ISSN: 2278 – 1323
International Journal of Advanced Research in Computer Engineering & Technology (IJARCET)
Volume 1, Issue 9, November 2012

A case study on application of Fieldbus in the automation of Coke Oven Battery

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***Abstract*—The use of Foundation Fieldbus technology in projects is increasing every year. The Foundation Fieldbus technology has been formerly employed as a simple digital communication protocol for field devices only. But with the development of, FF HSE (Foundation Fieldbus High Speed Ethernet) network standard, it has a much broader application now, on the controller level as well. This paper will discuss these issues using as a background a real project that was executed in a Coke Oven Battery and By-Product Plant at Tata Steel. The project has over 8000 I/Os, 6 Controllers, 16 workstations and several package units, and is a perfect scenario to highlight such issues. The paper will present the project showing the problems and achievements of all phases: Selection, Definition, Engineering, FAT, Commissioning and Start-up. With this paper the authors expect to share their knowledge and experience on FF applications, as applied to this particular project probably for the first time in India.**

***Index Terms*- Fieldbus Foundation, HSE (High Speed Ethernet) Networks, Redundancy, FAT (Factory Acceptance Test), EPC (Engineering, Procurement and Construction), Start-up, Commissioning, Ethernet, FISCO (Fieldbus Intrinsically Safe Concept), Control System, Engineering.**

I.INTRODUCTION

The project presented in this paper was executed by a joint cooperation of the Tata Steel Limited, Tata Consulting Engineers Limited and Larson and Toubro (Engineering, Procurement and Construction) company as the system vendor and integration contractor. The plant was a brand new plant designed to produce 1500000 tons per year of Coke. Coke is used as a fuel and as a reducing agent in smelting iron ore in a blast furnace. It is there to reduce the iron oxide (hematite) in order to collect iron.

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Figure 1 - Plant Picture

This project proved to be a very good engineering practice with several challenges for the modern Foundation Fieldbus control systems. All challenges were dealt with and overcome during the project through extensive testing and best practice engineering design. The main challenges probably were the lack of knowledge about the technology by the EPC and the end-user. The project evolution and design will be presented on the following section, under two different approaches. The project will initially be presented on a stage approach, where the different stages of the project will be described, along with steps and decisions involved in each stage, and in the second approach, the project will be presented on a technology and decisions standpoint, clarifying the reasons behind each decision and practice involved on the project. The paper will conclude showing the benefits reported by the EPC and the end-user.

II. PROJECT DETAILS

The following type of signals was used for data exchange:

1) Foundation Fieldbus Signals
2) 4-20mA / HART Signals
3) Discrete Signals

Some of the items were particularly special for a Foundation Fieldbus project compared to conventional system, and are worthy for detailing. The channel assignment consists of defining which field devices and signals will be grouped in each Foundation Fieldbus H1 network. The project documents also required some modifications to incorporate the characteristics of the Foundation Fieldbus technology. The project could be divided in 4 different phases:

1. Selection Phase:

The use of Foundation Fieldbus was an End-User decision, initially imposed over the EPC. The main reasons that led the End-User to specify Foundation Fieldbus were the desire for extensive and improved diagnostics for the field devices and the control system, and the necessity to reduce the quantity of panels, wires and control system equipment due to physical space constraints on the plant.

2. Engineering Phase:

The system architecture was discussed and defined; including the selection of FISCO model to be used for the field devices installed on classified area. FISCO was selected

due to the possibility to have more field devices per FISCO barrier segment and the need for less calculation in order to validate the design and installation. There were some field devices not available with Foundation Fieldbus compatibility, creating a need to integrate Hart devices into the control system. The adopted solution was to integrate the HART devices converting their signal into Foundation Fieldbus through a HART to FF converter. This gave to the higher layers of the control system and homogeneous and unique view of all field devices, independently of their technology and communication type. At this point the project team started evaluating the amount of cable required for the complete installation keeping in minds the intrinsically safe installations, which allowed only 4 to 6 field devices in each segment, instead of 12 to 16 field devices.

3. FAT Phase:

The FAT was witnessed by both the EPC and the end-user for ascertaining that the control system was manufactured and software developed according to the specifications.

4. Commissioning and Start-Up Phase:

In the commissioning phase all installed devices were checked, using the diagnostic features of the Foundation Fieldbus Control System, and it was here that one of the biggest benefits was realized: 70% reduction in commissioning time. It is important to mention that Foundation Fieldbus networks reduce from 3 to 1 the amount of all the time devoted to FAT planning and execution. This paid off during start-up, reducing its time, as well as the incident of problems during the start-up. All in all, the total reported reduction in Start-up time was around 20%, representing considerable reductions in labor costs and installation material costs.

III.FOUNDATION FIELDBUS HIGH SPEED ETHERNET

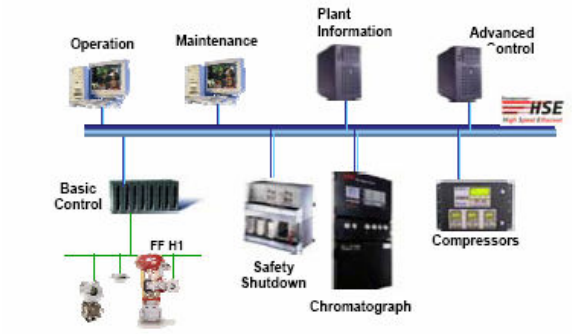


Figure 2 - FF HSE as a Control Network

FF HSE is the control level network standard created by Fieldbus Foundation. It is based on the Ethernet and TCP/IP standards, and brings openness and interoperability to the core of the control systems.

SYSTEM ARCHITECTURE:

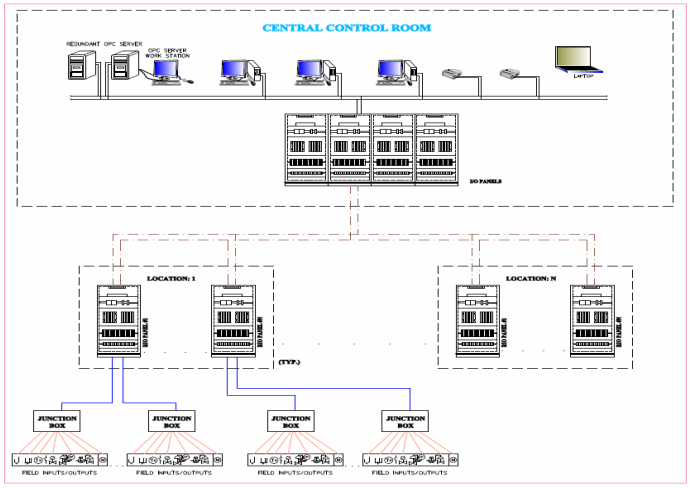


Figure 3 – Conventional Control System Architecture

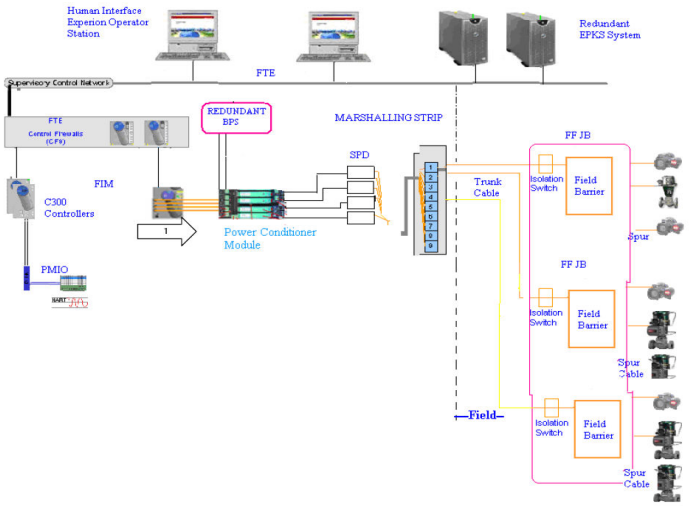


Figure 4– FF Based System Architecture using RI/O System

In order to achieve one control loop per segment and still maximize the use of the Foundation Fieldbus H1 networks, each Foundation Fieldbus H1 network was divided in several segments. It is important to understand at this point the difference between network and segment. A segment is any part of a network that has its own power supply and terminators. Several segments can be combined into a single network. The network is a group of segments, individually powered, sharing the same media, since the data on the network goes to all segment simultaneously.

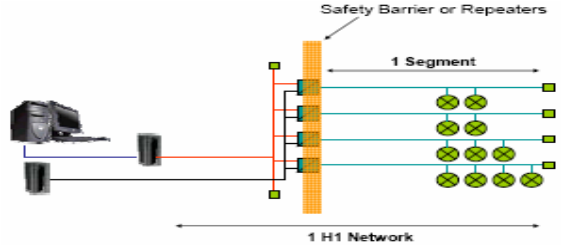


Figure 5 - Network Segment

The segment can be isolated from each other using a Foundation Fieldbus repeater or safety barrier. Since the whole plant was classified, and all segments required safety barriers, it was very natural to create such a design, which has not represented any extra cost. In order to achieve 1 second control performance, the number of field devices per network was limited to 10. This limit was based on performance calculations taking into consideration the estimated bandwidth required for each device for control and supervision. These calculations suggested an average performance of 100ms per device. The designed architecture also includes full redundancy of controllers.

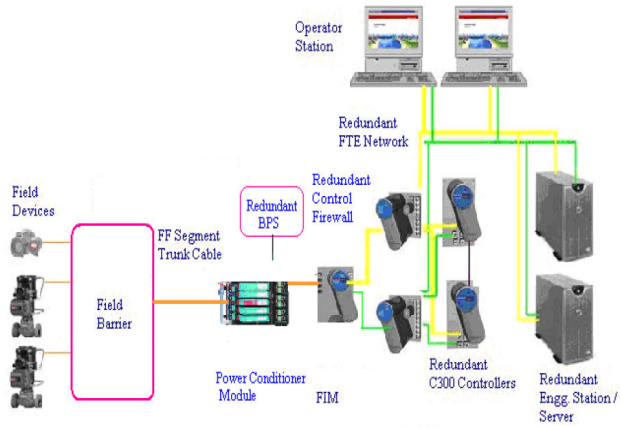
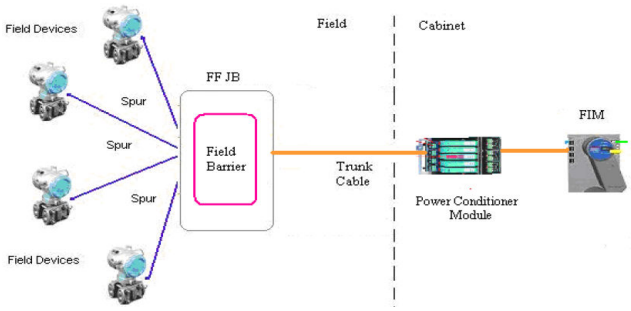


Figure 6 - Full Redundancy

IV.TOPOLOGY



. **Figure 7 - Bus with Spurs FF Topology**

In order to achieve the maximum reduction on the total amount of cable the bus with spurs topology was used in this project. And although short-circuit protection offers more protection, due to cost-benefit ratio T- connectors were used. This topology is similar to the tree topology, but instead of a field junction box distributing the wires to the devices, each device is connected to the trunk by a T-connector. This topology is the best wire-saver.

V.CONTROL DISTRIBUTION

Foundation Fieldbus liberates the control distribution, allowing it to be placed anywhere, from Controllers to field devices, or a combination of both. And the control distribution has direct impact on the control system performance.The control in the field devices reduces the amount of communication going across the wire, reducing the total time required to execute the control loop, but requires more supervision to be done through the Foundation Fieldbus H1 network.

VI. ADVANTAGES OF FOUNDATION FIELD BUS COMPARED TO CONVENTIONAL RI/O SYSTEM

- Huge saving of field wiring.
- Less time requirement for commissioning.
- Maintenance work easy and time saving.
- Self-diagnostic features.
- Ideal for Hazardous area up to Zone 0.
- By implementation of High Power Trunk Cable, same cable can be used in Zone 0, 1, 2 areas.
- Close loop can be controlled in field, thereby reducing the DCS CPU load.
- Less scan time.
- Better performance of process.
- Space saving and reduction of Inventory cost.

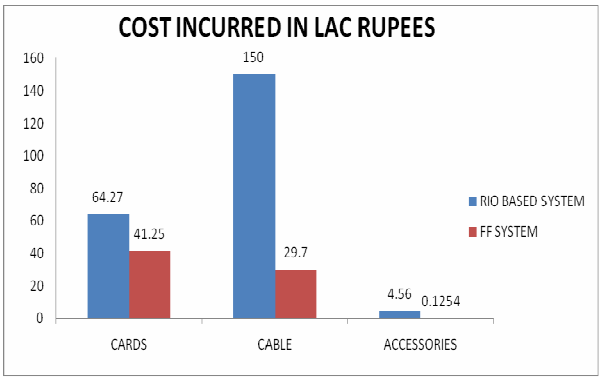
VII. COST REDUCTION TOTHE ENGINEERING FIRM

The less requirement of field wiring results in simple cable layout & cable routing diagram, which in turn makes the cable interconnection diagram simple. The wiring diagram becomes easy and Room layout drawing, automation configuration diagram, etc gets comparatively simpler. Additionally, there is reduction in FAT time.

VIII. CONCLUSION

The end –user confirmed the following savings:

- 20% Less cabinets than expected
- 75% reduction in commissioning
- 20% under the initial System budget
- 60% in cable reduction



Thus by switching to Fieldbus Technology, we are able to achieve a reliable cost effective solution provided we receive full support from System Supplier to assure interoperability and to impart comprehensive training.

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X .ACKNOWLEDGEMENT

We sincerely thanks to TATA Consultancy Engineering Limited, for providing required inputs and assistance from industrial domain for our reference.

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