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APPLICATION OF FIELDBUS TECHNOLOGIES ALLOWING ASSET MANAGMENT IN INDUSTRIAL PLANTS

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Abstract

Alunorte Alumina in partnership with ABB , adopted extensive use of Foundation Fieldbus (FF). as part of a major expansion to their refinery by adding two new production lines.

Alunorte chose fieldbus technology because it provided superior integration of Control Systems and Field Instrumentation and greater flexibility for future implementation of asset management tools and process optimisation regimes.

In a corporative effort, ABB, Alunorte and third party suppliers integrated 35 different field devices, from 11 manufacturers, to the Distributed Control System (HOST). This approach lowered the commission efforts and contributed to the successful expansion of the plant that makes Alunorte produce 4.2 Millions Ton/ year of Alumina.

Keywords:
FF- Foundation Fieldbus,
Profibus DP,
Asset Management
Commissioning.
H1
HSE

1 Introduction

1.1 Presentation

Alunorte is an Alumina Refinery controlled by CVRD; with stockholding of the Norwegian Norsk Hydro, CBA and Japanese company as NAAC (Nippon Amazon Aluminum Co.), JAIC (Japan Alunorte Investment Co.), Mitsui & Co and Mitsubishi Corporation.

The plant is situated in the state of Pará - Brazil, in close proximity to the Bauxite mine deposit. The plant utilizes the Bayer closed loop Caustic circuit rocess, to extract Alumina from the Bauxite.

The Bayer Process is logically split into to two main sections, Red Area and White Area. Each area is known by the colour that plant surfaces and buildings turns after a few months of operation. Red from Bauxite and White from Alumina.

The Red Area is the beginning of the process and is divided into sub-areas: bauxite milling (ore of red color), digestion, decantation and filtering. In the White Area, the end of the process, which the main characteristic is the production of alumina, are mainly the precipitation, filtration and calcinations sub-areas.

The Utilities Area supplies steam and electric power to the Bayer process. Alunorte utilizes three high pressure boilers and steam turbine generators.

The expansion raised the plant production by 75%, increasing its Alumina production from 2.4 to 4.2 million tons per year. This was achieved by installing two new Bayer process lines. Each line consisting of grinding, digestion, decantation, filtering, precipitation and calcination sub-areas.

The greatest departure from the existing technologies used on site was seen in the automation area. The existing process lines utilized conventional field instrumentation. 85% of the instruments on the new process lines were FF.

1.2 Objective

This paper presents the automation project of lines 4 and 5. Startup of the Plant occurred in March of 2006.

The project adopted the Profibus DP and Fieldbus Foundation (FF) technologies as the technological solutions that supported the integration of field instrumentation, equipment and the site control systems. And provide a platform on which to build advanced asset management systems and implement process optimization regimes.

The use of field networks and proper processing devices provides:

- Great availability of information: beyond the exchange of control variables, it is possible to get secondary variables, configuration and statistic data without the need for additional hardware;

- Faster fault finding due to online diagnostic information and integrated monitoring tools embedded in control system.

- Better use of limited maintenance resources. Simplified instrument configuration, calibration and data gathering and analysis.

- Possibility to implement monitoring services and asset management: the additional information from the devices is the necessary input for algorithms that monitor the "health" of the equipment. "Asset Monitoring", being able to predict the replacement or the preventive maintenance of the equipment. . Creating reports, sending e-mails or even SMS messages, when the time to carry through this work is reached.

The New Site Control System allows those resources to be explored in a centralized and integrated way. Through an engineering station, it is possible to monitor all the industrial network devices and access the configuration of any instrument. In a mouse click, it is possible to access the documentation, alarm lists and configuration tools of a specific plant component.

2 Materials and Methods

2.1 The Technology

FF is an open standard for instruments communication. It is a unique protocol that allows the ‘true’ distribution of control functionality.

Installed **FF** network architecture has two different physical levels: H1 (31.25kbit/s) to interconnect field devices and HSE (High Speed Ethernet of 100Mbit/s) to integrate controllers, servers and different H1 networks. The interface between these two levels is made through a device called LD (Linking Device). The control variables are exchanged between devices with cycle defined in the configuration application, while given and other information are changed way OPC by acyclic form, without affecting the control variable performance.

The exchange of Control/Process data between field devices and between the Host and field devices is control by a Link Active Scheduler (LAS). The control variables are exchanged between devices with cycle defined in the configuration application, while other information are acyclic exchanged via OPC, without affecting the control variable performance.

Profibus is another open standard for field devices communication. Based in the Master/Slave concept, ProfibusDP (Distributed Peripherals) is the solution of Profibus high speed, being able to reach the rate of up to 12Mbit/s. The DP-V1, used in the Alunorte MCC, is a variant that also allows configuration parameters exchange of acyclic form.

2.2 The Project

The following Figure 1 illustrates the main architecture of the Alunorte control system. It utilizes a collection of technologies in the form of fieldbus and Ethernet networks, controllers, field input/outputs cards, a mix of proprietary and open software applications, servers, PCs and HMIs. The interconnection between automation and the corporate network is done using third party equipment.

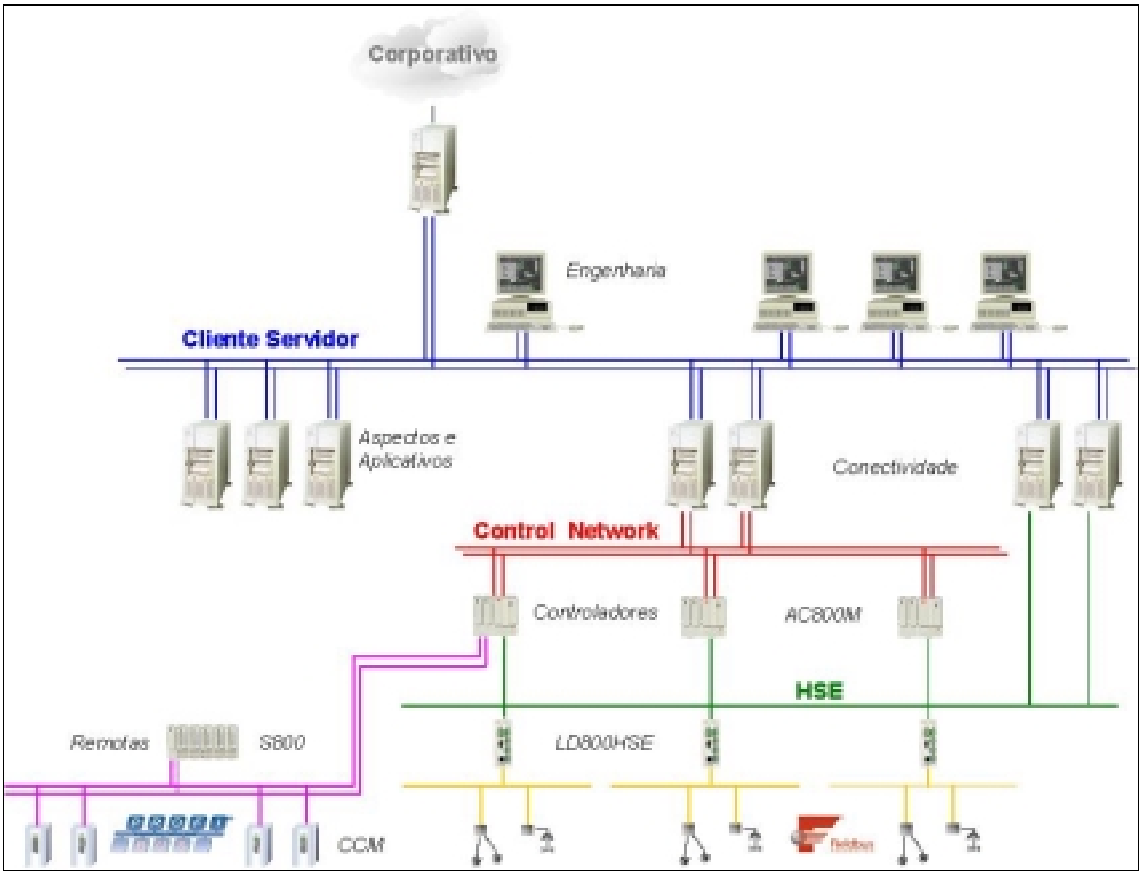

Figure 1: Automation Network Topology of Alunorte

The connectivity between the variables processed in the controllers and the client stations is carried through by three pairs of connectivity servers with OPC Server protocol. The connectivity servers supplies dynamic data and alarms and events information for the aspects servers (with redundancy 2 out of 3). In the Aspect Server process displays and other objects are configured.

Six pairs of OPC Servers FF (three pairs running in the same connectivity servers mentioned above), each one compose a High Speed Ethernet (HSE) network. All the pairs of connectivity servers work in redundancy.

Each HSE network, through the respective FF OPC Server, provides connectivity for the acyclic data exchange. It is through these FF OPC Servers that the applications are uploaded in all the network elements: controller, instruments and Link Devices.

Lines 4 and 5 have today a total of 1360 FF instruments installed. They are distributed in HSE Link Devices across the plant through a fiber optic network. Each Link Devices have four H1 segments.

As a site standard guideline, each H1 segment connects a maximum in of 8 instruments per segment, of these a maximum of two instruments are positional actuators of control valves.

Each Link Device has four inputs. Each input controls one H1 segment. The LAS (link activate scheduler) of each segment is always the respective input of the Link Device.

In total, there are fifty five (55) LDs grouped in six (6) HSE networks. Figure 2 below shows the connection of the instruments to LD.

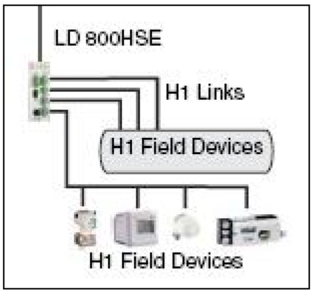

Figure 2: Schematically representation of the HSE and H1 levels in a Foundation Fieldbus network.

The application provides the exchange of cyclic variables for control between instruments and the controller, where the algorithms PID are being processed with cycle time of 1 second. For that reason, the macro-cycles are dimensioned or set for a 500ms scan.

Each one of the controllers has 3 or more of the following Profibus nets:

- A network for the communication with remote stations S800 of discrete I/O and 4~20mA. They are about 360 conventional instruments of 4~20mA and 3270 digital signals.

- "Power Network": A network for the communication with protection relays, electrical measurement device, alarm announcer and circuit breakers;
- "Process Network": One or more networks for communication with start-up control relays of low/average tension motors and inverters;
- A network for the communication with miscellaneous, such as PLC's, HMIs, etc.

Currently 1213 Profibus devices (slaves) are allocated in lines 4 and 5, distributed in 45 Profibus boards (masters).

Counting **FF**, Profibus and S800 (for physical signals), lines 4 and 5, has about 18000 signals, distributed in 14 redundant controllers (13 AC800M and 1 AC450). AC800M controllers are linked by TCP/IP over a 100Mbps Ethernet network

With the aim to simplifing object instancing and to take full advantage of the communication with each type of ProfibusDp equipment and FF instrument, typical objects for each fieldbus devices were created. During project development a library of device was configured on the system. Development of the library was a joint effort of the project players, Alunorte, ABB Brazil, ABB Device Integration Center (DIC) and instrument/equipment suppliers. This library now forms part of the standard library offered by the Control System manufacturer. During the process of developing the library compatibility problems were encountered and resolved and versions, mapping, data exchange format and configuration of the devices and the controllers configured and tested.

In summary, there are 16 types of FF instruments from 6 different suppliers and 19 types of ProfibusDP devices from 5 different suppliers. The following tables 1 and 2 lists these instruments and devices:

Table 1: List of used FF instruments in Lines 4 and 5 of the Alunorte

Manufacturer	**Model**	**Description**
ABB	2600T	Pressure Transmitter
ABB	264	Pressure Transmitter
ABB	TB82EC	Conductivity Analyzer
ABB	TZIDC	Positional Actuators
Dresser	FVP	Positional Actuators
Endress&Hauser	MICROP-M	Level Meter
Fischer Controls	DVC5000F	Positional Actuators
Rosemount	ROSE4000	Oxygen Analyzer
Yamatake	AVP	Positional Actuators
Yokogawa Eletric	ADMAG	Flow Meter - Electromagnetic
Yokogawa Eletric	EJA100A	Differential Pressure Transmitter
Yokogawa Eletric	DYF	Flow Meter
Yokogawa Eletric	YTA320	Temperature Transmitter

Manufacturer	Model	Description
Yokogawa Eletric	ISC202	Conductivity Inductive Analyzer
Yokogawa Eletric	SC202	Conductivity Analyzer
Yokogawa Eletric	PH202	PH Analyzer

Table 2: List of the used ProfibusDP devices in Lines 4 and 5 of the Alunorte

Manufacturer	Model	Description
ABB	ACS550	Drive Control
ABB	ACS800	Drive Control
ABB	IDM144	Electric Greatness Multi Measurement
ABB	SPA-SACO	Alarm Announcer
ABB	UMC22	Command Relay for Motors
ABB	SPA-REX521	Command/Protection Relay for Breakers
ABB	PP325	Human Machine Interface
ABB	SACE PR112PD	Intelligent Module for Breakers
Siemens	MicroMaster	Drive Control
Siemens	MasterDriver	Drive Control
Siemens	7SJ61	Command/Protection Relay for Motors
Siemens	7SJ62	Command/Protection Relay for Breakers
Siemens	7UT61	Differential Protection Relay
Siemens	Sentron	Intelligent Module for Breakers
Siemens	Simocode 3UF5	Command Relay for Motors
Siemens	DP/DP Coupler	Communication among Masters PLCs
Schneider	Sepam	Measurement and Protection Relay
Auma	Aumamatic	Motorized valve
Atlas Copco	Prof2Can	Compressor

2.3 Implementation

The automation project implementation begins with the careful design and installation of the network structure. In that stage, it is extremely important to have the installation carried out by, or supervised by, competent people and install the hardware in strict compliance with the project design and vendor guidelines/recommendations. This is taking care of the cabling routing, shielding and cable terminations.

The physical layer of each network must be individually checked and signed off (certified) as meeting specification by testing impedance and noise parameters. The checking and certification process is fundamental to a trouble free operation of any communication network.

Before advancing in the commissioning stage of the control functions, the automation team observed the integrity of each network, live list (presence of all nodes in the bus), the correspondence between physical devices and presence objects in the application, network stability and versions compatibility.

The Instrumentation and MCC teams responsible for the network design and configuration of the Motor Control Centers (MCCs) and the instrumentation as per site standard guidelines defined during the integration process.

Manufacturers' representatives, in accordance with the established site standards and guidelines, had pre-configured all the instruments and MCCs devices. Electrical equipment and field Instrumentation was configured to site requirements by the manufacturers before it was shipped to site.

Pre-commissioning was carried out on each device once it was associated to the respective software device on the control system. This was carried out safely by conducting a cold test and then a hot test. Cold testing was carried out without energizing the process or with the isolated process ie. motor detached, stopped process, empty plant. Hot testing involved operating the process equipment without the process materials present, this also included testing of interlocks, sequencing and logic.

Once hot testing is completed equipment/instruments were released for commissioning of the process. Commissioning of the process was carried out with support process specialist. During this process necessary adjustments to equipment/instrument and control configuration was implemented.

3 Results

Lines 4 and 5 of Alunorte reached their nominal production rates within 5 months from the beginning of the automation commissioning. An excellent result when compared to the times experienced on lines 1, 2 and 3. Line 5 reached its full production rate only 12 days after its start-up. This ramp-up time was considered a worldwide record in alumina refineries.

The reduced time of commissioning can be attributed to the increased index of equipment and fieldbus networks in the plant. This combined with the integration process that was adopted in the project phase.

All possible problems of interoperability had been identified and resolved early in the project well before equipment reached the field.

The early development of a comprehensive object library for use in any application reduced the need of specialist knowledge during design, construction and commissioning.

The easy and fast access to the centralized instrument networks reduces the need for commissioning resources and commissioning time.

4 Discussion

New technologies, like **FF**, have new challenges. The great implication of that process is the need to have qualified people to design, construct, operate and maintain new technologies. There are two possibilities to assist this workmanship necessity required in field:

a) The responsible personnel for the automation and maintenance of the DCS, starts also to assume the responsibility on the instruments. In that case, the automation team should be increased to assist the referring occurrences to the instrumentation. Or instrument techs absorbed into the automation group.

b) The Instrument/Electrical technicians are trained to work with the new technology. Companies need to invest in training their teams. In our case it is necessary a great effort to reduce the distance that exists between the use of conventional instrumentation tools and the new software tools.

The success in the use of the fieldbus technologies is intimately linked to the planning and implementation of that change of responsibilities.

The same reason type extends to the part of networks physical installation. The team's assemblers should have a great preparation and know-how to work with the technology.

5 Conclusion

Based on the Alunorte Expansion 2 project, it was evident that some care in the design was vital for the success of the project, standing out among them were the following:

- The project was conceived with an anticipated plan of the automation personnel's training, electricians and instrument specialists. Thus the technology had the necessary support for the operation since the beginning;

- The previous integration to DCS, as well as the instruments pre-configuration, control devices and protection, was a fundamental strategy to reduce the commissioning time;

- The engineers' participation and the customer's technicians during the project development, as well as during the factory tests, was fundamental for the plant startup and operation;

- The recruiting of specialized assembly teams and with experience in field networks saved time of attendance after the entrance in operation. With the same intention, the importance of the installed networks certification was observed.

The use of digital communication technologies for field devices provided a high integration degree among the control system, the motors control centers and the process instrumentation, centering the monitoring and diagnosis in maintenance benefit.

There is a lot of information data sent across the filedbus network. There is also information about configuration and health of the devices. This information, that after the integration is already duly treated, form the base for the asset-monitoring algorithm, plus a tool to be implemented to increase the availability and the efficiency of the plant.

The Alunorte case can be taken as a reference in the fieldbus technology application due to the great volume of devices operating and due to the success in the interoperability among the system ABB and the several manufacturers and involved models.