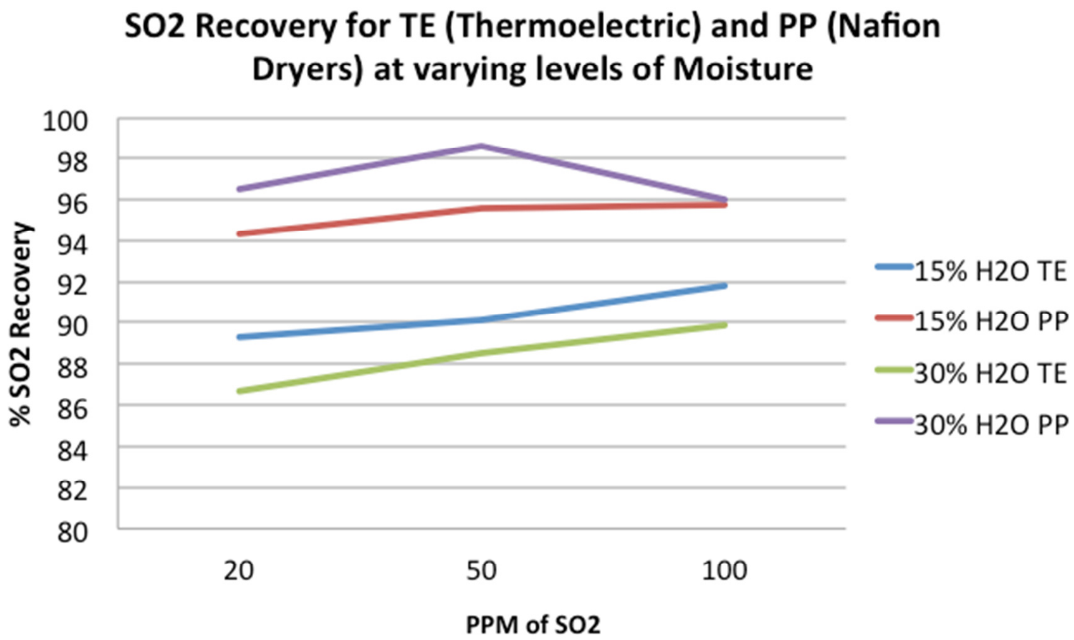

Figure 4: SO2 Recovery in Cooler Vs Nafion

In June 2013, at China National Environment Monitoring Center Lab, Nanjing laboratory samples were tested for SO2 retention in various humidity conditions comparing different gas conditioning methods – various condensing coolers compared to a Nafion™ based GASS system [viii]. The test results are shown in Table 1 below:

SO_2 concentration in the standard configuration: 500ppm; flue gas temperature: 120 ℃

Table 1 laboratory GASS sample gas treatment system test data table

Moisture content	Direct pumping hot wet method DOAS	Cold and dry extraction method NDIR A straight	Cold and dry straight draw method NDIR B	Cold and dry straight draw method NDIR C	Handheld cold and dry straight draw method NDIR	Handheld straight pumping cold and dry method Electrochemical	GASS System
	Full non-condensing temperature	Compressor Condenser	Compressor Condenser	Compressor Condenser	Electronic condenser	Electronic condenser	Nafion drying tube
6.6%	492	488	488	487	470	485	492
10.0%	486	484	484	469	412	481	484
20.0%	482	478	478	464	-	466	487

27.0%	479	477	477	450	460	461	496

The results clearly show that as the moisture content increases, traditional condensing coolers start to lose SO_2 from the sample while the Nafion™-based GASS system does not. For high SO_2 levels (>500ppm), losses of 20 to 50 ppm would not be problematic. As emissions standards tighten to 10-50ppm or lower, however, those levels of losses result in almost complete loss of SO_2 in the sample.

Real World Applications

Zoucheng Power Plant, China

Shandong Zoucheng Power Plant in China was regularly observing analyzer failure due to inefficient sampling systems resulting in large maintenance load, high failure rate and inaccurate measurement. Furthermore, introduction of “the most stringent emission limits in China’s history” further reveals drawbacks of conventional cooler-based CEMS, in particular the condensers’ problems of incomplete water removal and high failure rate of cheaply-produced local systems.

The plant installed Indi-GASS Nafion sampling systems, breaking the technological barrier for sub-zero degree dew point output gas and maintaining a -15C outlet dew point[ix]. The plant has dismantled the condensers, saving costs for purchasing and installing pipes and tubes (original pipes have been damaged due to heat tracing pipeline). Since the installation of the Indi-GASS, the analyzer has been free from humidity alarm and has not shutdown as a result of water ingress. All of those contribute to reduction in system failure and the consequential costs of maintenance and purchase. Encouraged by the good results, the plant installed additional Nafion based sampling systems.

Chevron – El Segundo - Monitoring SOx

Chevron’s El Segundo refinery in California was faced with air pollution requirements imposed by the South Coast Air Quality Management District for the Regional Clean Air Incentives Market. The RECLAIM rule required each source to reduce SO2 emissions on an annual, facility-wide basis.

Chevron had one source with extremely low SO2 emissions, within the single digit ppm range, which was extremely challenging to measure and continued to be unsuccessful in passing the RATA. Results were always close to zero because of loss of SO2 within the system.

A Perma Pure Nafion-based dryer system was installed just after the probe box. The proximity of the conditioning system to the source ensured that there was minimal condensation of SO2 while removing moisture from the sample and the RATA was successfully passed with a spiking method.

Calibration time was reduced from over ten minutes to under a minute.x Since then, Chevron also installed a similar conditioning system on the Catalytic Cracker Unit. The systems have been installed and running successfully for more than 15 years.

Toyota Motor Manufacturing – Measuring NOx

TABC, Toyota's oldest manufacturing plant in North America, operates a plant that produces stamped and welded parts, steering columns and catalytic converters for a number of Toyota's vehicle assembly plants. The plant uses a propriety coating process that generates NOx as a by-product at extremely high levels close to 1000ppm. Their multi-stage pollution control system reduces these emissions to less than 50 ppm. TABC's original sample conditioning system used condensation-based thermoelectric coolers that brought the sample dew point down to about 4C (1% water). Although the coolers were installed, TABC faced frequent issues with daily calibration failures and their analyzers couldn't achieve 90% of the span gas concentration within the time specified.

Recommendations from Brookhaven National Laboratories and the Gas Research Institute confirmed that Perma Pure's Nafion-based conditioning systems allowed more accurate analysis of NOx than coolers and TABC replaced their cooler with a Nafion-based conditioning system. After installation, NOx measurements stabilized and dramatic improvements were seen. The system dried the sample gas to a dew point of -18C (0.1% water) and TABC began to pass their daily calibrations. Because of these improvements, TABC could re-certify their analyzer system annually instead of every six months and cost savings were also realized in materials, labor and testing. [xi]

Comparison of GASS Sample Gas Conditioning System and Traditional Cold-Dry Direct Extraction CEMS

Compared to cold-dry direct extraction CEMS of traditional condensation methods, the GASS sample gas conditioning system based on Nafion drying tube technology has the following advantages:

Table 2: Comparison of GASS sample gas conditioning system and condensation cold-dry direct extraction CEMS

Item	Traditional cold-dry direct extraction sample conditioning system	GASS 6080 sample conditioning system
Particle removal	Three-grade filtration	Three-grade filtration, including 0.1um 2nd-grade coalescing particulate filter to remove acid mist and aerosol

Drying method	Low temperature condensation method, have condensed water. Display cold chamber temperature, to approximately represent the dew point of dehumidified flue gas. There is water discharge from peristaltic pump below	Nafion dryer gas dehumidifying technology without condensed water. Online dew point display.
Flue gas transmission pipeline	High-temperature heating cable	The processed flue gas dew point is lower than 0℃, so only insulating pipe required
Online dew point display	Condenser shows cold chamber temperature rather than the dew point of dehumidified gas	Exclusive Defender online flue gas dew point display, support the RS 485 signal interface and remote monitoring
System stability	Easy to precipitate condensed water. The water reacts with SO_3 to generate sulfuric acid. It will easily corrode probe, instrument, tubes and chambers and thus lead to high failure rate and poor stability.	Gas dehumidification, no condensed water. SO_3 mist can be removed in advance. No moving parts, low failure rate and high stability.
Analysis accuracy	SO_2 is easily soluble in condensed water, especially at low temperature (at the condenser), which reduces the	Dehumidification completely under vapor status, very low SO_2 loss rate, high analysis accuracy
System response time	Regular heating cable is over 30m, long response time	If choosing in-situ installation of sample gas conditioning system and analyzer, response time will be shortened.
Maintenance cost	Air chamber repair/replacement is complex and expensive; condenser, peristaltic pump, solenoid valve and so on are easy to be corroded by acid and acid mist	To eliminate the generation of condensate acid and acid mist and prevent the problems of corrosion, significantly reduce maintenance and cost.
Impacts on instrument lifetime	Acid and acid mist will shorten analyzer life cycle. The service life of analyzers is normally short.	Avoid chamber corrosion in analyzer and ensure proper function of various analyzers in long service life. The operation cycle can be extended.

The contents of the above comparison are recognized by relevant users (mainly I&C engineers of coal power plants using GASS sample gas conditioning system). It is able to fully satisfy the strict requirements of "Ultra-low Emission" CEMS on gaseous pollutant monitoring systems [viii].

Conclusion

Nafion-based Sample Conditioning Systems installed in the field have demonstrated their practical advantages by providing more accurate results, being more reliable and proving less expensive to install and maintain. Such systems are well suited for low-level of pollutant measurement in both high and low moisture applications. Today, as the regulatory bodies are continuously reducing the permitted levels of SOx and NOx emissions and as online measurement and reporting is becoming mandatory, it is even more important to consider specifying a Nafion-based system for your CEMS or process monitoring system. Accurate results from a nearly maintenance free system (just change the filters!) is the answer all plants have been looking for. With decades of real world experience, Perma Pure produces Nafion dryers and designs complete sample conditioning systems to provide end users with a cost effective and reliable moisture removal option to protect sensitive components of the CEMS while ensuring highly accurate analytical results.

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Emerging Technologies in the Design of Marshalling Panels – Opportunities and Challenges

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Introduction

Marshalling panels are the passive devices in design of entire control system and occupies a lowest rung in the hierarchy of control system hardware. But the design of this passive device has proven to be a biggest bottleneck that does not offer any flexibility to accommodate late changes including addition, deletion or change in the I/O types without running a risk of complex cross wiring and schedule delays. Every Instrumentation and Automation engineers would definitely recall at least one occasion where a package vendor has surprised them with a couple of dozen of additional I/O's much late in a project after the layout of marshalling panels are already finalized and released for fabrication. These challenges often bring engineering of Marshalling panel on critical path of project and require lot of rework in engineering or to live with bunch of cross wires. Recent advancement in product design by DCS OEMs' has reduced or eliminated the marshalling panels requirement and offers "Smart solution" to the automation engineers. This paper discusses about the new solutions which supposedly overcome the limitations enumerated above in marshalling design and also discusses the opportunities and challenges in adopting these solutions in Indian scenario. In bringing out the opportunities, a comparison is made between the conventional marshalling design and the new solutions for a mid-sized control system with I/O counts of 3701, in terms of engineering efforts including rework, project schedule, hardware footprint and maintenance spares.

Limitations of Conventional Marshalling and I/O design

Dedicated I/O cards for each type of I/O are used in the present day DCS for our power and Oil & Gas Projects. This conventional I/O cards combined with the traditional design methodologies (JBs at the field with segregation of AI/AOs', DIs' and DOs', usage of Intrinsic Safe philosophy for Zone 2 areas, having an intermediate termination panels, separating the I/Os' in different marshalling cabinets etc.) that is prevalent in all the currently operated plants in India has put in some limitations in the Marshalling design. The limitations can be broadly classified into 4 categories. A) Increased hardware thus increasing the footprint B) Elongated Project Schedule C) Engineering Rework D) Increased inventories of hardware.

I/O Type	I/O Count	I/O Count with 20% Spare	Total Count
AI	746	150	896
AO	475	95	570
DI	1646	330	1976
DO	834	167	1001
Total I/O	**3701**	**742**	**4443**

Table 1: I/O distribution of the case study project

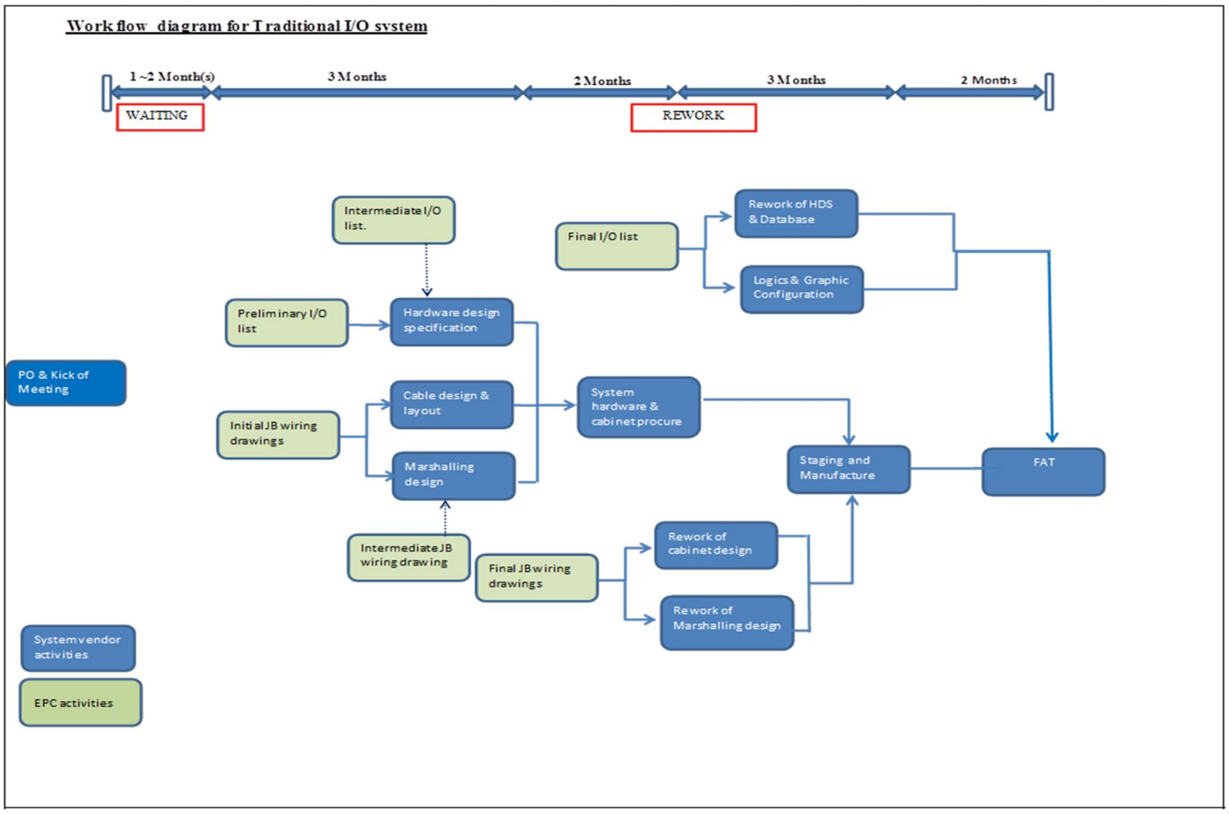


Figure 1: Work flow diagram for Conventional I/O system

Let us take a case of a mid-sized project with an I/O count of around 3701 with a requirement of 20% of the wired spares. The distributions of I/Os' are provided in the Table 1.

The work processes involved in the execution of the project is shown in the form of block diagram in the figure 1.

Increased hardware resulting in Increased Footprints:

The table 2 shows the hardware involved with the conventional marshalling design:

S.no	Description	Quantity	Remarks
1a.	No of JBs	313	Considering JB segregation of AI/AO, DI and DO
1b.	No of terminations	81886	Considering AI/AO as 2 wire + shield
1c.	No of home run cables	313	
1d.	No of Intermediate Termination panels	7	
1e.	No of Marshalling Cabinets	18	
1f.	No of IO cards	153	16 channel for AI/AO, 32 for DI/DO
1g.	No of Spare cards	32	

Table 2- Hardware components involved with conventional marshalling design

Elongated Project Schedule

While analyzing the work process block diagram, it is evident that after the KOM there is invariably a minimum of 1 to 2 months of no activity at the DCS vendor's side. The temporary HOLD is because the DCS vendor awaiting for the project input documentation, as the EPC contractor is still in the process of freezing the I/O summary (non-availability of majority of third party package vendor information etc.) and preliminary cable data. As a result, the ordering of the I/O cards and other bought outs are delayed. This delay is very hard to catch up and it is carried through the entire project cycle which may eventual derail the project schedule.

Engineering Rework

Conventional marshalling design is done on the basis of the home run cable and JB grouping details. A large amount of information such as JB numbers, JB terminations, marshalling panel nos, marshalling termination details, I/O card/ slot/ channel details go in the loop design. Considering the quantity of data that are needed in developing these loop drawings, any small change such as physical movement of the signal from one multicore to another or adding a signal amounts to a revision of many engineering deliverable.

As per the general benchmarking of the man hours spent by any EPC on the design of wiring and termination is around 12.5 % of the total man hours of the Detailed Engineering hours, as indicated in the table 3. When we look at the project execution diagram, we can identify the rework in the marshalling design and wiring drawings after the final I/O data base and the cable details are provided to the DCS vendor. The number of times the modifications/changes provided by EPC to the system vendor varies depending on the size of the system and may result in prolonged FAT/mobilization of system engineers at site.

Increased Inventories of hardware

Since each signal type has a unique and dedicated I/O card, higher spares are generally specified (like 20% installed spares) to allow contingencies and to address the revamps/expansion etc.

Recent offerings by OEMs to address the constraints of Marshalling design:

The industrial world is now changing at a rate in which the basic systems, structures, built over past decades cannot keep up with the demand being placed on them. "Automation system design" should offer greater flexibility for Engineers' to incorporate late design changes in process. The ideal situation will be that as soon as basic design and I/O counts are in-place, instrumentation engineers should able to finalize system hardware. This hardware should have flexibility to be configured/ reconfigured at any time with minimum efforts.

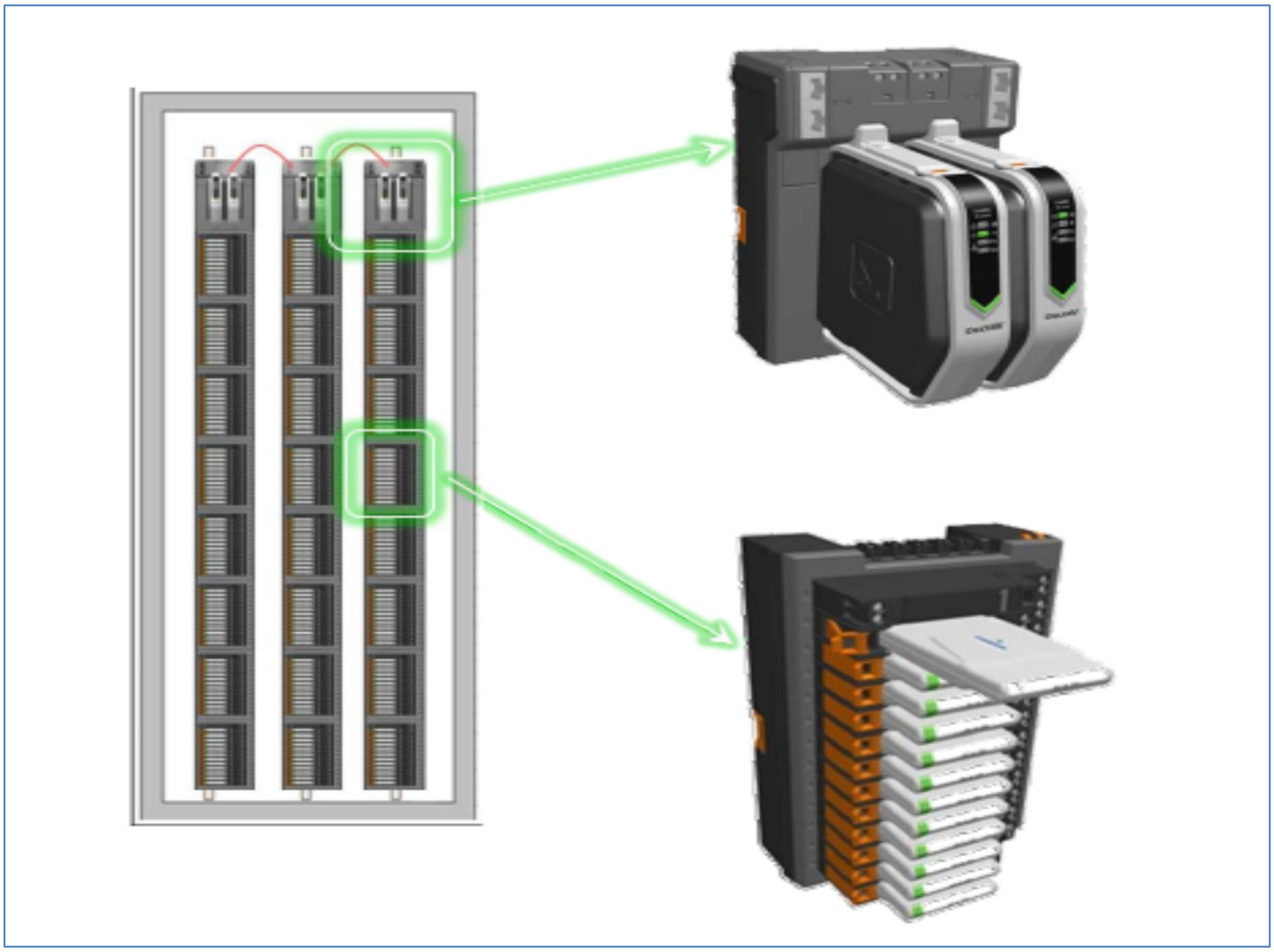
S.no	Description	Man hours	Remarks
2a.	JB Wiring drawings	3.75% (*)	* Of total manhours of the project
2b.	Loop Drawings	4.25%	
2c.	Termination and Marshaling wiring drawings	2.5 %	
2d.	Panel/cabinet Layout drawings	2 %	

Table 3- Typical Engineering efforts for marshaling design

With the project schedules becoming more aggressive, the time available for the delivery of the DCS also shrinks. It is now realised that the classic way of designing the I/O system is neither attractive nor cost effective. Keeping in tune with the growing demand of finding solutions to overcome these difficulties, DCS OEMs, in recent days, have come up with solutions that bring a paradigm shift in the way the marshalling panels are designed and thus providing efficient way of DCS project execution.

The OEMs have given different terminologies- Emerson leading the pack with "Electronic Marshalling (I/O on demand)", while Honeywell names this as "Soft Marshalling (Universal I/Os)", Invensys "Intelligent Marshalling" and Yokogawa as "N-IO, New Software Configurable I/O".

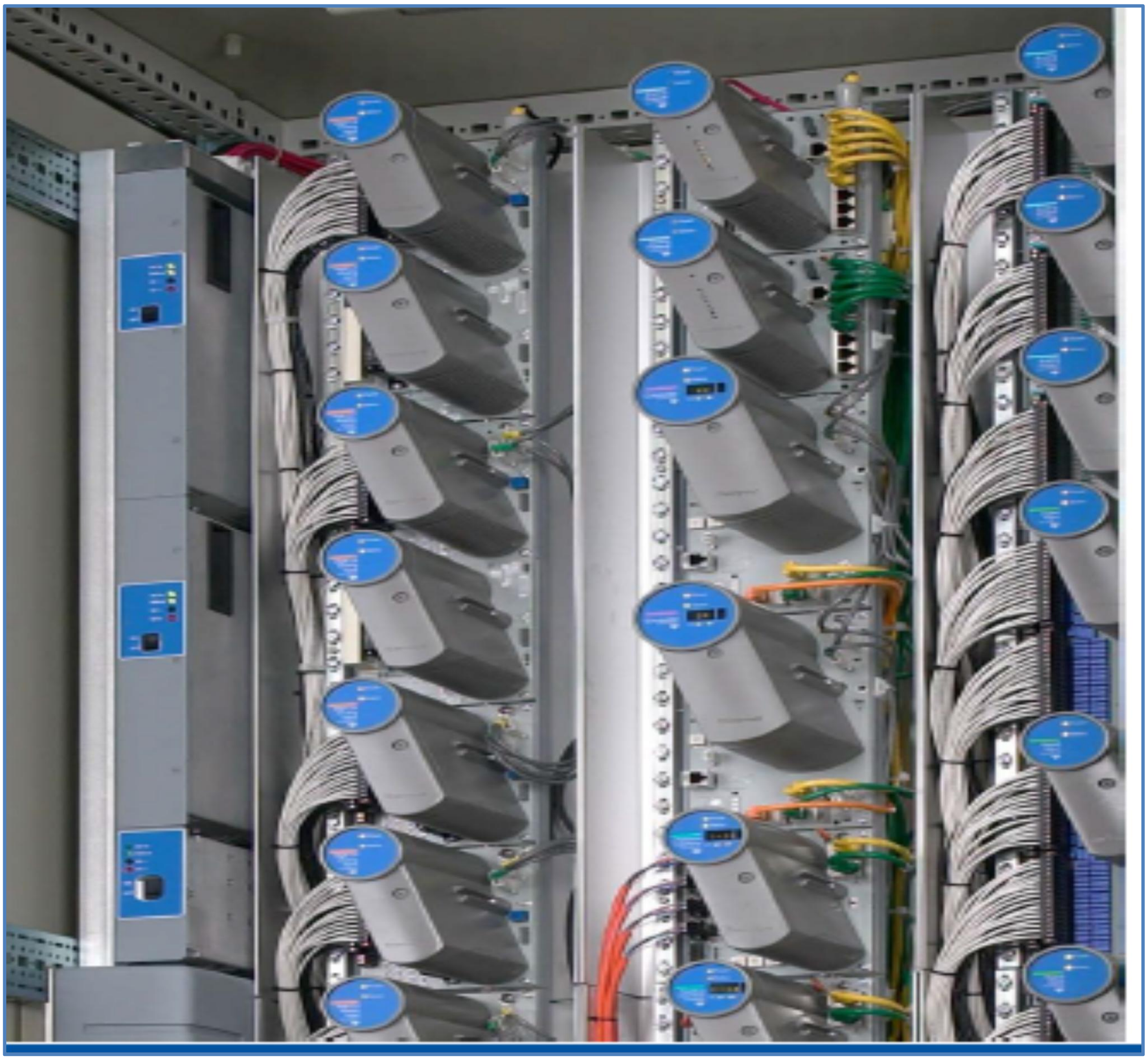
Emerson has started the "I/O on demand" with its CHARMs or Characterisation Modules. The field devices communicate via a small CHARM to the Charm I/O Card. This small Charm is unique for each I/O type. As explained by Emerson marketing personnel, "We have replaced the marshalling with the I/Os' landing on the charm which acts as individual channel". Effectively, each loop's field wiring is landed on one of the special terminal blocks and the loop signal is characterised by plugging the appropriate charms into the terminal and the marshalling is configured electronically, eliminating the cross wiring and thus successfully allowing the changes in the I/O type very late in the project. If there is a change in I/O type, all that is to be done is to unclip the Charms from the terminal block and clip the required type of Charm.



Delta-V Electronic Marshalling with CHARMS Modules and CHARMS IO Cards

Honeywell Process Solutions offers a similar product design by its Universal Process I/Os. This 32 channel Universal I/O module eliminates the marshalling and allows each of its 32 channels to be configured into any of the I/O type by simple software configuration through its engineering console. “You may use any channel on the module to serve as any I/O type, and it is all software configurable using the existing control builder tools,” say Honeywell Process Solution marketing personnel. “ You could land the entire field wiring on your Universal Process I/O module, close the box, walk away, and never have to open that box again. Everything else is done from the Engineering station.”

Both Honeywell Universal I/Os and Emerson CHARMS are offering to be mounted remotely in the field thus eliminating the marshalling panels completely in the Instrument Rack room and communicate to the proprietary controllers on fiber optic cable.



Honeywell Soft Configurable Universal Process I/Os in a Universal cabinet design

Invensys Foxboro's I/A series Intelligent Marshalling addresses the marshalling design problems with its FBM247 Universal Field bus Module.

The new product design breaks down the reliance of the marshaling panel design on the changes in the input documentation of the EPC such as I/O list, JB loading and home run cable details.

Opportunities with the new technologies of "Any Signal, Any Channel"

With the above proprietary solutions offered by DCS OEMs' and possibility of terminating any field signals to any I/O at will, let us compare the scenarios of reduction in footprints, shrinking project schedule, reducing engineering rework and finally less spares and inventories.

The work flow processes under the environment of new technologies is depicted in the figure 2.

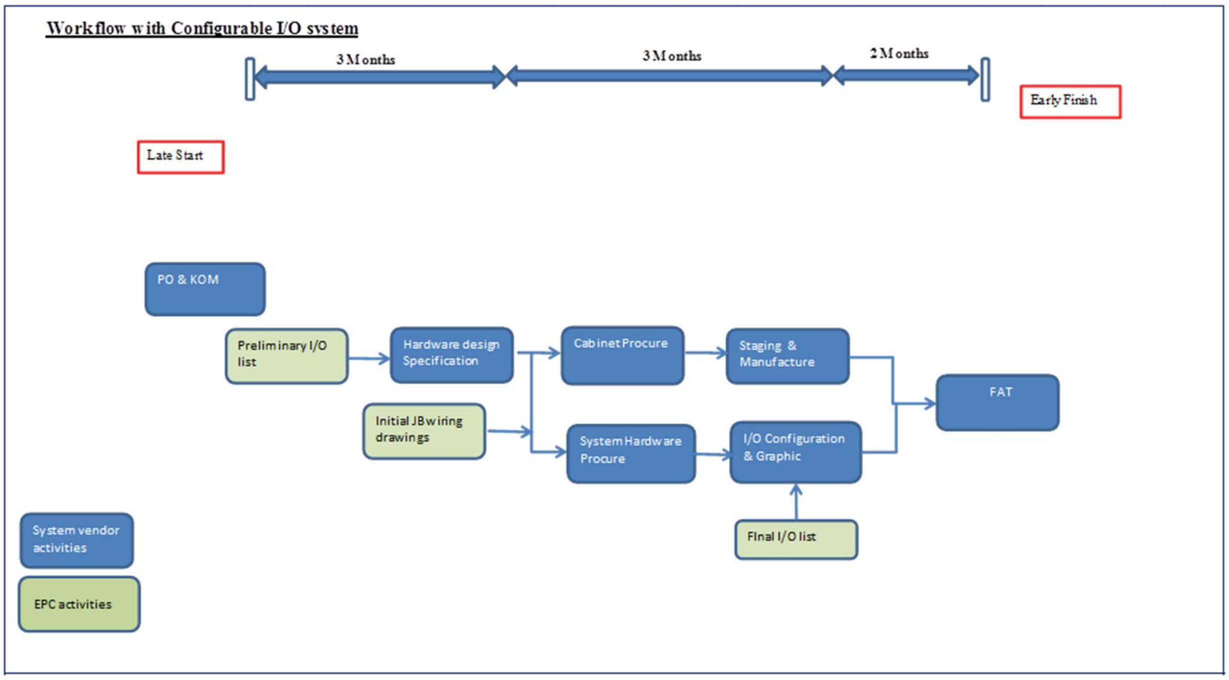


Figure 2 – Revised Work flow diagram due to the new technologies

IO Type	I/O Count	Spare	Total Count
AI	746	445	4146
AO	475		
DI	1646		
DO	834		
Total I/O	**3701**	**445**	**4146**

Table 4- I/O distribution and Spares using the new technologies

Reduced Hardware and footprints:

With our previous I/O count of 3701, the table-4 indicates the I/O distribution and spares requirement in the scenario of using the new technologies. Hence we see a reduction of no of spares by about 40% from the classic I/O cards as it is now possible to configure any spare I/O point as any I/O type. The outcome is elimination of cross-wiring and reduction of number of terminations and quantity of panels.

Reduced Schedule Uncertainty and Rework

When we compare the work processes in figures 1 and 2, we can see that work processes has become more simplified and the marshalling design is now less dependent on the JB wiring drawing / home run cable information from the EPC contractor. The initial no-activity in the DCS vendor side is eliminated as the hardware definition and the subsequent hardware ordering could be started immediately. The schedule of the project now reduced up to 8 to 12 weeks. The Marshalling panels design shall be standardised without being custom made. This also helps in accommodating any late changes in the I/Os' without worry of cross wiring and thus reduces the rework in the I/O loop design.

Reduced Engineering Efforts

Reduction of JB's, termination details, marshalling panel etc. will lead to reduced man-hour requirements for EPC contractor. Typical man-hour consumption for different activities will be 6.4% as compared to 12.5% for conventional system. Break-up of hour's for different activities are as per table-6. The rework in a lot of engineering documents for accommodating the late changes in the project is reduced due to less reliance of the marshalling design on the inputs by the EPC and standardisation.

S.no	Description	IOs' at Field	IOs' at the Rack Room	Remarks
1a.	No of JBs	75 (for I/O)	208	AI,AO and DI in the same JB and DO is separate JB.
1b.	No of terminations	20735	40059	
1c.	No of home run cables	150 (FO)	208	FO connectivity between the field mounted I/O cards and controllers
1d.	No of Intermediate Termination panels	0	0	
1e.	No of Marshaling Cabinets	0	3 to 7	

Table 5 – Hardware components required using new technologies

S.no	Description	Man hours	Remarks
2a.	JB Wiring drawings	2.5%(*)	* Of total manhours of the project
2b.	Loop Drawings	2.0%	
2c.	Termination and Marshaling wiring drawings	0.7%	
2d.	Panel/cabinet Layout drawings	1%	

Table 6- Engineering efforts for marshalling using new technologies

Summary of Comparison:

The comparison could be summarised as follows:

Commercial Benefits

a) Reduction in hardware e.g. Junction boxes, Home run cables by 34%. This also ensures reduce commissioning time and simplify field checking.
b) Reduction in Marshalling panel/ cabinets by 72%, this will also have a reduction in the space in the rack room, reduction in the capacity of HVAC thereby reducing the Opex.
c) Reduction of engineering efforts by 50%.
d) Reduction of 51% mistakes on account of termination points. This reduction of termination point also ensures reduced maintenance, trouble-shooting activities.
e) Reduction in overall project schedule by 8 to 12 weeks .This may be very high for a large petrochemical complex. Also ensures flexibility in schedule and keeps automation out of the critical path of project.

This case study is done on a small unit of a large Petrochemical or a Refinery complex. However when extended to the entire complex, where the I/O's will be in the range of 50 thousand, then the lost opportunity cost (early bird opportunities such as early oil or capturing the market share for the products) could run to crores of Indian rupees. While there are many positive features and advantages, the flip side is the higher costs of these I/O cards in comparison to the classic I/O cards. The cost to benefit ratio will make the usage of these new technologies attractive for a large project, small automation projects may have to wait for more time (till the initial investments in R & D and efforts to bring the product to market has paid off for the manufacturers).

Project Execution and Work flow transformation

The most important benefit that the new technologies provide is that it brings up a paradigm change in the project execution and work processes. It makes the individual tasks less reliant on each other and allows for a parallel execution of tasks a possibility. In the world of EPC, where time is money, the wastage of time in waiting for the inputs and to cut down on the modifications and rework is the greatest opportunity that is offered by the new technologies.

Challenges in adapting the technology advancements in Indian Power and Oil & Gas Industries:

New offerings by DCS OEMs' seem to provide solutions for everything that currently ails our conventional control system engineering. These new product designs were introduced in the world market since late 2011/early 2012, and some of the upcoming large petrochemical complex projects in the other parts of the world are currently using one of the above Smart Marshalling Solutions. However some of the interesting questions would be:

- Can these new offerings be able to gain market share in India and if so, how soon?
- Can these offerings be able to fulfil the requirements of flexibility in Marshalling/IO design?

With the current model of execution of large Refinery/Petro-chemical complexes in India as LSTK, the requirement of using the new technologies need to be built-in in the ITB stage itself by the end user (Operating companies) with collaboration with the OEMs and binding on the EPCs of different units of the complex during the execution stage.

From the authors' point of view, the following are some of the additional challenges:

a) Segregation of signal types like AI/AO, DI and DO – This is the prevalent method of cabling and will defeat the purpose of "Any Signal, Any I/O" design. In the other parts of the world, specifically North America, AI,AO,DI are taken in the same home run cable.
b) Segregation of the Signal terminations in different cabinets in the rack room and in some of the projects even follow the use of intermediate termination panels.
c) Use of Intrinsic Safe Barrier/Isolators for Zone 2 (or Class 1, Div 2) are quite common, though not required as per codes and standards.
d) These new solutions will bring in more flexibility and cost effectiveness, if the I/O are located remotely in the field. Will there be acceptance of such Field mounted I/Os by our operating companies?
e) The commonly used DCS systems in Power industry are yet to come up with such solutions.
f) Training of existing maintenance staff to the new technologies.

Conclusion

To quote Albert Einstein - No problem can be solved by the same consciousness that created it. To utilize full potential of new technology and to ensure utilization of all opportunities probably we need to change the perspective with which we do our design and find optimum way to embrace the new technologies.

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DC Microgrid: The revolution is approaching

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ABSTRACT

This paper is about "War of Currents" and mainly discusses the benefits and issues with DC and AC power systems. There are several equipments and inventions which have hidden DC system and therefore favor DC power system; however DC systems have various issues as well. With increasing presence of renewable energy sources which mostly generate DC, battery storage etc. DC Microgrid with AC interface is the need of today, so as to get advantage of both AC and DC system. A DC microgrid system consisting of Solar PV, battery integrated with DC loads has been designed and installed at NTPC NETRA office and challenges/ issues are being studied. This paper highlights benefits, challenges and future prospects of DC Microgrid system.

KEYWORDS

Microgrid, Renewable energy, Solar PV, Battery storage, NETRA

I. Introduction

The Electrical world is changing, the environment is conspiring, the new inventions are favoring, the economy of scale is paving the way and all these are leading to yet again another "War of Currents". Though it is not as furious as it was some 100 years back but in a subtle way DC (Direct Current) is returning the favors by overcoming the prowess of AC (Alternating Current). Some of the great inventions like Induction motor, Transformer, Arc lamp took it away from DC which had established itself at that time as preferred medium of generation, transmission and distribution. Transformers with their ability to transform AC voltage i.e. step up for transmission and step down for distribution made AC a favorable choice as it made it possible to transfer large amount of power from one place to another. It favored the centralized generation at thermal and hydroelectric power plants as high efficiency transmission at high voltage and economy of scale helped in bringing down cost of electricity. Further advent of induction motor further took it away from DC as reliability and ruggedness of induction motor is unmatched even today. Though Edison and team used series of scare tactics to show how dangerous these higher voltage alternating currents were but failure of Harold Brown in proving AC as an instant killer [2] fell in favor of AC. Further when Westinghouse received the contract to light the 1893 World's Fair in Chicago, it finally showed AC as a safe source to the masses, and then the growth of AC power exploded.

Over a century has passed since the last "War of Currents" took place. A lot have changed in this century in terms of environment, semiconductor devices, converters, photovoltaic generation, fuel cells, wind generators, electricity storage, led lighting, computers, electronic devices and electrical vehicles. Edison could have given a much fierce fight to AC if he has got the support of DC to DC converters. Today, though the primary infrastructure is of AC but we are using DC in one form or other and converting it from DC to AC or AC to DC at several places to get it compatible to the primary infrastructure. The advantage of DC system with renewable generations and DC loads can be better achieved with DC Microgrid. DC microgrid is a network of DC generators with connected loads and which can work autonomously without the support of mains AC power from grid. This paper describes the advantages and issues of DC power networks and a case study of DC microgrid in a building.

II. HIDDEN DC PRESENT AROUND

Many a time various interfaces are used in the new inventions to make them compatible with the present infrastructure available without knowing what actually is their inherent characteristics are. Some examples are as below

1) VFD (Variable Frequency Drives): Induction motor was the major weapon of AC that kept it way ahead of DC in "War of Currents". It is an industry workhorse and DC motors are unable to match its ruggedness, reliability, cost effectiveness, and efficiency but it was unable to replace DC motors from applications which required precise speed control. A lot of work was done to control speed of induction motor and VFD (variable Frequency Drive) was invented. VFDs have the capability of providing speed control for induction motor but its inherent characteristics is much more supportive to DC than AC. As indicated in the working block diagram of VFD, DC source can eliminate one level of converter and can increase total system efficiency.

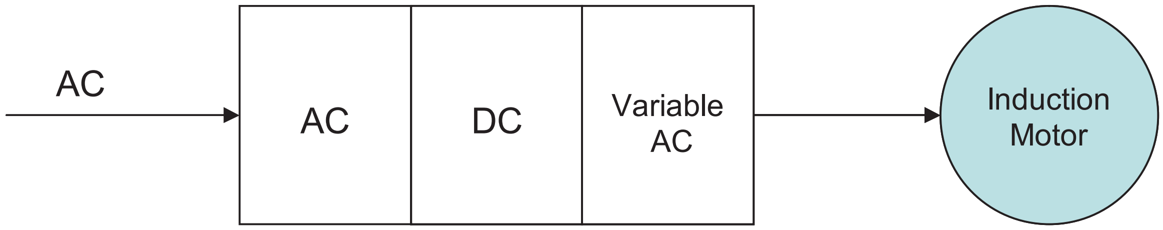

Fig 1: Present VFD usage with AC source

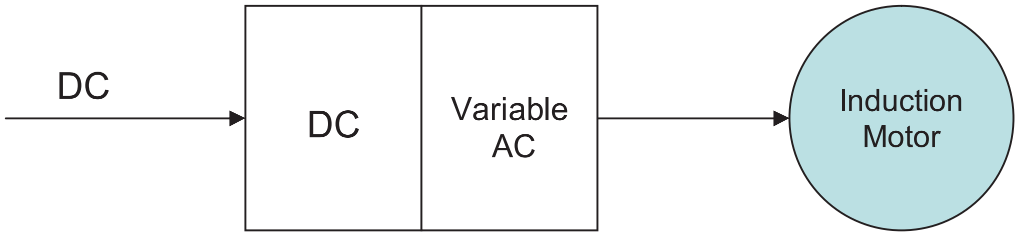

Fig: 2 Proposed VFD usage with DC source

Variable speed is a highly desirable feature in most of the industrial application and even in home appliance like refrigerators, air conditioners, washing machines etc. So the advent of VFDs has paved way of DC as preferred source of distribution.

2) Renewable Source of generation: Renewable energy as sustainable future energy sources are increasing their presence in the present grid and are changing the generation spectrum. Distributed nature of renewable energy sources have changed the concept of centralized generation to distributed generation and major advantage of AC in transmitting large quantum of power to large distances is diminishing now. Generating at the load centers is not only environment friendly but also efficient as there are no transmission losses.

a) Solar PV: Day by day increasing efficiencies of solar cell, availability of newer and better technology, increasing efficiencies of inverters, dipping prices, with little or no maintenance and environment friendliness is favoring large scale solar PV installation in both centralized and distributed way. Solar PV is inherently a DC generator. In present systems solar inverters are used to convert the DC power to AC for grid integration purpose which leads to some loss of efficiency in form of converter losses. Use of DC grid to integrate solar PV is more efficient way to utilize solar power.

b) Wind Generators: Wind generators either use induction generators or use converters to cater to the intermittency of the wind power. Induction generators are unable to provide reactive power to the system and rather need reactive power for their operation from the system. Capacitor banks are used to support their reactive power requirement. Also they need to be run above the synchronous speed to generate power. Due to this they are unable to produce below a certain wind speed and hence require multiple winding generators to generate at broad band of wind speed. They also require gear box for generating high rpm to keep the number of poles in generator low. Other means used by the wind generators is use of convertors. Power Electronic Converters convert generated power to DC and again convert it to AC hence eliminating requirement of gearbox and capacitor bank. Use of DC grid to integrate the wind power can eliminate the requirement of reconversion to AC and hence saving conversion losses.

c) Fuel Cells: Intermittency of wind and solar are paving way for storage. One of the proposed storage medium is hydrogen. For utilizing the hydrogen efficiently fuel cells provide a great option and they inherently produce DC.

3.) Battery Storage: Battery storage is one of the major proponents of DC. It has kept DC alive even in AC era in UPS, backup inverters, railways, vehicles, generator cranking, and now recently in electrical vehicles. Further with large quantum of renewable energy getting integrated to grid, the issues of grid stability due to intermittency, variability and unpredictability of renewable energy can be mitigated with storage. Fig 3 & 4 block diagrams explain that huge savings can be done with DC usage in UPS and inverter application.

4.) Electronic Loads: In the last century load pattern has changed drastically. Electronic components load which was nil at the time of "War of Currents" is now a significant load. Personal Computers, laptops, mobiles, TV, radio, music players, video players, and many other small and big household electronic items works on DC. Similarly, majority of control and instrumentation of industry works on DC. Presently they use several small AC to DC converters to get DC supply but efficiency of these converters is not good. Working on DC can avoid these converter losses.

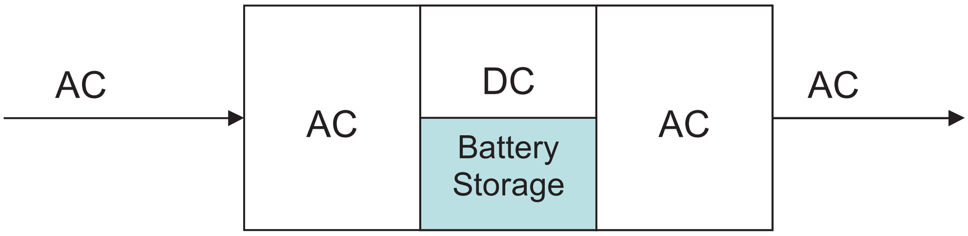

Fig 3: Present UPS usage with AC source

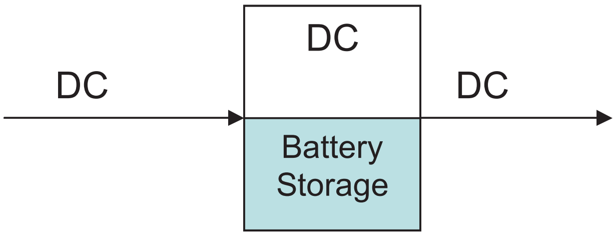

Fig 4: Proposed UPS usage with DC source

5) Lighting: Lighting has been the major electrical load since the advent of commercial use of electricity. Today, majority of lighting is fluorescent lighting or solid state (LED) lighting. Fluorescent lighting is nowadays using electronic ballasts which convert AC to DC and DC to high frequency AC. Hence similar to VFDs usage of DC can eliminate one conversion phase. LED lighting inherently use DC as power source. AC is converted to DC to use it with LED lighting. Use of DC can definitely help in getting savings with LED lighting.

6) Electronic transformer: Transformer as an equipment of stepping up and stepping down, cannot be replaced even today in term of efficiency but researches are going on into the field of electronic transformer to utilize semiconductor switches with High Frequency (HF) transformers to replace present LF transformers. These transformers favor DC through availability of DC bus in them where interface can be created to join DC and AC. These electronic transformers have high probability of replacing present LF transformers in distribution networks as they have better efficiency, control and stability than LF transformers at part load condition which is very frequent in distribution networks.

III. DC ADVANTAGES AND DISADVANTAGES

As described in the previous sections, that with a century of development, lots of changes that occurred in course of time are favoring the DC in terms of increased system efficiency. Also with the lesser conversion phases/units, systems will be more reliable and easy to maintain. Easier storage integration in DC helps in maintaining stability of grid at a lesser cost to the system. DC is having some of other benefits also as described below.

a. **Impedance of wires and cables**: The total impedance (Z) of conductors is: $Z=\sqrt{R^2+X^2}$. By operating the system with DC (0 Hz) and eliminating the "X" component will reduce impedance drastically. Even 'R' value also changes due to skin effect. The skin effect causes the R value at 50 Hz to be slightly higher than it is at 0 Hertz. For typically sized overhead conductors at 50 Hz the effect of skin effect results in about 2 to 5% more resistance than for a similarly sized conductor operating at 0 Hz [4]. The low impedance will cause low power loss also and hence less heating effect.
b. **Voltage regulation and voltage drop:** Voltage regulation for a DC system is better than an AC system. This is because the reactive component of the impedance is gone and the resistance value is slightly better (reduced) due to skin effects. However, the net improvement in going from DC to AC is not as straightforward as reactive and real components of voltage drop add vectorially. The voltage drop has as much to do with the power factor of the load current as it do with the values of reactance and resistance of the line.
c. **Fault currents:** In term of fault currents, differences between DC and AC systems is that on a DC system, all power generation equipments are almost certainly going to be electronically interfaced. Electronically interfaced equipments will have lower fault contributions and more rapid "clearing" of fault contributions than conventionally interfaced generators.
d. **Voltage sag/Interruption mitigation**: A major advantage of DC power is the ability to block the flow of current in the reverse direction with nothing more than a simple diode. If such diodes are placed at strategic points in the network (i.e fault current "blocking" or "steering" diodes) power quality and reliability of a DC microgrid can dramatically improve by preventing the collapse of voltage on the system downstream of the fault location and preventing backfeed [4]. Momentary interruptions can also be prevented. This type of arrangement is something that is not possible with an AC system since current must flow in both directions if AC power is used.
e. **Synchronization:** As in DC, frequency component is not there, therefore synchronization of different sources just needs voltage matching whereas in AC, frequency voltage and phase have to be matched for proper synchronization.

DC has number of disadvantages also as described below:

a. **Large size Centralized Power plant favor AC:** Centralized generation in term of coal based thermal, hydro electric, and nuclear plants are even now favoring AC due to AC synchronous generators. Transformers are another factor for which DC does not have a comparable answer even today. So in case of centralized generation AC is even now a preferred media.
b. **Lack of zero crossing**: DC faces a major disadvantage of lack of zero crossing. Quenching a DC arc is much harder than AC and hence circuit breakers for DC are much more costly.

c. **Lack of codes and standards:** Talking of other major disadvantages, unfamiliarity is one of the major hassles in implementation of DC. AC power is being used for more than a century now and workforce is much more adapted to use of AC installations. This unfamiliarity can also be seen in lack of codes and standards. There is not much of documentation on the level of DC voltage to be used, safety standards, etc. As part of unfamiliarity in terms of production of products and equipments related to DC, an initial cost is there to start production and it will take some time to bring economy of scale comparable to AC products.

But, above all these benefits and issues, one major question that looms is that, is it correct to discard so much of infrastructure created for AC systems. AC system is even relevant today in centralized generation. So a hybrid system of AC grid with integrated DC microgrids seems to be possible answer to technological, sociological and economic implications.

IV. DC MICROGRID

A microgrid is a localized grouping of generation, storage, and loads coupled to the centralized grid at one point. The two main features which describe the microgrid are

- A microgrid consists of interconnected distributed energy resources capable of providing sufficient and continuous energy to a significant portion of internal load demand.
- A microgrid possesses independent controls and intentional islanding can take place with minimal service interruption [1].

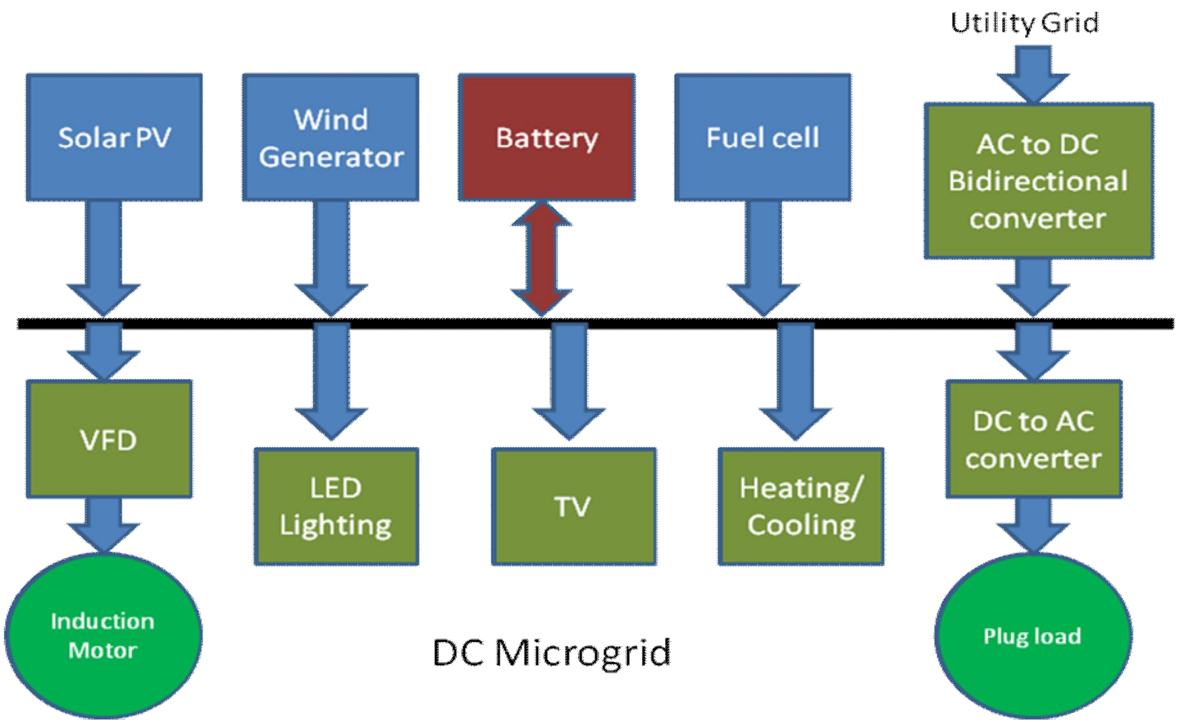

Fig : 5 DC Microgrid

DC microgrid is a microgrid with primary bus of this microgrid working of DC. It can have AC components in load or generation side but the primary bus will be a DC bus and these AC components will be connected to bus via converters. It may be connected to AC primary grid via a converter also.

As AC network cannot be removed completely, use of several DC Microgrids in interconnection with AC utility grid is a better option to take advantages of best of both worlds.

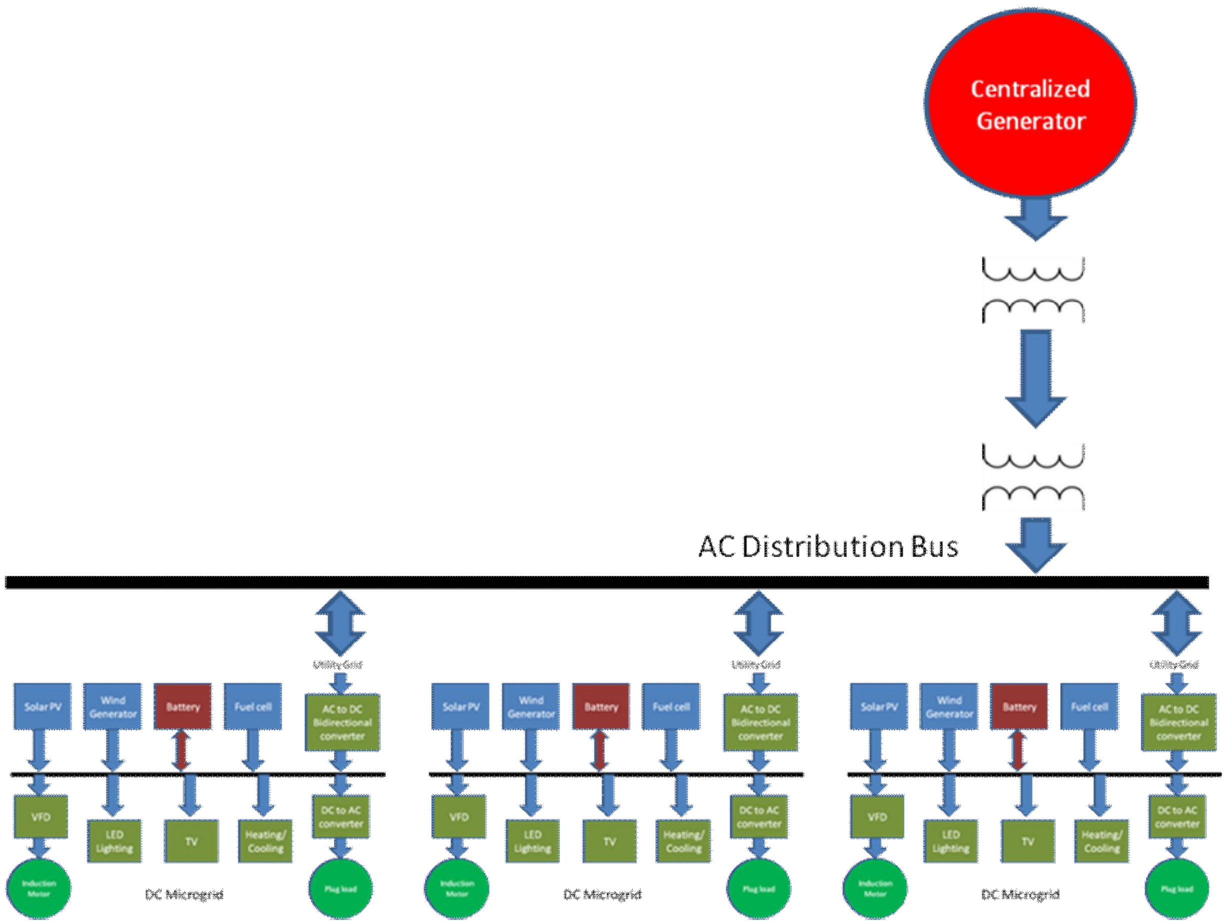

Fig : 5 DC Microgrid in interconnection with AC utility grid

V. NETRA DC MICROGRID

NETRA (R&D Deptt. of NTPC Ltd) at its Greater Noida centre has established a small DC microgrid with DC lighting and fan loads. It is getting its power through 8X80Wp thin film solar panels. Storage has been integrated via 3X42AH batteries. This microgrid is working on 12V DC. AC interconnection with single phase 230V utility supply has been provided to support the microgrid. Whenever solar generation and battery are not able to cater to the load demands power is imported from utility AC via rectifier. A hybrid charge controller is used to materialize the whole setup and it acts as interface between load, solar PV panels, AC utility and storage. Block diagram of the NETRA's DC Microgrid is as shown in fig 6:

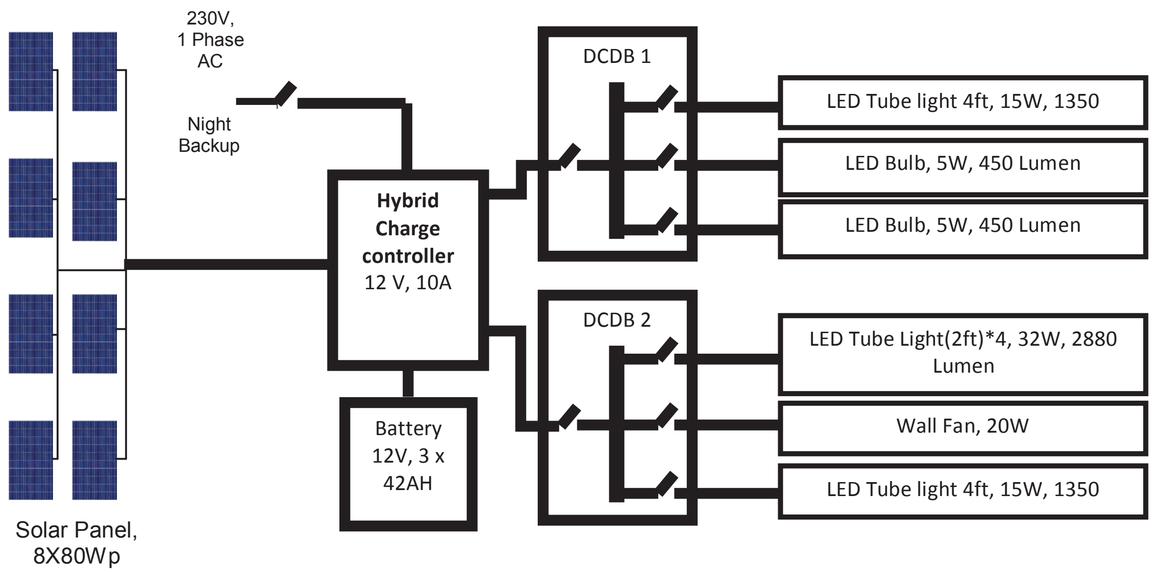

Fig 6: NETRA's DC Microgrid

VI. CONCLUSION

With the world's AC grid designed and installed in over a century using standards established over 100 years ago, it would be difficult to have a complete changeover in a short amount of time. Many points about the electrical efficiency favours DC but unfamiliarity is the biggest hurdle for DC to outclass AC. Codes and standards are very much required for safe and reliable installations of DC systems. Initial prices are also an obstacle in increasing the presence of DC. Though, as more individuals and companies begin to invest in renewable power sources, DC microgrids will definitely increase its presence and familiarity. World Community is already working on creating codes and standards and several communities like Emerge Alliance are working in this area. So, it is expected that DC can capture its fair share in upcoming years.

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MODBUS RTU COMMUNICATION BETWEEN DCS AND PACKAGE PLC – ACASESTUDY

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ABSTRACT: In a major Indian refinery and petrochemical complex, during the commissioning of a Steam turbine driven large capacity air blower an unique problem of Modbus communication was observed where the data transfer between the two systems were observed anything between 4 to 40 sec. The unpredictable delay is attributable to the undeterministic way of transfer of data in a Modbus network. The data transmission speed is generally in the order of millisecond for a Modbus RTU with 19200 bits/sec speed, and therefore a delay beyond 3 to 4 sec is quite unexpected by our experience and such delay in data transfer rate, makes the communication untenable. A critical review was initiated and we had to delink this communication path with the control function of the package system. Machine specific critical control functions were made independent of Modbus communication data. Initially, there were some control functions having control action both from the Distributed Control System (DCS) and package Programmable Logic Controller (PLC) system. Such control functions were fully shifted to either DCS or package PLC to achieve the independency to serial data. As a recommendation, instead of Modbus RTU, in the future projects of such configuration, Modbus TCP /IP protocol is suggested which will ensure faster data transfer rate.

KEY WORDS: DCS, PLC, Modbus RTU, TCP/IP

INTRODUCTION: Modbus RTU is an open, serial (RS-232 or RS-485) communication protocol derived from the master/slave architecture, is an industry standard with worldwide acceptability. This communication is largely used in industrial automation systems especially for process industries for serial data communication of electronics devices with basic process control system such as DCS or SCADA system. The Modbus protocol was developed in 1979 by Modicon. Initially it was developed as Modbus ASCII and became industrial standard with Modbus RTU. It is inherently undeterministic. Other recent version is the Modbus TCP/IP over Ethernet with a transmission speed of the order of 100mbps.

Being transmission speed in the order of millisecond, for simple monitoring purpose (including critical data transfer which may be used for control as well), Modbus RTU over RS-485 is considered adequate and this fact is well established.

THE CASE SUDY & PROBLEM: In one of the recently commissioned domestic petrochemical projects by EIL, this communication protocol was adopted for a complex Air blower package. The Air Blower is driven by a steam turbine. The control system consists of a redundant PLC for the package, electronic speed governor, electronic over-speed trip system as per API 670 and machine vibration and temperature monitoring system. The function of the package PLC is the emergency safety interlock execution, extraction control, condensate level control, anti-surge control and associated critical control operation related to the machine. Main plant ESD system is utilised for execution of the auxiliaries. Main plant DCS has redundant serial link with the package PLC though Modbus RTU. The DCS is the master and package PLC is the salve. The main plant ESD is in the same network as DCS, therefore, the package PLC and main plant system can exchange serial data.

The most proven and generally adopted control system for similar application is to have safety interlock and logic in the main plant ESD and other conventional loop monitoring and control through the main plant DCS. In such control system the package vendor supplied PLC is not necessary.

However, specifically talking about this package, the Original Engineering Manufacturer(OEM), insisted on providing their own PLC system for the control and safety functions without any cost implication during detail engineering stage citing their proprietary requirement. This package PLC functionality included anti-surge control, extraction control, condensate control, emergency safety shutdown for the machines but at the same time all the other aux controls and interlock remained with the main plant DCS/ESD as per the the original control scheme. Speed governing, machine vibrations and temperature, and over speed protection system also un altered.This post order configuration change has complicated the control philosophy and introduced multiple interfaces between the package PLC and customer's main plant DCS and ESD system. All these interface issues were sorted out amicably with sustained effort during engineering, site installation and testing stage, until a hurdle has been encountered in communication between the customer DCS and Package PLC.

As some of the control functions are being executed in the main plant system (DCS/ ESD)- the status of these signals associated such control functions were necessary to be monitored by the package PLC from the overall machine operation point of view. The monitoring of these data is through the redundant Modbus serial communication.

The Modbus configuration was carried out as under:

Serial Interface DCS and Package PLC: Protocol MODBUS RTU **Configuration Parameter Modbus Slave (RTU-Format) Package PLC)** **Protocol Parameter** Slave Address: 1 & 2 (Slave Redundancy) Operating Mode Normal Operation Multiplier Character Delay Time 3 **Speed** Baud Rate 19200Bits/s **Character Frame** Data Bits 8 Stop Bits 1 Parity even **Interface** Operating Mode Half-Duplex (RS485) Two-Wire Operation Presetting of the Receiving Line Signal R(A) 0 Volt Signal R(B) 5 Volt **Conversion of ModbusAdresses** Function Code FC03- Read Access in Package PLC Data block commence at DB2 DW0 **(Base-DB-Number)** Function Code FC06, FC16 - Write Access in Package PLC Data block commence at DB5 DW0
The Modbus Master switch over automatically to the redundant port, if the active port is not alive.
Detection of frozen data link has to be done via evaluation of Life-Counter.

A software programme was developed in the package PLC to check the healthiness of the Modbus and its redundancy. It checks the change of data in the Modbus. The change of data happens from the DCS side through a counter. The comparator block in the package PLC compares the old life count with the present count value. If the value does not change let say within 3 sec [3 sec is a pretty high figure and hence it was least expected to generate error where the expected speed was of the order of 500 msec] than, there is a generation of Modbus communication error flag in the package PLC. This alerts the package PLC to initiate trip/ shut down action for the machine.

During the commissioning stage, the error started appearing and hence the machine could not be taken in line. The problem was referred both to the OEM and DCS manufacturer, but both sides expressed that there is no configuration mismatch or error. The redundancy check was carried out and the same was found successful indicating that both the lines are healthy. A simple test was carried out with all the auxiliaries running with the Modbus timer set point of 30 sec. The error frequency has gone down but it still exists. The set point is further increased to 40 sec. The error appeared after a full 1 and half day. This meant that, the communication is unreliable for this application. With no clarity for such a huge delay in the transmission speed, it was decided to delink the communication signal with control function by disabling the error bit. Further, in order to operate the machine safely, those control loops which were operated in mixed mode were completely shifted either to the DCS or to the package PLC as per the recommendation of the OEM as well as our experience. The newly configured loops were functionally tested and found satisfactory. Finally the machine was taken in to operation and ever since running smoothly.

PROBABALE CAUSE OF DELAYED DATA TRANSMISSION:

The unpredictability of data transmission is understood, because of the non deterministic nature of the master slave protocol adopted in Modbus RTU, where the slave (the package PLC) has to listen as per the Master. But, the point here is the un-precedential delivery of data from DCS to the package PLC. The physical distance hardly matters as both DCS and package PLC system cabinets are in the same rack room. No error is recorded in the DCS side for communication. There is no hardware fault diagnostic message in any of the communication media. Could the data volume be a problem? We had curtailed down some of the non significant tags of Modbus signalform the DCS-package PLC communication list. No improvement found in the delivery.

In a normal Modbus RTU communication, DCS normally reads the data from the Slave- a simplex mode. But in this case, the Slave also reads data from the DCS, therefore it is duplex communication configured as Half Duplex type. Therefore, a lab based analysis is required to establish, whether for a half duplex communication, there is possibility of higher delay in data delivery.

CONCLUSION AND RECOMMENDATION:

Where ever package PLC and main plant DCS system require serial interface, the same shall be only for information exchange only and shall not be linked in the trip interlock. For trip interlock and critical control, only hardwiring shall be adopted. Even if there is requirement of duplex communication, it is recommended that the higher version of Modbus communication that is Modbus /TCP shall be adopted which has considerably high speed of 100 mbps. Modbus/

TCP is an Ethernet based network with Modbus protocol and the hardware configuration can be configured in such a way that it provides near deterministic transmission of data. Integrated platform for control function eliminates such problem, and therefore, wherever possible if the OEM insists upon inclusion of package PLC, then the scope shall be defined to cover the entire package with the package PLC.

ACKNOWLEDGEMENT:

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Biographies

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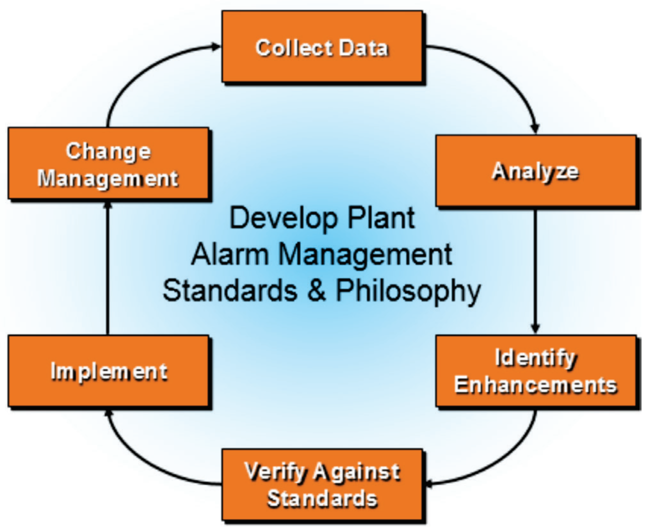
Alarm and Information Management System

Why Alarm Management is Important

Alarm and Information management system is playing vital role in safety and effective control of plant systems. It provides inside views and analytics about how stable your control system is and what is stress level on your operators. Sectors like power generation and Oil & Gas which has very high value of downtime and safety concern are most benefited by such software.

Alarm Management Lifecycle



Alarm management is continuous improvement process. Control system needs to analyze on regular bases to evaluate performance of system against standard KPI and rationalization of alarms to be carried out as regular activities as kaizen or 6sigma drives.

Features you should look in AIMS

Basic Features

- Connectivity and integration with control system for efficient and high performance data transfer.
- Performance of system in terms of handling alarms and creating KPI / Analytics.
- Accessibility of system in forms of you need. Windows or Web clients, configuration consoles, reports on email or alerts on SMS or mobile application to view KPI.
- Extensibility in terms of number of control system connected, tired architecture to create plant, site and organization level structure of KPI.
- Technology support to keep it current. Should be aligned with latest technology and vendor should have comprehensive road map of development and upgrade.
- Ease of Use should be taken as prime feature as it makes acceptability in employee for such system and encourage people to use it effectively.

Specific Features

- Compliance with standards: Should provide reports, analytics and KPI based on international standard as well as possibility to define your own value to start with lower targets and uplift the same step-by-step.
- Logic Engine: Possibility to configure complex logics for various tasks and triggers. It should be able to handle Early Event Detection, Root Cause , Dynamic Alarming, Notification(SMS/Email/PA Connectivity)
- Alarm Rationalization: Process management and workflow handling for alarm rationalization management. Single place to manage whole life cycle of alarms. Workflow to adhere your internal processes.
- Change Management: Should provide comprehensive change management integrated with your all control system

and full support for internal process and compliance procedures.

- Composite Views: Composite view of alarms and trends to give value added decision support system for process analyst.

- Alarm banner: Integrate alarm analytics with your existing operator panels or LVS to focus your operator on most critical task.

- Operator messages: Integrated operator or engineer's messages in terms of pop-ups or SMS to show them additional information or guidelines generated by experts.

- Critical Alarm Handling: AIMS system may provide additional support to acknowledge and commenting of alarms by level of stakeholders in process control to create more involvement in process of handling critical alarms.

- Dashboard and Alarm Portal: Latest technology supported dashboard and alarm portal for maximum accessibility and usability by all the people involved and personalized contents. It should provide right information in time.

- Service and support: Service and support is vital part, vendor should have established support system with alarm experts to help you in all the way of achieving your goals.

Conclusion

AIMS is vital system which effects safety, control performance and finally profitability of plant and should be chosen wisely.

About Author

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Application Note: Remote Vibration Monitoring Analysis

Remote Vibration Monitoring Systems

1. INTRODUCTION

Most of today's maintenance managers are continuously seeking new methods and tools that can enable them to do more with less in order to enhance and improve a company's existing Maintenance, Repair and Operation (MRO) programs. Referred to as "remote condition monitoring and diagnostic systems," such technologies can help cut overall production costs, improve quality, minimize downtime and increase operational efficiency. Thanks to the internet, new diagnostic tools for vibration signal analysis, and high speed communication networks, vibration specialists can acquire vibration data not just on site but also remotely, using internet.

2. DEMANDS FOR REMOTE CONDITION MONITORING:

Machine uptime increase i.e. minimization of the number of equipment failures is the crucial element for maintaining and raising the productivity of every plant. Failures with random occurrence cause huge losses of production capacity. In some cases these types of failures can lead to the loss of human lives as well. Therefore the implementation of some type of maintenance strategy with the purpose of monitoring the operating condition of any machine is an absolute must.

There are two different approaches to monitoring the operating condition of a machine:

1. CURATIVE maintenance i.e. "run to failure maintenance" and

2. PREVENTIVE maintenance which can be divided into:

A. Systematic i.e. time based maintenance. Also known as resource based maintenance

B. Condition based maintenance (CBM). It is based on the monitoring of a specific parameter which directly corresponds to the operating condition of the machine/equipment. Mechanical vibration is one of the best candidates for such a parameter.

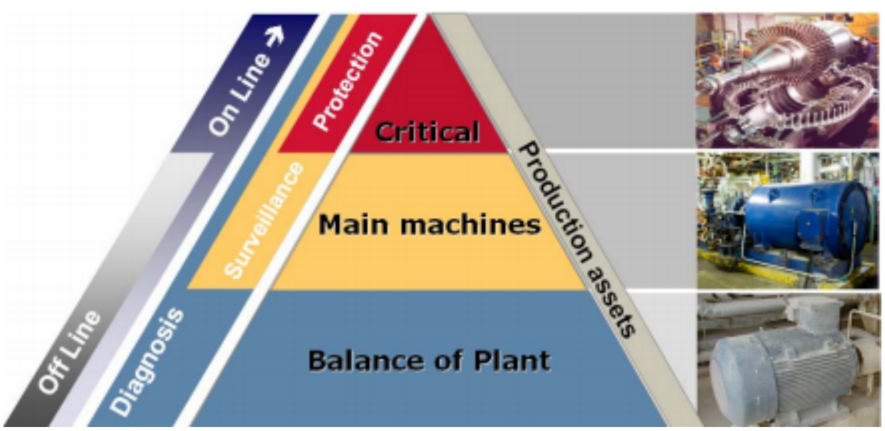
Condition based maintenance has three complementary levels of implementation:

Protection Surveillance Diagnostic, from the point of data acquisition and periodicity analysis, systems for machine protection, monitoring and diagnostics can be:

1. OFFLINE SYSTEMS: systems for periodic maintenance of machines, mean periodic data acquisition and analysis based on a time base, determined by vibration specialists and responsible maintenance managers. Periodicity of data acquisition and analysis should be highly dependent on the current vibration levels of the machine.

2. ONLINE SYSTEMS: permanently installed systems for vibration signals acquisition and analysis. The protection system must be an online system.

For example, a critical machine requires an online monitoring system with protection, surveillance and diagnostic functions. On the other hand, condition monitoring of simple machines like pumps or fans can be based on portable handheld vibration analyzers and periodic measurements and analysis.



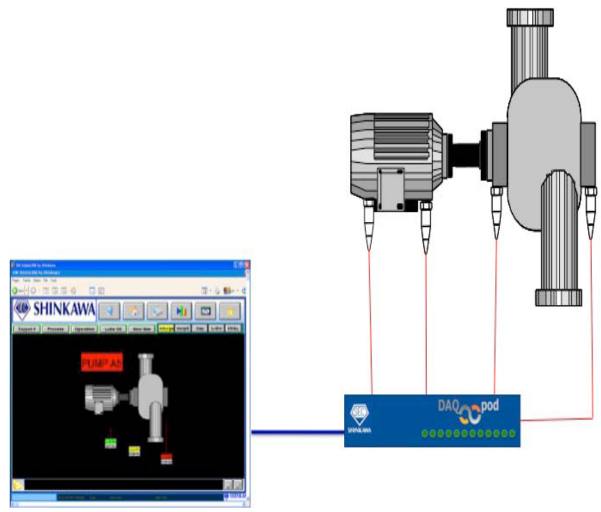
In addition, when choosing the proper maintenance approach for a specific machine group, some additional elements should be evaluated too. This element vindicates the concept of remote condition based monitoring. Despite the fact that traditional condition based maintenance methods guarantee the total production improvement through the reduction of maintenance costs and maintaining the invested capital, the basic request for an on site presence of qualified personnel can sometimes be very expensive.

The online monitoring of critical equipment includes multichannel protection and diagnostic data acquisition online system (measuring device + sensors + cables + PC + software). On the other hand, if the plant has already installed the system on site, highly skilled and educated vibration specialists can perform for vibration data analysis, and in the case of offline systems, for on site data acquisition as well. Well trained and skilled personnel can do it on site. The investments required for the mentioned personnel engagement can be analyzed from an additional point of view, especially in the cases where the company does not have plants centralized in one region. We can note an ongoing trend of big multinational corporations setting up plants all over the world. In order to cut the production costs through the reduction of workers and also through the engagement of cheaper labor, big companies tend to physically (geographically) divide management and administration from production. They are moving their production to different parts of the world where they can find cheaper labor. Unfortunately, as a consequence, these structural changes raise the costs of traditional on site condition based maintenance implementation.

As a result, a new approach in the condition monitoring of machines using internet technologies has arisen: REMOTE VIBRATION MONITORING OF MACHINES. Here the traditional on site maintenance (physical on site presence) is replaced by the web based maintenance of equipment. The main benefit of a computer network, compared to the old fashioned way of on site data collecting, is fast and cheap data acquisition and data transfer from one place to another. By including a high speed computer network into a vibration monitoring system, vibration signals can be transferred into a specific database. Using this database maintenance, managers and vibration specialists have a real-time insight into a machine’s condition. Web based condition monitoring can be applied to both offline and online monitoring systems. However it is much more present in online systems since web based monitoring in the case of offline systems means only remote database and vibration specialists while the presence of maintenance personnel on site is still required for the purpose of vibration data collection.

3. REMOTE VIBRATION MONITORING SYSTEMS:

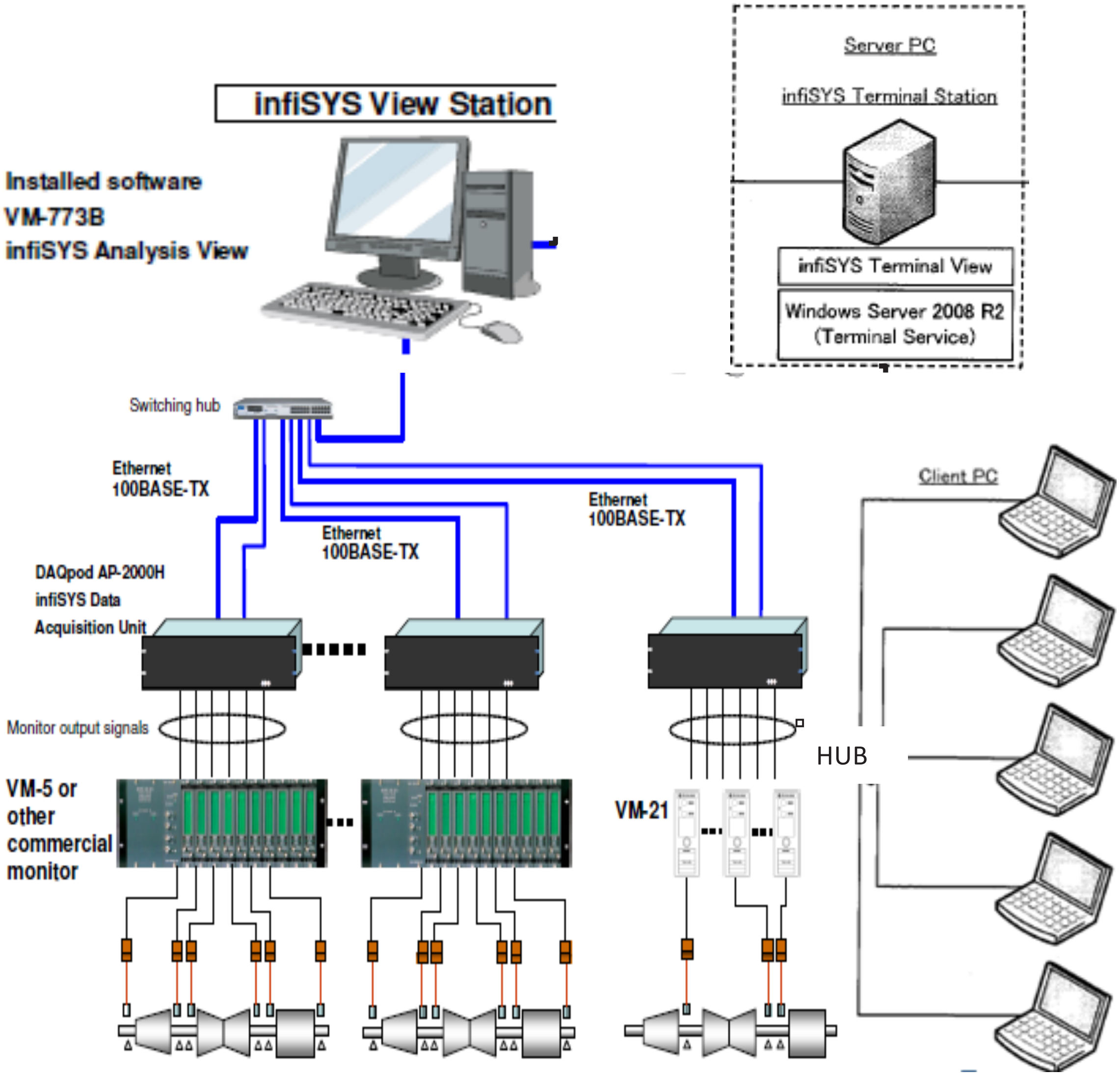
The infiSYS™ software core is a key component of our Monitoring Array family of products that offer unique advantages over our competitors from both a performance and value perspective. infiSYS™ offers cutting edge analysis and diagnostic capability, but is designed in accordance with the philosophy that technology should simplify our lives. In the current business environment, our customers are under extreme pressure to maintain higher machinery reliability levels than ever before and to do so with constant reductions in manpower.



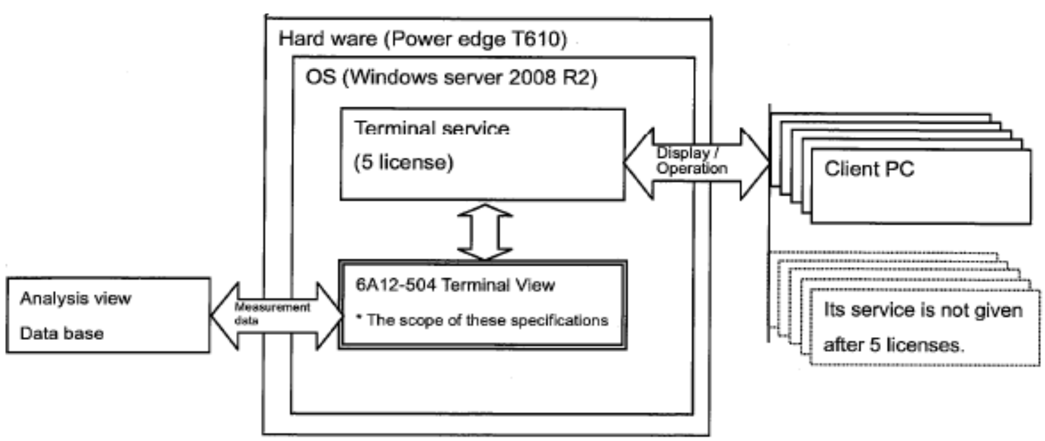
4. SYSTEM DESCRIPTION:

Realtime data acquisition and analysis systems are a great tool to optimize the performance and reliability of critical rotating assets, but traditionally these systems have been expensive to deploy, complicated to learn, and costly to keep updated. infiSYS™ software, along with our DAQpod™ high-speed data acquisition hardware, changes the value equation of machinery protection and analysis by finally making widespread, continuous condition monitoring simple, reliable, and affordable. By simplifying access to your machine data with flexible visualization tools and powerful Web access via the optional webLINK, infiSYS™ enables you to continuously monitor equipment over a large or remote site with exceptional ease. Whether deployed on a local PC, in a LAN configuration, or over the Web, all the features of infiSYS™ are right at your fingertips.

5. TYPICAL LAYOUT



6. SOFTWARE LAYOUT:



7. **FEATURES:**

- **High speed data collection.**
  - Trend Data – updates every 1 second
  - Waveform Data – updates every 10 seconds
- **Wide variety of input functions**
  - VM-7
  - VM-5 (Using DAQPod)
  - Third Party Monitors
- **Multichannel (Streaming / Simultaneous).**
  - Upto 480 Channels
- **Full range of analytical functions.**
- **Supports access to data by employing a SQL Server.**
- **Easy to use graphical interface.**

8. **GRAPHS AVAILABLE**

Trend, Long term trend, Bar, S-V Graph, X-Y Graph, Vector plot, Lissajous (Orbit), Lissajous waveform, Shaft centerline (SC), Waveform/Spectrum, Transient graphs (bode, trend, long term trend, waveform/spectrum, SC, polar), Alarm graphs (trend and waveform/spectrum).

Mr. Mukesh Vyas

Aggregator platform for effective environment monitoring

- Dr. Arvind Tilak,
CEO, Ascent Informatics

Introduction

Petroleum industry and Power plants are most essential components of industrial infrastructure. In an aspirational society and country like India where per capita electricity as well as fossil fuel availability is way below the levels of developed economies, increasing power generation and availability of fossil fuels has to be a national priority. Various options for generation of power are debated in various forums. Also there is very active discussion on use of alternate and renewable fuels. However, one of the definitive inferences is that coal and gas based thermal plants as well as conventional petroleum industry will continue to grow in India for foreseeable future.

The flip side of this is the adverse impact on environment due to considerable emission of polluting gases and particulate matter from power plants and petroleum industry. India already has the dubious status of one of the most polluted country and 11 of the 20 most polluted cities in the world are in India. Delhi has become pollution capital of not just India but the whole world. Our rivers are most polluted water bodies and dead in most cases and they cannot support any animal life impacting their regeneration. All these high pollution levels are taking heavy toll on health and quality of life across the sections of society. Businesses are coming up setting up "Good air" parlors to tide over breathing the polluted air.

Where do we go from here? Globally there are two major policy level initiatives happening. In most cases national regulatory authorities are enhancing their capability and technical tools to acquire data about pollution performance of polluters. In other cases countries are trying non-regulatory and market drive mechanisms to reward good performer and punish non-compliant actor by way of financial costs. ETS for Particulate Matter pilot program being implemented in India is a good example of the second case.

The most critical aspects of this problem are firstly to measure and store in real time pollution performance and have a follow up mechanism to act upon this data. Both are essentially regulatory functions. For both these tasks regulators need an aggregator platform for effective monitoring.

Monitoring pollution

Measuring emissions at local industry level is happening to some extent for some time now. However, this data is currently and in most case not being taken to a central regulatory system and used for effective monitoring and policing. Technology and IT tools for setting up and operating such a platform are available and some of the agencies have taken lead in setting up these. However, currently there is wide debate on exact model that should be adopted and which is most appropriate for the monitoring objectives.

One school of thought for such a central monitoring platform prefers that this platform be set up by the regulator and made accessible to all polluters for uploading data in real time. Onus for providing validated and genuine data rests with the end users and polluters, while onus of setting up and operating the systems rests with the pollution monitoring regulator.

There is a completely different school of thought which considers it critical to make only one party responsible for not only providing instrumentation and installing these, but also for setting up an appropriate software system for online and real time data acquisition. Onus for the entire operations and making data available in this case rest on the polluter but equally with the companies supplying monitoring hardware.

In either of the cases it is necessary to take a holistic view of industrial pollution in an area and its impact on environment. Both models discussed above have pros and cons and are being implemented by various regulators. In this paper I am not attempting to evaluate these pros and cons or argue for one or the other model. In this paper I wish to put forth the need for an integrated aggregator platform to monitor, analyze, validate and benchmark air quality across multiple plants. The paper also presents architecture, characteristics and features of such a platform.

Key challenges

Air pollution measurement technology for various gases, particulate matter, VOC, etc. are fairly advanced. These on line analyzers measure pollution levels at a given location and make it available locally at the point of measurement. The data needs to be acquired from this point and uploaded to a central location and then processed. Again this is not a technological challenge. So what are the challenges in deployment and continuous operation of such a system?

1. Different hardware vendors offer central systems that connect with only their own devices. Plants almost always have devices from multiple vendors and hence multiple such systems. Thus the challenge is to collect data from devices of different makes and models and aggregate it on a single central server
2. Various analyzer companies' use and leverage varied technologies for measurement and analysis. Also different plants have different operating conditions. In an aggregated central system, it will be very critical that data from such diverse technologies and conditions is normalized and made truly comparable.
3. Evacuating data from local pollution sources to a central server over internet or any other telemetry is an operational challenge but lowering of costs and better availability of connectivity are making things easier compared to 5 years back
4. Eliminating attempts of data cleansing to keep it in permissible limits before it is sent to central system
5. Ensuring proper upkeep (maintenance and calibration) of devices so that data measured is reliable

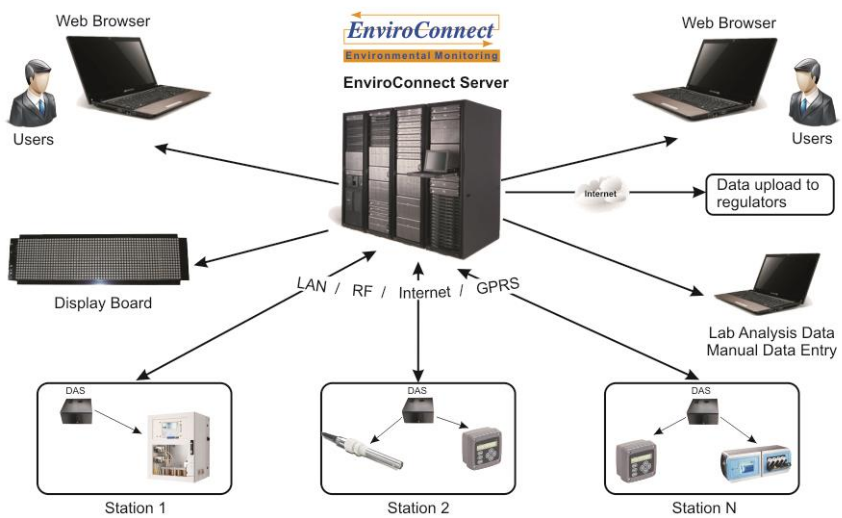
6. Creating a state / national level database(s) of emissions of all industrial (and later other) sources in that region
7. Validating and maintaining such database(s) over a long period is a huge challenge
8. Creating a participatory system where industries have some incentive to pollute less. In other words moving from regulatory driven system to market driven system

Aggregator platform and software

As suggested earlier it will be very important for the regulators (and others like health workers) to get all data for relevant industry/ area/ city, etc. at a single location and without being required to fetch it from diverse platforms. The data must be acquired directly from the analyzers in real time and on line to avoid any chance and incentive for cleaning of data. So how will such a platform look and how can we go about implementing this and using it for regulatory objectives?

Aggregator platform components

The system overall is multi layered system that will be closely integrated and operated as a single entity. These multiple component architecture allow required flexibility to add additional modules, technologies of measurement and most importantly presentation of the output to the users.



- Device drivers for connectivity in real time and directly to various devices measuring stack emissions as well as ambient air quality, water quality, noise, etc.
- Data acquisition software(s) at each plant to acquired data from above, store locally till such time it is uploaded to the central system and remote administration of devices
- Central server(s) on internet accessible to all stake holders to which all data from all such numerous installations is uploaded in real time and stored for analysis, reporting, etc.

- Web portal for all stake holders with appropriate access for various types of users via which they can carry out their business objectives leveraging the acquired data and initiating appropriate actions as required

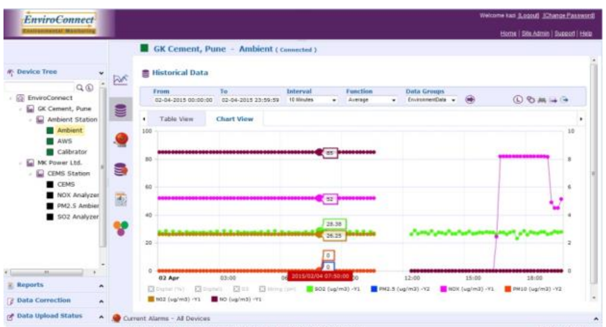
Aggregator platform characteristics

Such an aggregator platform must conform to certain technical and non-technical terms. Some of the major terms of reference are as below

- The platform must be vendor/ hardware agonistic and neutral. That is, it must have capability to connect up with and acquire data from any analyzer hardware
- 24 x 7 operation with uninterrupted availability
- Seamless data collection and upload to server without user intervention
- Ensure maximum data availability and identify gaps if any, with a mechanism to substitute data for such missing periods
- Guarantee of data authenticity and security by way of cross validation and standards
- Capability to present integrated information for a factory or whole region by collating data coming from all sources in that region
- Collaboration platform for regulators, industries, experts, researchers, etc.

Important features

Such a platform will be a complex piece of system of systems and will need involved support and operations. Some of the key features of the platform could be

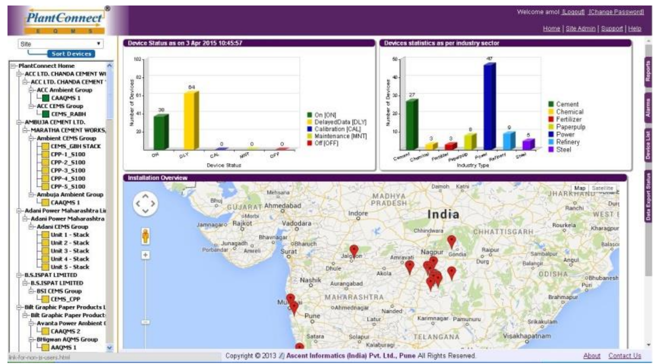


- Real time data collection and presentation as dashboards, tables and values, graphs, widgets, etc. making it easier for users to leverage data for their business objectives
- Data validation, flagging and alarms for assisting users in regulators tasks and for identifying and flagging divergence from standards and norms
- Secure data storage and transportation
- Data collation and analysis as required by users and ability to grow these with requirements
- Exhaustive reporting and querying and dissemination of same to various stake holders in either automated mode or explicit mode
- Control and monitoring of device conditions including remote calibration to ensure proper working and quality of data so acquired
- Ability to provide maintenance as well as process improvement inputs to manufacturing process based on emissions data
- Appropriate work flow for intimation and handling of extra ordinary conditions
- Tools for regulators such that they can ‘regulate thru exception’

- Finally a portal for general public to access relevant data of environment quality which is validated and presented in a easy to understand format

Case study

Maharashtra Pollution Control Board has adopted the model of installing and operating an aggregated solution for AIR. It covers all types of analyzers across state of Maharashtra measuring stack emissions and ambient air quality. EnviroConnect (earlier called PlantConnect EQMS) is the aggregator platform and currently connects up with over 120 stacks / ambient stations. Data so acquired is used by regulators for various tasks including enforcement, advice to end industries etc.



Conclusion

Finally, I will like to propose that such a system should be driven with integrated top down approach against the current bottom up approach. Rather than building silos of measurement, it is important to ensure that irrespective of hardware, all emissions data can go to a central database at state / national level. Ultimate goal should be to integrate a Cap and Trade mechanism which incentivizes industries to reduce emissions. World over this has proven to be far more effective in reducing pollution as compared to regulatory regime. Such approach will benefit all stake holders by reducing air pollution and at the same time reducing cost of ownership for industries and also creating a reliable reference data base.

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Arvind drives business and strategy side of environmental monitoring business at AIPL. He is instrumental in conceptualizing and building the aggregator monitoring platform and its adoption by various stake holders across India and abroad.

Agile Collaborative Engineering Infrastructure

A Novel Comprehensive Engineering Platform to Achive Highest Efficiency in the Engineering Lifecycle of Plants

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Agile Process & Plant Design, Collaborative Engineering, CAE Tools, Software platform, Instrumentation, PLM

ABSTRACT

Agile, parallel and collaborative engineering is the future for modern Process and Instrumentation Design of a plant. Everyday increase of tight competition, high demanding quantity and quality of deliverables and short deadlines of project plans put engineering teams in a desperate need of flexible, open, collaborative and advanced technologies for process design and automation project executions. This paper presents the results of a 4 years research project for design and development of an integrated platform that covers broad range of engineering activities in the plant lifecycle and addresses the ideal environment for each phase considering major criterion affecting various engineering and design activities specific to Oil and Gas and Power Plants industry. Accordingly, we have characterized the conceptual challenges and solutions, benefits and potential time/effort savings that will be achieved in consequence of utilizing such methodologies in the engineering environments.

INTRODUCTION

Process and Instrumentation Engineering projects can be characterized as a series of complicated, multi-phase, and interdisciplinary design and engineering activities that involve interdependent contributions from chemical, Instrumentation, and electrical engineers. [1] Process design traditionally proceeds in a sequential approach [2]. In general, it starts with conceptual design of plant and follows by basic process design. Next steps would be normally detailed process design that also can ignite the instrumentation engineering, basic and detailed electrical design of the plant and consequently DCS configuration. These steps follow after each other and during many iterations become mature. At the end of the workflow, there is a task for making As-Built documents and prepare the plant for pre-commissioning and commissioning.

Consequent to this step would be operation of the plant, maintenance and revamping through the life cycle of plant. Figure 1 shows the traditional sequential process and plant design. Each step follows the other and with numerous iterations the data will be matured and verified to be passed to the next steps of design.

organizational aspects must be considered with the same importance. The success of any collaboration process is strongly linked to the need to share knowledge between actors to ensure a common representation of the problem to be solved. However, the shared knowledge is composed of set of fragments that are created by various actors according to

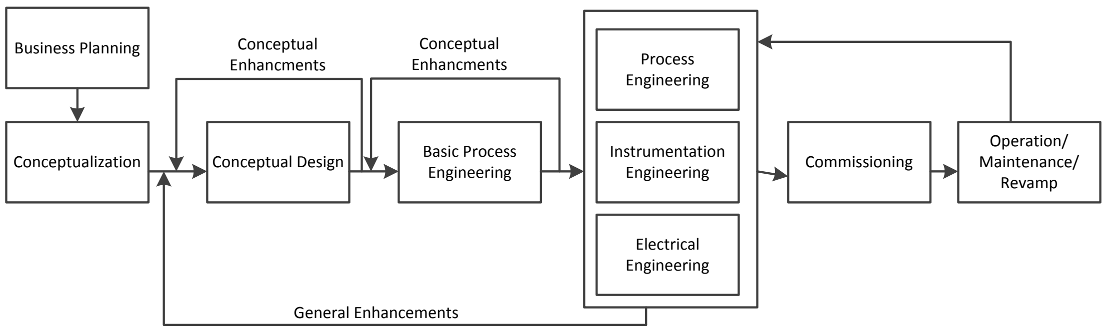


Figure 1 Traditional Sequential Process and Plant Design

their expertise domain. An important aspect to be considered is then the consistency of interconnected data and information coming from different activities and managed by different information systems. [5]

Agile and Collaborative Design

The keen market competition calls for a short lead-time for any plant design projects, with zero tolerance for faulty design. [1] Collaboration Engineering is a rapidly evolving design approach that is used for modelling and deploying repeatable, predictable and transferable collaboration processes for recurring high-value collaborative tasks to be executed by the practitioners themselves [3]. Classical approaches for remote visualization and collaboration used in CAEs applications are no longer appropriate due to the increasing amount of data generated, especially using standard networks [4]. During the design process, Experts from different fields work together to exchange information, expertise, and resources to solve the problem. Everyone contributes according to his specific knowledge Milestones can be programmed to a pooling of the work, to obtain the approval of the hierarchy, and to define the following tasks to perform, but the goals or sub-goals are not previously defined. In this context, communication between members, in addition to coordination, is seen as vital. However, this is not enough, social and

CAD, CAE and Next Generation

Evolution of computers utilization in the engineering has started by digital drawing of plans that were the Computer Aided Design (CAD). This generation could not bear any sort of information behind the drawings and engineering information was stored in separate tables. Second generation was Computer Aided Engineering (CAE), which was integration of some information behind the drawings to make them more intelligent. Currently large amount of commercial engineering software tools are defined in this category. The complexity of projects has led to the development of CAE packages. Such CAE tools provide engineers with more powerful and intelligent functions and capabilities for individual engineering areas, such as Process design, Instrumentation design, and Electrical design. Unfortunately, software tools are usually developed by different vendors emphasizing individual domains of engineering, and hence have different semantics and data structures. While such individual tools are widely applied, there is still no integrated solution for industry use. This situation leads to collaboration difficulties among engineering disciplines, as well as the corresponding tools, due to the difference of specific syntax and semantics embedded in the proprietary data representations

Infrastructure for collaborative Engineering

With this introduction, it is clear that current state of the art for CAEs is not efficient enough for having an integrated comprehensive platform to achieve the highest efficiency needed for the modern competitive design industry.

A paradigm shift is needed in the software design to not only create an integrated base for multi disciplines but also provide a highly optimized data repository and platform that can feed entirety of the lifecycle and provide integrity to all the relevant disciplines that play a role. This multidisciplinary collaborative platform can significantly reduce the time and effort for the tedious and error prone data transportation between disciplines and consequently increase the pace and quality of engineering dramatically.

This platform should provide the required functionalities for entirety of the workflow as well as openness for integration and interoperability to specific engineering or management, Product Life Cycle Management (PLM) tools.

Design of such platform have been the main focus of this research for past few years in the Research and Development Department of AUCOTEC AG that is an Engineering Software vendor in various industrial sectors worldwide. [6–12] Figure 2 shows the conceptual ideal workflow of a collaborative and modern plant design in which an interdisciplinary data platform is the backbone of the complete lifecycle.

DESIGN METHODOLOGY

User-Requirement Driven Software Design

In order to analyze all aspects of a plant lifecycle, a multidisciplinary extensive survey to different engineering phases such as conceptual design and simulation, process and instrumentation design, 3D design, logical control design, basic and detailed electrical design, controller design and configuration, commissioning and finally maintenance and revamping has been performed. Additionally, at each step there are some specific and generic activities that need to be considered e.g. request for tenders and comparison of subcontractors, iterative exchange of instruments specification with multiple automation contractors on the base of available standards such as ISO15926 and

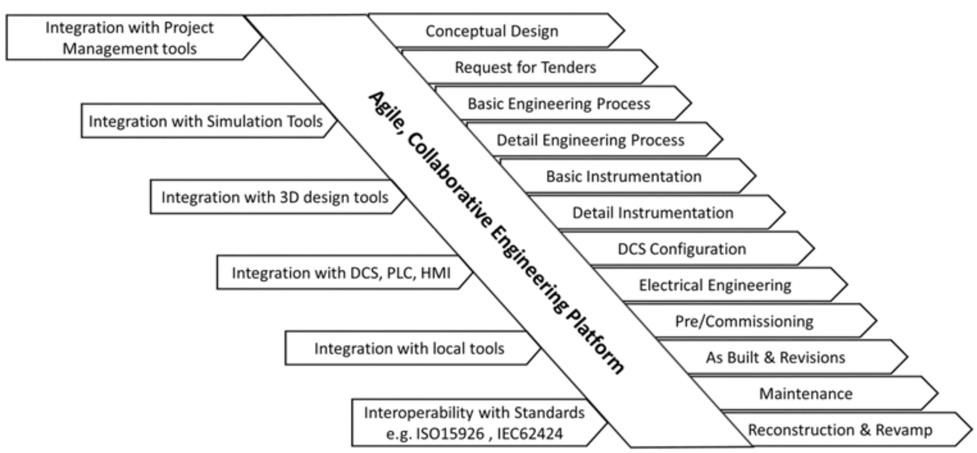


Figure 2 Collaborative Modern workflow for Plant Design

IEC62424, parallel engineering on revamp projects, integration with PD or PL Management tools etc. Combination of numerous activities with individual phases of the lifecycle creates some hundreds of unique demands that in a multiple joint ventures with a wide range of industrial partners in Oil and Gas and Power Plants industry through a research period of 4 years, have been extensively investigated. Subsequently, for each demand, a comprehensive description of requirements have been generated. Table 1 shows the list of industrial partners sorted alphabetically that contributed their special needs and requirements during the design phase of the platform

Table 1 Industrial Partners for design of the platform

Company Name	Company Name
ABB	HOLCIM
ALSTOM	INEOS
BAYER	INFRASERVE
E.ON	OMYA
EMERSON PWS	RWE
EVONIK	SCHNEIDER
FLSMITH	SIEMENS

Design Approach

In the approach for designing a platform, contradictory to the common approach of analyzing individual requirements, finding and offering an ideal individual solution, all the relevant demands were merged and packaged together iteratively and the similarities were identified. Based on these Clusters of demands, a methodology for addressing the Clusters of solutions have been developed. This methodology resulted into design of a platform that can manage all the expectations of specific and generic tasks and provides the possibility of overcoming the future specific requirements. Having such platform will inevitably create an amazing synergy between different disciplines and provides a significant amount of engineering time and efforts savings. Figure 3 shows the procedure of clustering relevant requirements from industrial partners and creating synergy between possible solutions to build up the platform.

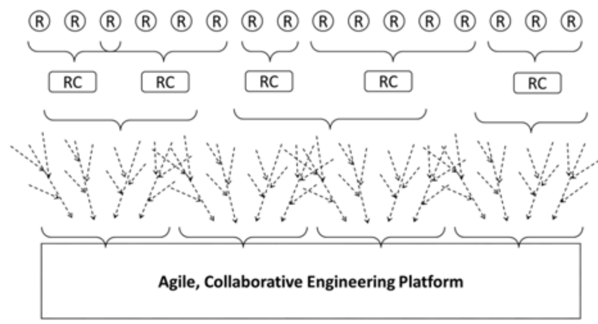


Figure 3 Clustering requirements for designing the platform

In the design of such platform, many considerations such as IT Architecture, global platform data model, Project data model and semantics, Projects execution methodology, specific tasks execution methodologies, openness of the environment and its global interoperability and Projects maintenance methodologies have been taken into account.

The suggested design has been optimized in many interactive steps with feedbacks from industrial partners in many aspects and potentially can offer the highest efficiency in performing tasks in a parallel collaborative engineering environment. In this paper, authors will explain the methodological and technical details about mentioned aspects of the platform and elaborate how such platform can be adopted in a design or operation environment and can significantly save time and effort in the engineering lifecycle of a Process and Plant.

PLATFORM IT ARCHITECTURE

Introduction

IT architecture design of such platform is the first step in the conceptual design of the software. The IT structure should support the concept of parallel engineering in which multiple users need to collaborate in one project and occasionally work on the same drawing or set of data. Considering the various numbers of engineers, working together that can vary from 5 to 200 or more in the same project, IT architecture should be powerful enough to handle the data traffic and simultaneously provide a fast and online accessibility to all users. Different candidates were available to serve as the data repository of the platform. Due to wide acceptability, high performance and large number of integration possibilities, Microsoft SQL server was the winner of the contest between other candidates such as ORACLE or IBM DB2.

Client/Server architecture

In order to make the multi user environment and provide the possibility of multiple users to access the SQL Server database, an application server have been designed to manage the traffic of data to and from the server. Consequently, clients will be able to connect to the application server and then application server will manage the queries to the database. This architecture will significantly increase the performance in a multi-user environment. Figure 4 shows the client server architecture.

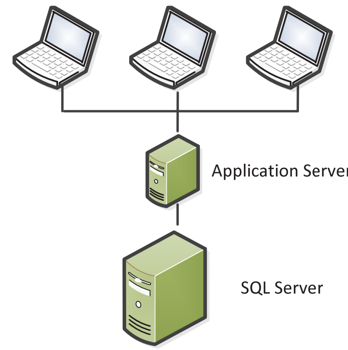


Figure 4 Client Server Architecture

Flexibility of the architecture

Discretization of the Application Server from the SQL server will extremely increase the flexibility of the IT structure to be adopted in various business sizes and environments. In small size environments, SQL and Application server can be installed on one machine and depending on multi user or single-user, clients can be installed on other machines or the same machine. In the case of large size business, SQL and Application server can be installed on different machines to improve the performance and accordingly various other technologies such as clouds, firewalls, and CITRIX capability can be adopted to the architecture. Figure 5 shows the possible full-blown architecture of the platform.

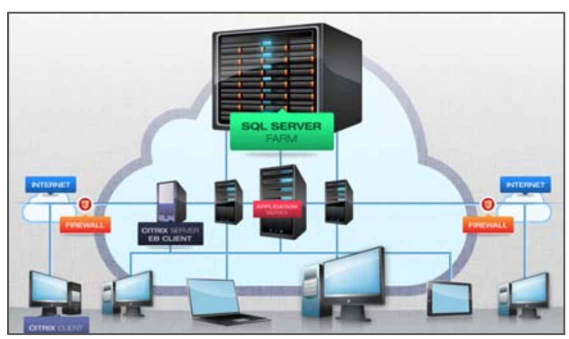


Figure 5 Infrastructure as a Service (IaaS) Architecture of the platform

META DATA MODEL

Introduction

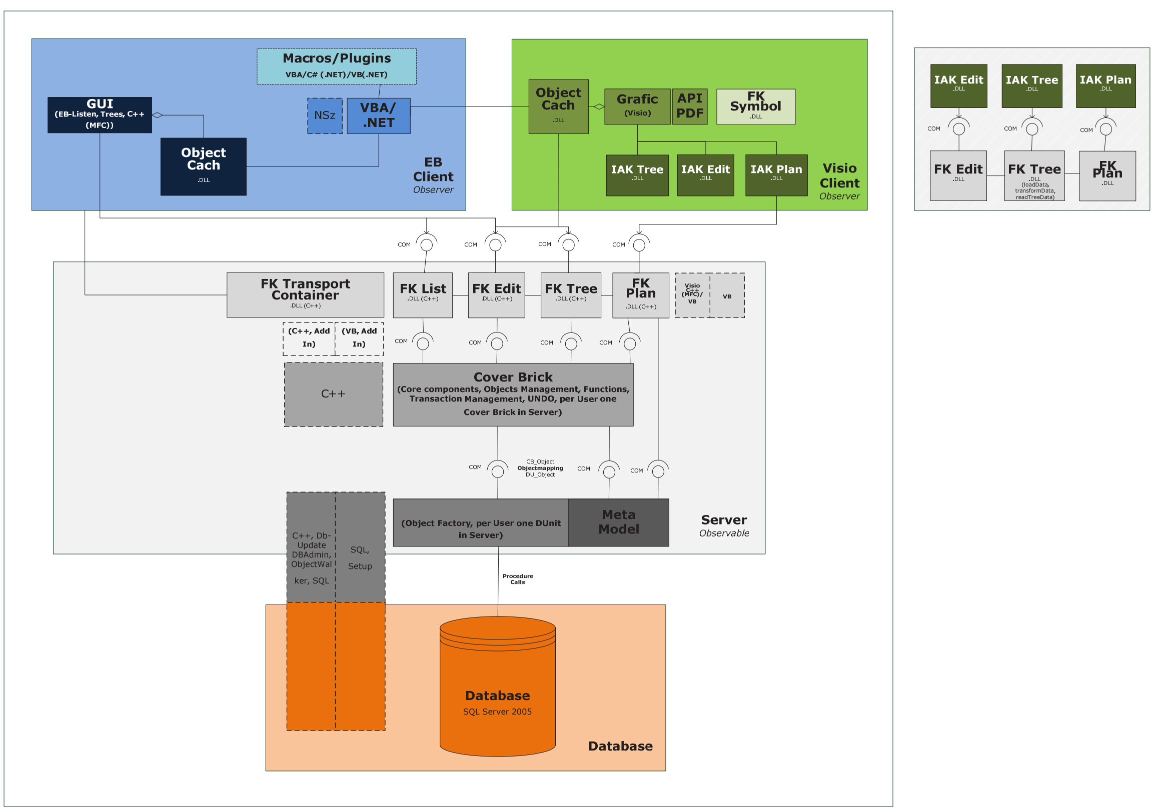
In principle, there are plenty of criterion that has to be fulfilled in the design of the meta-data model. Meta data model should be comprehensive enough to cover all different aspects of designing a plant through the complete lifecycle from conceptual design to process, instrumentation, electrical and controller configuration in a multi user, multi-language, multi project collaborative engineering environment. Moreover, it should provide very high level of customization possibilities to end users while it keeps the aspects of flexibility and user friendly architecture. Fulfilling these requirements are the fundamentals of any meta-data model for a platform that has been explained above. [13–15]

Database Driven and Object Oriented

Utilizing the database driven and object oriented technologies is a clear path of design for any modern advanced engineering software tool. Therefore, the meta-data model and semantics that can absorb the full power of these technologies is a necessity in order to have a high performance orchestra of elements in the system.

Platform Technology

The technology behind the platform is represented in the Figure 6. In this picture, it can be that the Meta data model is divided in three main divisions. In the bottom, there exist a SQL server 2005 database that acts as a repository of data. Above the database, there is the application server that acts as an intermediate level between clients' side and database. Application server contains the semantics of the meta-data model and controls the transactions between clients and database. For each type of inquiry for each user there will be a cover brick acting as an agent to manage the extraction of data from the database for the user and transporting it to the client side. On the top level, there is the client side. In this sector, there are two sub-sectors. In the left side, there exists the client explorer that follows the look and feel of Microsoft Explorer. On the left side,



Microsoft Visio is used for representation of the objects on sheets.

Platform Specifications

Above the explained architecture and Meta Data model, there should exist a user friendly, flexible, comprehensive user interface. This interface has to cover the all the interactions between the users on the client side including the explorer part and Visio part. In the following, there will be elaboration for each building block of the interface. Structure of each building block or in the other words each section is unique to its functionality but in principle, all of them follow the aggregation, association concepts in tree views of the objects in analogy to Microsoft Windows folders and files explorer. This similarity will highly reduce the learning curve for final users due to common competence of engineers to Microsoft Windows architecture.

Projects

The first section of the interface is a container for active projects. Like all other sections, it is possible for the user to structure the objects in hierarchical folders based on various categories. Details inside each project will be elaborated with details in further sections.

Catalogs

One of the fundamental ideas of increasing the pace of engineering and design is to use proved and certified modules from technical libraries of data that not only include the technical specification of equipment and instrument, but also contain the complete data model of each equipment and its aggregated devices. In our platform catalogs is the section for storing these libraries so multiple users can use them in any arbitrary project.

Catalogs should have three main characteristic. First, user should be able to populate and update them directly and automatically from the websites of vendors. This will ensure a genuine data library and keeps the consistency of using correct shapes and specifications through all lifecycle of the project. Second, catalogs should be designed in a way that can be associated to many different projects at the same time in a many-to-many relationship. Once the association has been built, project executors can benefit from huge amount of automation of tasks regarding specifying the equipment and building the equipment blocks.

Third characteristic of the project should be their flexibility in their classification. They should be flexible and user friendly enough to be classified and reclassified by various categories during the project execution. This will significantly reduce the time and effort for finding the correct equipment in the design phase.

Dictionaries

One of the main requirements of modern project execution is to have the same project in various languages for presenting the data and reports as well as performing the engineering. This section of our platform includes the tables for multiple languages. Each column of these tables is dedicated to one language and each row includes one word and its translation in multiple languages. Following the same concept as catalogs, these tables also can be associated to multiple projects.

Dictionary tables are designed to be open and flexible. Therefore adding new languages to the system or adding new words or combination of words and their translation or their meaning in terms of common understanding of engineers in specific industries and cultures is as simple as adding columns and rows to a dictionary table that is associated to the project.

Once the dictionary is associated to project, engineers can use a specific keyboard shortcut to use the dictionary translatable text instead of plain text in the project.

Types

In principle, every engineering physical or logical object in a project can be classified into a type. These types will act as holder of necessary attributes and stencils. Therefore, whenever a new object has to be born, the first parameter that has to be specified is the type of that object. Once the type of the object have been specified, system will follow the data model to extract the necessary attributes and stencils from the type definition and assign them to the newly created object. Note that during this progress, no new instance of the attributes or stencils will be created but an association will be made between the object, stencils, and attributes. This concept will significantly increase the consistency of the projects when it comes to situations such as changing the name of attributes or changing the stencils or shape. This means if name of an attribute has been changed in the database, all the objects in all the projects that inherit that specific attribute will inherit the new name of the attribute without any updates required.

Stencils and Attributes

There are two separate sections for storing all the attributes and stencils in the database. Following the same conceptual architecture of other sections, these objects also can be classified in various categories to simplify their accessibility during customizations.

Based on the requirements of the project users are able to create various types of attributes. They can be plain texts, numbers, Booleans, Data/Time or attributes that are structured based on combination of other multiple attributes. Each attribute has its unique ID that makes it independent of the system language and increases the performance of accessing them through various channels and protocols.

Stencils are packages of shapes that have their own attributes. These stencils can be associated to different types and utilizing the bridge of types, they can be used as graphical representations for engineering objects in the project. In design of each shape user can choose from any of attributes of the related type and show them on the shape. The value of these visible attributes on the drawings is directly fed by the object attributes. Thus, a huge amount of synchronization of multiple sheets is immediately omitted due to complete and seamless object oriented architecture. This very important concept and advantage will be explained in further details in next chapters.

Moreover, shapes have a version number as one of their attributes. This will give the maintainers of the system to update all the used shapes in all projects and drawings to the current version without any further consistency checks.

Templates

As it has been elaborated before, one of the major parameters of achieving the high performance and efficiency in a collaborative engineering environment is utilizing the template driven workflow. To realize this fact, there is a section designed in the database for storing high abstract level templates e.g. project templates. Here users can create unlimited number of project templates based on different industry sectors, costumer classifications etc. and in the event of new projects, instead of starting from the scratch, project can be started from a template with readymade infrastructure or from 150% project followed by omitting the unnecessary parts.

Assistants

In general, assistants are divided into two categories. Category one of the assistances are the ones that will be called at some point of the project execution to perform certain tasks and routines and after the expected results have been achieved, they will be closed. These assistances are called macro in our platform. In a multi user environment that any user can call each macro at any time are certain amount of rules that have to be implemented in the data model to keep the integrity and consistency.

Second category of assistances are the ones that are running in the background as long as they are in the active mode. Their range of functionality covers all the users in all parts of a project and these assistances have the possibility of direct communication with the database. This will highly increase their performance to assist engineers in their daily work. One example of such online assistances is automatic numbering of devices based on various naming conventions and rules. Enabling such assistance will name and number the entire relevant device that are created project wide.

PROJECT DATA MODEL AND SEMANTICS

Different aspects of a plant

Modern design of a plant needs a clear distinguish between different viewpoints to the plant. A production or power plant can be viewed and design in three major aspect; Functional Aspect, Equipment Aspect and physical location aspect. Utilization of each of these aspects will be explained in this chapter. The most important consideration in the data model of a project that has to be taken into account is the flexibility of the data model in each section. This means engineers should have no limitation to structure their plant and project in various aspects of viewing a plant.

Functional View

The functional view to a plant can be the main backbone for designing a plant. If we consider that every element or group elements in the plant has a functionality, cascade of these functionalities will create a structural architecture for the plant. Functional view to the plant will greatly increase the possibilities of reusing the proved and certified readymade modules as blocks of functionalities that can be plugged in to different parts of the project.

Each function has to fulfill a certain task in the plant thus, it is associated to various mechanical equipment and instruments. These associations will give significant degree of freedom to mechanical engineers as well as process engineers to work on the same project and plant simultaneously but just in different aspects.

Equipment View

As it has been mentioned before, another aspect of designing a plant is to design the units, equipment and instruments. Considering that each unit can be consisted of multiple equipment, pipes cables, wires etc. and each equipment can be consisted of other sub equipment, pipes or instruments etc. Aggregating all these objects during the design of the plant will provide the architectural structure for the equipment design aspect of the plant. Obviously, every single item in the equipment folder can be associated to a functionality in the function folder.

Physical Location View

The third aspect of designing a plant is the physical location aspect. Each unit, equipment or group of equipment have a specific physical location. Same as before each location such as a room or a building also can have an aggregated or parent location and combination of all these locations will structure an architecture for the physical location design aspect. It can be derived that each unit, equipment or instrument can be associated to a location in the data model of the project.

Visualization of Objects

So far, we have explained the alphanumeric data model and structure of the plant. This shows the true colors of an object oriented project execution that gives significant possibilities for various activities such as re use of data, automatic reports creation, Import and export capabilities, quality checks etc.

Next optional level for engineers is to visualize the data model of the project. For this reason, we have designed a documents section in the project. In this section, all types of documents regardless of the industry sector that they are related, can be stored and classified if needed. As explained before for each object there can be unlimited shapes related to various types of drawings, users can drag and drop each shape on each drawing, and consequently an association between those representations and the objects will be created. It can be concluded that all the representations of objects get their information via their associations directly from the object and also there is no limitation of drawing types such as Block diagrams, PFD, P&ID, Logic Diagram, Interlocks, Single Lines, Circuit Diagrams, Loop Diagrams, Hookups, various sorts of reports etc.

3D Representation of plant

Designing a comprehensive platform that can cover the entirety of plant data model, requires many different considerations and compromises. As it have been explained, all sorts of 2D drawings can be designed with the backbone of the database. Nevertheless, there are certain areas that have extreme specialties and there are specific and professional software tools available for them. Some examples of these areas include Process or Electrical static or dynamic simulation, 3D design of equipment including detailed mechanicals, cables and wires, mechanical Stress analysis of equipment, 3D design of piping and plant or 3D civil design of plant etc.

For these cases, we have designed an open Application Programing Interface (API) that has access to the complete data model of the project. Thus a seamless, On/offline integration with all the modern 3D software tools or simulation tools with an open API. This concept will save a lot of learning curve time by giving the chance to engineering teams to keep their own specific local software tools and integrate them with the platform.

PROJECTS EXECUTION METHODOLOGY

Introduction

Structure of the data model for an executable project is designed in a way that users have very large degrees of freedom for starting a project and performing engineering tasks in sequential or parallel workflow. Nevertheless, here we explain an example use case for executing the project that can be started from Block diagram and can continue up to the transporting data directly to DCS configurator tool.

Conceptual Design

Following the concept of workflow driven, based on the class of current project, user can use an intelligent search method to find the best matching project template from the project templates and start the design process. Next step can be design of the block diagram. Each block is a functional object in the plant and the topology of connecting these functional blocks can be shown in a block diagram. The information of each block can directly be sent to simulation tools such as Aspen Plus or ProII.

Basic Process Design

After the simulation and optimization of blocks have been performed in simulators including the material and energy balance calculations for pipelines and equipment, all these information can be called and extracted completely automatically to the current project in the platform. From this point, process engineers can start designing Process Flow Diagrams (PFD) based on the information from simulation tools. It is clear that each object is directly associated to the objects in simulation tool. Thus, any sort of updates in the specification in both sides is synchronized online including the delta management capabilities.

Detailed Process Design

After the design of PFDs, The next step is designing Process and Instrumentation Diagrams (P&IDs). Design of P&IDs is based on the same objects that are already available on PFD but with different shapes suitable for P&ID, drawings that have more details to be shown. In the design of P&IDs, following features can be utilized:

- Pipes Spec Driven workflow for Pipe Classes and Specs
- Modular P&ID Design – Reusing already available modules
- Transporting the information about the chemical substances in pipelines and related equipment
- Pipelines and Pipe segments with automatic generation of Pipe Schedules and Pipeline BOM.
- Highlight of process steps and Process sequence
- Generation of Cause and Effect table from P&ID and data model
- Assigning or generating Specification reports for variety of devices
- Assigning or generating Hook-Up Drawings for instruments
- Creating Process Control Equipment (PCE) Requests
- Design and configuration of Control Philosophy and concepts
- Using catalogs for instruments
- Automatic Generation of BOM report, Instruments list, Motor Lists, Equipment's Data Sheets, etc.

Instrumentation and Control Design

Next step after designing P&IDs can be instrumentation engineering. In principle, instrumentation engineering is creating the bridge between instruments in the field and Digital Control System (DCS). Thus, the starting point can be the instruments list. From this list, engineers can again use the template driven workflow concept and utilize the typical loop diagrams for each instrument. Using Typical Manager feature user can find the best matching typical and automatically assign it to the instrument. As a result, of creating the loops, all the wiring and connections between the instruments, terminals in junction boxes will be generated. Reports such as cables schedules, wire schedules, junction box configurations etc. will be generated resultantly. Also consequently, the floating I/Os have been created and the I/O list is ready for next step that is controller assignment.

Detailed Electrical Design

In parallel to instrumentation engineering, electrical engineers can perform activities such as designing Single Line Diagrams (SLD), Circuit Diagrams, Topology structures for cable routings, Automatic cabinet lay out design and wiring inside the cabinet. Interlock and logic diagrams, etc.

DCS engineering and configuration

For the next phase, necessary data can be transported to the DCS configuration tool. Currently there are seamless and deep integrations with EMERSON OVATION, EMERSON DeltaV, ABB 800xA. In addition, there are other interoperability options through ISO15926 or IEC62424 via AutomationML. These integrations are bidirectional including the delta managements for multiple iterations of data exchange between the platform and Process control design tools.

OPENNESS OF THE ENVIRONMENT

Openness of the system to other engineering tools is one of the main important factors for evaluating any engineering system. Here we name some of available functionalities available in the platform in very short description to show the tip of the iceberg.

Import and Export

In principle, it is possible to export or import the alphanumeric data in arbitrary custom tables to excel or access formats or XML formats via intelligent importer or exporter tools including the delta management functionality. For the graphical representation of data, there are numerous features for exporting to various formats of DWG, PDF, TIFF. All the imports and exports to DWG formats are following intelligent concepts and include the necessary data for blocks and attributes of blocks in the DWG files.

Application Programming Interface (API)

API of the platform is a very powerful gate for integration through any sort of open software tool. Programming languages that are supported by the API are VBA, and all the family of .NET i.e. C#, C++, VB.

Moreover, through API, it would be possible to create the required exporter or Importer functionalities based on special customized formats that might be needed in special cases.

Web Services

Another gate for creating communication bridges to the platform is web services that are provided in the platform. Web services create the possibility of connecting to the platform from any external machine through Hypertext Transfer Protocols "https:\". This provides any local developed application for smartphones or web applications based on browsers to connect to the platform and provide extreme amount of possibilities to various types of user such as maintenance engineers and sales engineers. Thus, maintenance engineers can benefit from concepts such as online As-Built Documentation or equipment with QR code that can be scanned and then all the related documents will be available for reviewing or redlining.

CONCLUSION

It has been explained that how an integrated object oriented database driven platform can provide an environment for agile collaborative engineering through the complete lifecycle of designing and operating a process or power plant. Differences between the traditional sequential design workflow and agile parallel and collaborative workflow have been explained. To achieve such environment, the IT infrastructure, data models, interface principles, openness of the platform and a sample use case have been elaborated.

Real industrial implementation of this platform in various multi user international and interdisciplinary projects show significant time and effort savings, in some environments 30% up to 65% save. This dramatic time and effort save resulted into huge savings of budgets and simultaneously significant increase in the quality of documentations and deliverables.

Usage of Platform have been tested in both green field projects and brown field projects that the data model was not already available. Migrating the available extreme heterogeneous documentation to the platform was not a straight forward path but this effort have been justified by the investments savings through the maintenance of the plant and costly activities such as revamps and retrofits.

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VIRTUAL INSTRUMENTATION

FOR TEST, MEASUREMENT AND PROCESS CONTROL IN POWER PLANT AND REFINERY

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ABSTRACT:

Computer-based instrumentation has been the choice of the day due to the increasing power of microprocessor chips and software techniques. Virtual instrumentation is the natural evolution of computer-based measurement systems and makes use of the enhancements in the computer hardware as well as the new programming techniques. Virtual instrumentation represents a new generation of instrumentation and has been widely adopted by the test and measurement community. A virtual instrument, in principle, is a computer based software-driven instrument for test, measurement, or process control applications. The use of computer allows confining the hardware components (dedicated to the measurement application) to the data input/output subsystems responsible for data acquisition and generation. All operations of the ,test and measurement procedure, like control of information, display and analysis of acquired data, data management (such as archiving, printing, internet publishing. etc.) are performed by the software. Thus, a virtual instrument defines its specific functions through software programming and is software-intensive.

KEYWORDS: Photovoltaic power plant, Refinery Process Control, DAQ, LM35, IC293D , DC Motor Control , Level Sensor.

ADVANTAGES OF VIRTUAL INSTRUMENTS:

One of the main advantages of virtual instruments is the fact that students are able to define instruments inside the software. Other characteristics of virtual instruments are:

- lower costs of instrumentation
- portability between various computer platforms
- easy-to-use graphical user interface
- graphical representation of program structures
- code can be compiled to standalone.EXE or .DLL file
- TCP/IP connectivity (Web server integrated into virtual instrument).

OBJECTIVE OF PAPER:

The topic of discussion here is the Use of Virtual Instrumentation in Measurement, Test and Process Control in Power Plant and Refineries.

Challenges faced in Power Plants:

Over the coming decades, the power generation industry faces a daunting challenge in meeting global energy needs. By 2030, electricity use will double globally and triple in developing countries. To fulfil such high requirements there is a need to develop a program with greater efficiency and less flaws.

In power plants operated on photovoltaic technology, the power generation depends on the environmental conditions, on the amount of light falling on the panels. Another major problem is the panels get covered by dust which reduces their efficiency.

The panels and other instruments used for power generation have variable parameters like orientation etc which needs human consideration so that the right amount of light should fall on them.

Solution by virtual instrumentation:

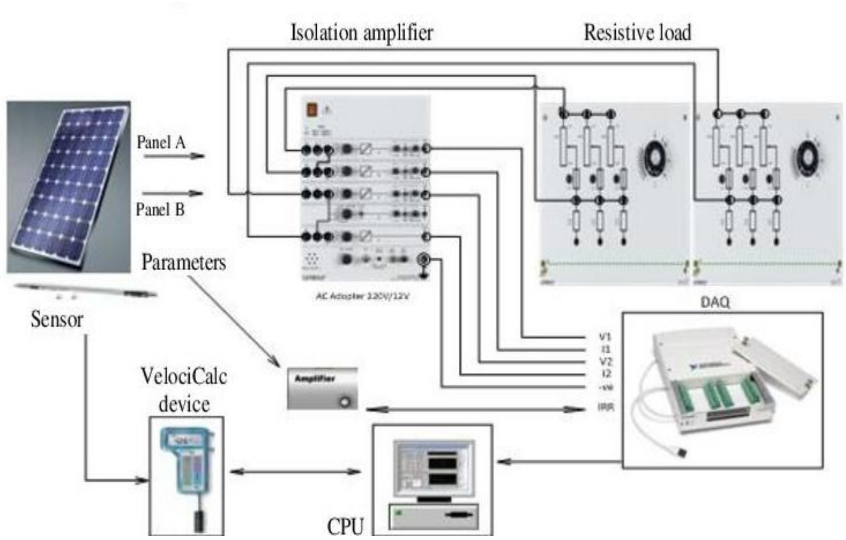
With the advent of technological advancements as a solution to the problems faced in power plants came the virtual instrumentation. Virtual instrumentation is the use of customizable software and modular measurement hardware to create user-defined measurement systems, called virtual instruments.

The concept of a synthetic instrument is a subset of the virtual instrument concept. A synthetic instrument is a kind of virtual instrument that is purely software defined. A synthetic instrument performs a specific synthesis, analysis, or measurement function on completely generic, measurement agnostic hardware.

We can obtain the IV and PV curves with help of virtual instrumentation and with use of those all the parameters can be calculated .Orientation of the panels can be changed in a predefined manner according to the data.

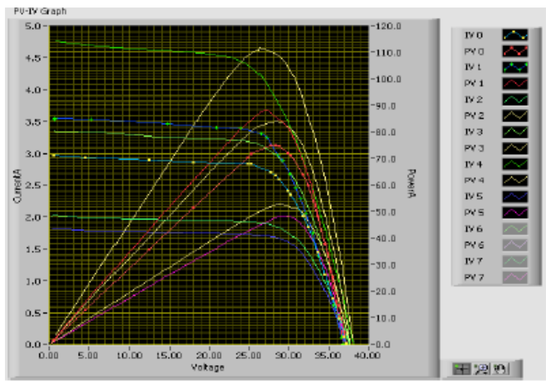
Application to Photovoltaic Power Plants:

In the analysis, process control and test of PV power plants the Virtual Instrumentation can be very efficiently used. System is formed by two solar panels, environmental parameters and irradiation sensors, isolation amplifier, resistive load banks, amplifier circuit and data acquisition instrument (DAQ). The entire system is monitored and controlled by LabVIEW environment.



Layout of Photovoltaic Power Plant Using Virtual Instrumentation

This paper presents and discusses the performance evaluation, monitoring and analysis of a stand-alone Photovoltaic (PV) system. This experimental investigation achieves its objectives using Laboratory Virtual Instrument Engineering Workbench (LabVIEW) interface capabilities. The installed PV generator system operates in extreme and severe weather conditions. The local area is characterized by a high level of irradiation, high humidity variations, very high ambient temperature and frequent dust storms. Two PV panels of 150 W rating each are used. Each panel feeds a variable resistive load separately and simultaneously. The constructed setup engine displays environmental parameters and the associated electrical variables (voltage, current and power) on dedicated graph windows continuously in a real time manner. The current versus voltage (I-V) and power versus voltage (P-V) characteristics are taken for any chosen panel, displayed and stored accurately.



I-V AND P-V CURVES

LabVIEW allows appending any characteristics for the sake of comparison, investigation and research purposes. LabVIEW has shown high performance in communicating with several devices simultaneously and high capability of displaying several variables behaviour at a time. The designed virtual instrument (VI) filters are programmed to execute different tasks on a priority basis. The developed system reveals and stores the pronounced impact of dust, the variation of temperature and the irradiation changes on the PV panel power output behaviour. The monitoring results are very satisfactory. The online data display in multi-scale window frame is very informative. The online efficiency evaluation is very useful for system operation and analysis.

Thus using LabVIEW environment, the whole integrated system can be tested for real time measurements as well as for I-V and P-V characteristics under different environmental conditions.

Inference of power plant application:

1) LabVIEW shell can be tested during clear day time under normal ambient temperature and clean panel conditions. The output power monitored at real time rate. The stand alone system performance is mainly affected by the irradiation variation during the day. The developed system displays graphically and recorded all the weather parameters as well the relevant voltage, current and power at high frequency measurement and at the designated average time interval.

2) The interface capability of displaying several parameters and variables simultaneously in a multi scale window frame is very useful for analysis purposes. Each panel variable could be monitored separately on real time basis for unlimited number of days. The data is continuously stored and recorded by a file per day.

3) The simultaneous performance of PV clean panel and similar dusty panel can investigated using LabVIEW system through the I-V curves along with its corresponding P-V curves for each panel. The curve results have demonstrated clearly better performance in favour of the clean panel. LabVIEW graphs have revealed a different slope for the dusty panel I-V curve to declare the change in the electrical parameters such as parallel and series resistance of the dusty panel.

4) The automatic appending capability for online environment is a very good feature of the developed LabVIEW system. Power output evaluation as well as the monitoring of panel temperature under different irradiations would be essential for the healthy and efficient system exploitation. System levels evaluation and a comparative feature can be successfully tested and the performance of clean and dusty panels under the impact of different levels of irradiations can be displayed.

Challenges faced in refinery:

One of the major problems in refineries is to obtain the correct composition of the chemicals which are to be used.

Another factor which needs consideration is the use of level sensor indicators in various parts of refinery where the level of raw materials needs to be maintained.

Some of the chemicals used are volatile in nature which brings the temperature sensors in action. These are required to control the temperature of such substances as exceeding the maximum limit can cause a severe damage.

Monitoring also becomes a big issue when so many devices are to be worked together and to be controlled for proper functioning.

Solution by virtual instrumentation:

It is not feasible to apply manual approach to make the correct composition of the chemicals used for various refining processes and hence the use sensor technology comes in.

With virtual instrumentation this can become easy as all the sensors and proportions can be controlled in combination with the virtual instrumentation technology.

Temperature sensors can also be connected with the virtual automation system which can work to control the temperature of highly volatile substances.

The major advantage of virtual refinery comes with centralized monitoring and controlling feature. From a single place all the components can be easily controlled reducing the complexity.

Application in Process control in Refineries:

Refineries make use of fractional distillation columns which make use of the property of crude oil that different components of the crude oil have different volatility hence vaporise at different temperature. Virtual instrumentation can be used to accurately monitor the temperature and take necessary actions. The actions can be broken into various steps:

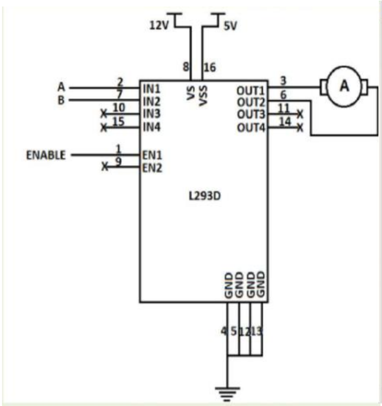
1) Sensing the temperature.
2) Controlling a DC motor so as to move the pipe arrangement for collecting a particular component of crude oil.
3) Sensing the level of crude oil left.

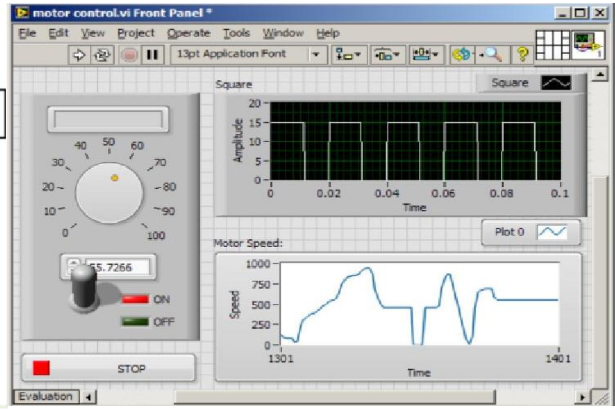
In this type of arrangement we may firstly sense the temperature and accordingly the pipe leading to the storage tank of particular component of crude oil is brought in to carry the component to tank. For eg. say we get “X” component of crude oil at “Y” temperature then the motor is to be controlled using VI and as soon as “Y” temperature is sensed and the motor connected to the pipes arrangement of “X” component starts working in order to collect it.

The three key processes can be carried out using Virtual Instrumentation and they are as follows:

(1) DC MOTOR INTERFACING WITH DAQ CARD:

IC L293D L293D is a quadruple high current half-H driver for the DC motor. The L293D is designed to provide bidirectional drive currents of up to 600mA at voltages from 4.5 V TO 36 V. All the inputs are TTL compatible. Drivers are enabled in pairs, with drivers 1 and 2 enabled by 1,2EN and drivers 3 and 4 enabled by 3,4EN. L293D is used to drive the motor. Basically the output of the PWM Generator is given to the EN1 pin of the L293D. When the PWM Generator output is high it enables the driver. 1A and 2A are two inputs; 1Y and 2Y are the outputs. The output terminal of the L293D is connected to the dc motor input. When 1A is high and 2A is low the motor will rotate in anti clock wise direction and when the polarity is reversed then the motor will rotate in clock wise direction.

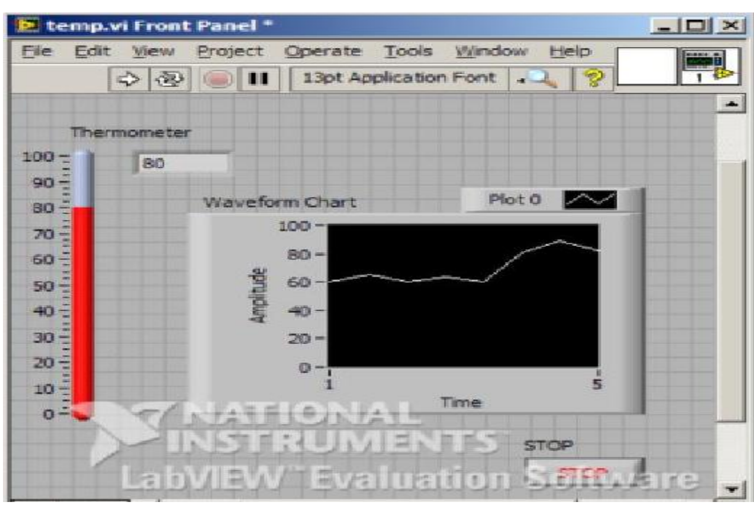




IC L293D **FRONT PANEL FOR DC MOTOR CONTROL**

(2) SENSING THE TEMPERATURE OF FURNACE:

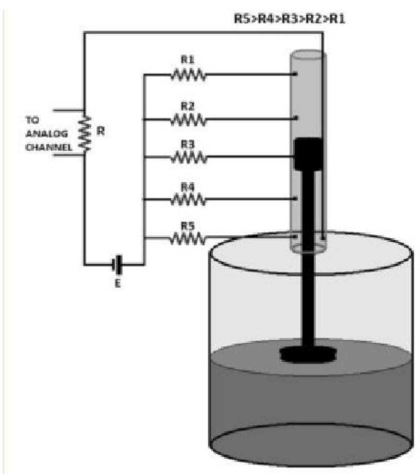
The temperature monitoring of furnace will be done using LabVIEW. The temperature sensors will send analogue signal to the DAQ card which will convert it into digital form and send it to the PC. Sensors will constantly send signal to DAQ card and thereby to the PC. Once the temperature is reached to set point, which is set by the user the PC will send analogue signal to alarm which may be the LED'S or the buzzer according to the user convenience. Once the fed is turned ON user may take appropriate steps to control the temperature. Qualitatively, the temperature of an object is determined by the sensation of heat or cold felt by touching an object. Technically, temperature is a measure of the average kinetic energy of the particles in a sample of matter, expressed in units of degrees on a standardized scale. You can measure temperature in many different ways that vary in cost of equipment and accuracy. Thermocouples are one of the most common sensors used to measure temperature because they are relatively inexpensive yet accurate sensors that can operate over a wide range of temperatures.

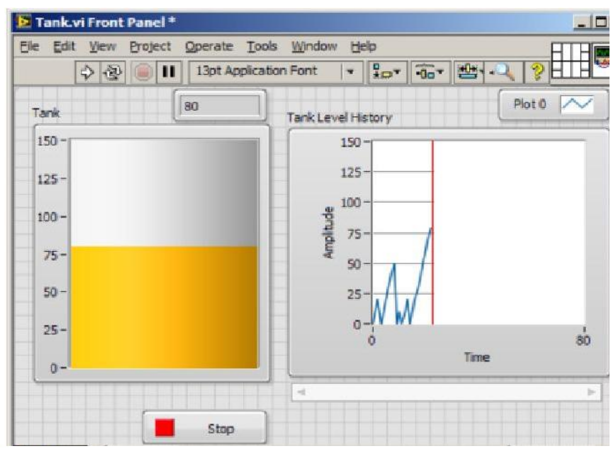


Front Panel Of Temperature Control

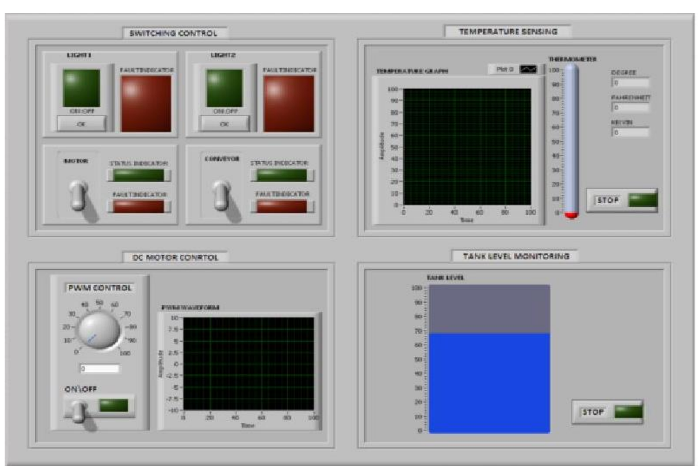
(3) **<u>FLUID LEVEL INDICATION:</u>**

We will be indicating the fluid level it can be a water level in tank, coolant level in transformers, etc. on the PC using LabVIEW .For measuring the fluid level we have thought of float mechanism. We can even use sensors to do the same. There will be electrical circuit at different levels .this circuit will have a DC supply. When the float touches the contact of the circuit, the circuit will get completed. This signal will be sent to DAQ card which will convert into digital signal and display it onto a PC. The control of liquid levels, for example in a process tank, is an important function. An example would be a hot water tank where water is removed, perhaps for washing down, and the level needs to be restored ready for the next wash cycle. Float operated types- a float rises and falls according to the change in liquid level and operates switches at predetermined points in the range. As the liquid level in the tank changes, the float present on the liquid surface goes UP\DOWN accordingly. The metal contactor attached to the float makes contact with the resistance chain. With the change in the level of liquid, the voltage across the resistance changes. This voltage is measured using DAQ CARD and accordingly the level on the FRONT PANEL is indicated.





<u>Level Sensors</u> **<u>Front panel of level sensors</u>**



<u>Combined Front Panel of the VI</u>

Conclusion:

The objective of the paper was to develop a control system that can be used to control the four basic industrial processes of switching, monitoring, motor speed control and tank fluid level indication in refineries and monitoring of photovoltaic power plants which was done using the powerful virtual instrumentation tools provided by the LabVIEW software. Four control system front panels for the four different industrial processes using the LabVIEW software, DAQ system and the NI ELVIS prototyping platform can be created. A single front panel was created for both the applications which combines all the control panels into one front panel and can be controlled by a single person.

Thus a person can visualize the process equipment and study the dynamic behaviour of the process by introducing disturbances .The effect of Proportional, Integral, Derivative controllers and their combination on temperature control loop can be demonstrated . It is not feasible to built even small scale plant in educational institutes. Hence such simulations can serve as a quasi-plant.

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Take the guesswork out of measuring solids

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Abstract

Measuring Solids can be quite a challenge due to the process environment – irregular surfaces, dust and humidity and they are typically stored in long and wide silos. The technologies developed till datefind it hard to address all of the above challenges and most of them rely on Single Point measurements to estimate the surface. It can be inferred that such estimates can suffer from accuracy and reliability.The purpose of this paper is to illustrate how Emerson's Rosemount 5708 3D Solids Scanners can address these challenges.

Emerson's Rosemount 5708 3D Scanner

Emerson's Rosemount 5708 3D Solids Scanners provide continuous volume measurements that are based on the representation of the material's surface. They are ideally suited to measuring solids in silos, large open bins, bulk solid storage rooms, stockpiles and warehouses. They can measure practically any kind of material including grain, lime, cement, plastic powders, difficult-to-measure fly ash and materials with a low dielectric. Self-cleaning designs require minimal maintenance even when used in the dustiest environments.

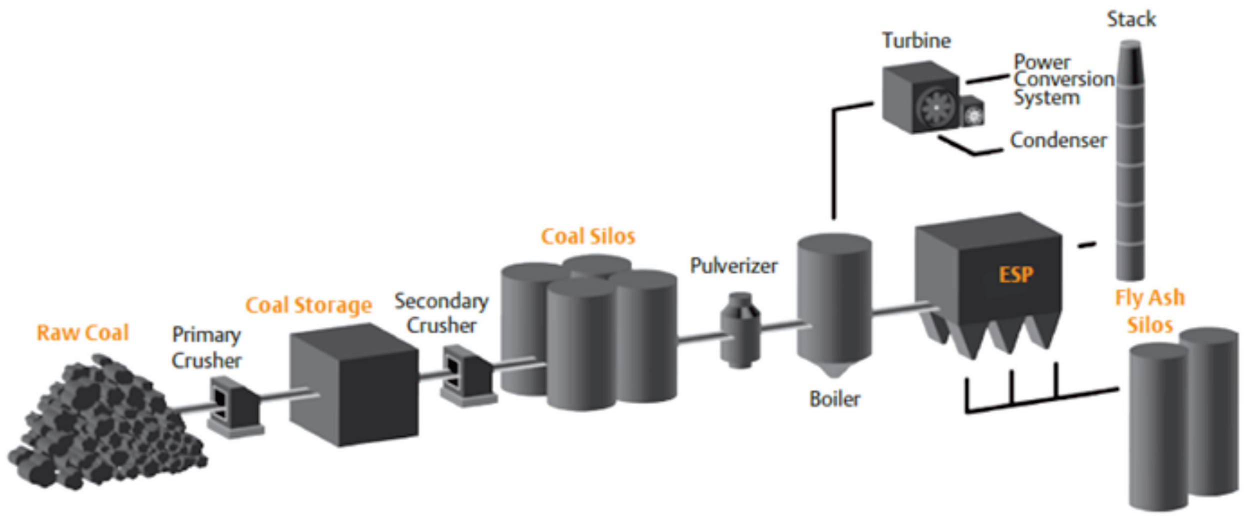
Acoustic based devices measure level by transmitting low frequency pulses that reflect off the surface of the contents of the silo, bin or container. Because of the nature of the acoustic signal, which transmits over a wide area, it can be challenging to obtain the correct echo from the surface. Acoustic systems such as the Rosemount 5708 3D Solids Scanners use three horn antennas that detect not only the distance to the surface, but also the direction of the echo to the object reflecting the signal. A Digital Signal Processor then samples and analyses the received signals to provide very accurate measurements of the overall surface of the stored contents, and generates a 3D visualization of actual allocation of product within the container for display on remote computer screens.

For larger vessels and silos, acoustic based systems provide highly accurate measurements of stored contents. The Rosemount 5708 3D Scanners map the uneven surface typically found in solids applications and can provide the minimum and maximum level, the total volume and a 3D visualization of the surface. For application in large areas such as warehouses, several 3D Scanners can be combined to provide an accurate and reliable monitoring system for inventory and production process control in industries.

The Rosemount 5708 3D Solids Scanner will be soon available with the Wireless THUM AdapterTMwhich allows the full benefits to be utilized wirelessly. The Rosemount 5708 with THUM Adapter can be integrated directly into existing automation architecture without the need for upfront engineering, site surveys or additional software. The unleashing of Wireless capability will furtherhelp to save time and money on installation, provide robust measurement with large area coverage, install in locations where power is available but no signal wiring and seamlessly integrate to the Emerson wireless network.

Efficient Inventory Management can result in significant cost-savings across the supply chain through accurate ordering, managing safety stock, reducing carrying costs and utilizing best the storage capacity. The Rosemount 5708 3D solids Scanner takes the guesswork out of measuring level, volume and mass of materials. From a CAPEX and OPEX prospective, the Scanner is designed to help you make informed decisions about inventory control while addressingyour safety and maintenance concerns in managing your inventory.

Applications in Coal-Fired Power Plants

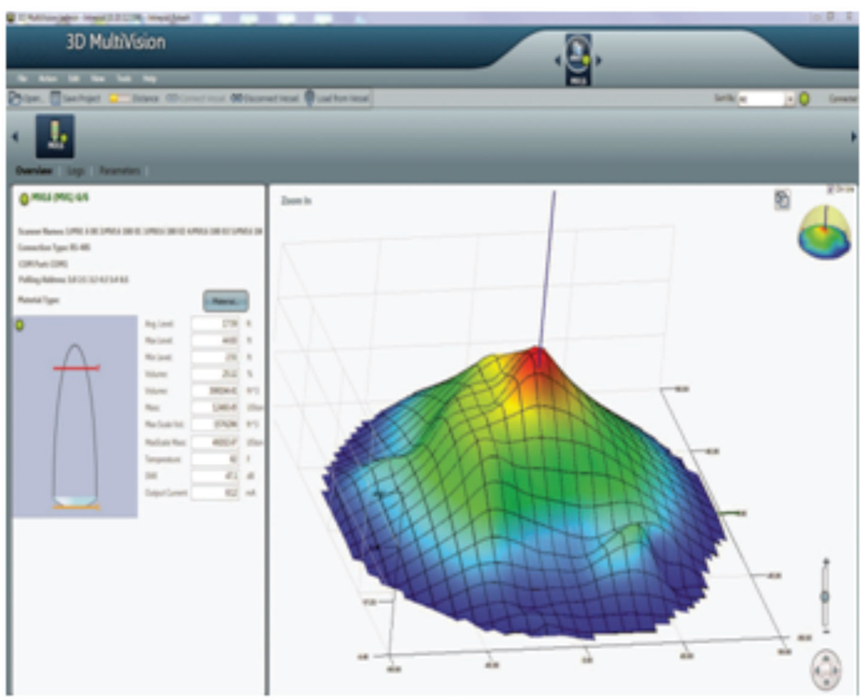


Rosemount 5708 3D Scanner finds multiple applications in Coal-Fired Power Plants. We have tried to briefly capture them.

Application	Challenges Addressed
Raw Coal Raw Coal Yard / Warehouse – Raw coal is delivered to a coal yard in aggregate pieces of approximately 15 cm (6”) that are later reduced in size by a crusher to approximately 4 cm (1.5”).	The raw coal is stored in stockpiles. A system of Rosemount 3D SolidsScanners can accurately measure coal inoutside piles or warehouses despite the verywide surfaces. This information can then be integrated into ERP systems, greatly improving inventory management, control and reporting capabilities.

Application	Challenges Addressed
Coal Storage Coal Storage / Bunker / Coal Blending Facility - The coal goes through a moderate grinding process and then is stored in a coal bunker.	Coal bunkers can contain thousands of tons of material. Their size and the dusty conditions make it difficult to accurately measure the amount of coal in the bunker or blending facility. There are also safety risks to personnel who enter the storage areas to "guesstimate" levels. The Rosemount 3D Solids Scanner is self-cleaning and virtually maintenance-free. It accurately measures coal inventory even industry and harsh conditions. It also greatly reduces the time, costs and risks associated with sending maintenance personnel into such hazardous environments.
Coal Silos **Coal Hoppers / Coal Day Vessels / Coal Silos - Coal is transported by conveyor and tripper cars to coal hoppers. These hoppers feed ball mills which in turn feed the pulverized coal to the boilers. There will be at least one hopper for each boiler. Typically there are two boilers per unit.**	Coal hoppers and silos storing pre-pulverized coal are large and very dusty. The silos hold several hours' supply of coal and can continue to supply coal to the boiler in the event of a problem in the coal handling system. As coal is critical for the continuous process, it is necessary to monitor and control the actual volume of coal in to prevent process stoppages. The Rosemount 3D Solids Scanner's sophisticated surface mapping technology delivers accurate real-time volume measurements of the coal, taking into account irregular build-up of material or other problems that may occur. The Scanner's 3D visualization tool allows the user to see the actual allocation of material inside the bunker/silos, including build-up, avoiding costly interruptions to the process.
ESP Hoppers **Fly ash is captured and removed from the flue gas by electrostatic precipitators or fabric bag filters located at the outlet of the furnace and before the induced draft fan. The fly ash is collected in hoppers below the precipitators or bag filters and periodically removed from them.**	SP hoppers are continuously filled with hot fly ash. Along with the effects of humidity and high temperature, fly ash tends to stick to the sides of the hopper, causing buildup and clogging which may damage the ESP plates. Users need to continuously monitor the volume and distribution of fly ash inside the hopper so that they can be emptied on time, maintained and cleaned when necessary. This is essential in order to prevent damage to the ESP plates. Damaged plates can also create environmental and health concerns. The Rosemount 3D Solids Scanner provides continuous volume level measurement of fly ash inside an ESP hopper. The 3D visualization tool allows the user to see the actual allocation of material inside the hopper and detect buildup as it occurs, facilitating timely maintenanceand avoiding interruptions to the process, and damage to the ESP plates.

	At coal-fired power plants where Rosemount scanning technology is not used in ESP processes, the hopper emptying is disconnected from the filling. With no reliable way to measure the fly ash in the hopper,a timer is set to turn on the emptying process regardless of the amount of fly ash in the hopper, making the process inefficient. The Rosemount 3D Solids Scanner allows users to reliably coordinate and automate the filling and emptying process.
Fly Ash Silo **The contents of the fly ash hopper are pneumatically conveyed to a fly ash storage silo. The silo is emptied on to trucks that then haul the material off for use in other applications.**	Fly ash derived from burning coal creates a very dusty environment and tends to stick, creating build-up inside the silo. Fly ash silos are typically very large to allow continuous flow from the hoppers. Density and dielectric constant of fly ash is low. Users need to continuously monitor the amount of fly ash inside the silo so that it can be emptied on time, and maintained and cleaned when necessary. The Rosemount 3D Solids Scanner's unique dust-penetrating technology, sophisticated surface mapping approach and 3D visualization tool provide accurate measurements of the fly ash volume and a 3D display of the ash distribution inside the silo. The measurements take into account irregular formations, including build-up and rat holes that may form over time.



Summary

Measuring powders and solids isn't easy because all available technologies are based on Point Level measurement (eg : Radar, Laser etc).However, uneven surfaces and hard, dusty environments do not pose a problem for Rosemount non-contacting 3D Solids Scanner which measures average, minimum and maximum levels, and provides 3D visualization of stored contents. Using dust penetrating low frequency acoustics waves to generate surface mapping of stored materials, the 3D Solids Scanner takes the guesswork out of solids level measurement.

Biography

Sachin S Bendre is National Head of Level Business for Emerson Process Management India. He has worked with Process Industry Customers to offer solutions to customers on Overfill Protection and Level Control Applications.

Sachin has over 21 years of experience in the Engineering and Instrumentation Industry. He holds a Diploma in Industrial Electronics from LTIT, Mumbai and Bachelor's degree in Electronics Engineering from VIT, University of Pune.

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