation more difficult.

The acoustic temperature measurement has had a pioneer role for the diagnosis of the combustion. The significant advantages result from the fact that the measurement is not influenced by radiation. Using this information the goal is a temperature-optimized operation of the furnace to operate with

– a wide range of variable coal quality
– not yet specified optically “bright” fly ash
– low-NOx (locally substoichiometric) operation
– stable fuel/air ratio at low excess air

The experience in applications by boilers and with difficult fuels and the implementation into the control has led to significant developments concerning two-dimensional resolution, reliability and measurement speed.

COMBUSTION TEMPERATURES

Often only little information is available about the fire in combustion chambers. The result of temperature measurement is often significantly influenced by radiation effects; an example for this is quantified in Figure 1.

The figure compares a measurement made by thermocouples (green and blue) and a suction probe (HVT, red) at the same position. At a relatively low temperature the radiation error in the thermocouple reading is already -60 to -100 K. The considerably more sensitive curve for the suction pyrometer is particularly noticeable.

The most interesting information (which is mostly unknown) is about temperature imbalances. Corrosion and slagging are affected by the maximum temperature values (not on the averages). Minimum temperatures affect efficiency and eventually NOx production. Temperature fluctuations can be important for flame stability, but also the range of the average temperature can surprisingly vary with “unknown” fuel properties.

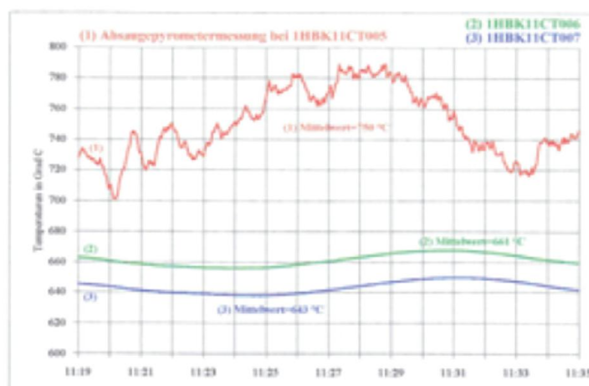

Fig. 1: Comparison of measurements made with thermocouples (green and blue traces) and a radiation free suction pyrometer (red trace) at the same position.

Average temperature

It is known that power plant boilers are often operating above the design temperature values. This is due to a new and wide range of coal quality. Figure 2 shows the average furnace exit temperature (green = measured and red = calculated by a diagnosis software) and the boiler load (steam quantity, green) for a lignite power station. The boiler is operating with constant load. At full load the acoustic measurement shows a range of

1080 to 1200 °C. In several situations the temperature increases up to 100 K although the load decreases (red arrows). This is not explained by variations in the excess air or fouling.

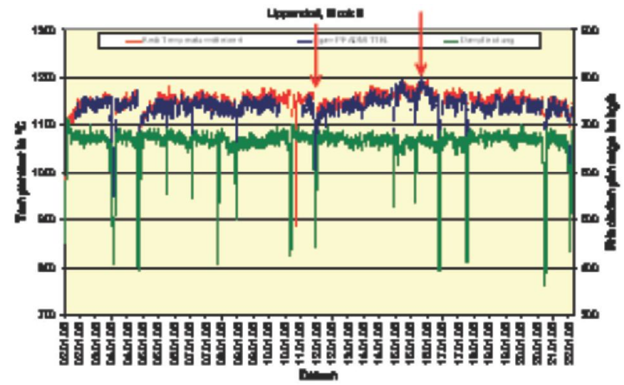

Fig. 2: Average FEGT (blue and red) and steam flow (green)

The temperature range at the furnace exit can be significantly influenced by the optical emissivity of the fly ash. Emissivity values (ε) of around 0.8 have been used in the past. Nowadays ε-values of around 0.4 or less are considered for some types of coal. The view into a furnace is shown in Figure 3 with bright ash covering the furnace walls of a hard coal fired steam generator. A mixture of 25 % South African coal (ε = 0,46 %) and 75 % Columbian coal (ε= 0,69 %) has been used, the average emissivity ε ~ 0,6 %.

At low ε-values the absorption is lower, the furnace becomes more "transparent" and due to a higher degree of the reflection optically "brighter". The radiation arriving at the furnace walls does not only come from the heat of the observed level - it also contains radiation from the lower parts of the furnace which are 200-300 K hotter.

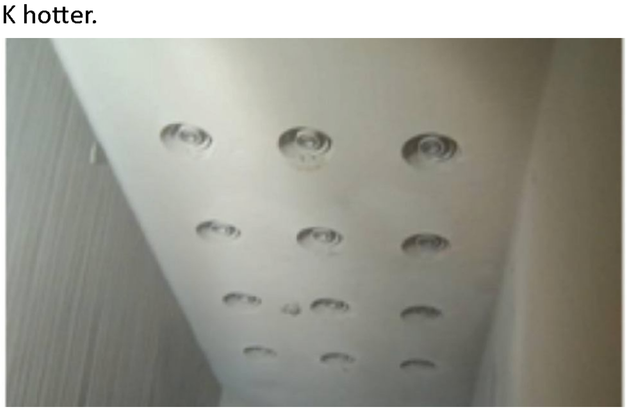

Fig. 3: Walls of a hard coal fired steam generator covered with "bright" ash [1].

The resulting uncertainty of the gas temperature at the furnace exit is 100-150 K. Figure 4 shows the vertical temperature profile for ε-values from 0,45 to 0,68 [1].

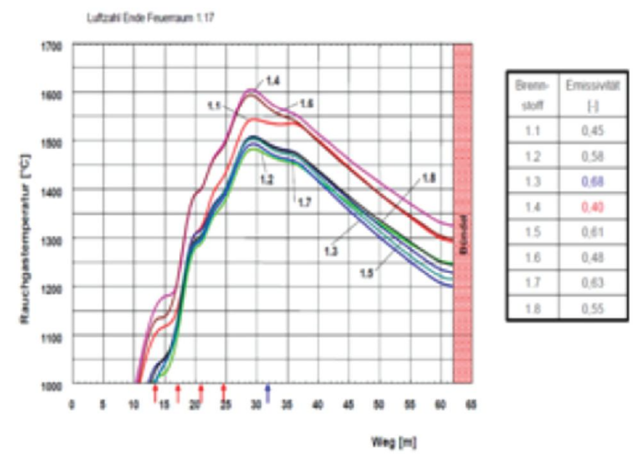

Fig. 4: Variation of FEGT for hard coal with different emissivity values ε [1]

Temperature fluctuation

The fluctuation of the local temperature can be interesting information for the stability of the combustion, especially at critical low load conditions or during start up. Figure 5 shows the trend graphs of 3 path temperatures, measured by an acoustic system in lignite fired furnace over 3 days.

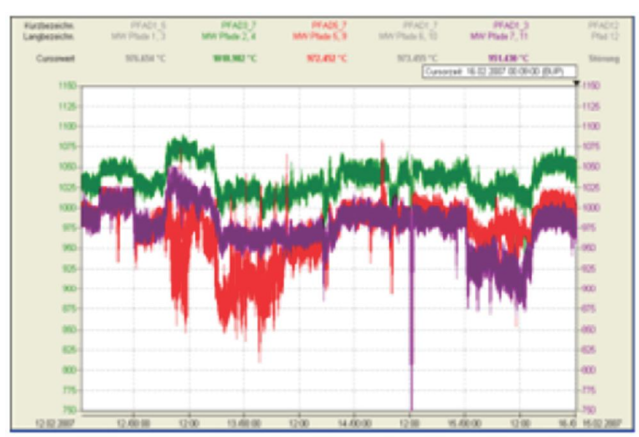

Fig. 5: Temperature range indicating local fluctuations.

At two operational situations the load has been reduced 30 % (burner shut off). It can clearly be seen that the fluctuation of the temperatures in cold section (red graph) is significantly higher. The information can be important for boilers with the tendency of "flame blow off" (flame out).

Temperature imbalances

The following graphs in Figures 6 show examples of two dimensional temperature distributions in hard coal and lignite fired boilers.

Local temperature deviations of 200 – 300 K are commonly found in power plant boilers and 300 – 400 K in waste incinerators, often even higher. The maximum local values from imbalances plus superimposed time dependent fluctuations result in temperature peaks and these must be reduced.

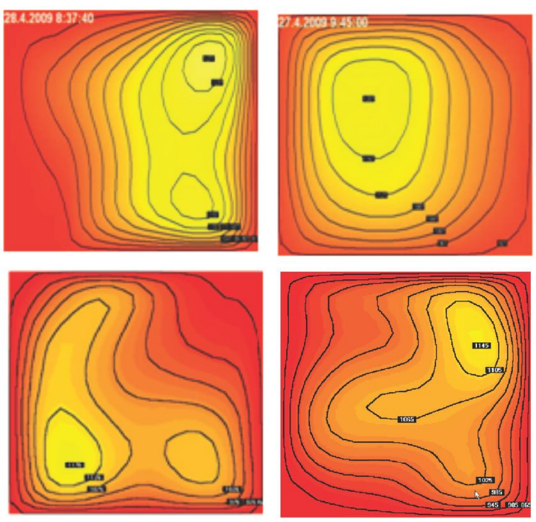

Fig. 6: Temperature distributions in 200 MWel hard coal, opposite wall fired (above) and in 800 MWel lignite, tangential fired (below)

MEASUREMENT METHODS

The following temperature methods used for the diagnosis and control of boiler operation are briefly discussed.

Thermocouples

Thermocouples, used since approx. 100 years, are the oldest possibility to measure temperature in the combustion. The influence of the radiation coming from the background of the furnace leads to errors of -100 K to +200 K of the thermocouple measurement at the furnace exit.

HVT probes offer a possibility to measure without the influence of radiation, but this method cannot be used continuously in combustions.

Optical pyrometer

Radiation thermometry is being used for more than 70 years. Errors of 100 K - 200 K due to the radiation influence from the background have to be considered for their appliance at the furnace exit [2]. The use of various optical measurement systems (different frequency ranges, detection of the CO2 band) results in significant differences of the measurement.

Laser

Lasers are being used since 40 years for the non-contact measurement of gas components and aerosols. Physical basis for the flue gas temperature measurement is the Boltzmann radiation law applied to specific gas components. Only few information on the accuracy are available (manufacturers state 5%). Information on interference and cross-sensitivities in the boiler environment are not known. Comparative measurements from both directions on a common geometric measurement path are not known.

Acoustic pyrometer

The acoustic pyrometry is comparably a young method (since approx. 20 years). Due to the physical principle, the measurement is not influenced by radiation and has clearly defined measurement geometry. Due to the propagation of sound the measurement allows multiple path measurements between all sensors in a grid. Sensor adjustment is not required. It is suitable for high dust loads (blast furnace, fluidized bed). The guaranteed accuracy is 1 - 2%. In some boilers disturbances of the acoustic measurement by the operation of certain levels of soot blowers was observed. This required an additional filtering of the acoustic signals. Each geometric path is always measured in both directions.

ACOUSTIC GAS TEMPERA-TURE MEASUREMENT

The acoustic gas temperature measurement technique operates on the principle that the speed of sound in a gas is dependent on its temperature. The system measures the transmit time of a sound pulse over a known distance between transceiver units (transmitter and receiver) and computes the average temperature of the gas along the acoustic path (Figure 7).

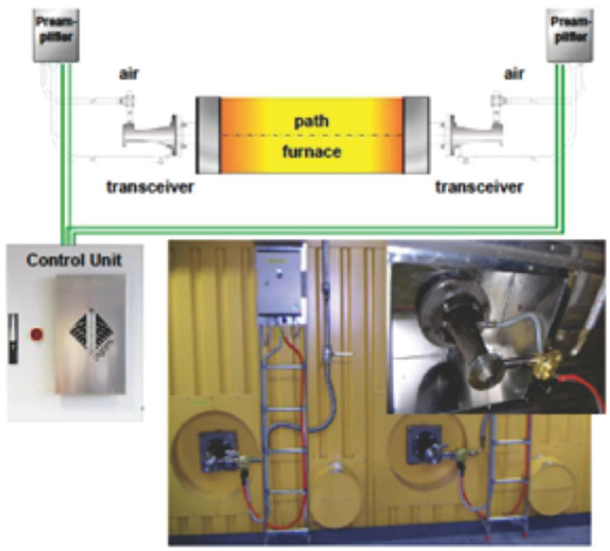

Fig. 7: Schematic representation of an acoustic temperature measuring system

So-called multiple path configurations can be obtained by placing several transceivers in a plane with up to 96 paths. Figure 8 shows a typical configuration in coal fired boilers with 8 transceivers providing 24 paths (48 paths in both directions).

Plant air is used to generate a random noise signal and also keeps the opening free of fly ash. During sound transmission, signals are simultaneously recorded at all positions; up to 16 paths can be sampled simultaneously. All paths are measured bi-directional and the number of paths is not limited.

In the example of Figure 8, a total of 48 path temperatures is measured in both directions. A control unit controls the transceiver units and digitizes the signals, an external computer determines the flight time of the sound pulse using special correlation techniques.

By using tomography algorithms a multiple paths arrangement allows the generation of temperature distribution profiles in the plane which is displayed as an isothermal contour plot or as a zone average temperature diagram. The zones are user defined sub-areas in the grid.

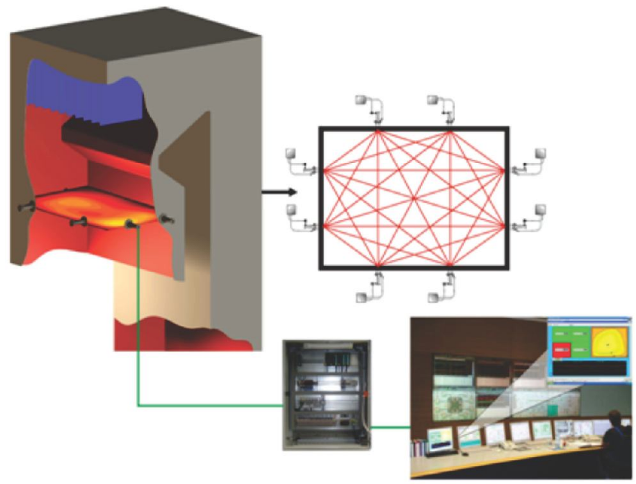

Fig. 8: Multiple paths arrangement at the furnace exit

The acoustic pyrometer makes use of the physical properties of the gas and gives a 'sensible' true gas temperature free from the effects of radiation. Due to the signal processing the measurement is not susceptible to drift and free from aging, also in the case of fouling of the components or sound pressure variations. A calibration is not necessary.

DIAGNOSIS AND EFFECTS

Temperature imbalances and layers are synonymous with imbalances between local O_2 values. High local temperatures correlate with low O_2 values (eventually with a lack of oxygen and CO), and can increase the danger of corrosion and slagging. Locally low temperature reduces efficiency and can affect NOx.

Figure 9 shows the influence of temperature imbalances in the furnace on CO peaks. A reduction of the imbalances from 100 K to about 50 K (left graph) already reduced all CO peaks significantly (right graph). The balancing procedure has been carried out by small adjustments of the amount of fuel charged to the mills.

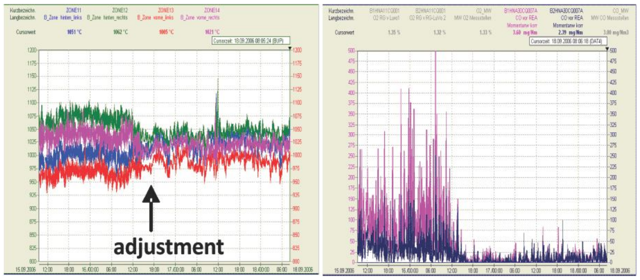

Fig. 9: Effects of a balancing on CO (800 MW, Germany)

The relation between the local temperatures at the furnace exit and the local O2-values has been determined as follows: A local change of 1 % O2 (i.e. alteration of the λ value by 0.05) corresponds to a change of the local temperatures of approx. 70-120 K (a 1 % change of the average O2 only correlates with a change of the average temperature of 20 to 30 K). A relatively small local change in the stoichiometric ratio of 0,05 (5% changing of the fuel consumption or 5 % change of the heat value) leads to a local temperature change of approx. 100 K. This means:

- Small changes in the fuel to air ratio significantly influence the temperature.
- Balancing can be carried out by small changes in the fuel charge or air supply.

As an example the following Fig. 10 shows the effect of a manual adjustment of secondary air distribution (front-back) to temperature imbalance. It is seen that a relatively small trimming of the air distribution (2-5 % of the total consumption) changes the temperature imbalance significantly.

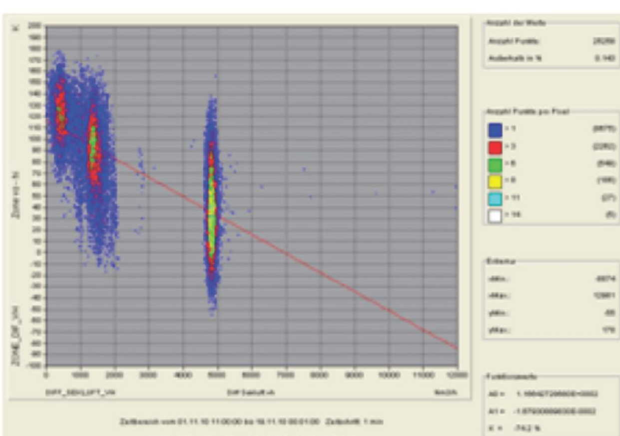

Fig. 10: Temperature deviation front rear (Y-axis) vs. secondary air deviation (X-axis)

The imbalance is of course still present and fluctuates at the last setting between -50 K

automated balancing control which is a standard measure of the acoustic system in incinerators.

Manual balancing has been carried out for the first time in coal fired power plants in 2004 in 800-950 MW tangential fired lignite furnaces (Figure 11).

The isothermal profiles shown in Figure 11 below, have been made by an acoustic system at the furnace exit during balancing.

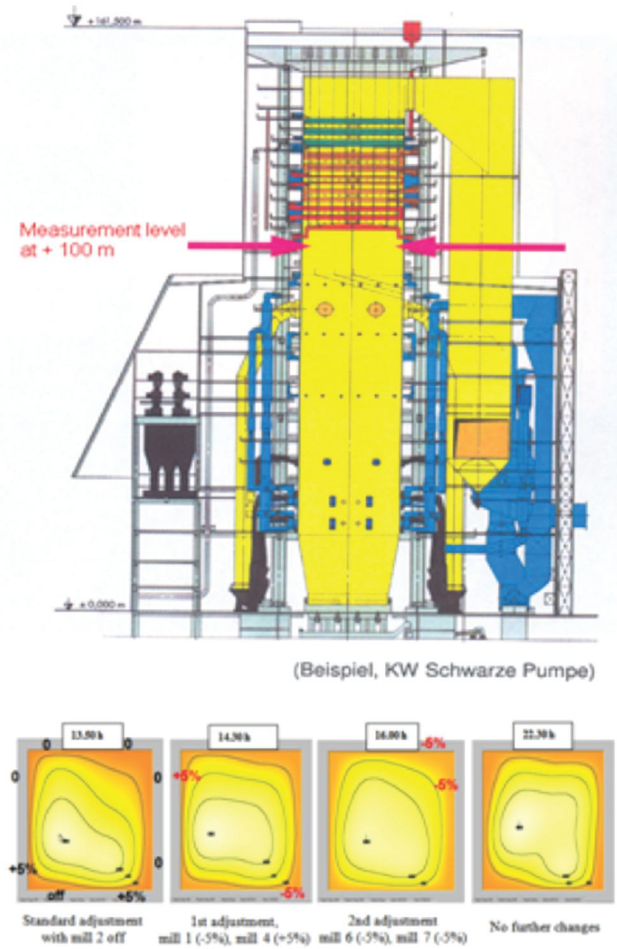

Fig. 11: Configuration of an acoustic system at the furnace exit of an 800 MW boiler. Below, typical temperature distributions made during balancing.

The graph at 13.50h shows the situation after burner/

mill 2 in the front left corner has been turned off. The first balancing step (fuel charges to mill 1 -5 % and to mill 5 + 5 % caused a temperature increase in the front-right area (see graph at 14.30h). The adjustment is completed after the coal flows to mills 6 and 7 are reduced by 5 % (see graph 16.00 h). The temperature distribution remains stable during the following hours (see graph 22.30h).

USE OF BALANCING

It has been shown above that CO and especially CO peaks can be reduced by balancing without increasing the air surplus. This improvement (lower maximum temperatures and lower CO) can be used to reduce the amount of excess air as shown in Figure 12.

In the first half of a week the boiler runs with an imbalance of 80 to 100 K between the left and the right sides of the furnace. In the second half of the week the temperature distribution is homogeneous. The O2 surplus, which is already low at the beginning, could be reduced from 1.75 % to 1.3 %. It is important to note that the CO also decreased although the O2 content was reduced.

There are additionally improvements to be found on the steam side (injection water and at the super heater temperatures) which lead to a net efficiency increase of approx. 0.5 %.

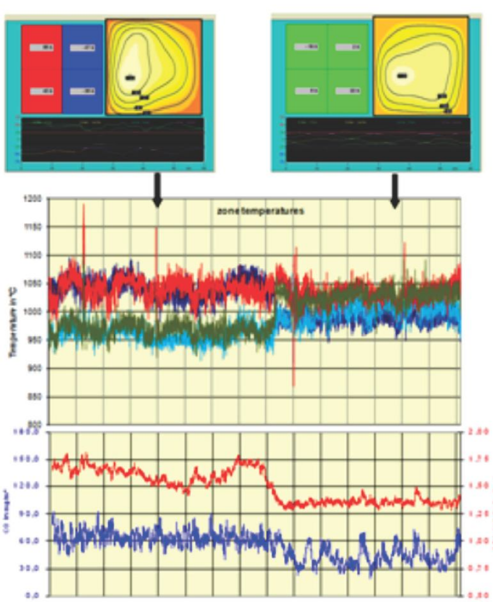

Fig. 12: Effects of temperature balancing on 4 zone temperatures above, O2 (red) and CO (blue), 800 MW lignite

The relation between net efficiency and imbalance has been observed in a 660 MW hard coal fired furnace. The net efficiency and the average imbalance are illustrated in the following XY diagram of Figure 13. (The average temperature imbalance at the x-axis = the average of the absolute values of the 4 zone temperature deviations from the average temperature. This value is approx. half the size of the imbalance, e.g. front-left to rear right).

The diagram shows that a 50 K reduction of the average imbalance (imbalance approx. 100 K) correlates with an improvement of the net efficiency by 0.5 %.

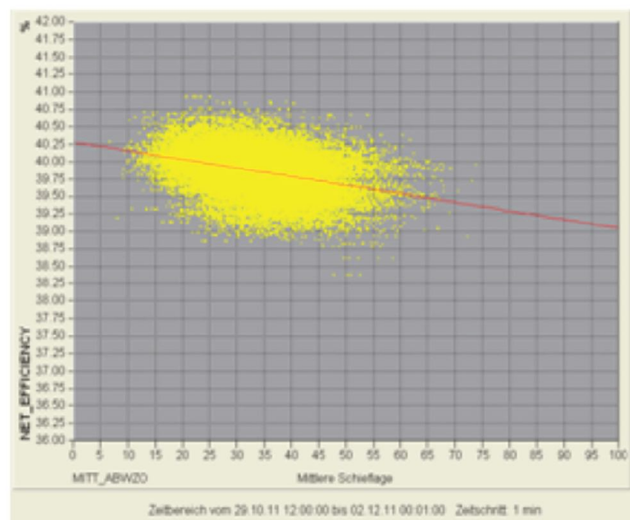

Fig. 13: Net efficiency vs. temperature imbalance, 660 MWel hard coal

The automatic balancing control is state of the art for waste incinerators. It was used for the first time in the waste to energy plant Moerdijk, Netherland. AZN has quantified the benefits of temperature controlled balancing [3]. This includes a reduction of the use of ammonia for the SNCR system, an increase in the operational availability and capacity, less use of the auxiliary burners, reduced maintenance costs, less use of electrical energy, less fly ash and less corrosion. The corrosion reduction is illustrated in Figure14.

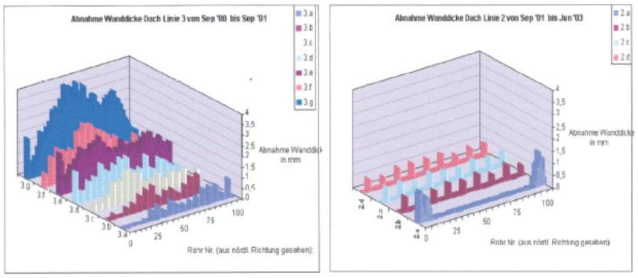

Fig. 14: Corrosion diagrams before balancing (left, rate after 12 months) and after balancing (right, rate after 22months).

REQUIREMENTS AND NEW STANDARDS OF TEMPERA-TURE DIAGNOSIS

The operation of combustions with difficult fuels is currently and prospectively characterized by

– extremely varying coal qualities
– varying slagging and corrosion conditions
– higher standards for boiler efficiency (less excess air)
– integration of the temperature diagnosis into the boiler DCS

The diagnosis of the combustion and the operation has to comply with rapid local changes of the temperatures and spreads of the temperature profile > 200 K. This has led to new standards for acoustic systems concerning resolution, speed and reliability. These are

– high resolution (> 100 temperature paths)
– increased measuring speed (< 20 sec. per complete cycle)
– 3-dimensional measurement between different levels

Automatic balancing control requires a measurement with increased reliability (100 % bi-directional measurement of every path, acoustic signal surveillance, alarm functions), bi-directional data transfer between the measurement system and the DCS and redundancy.

New tomography algorithms have been developed for a high 2d-temperature resolution. This is applied in the top of blast furnaces in order to detect the channeling of high temperature layers (blow through). The developments of small layers in the center and in the boundary area of the blast furnace top are shown in Figure 15.

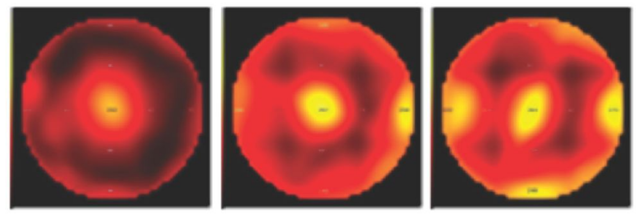

Fig. 15: High resolution tomography in blast furnaces

SUMMARY

The diagnosis of the combustion and the operation of boilers with difficult fuels have to comply with rapid temperature changes, high local imbalances and an unknown wide range of average temperatures.

The required information about the fire is available since the introduction of the acoustic temperature measurement technology. The significant advantages result from the fact that the measurement is not influenced by radiation.

Temperature balancing improves the local O2-distribution and reduces CO-peaks and this is particularly relevant for boilers with corrosion problems or slagging. At the same time, an even temperature distribution leads to higher efficiency and is important for a stable fire at low load with difficult fuels or during start up (flame out prevention).

The requirements from combustions with difficult fuels and with control application have led to new standards for acoustic systems concerning resolution, speed and reliability.

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[2] VDI/VDE Guideline 3511, Technical Temperature Measurement

[3] Ir. Herman van Diederen, Erfahrungen mit Prisma und Kessel in der AEC Moerdijk VDI-Fachkonferenz "Feue-rung und Kessel - Beläge und Kor-rosion - in Großfeuerungsanlagen 2011", 07./08.06.2011 Kassel

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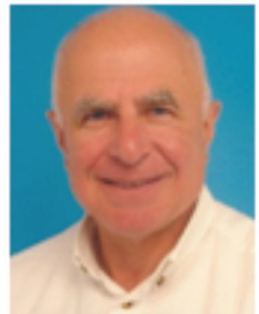

Hans Paul Drescher,

Prof. Dr.-Ing., was born 1945 in Rheydt, Germany. He graduated as physicist at the Technical University Aachen and joined the Nuclear Research Center,

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INNOVATION IN CONDITION MONITORING

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INDEX

1 Introduction

Innovation is the driver to meet continuously evolving market expectations. The objective of innovation carried out – as described herein are to commercialize machinery protection systems which are more reliable and accurate, bring more value for money and are easier to operate. Importance of Condition monitoring in Turbo machinery is something we are all aware of and Vibration monitoring has revolutionized the way today machine condition monitoring is practiced.

The techniques and instrumentation for data acquisition and analysis in condition monitoring are evolving and upgrading along with the advancements in the IT industry globally. However up gradations in the basic concepts of monitoring are seen only occasionally and with turbo-generators growing in size from 210 and 250 MW to 500, 660 and 800 MW, the turbine vibration monitoring has remained the same. It has been observed and felt that monitoring of Generators requires additional and critical monitoring of vibration parameters, not only of the bearings and machine housing but also for windings and stator bars which is discussed briefly in this paper.

This document presents three examples of benefits of improvements carried out on existing systems used in:

- End winding Monitoring;
- Airgap Monitoring;
- Partial Discharge Monitoring.

2 End-winding Monitoring

2.1 Requirements

For economic reasons, the current trend among machinery users is to extend the life of their rotating machinery and increase plant availability and reliability. Instead of replacing 20 to 30 year old machinery, plant life extension programmes are being implemented to operate machinery up to and beyond its original lifespan. However, current operating practices impose severe voltage, thermal and mechanical stresses on the rotors and stators. One such practice involves the run-up and run-down of machines two or more times per day which can lead to premature ageing and cycle-related stator winding deterioration.

Hydro generator application of fiber-optic vibration system is more or less limited to generator-motors of pump storage plants because of their very demanding operating regime; several starts and mode changes(e.g. SpinGen to Generate) a day. This causes the generator-motors to undergo high thermal and mechanical stress causing quick deterioration of the bar insulation, bar solder joints, and bar wedging.

Fig. 1 : Insulation crack and abrasion between end winding support elements

By fact, pump-storage hydro generator and nuclear turbo generator designs exhibit very long end-windings and complex bracing system which are submitted to strong mechanical and electrical stresses.

The following generic failures have been reported which could affect generators availability:

- progressive wear of insulation;
- structural weakness and electrical disruption;
- stator bar rupture due to mechanical fatigue due to machine vibrations.

Life extension and increased availability can only be achieved through condition monitoring of vital machine parameters. This includes the continuous monitoring of end-winding structures for anticipated degradation.

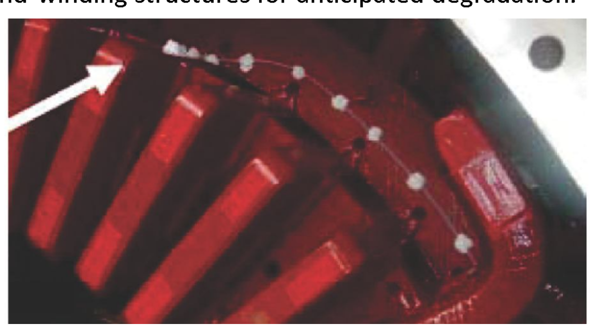


Fig. 2 : Sensor on the end windings cap

2.2 Application and advantages of End winding Monitoring

By generator design, the natural resonance frequency of the end windings, lie nearly above the double of the network frequency. Electromagnetic forces combined with thermal expansion stresses lead to end windings deterioration. The natural resonance frequency of end windings being closer to the double of the network frequency, imply that end winding may enter in resonance during operation. Life extension and increased availability can only be achieved through the continuous monitoring of end winding structures for expected deterioration caused by these electro-magnetic and mechanical forces.

A key factor in the diagnostic monitoring of end windings in particular is the selection of appropriate sensors and measuring systems. The sensors must comply with accuracy, reliability and repeatability requirements and for safety reasons made of non-conductive material in order to avoid any possible electrical hazards.

By design and because of the fiber-optic transmission ensuring high voltage insulation, the fiberoptic acceleration sensor is perfectly adapted for this application of vibration measurements of elements under high voltage like stator bars and end windings. Also, the non-metallic head of the sensor does not disturbe the magnetic field distribution at the end windings. No active electronic elements are used in the sensor head but only optics.

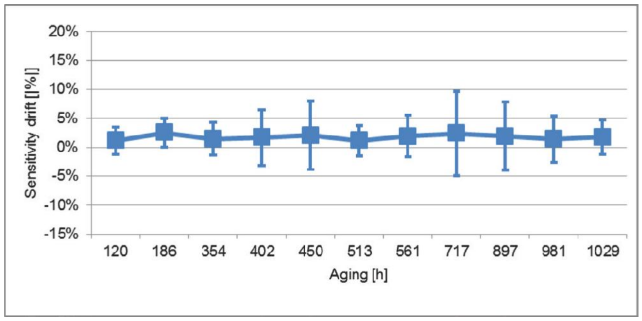
2.3 State of the art Fiber-optic Acceleration Sensor

The sensor is a single piece consisting of three key parts: optical sensor head, fiber-optic integral cable and sealed feed through connector/conditioner. The sensor body is made of ceramic material providing excellent thermal stability and insulation. The fiber-optic integral cable is 5mm diameter, six (6) or ten (10) meters long, and protected in PTFE tubing with an 80mm bend radius. The sealed feed-through connector/conditioner contains the optoelectronic conditioning circuitry. A single+ 24Vdc external power supply is required. The 100mV/g output voltage is directly proportional to vibration acceleration and is transmitted to the centralized vibration monitoring system.

A current version of the fiber-optic acceleration sensor has a built-in double integrator providing a displacement output proportional to measured acceleration. Both, acceleration signal and displacement signal outputs are provided.

2.4 Benefits of new fiberoptic sensors technology

Operational experience shows, that the temperature inside the generators may, from time to time exceed 90°C. The latest generation of sensors remains stable above 1000 hours of 3h 100°C and 3h room temperature cycles. The sensitivity drift at 100°C is well below 10%:

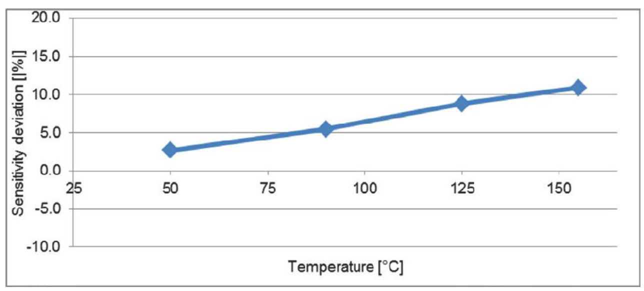


MC-Monitoring Fibre Optic acccelerometer 1

Fig. 3 : Sensitivity check of one FAS-sensor after 5 years of permanent on-side operation –

Characteristic frequency fn = 665 Hz of the individual sensor remain unchanged.

The typical sensitivity drift of the sensor with the temperature shall be well below 10% at 100°C:



MC-Monitoring Fibre Optic acccelerometer 2

3 Airgap Monitoring

3.1 Requirements

Early detection of air gap anomalies shall ease the maintenance tasks by giving the user time to plan for repairs before scheduled outages. Prediction of long term evolution of air gap and shapes of the stator and rotor can be used in operational and rehabilitation planning.

Knowing the magnitude of the air gap between rotor and stator and magnetic field can inform the operator of the need of removing a machine from service before serious damage due excessive or rotor-stator rub.

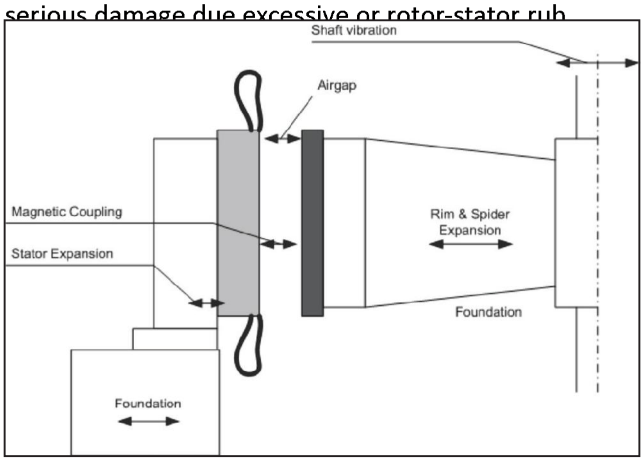


Fig. 4 : Factors influencing the airgap distance

The Air Gap Monitoring system shall detect synchronous machines stator and rotor mechanical or electrical defects. These defects of mechanical origin (wrong positioning of the rotor, mechanical unbalance, mechanical deformation, etc.) or electromagnetic origin (partial short-circuit of the coil, magnetic circuit defect,,etc.), may create important magnetic strengths between the stator and the rotor giving rise to vibrations and in the worst cases a sticking of the rotor and the stator.

3.2 Application and advantages of Airgap Monitoring

Large low speed hydro-generators have a very small air gap stator bore diameter ratio making it impossible to have a perfect centering of the elements during the assembly process. This results in that the machines are operated with an eccentricity that though small is not negligible because of the large rotating mass, and is the cause of undesirable effects like considerable unbalanced magnetic pull forces, vibrations, additional eddy current losses, pole ttips temperature increase, etc.. It is therefore important to assess the eccentricity, the maximum and minimum air gap, the shape of the stator and rotor, the magnetic flux of each pole and even more to check its trend to guarantee a safe operation and prevent any serious damage.

The high precision airgap monitoring system uses a capacitive measuring technique developed and commercialized by MC-monitoring SA to measure static and dynamic movements (distance) in severe electrical and electromagnetic environments in large generators and electrical motors.

Non-contact measurement ensures an unlimited sensor lifetime without wear. In air gap measurement application, the measuring sensor glued onto the surface of the stator wall measures the variations of the distance to the rotor pole surfaces. The rotor pole surface target consists of steel laminated core.

3.3 State of the art Airgap Sensor

The capacitive type sensor measures the distance between its surface and the rotor pole surfaces.It measures the variation of the capacitance between the two surfaces separated by an air dielectric.

The impedance adapter provides an amplitude modulated signal being the image of the measured distance at the carrier frequency. This signal shall be narrowband filtered and demodulated to obtain the static and dynamic signal outputs proportional to air gap as current and voltage signals. These outputs reflect the raw air gap signal so called "Pole Profile". After peak detection and filtering a minimum air gap signal" Minimum gap" is provided for protection system.

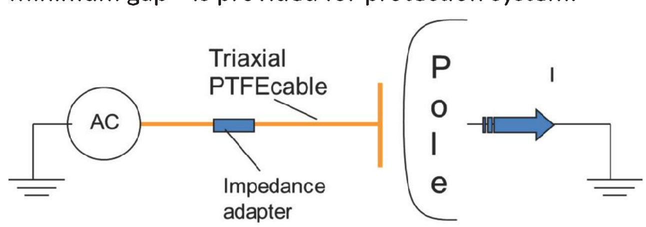


Fig. 5 : Airgap Transducer measuring principle

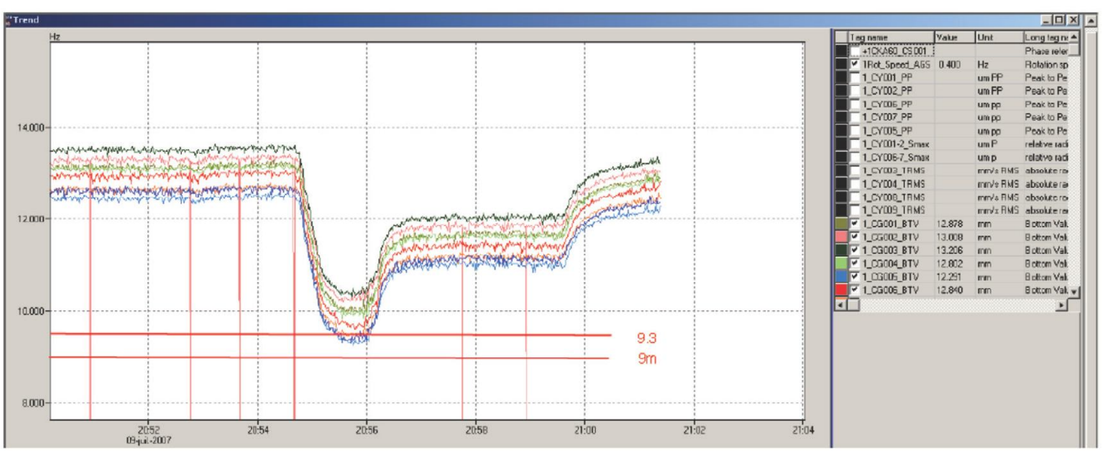
3.4 Benefits of the new Airgap Transmitters technology

New developments have been carried-out to replace existing analog-based conditioner by a digital model offering many advantages. The capacitive measurement is carried out via a regulated carrier frequency making it very stable over time. The digital linearization allows a greater fineness and accuracy of the output sensitivity. The 4..20mA output has been designed with galvanic insulation allowing the use of standard input cards with the monitor site. The overall measurement chain is consequently less sensitive to grounding effects.

3.5 Results

Air Gap system is extremely helpful in monitoring the condition of the generators and has helped many customers and OEMs alike in analyzing and detecting generator problems. The example below shows a machine problem during its first run. The Air Gap changed after the overspeed trial from in avg. 12.9mm to 9.3mm. Air Gap Monitoring is very efficient to detect and analyze this problem. As a result of the data analysis, design modifications were carried out by the OEM.

Zoom of Overspeed Operation



Comments:
Before overspeed operation the Air Gap comes back to (13.5mm – 14.5mm at 0% speed), after overspeed the Air Gap never come back to initial values. Air Gap values after overspeed remain at 12.2mm to 13.3mm.
Air Gap at 100% speed before overspeed was 12.3 mm to 13.4mm
Air Gap at 100% speed after overspeed is 11mm to12mm
Air Gap at 152% speed are coming down until 9.3 mm

Fig. 6 : Airgap monitoring results before and after overspeed testing

4 Partial Discharge

Online PD systems are widely used to detect and identify in advance several failures in the insulation of generators' winding. MC-monitoring are developing for more than two years a PD product family able to cover online basic, expert and portable PD expert analysis. Our large and long experience of partial discharge experience in machine insulation testing and analysis and a combination of latest innovative technologies was used to develop a complete new state of the art partial discharge analyser. Standalone operation or in combination with a computer makes it very user friendly in on-site partial discharge testing. The unique system uses mostly all available technologies found on the market today.

Long year discussion on the PD market indicates clearly the acceptance on both major measurement technologies. One of the technologies uses 80pF coupling sensors with time of flight method and the other uses "high capacitance" coupling sensors or called LF Sensors (low frequency sensors using typically 1000pF coupling capacitance) in combination with adapted filters and gating techniques to eliminate noise from outside the generator.

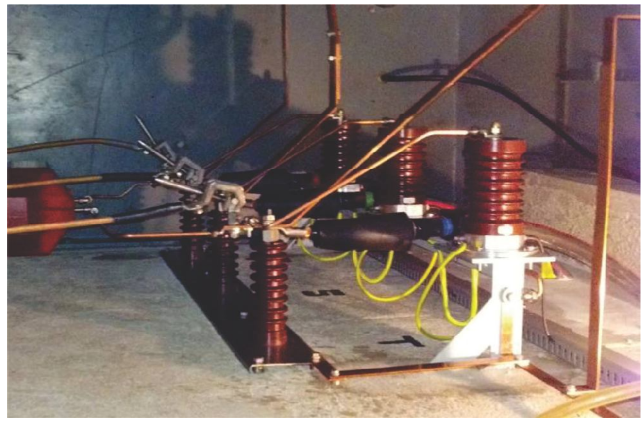
Physical law shows that the use of 1000pF coupling capacitor allowing much higher sensibility in lower frequency ranges and therefore, compared to 80pF couplers, allow an installation outside of generator without loosing the possibility to measure partial discharges even deep in the machine winding. Installation of 1000pF is a relative simple and non-intrusive method and does not need to open the generator winding which weakens existing machine insulation designed by the generator manufacturer.

As larger the sensor capacitance (and therefore measurements in lower frequency ranges) as deeper partial discharge signal can be measured from outside into the generator winding. Comparison measurements between 80pF and 1000pF coupling capacitors have shown that an attenuation of up to factor seven (7) over just one stator bar.

4.1 PD Sensors and its IEC 60270 Compliance

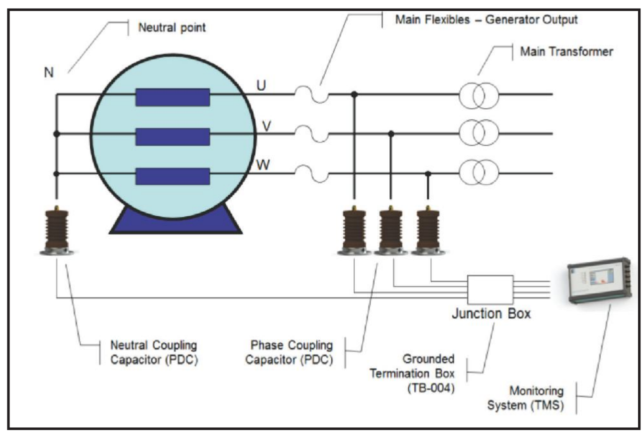
IEC60270 standard requires to measure the partial discharges in its appropriate unit charge “Q” in Coulombs. Additionally it is mentioned that partial discharges should be measured in lower frequency ranges up the a few MHz.

Partial discharge coupling capacitors are widely used for online and offline partial discharge measurements on rotating machines. The sensor is usually installed between the exit of the generator and the bus bars (e.g. at the main flexibles). Permanent or temporary partial discharge detectors / analysers can be connected via standard RG58 BNC cables to the couplers, usually by using a safety termination box in between. The couplers are connected by high voltage lead or copper bars to the busbars or high voltage terminal of the rotating machine to pick up partial discharge signals without any loss. Special adapted measurement impedance located in the bottom of the sensor allows to pick up partial discharge signals as well as the network frequency (integrated voltage divider of 1:2000). This allows transferring partial discharge signals and line frequency (used as a reference) signal over the same signal cable to the partial discharge detector. The Signal output is protected via 90V surge arrestor for personal safety and instrument protection. The shield of the coaxial output is capacitive floating to avoid eddy currents in the signal cables due to high magnetic fields.



4.2 Installation

The picture below shows a typical example of PD installation:



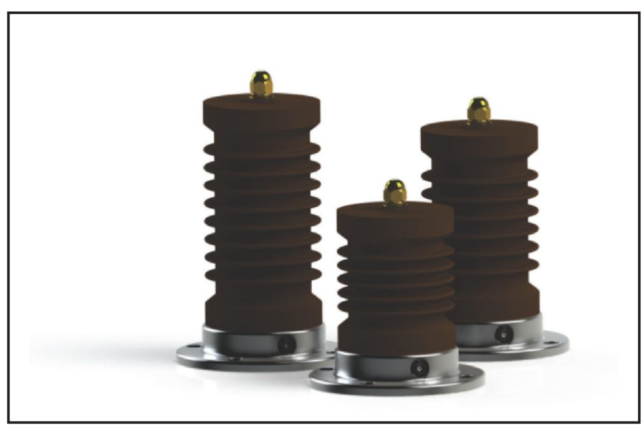


Fig. 7 : Example of installation

Sensor Safety Termination Boxes shall be used to terminate properly the sensor cables includes additional over voltage protection for personal and instrument safety. External BNC terminals allow every time to connect a portable measuring devices on fixed permanent monitoring system installations.

4.3 Automatic Pulse Level Detection (APLD)

Efficient and useful partial discharge monitoring system should give the possibility to compare PD activity evolution within time. As measurement sensitivity depends on the used sensor and the installation setup it is mandatory to calibrate the partial discharge measurement system by using a partial discharge pulse generator, designed and calibrated according to the IEC60270 standard. Modern PD systems shall be featured with built-in APLD to calibrate the amplitude to the actual test and measurement setup.

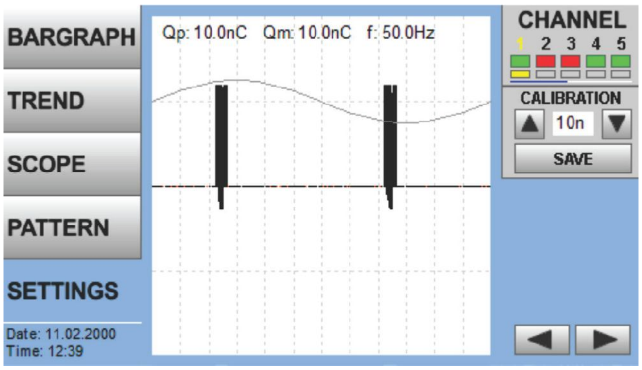


Fig. 8: Automatic pulse level detection

Fig. 9 : Partial discharge calibrator (10nC)

4.4 Benefits of modern PD system

State of the Art PD systems shall be designed with a built-in touch screen display allowing calibration and commissioning without computer to allow easy and fast expertise's of partial discharge activities. High resolution PRPD pattern and active noise elimination through gating channel and variable selectable filters to optimize the frequency ranges, provide particularly accurate analysis. Current PD activities can be locally evaluated thanks to local data presentation such as bar graphs, oscilloscope views, time relation pattern, pulse height distribution and phase resolved partial discharge patterns:

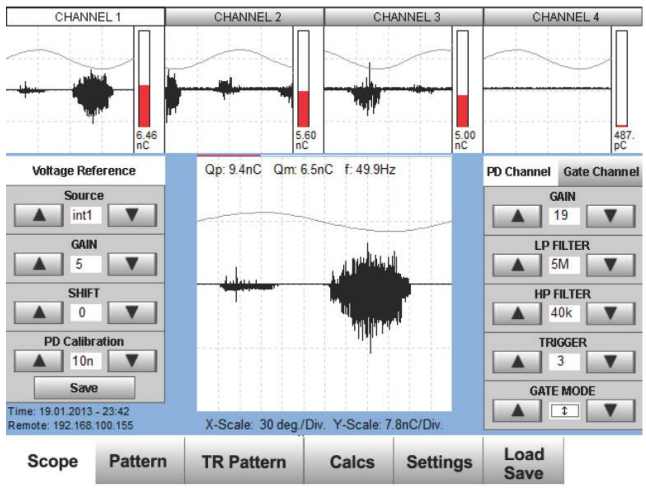


Fig. 10: Oscilloscope Scope View in Persistance Mode

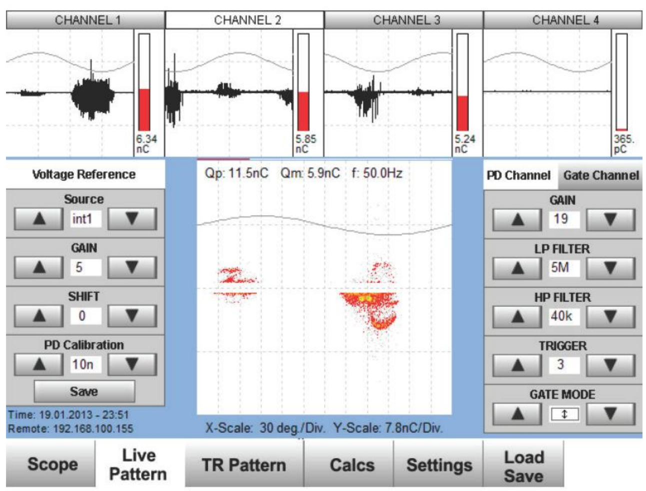


Fig. 11: Real Time Live phase resolved partial discharge Pattern