INSTRUMENTATION AND AUTOMATION SYSTEMS ON PERFORMANCE OF FERRO-ALLOYS PLANTS

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ABSTRACT

Ferro-alloys are very important ingredients used for making of quality steel with desired composition. In view of high demand in various types of ferro-alloys, it has become necessary to produce the same efficiently, safely and cost-effectively with consistent quality maintaining the anti-pollution norms. To achieve this goal, it is necessary to adopt latest process/equipment with the state-of-the-art instrumentation and automation system. A Programmable Logic Controller (PLC) based automation system with suitable Human Machine Interface (HMI) terminals along with intelligent field mounted sensing/control devices allows to monitor and control the complete plant effectively with optimum deployment of man-power. In association with this, use of process optimization controllers enables to achieve specialised functionalities of the submerged arc furnaces like material management, lining management, electrode management, power management, overall production management etc.

1. INTRODUCTION

Instrumentation and Automation System has a predominant role in efficient and safe running of any process plant. With the availability of modern and proven technology of various types of sensors and detectors as well as computer processing and networking facilities, the centralised control and operation of plants with the deployment of optimum manpower is becoming more and more reality in the present day scenario.

A Ferro-Alloy plant with all its main production as well as auxiliary unit is no exception to benefit from the capabilities of modern Instrumentation and Automation systems to achieve increased throughput with enhanced quality and reduction in operation cost.

2. FERRO ALLOYS PLANT

Ferro-alloys are important inputs in steel production and a major cost constituent. The cost of ferro-alloys contributes about 5-6% of the total cost of steel production. In case of special steels, this figure would be even higher. The growth of the ferro-alloys industry is directly linked with the growth of the steel industry. In keeping with the increased demand in the production capacity of tonnage and special steels, ferro-alloy producers across the globe have embarked upon major expansion/modernisation programmes in their existing plants including bringing up of new plants.

The history of ferro-alloys plant operation is quite old, when individual process equipment used to be operated manually with the help of conventional process monitoring and control system and successful integration of total production system was depended on the capability and efficiency of the operating and management personnel, leaving little scope for improvement in quality of product, improvement in efficiency of process and reduction in consumption of input raw material and energy.

The modern ferro-alloys plants are featured with all new technological, innovations in the field of electrics, instrumentation and automation utilising various techniques of theoretical modeling, design experiments and evolutionary operations with the help of latest state-of-the-art computing and networking technology.

Basically, there are two independent but mutually inter-related process sections in a ferro-alloys plant.

- Raw Material Charging and Feeding process
- Smelting of the Raw Materials in the furnace

The main objectives of Process Automation and Control System are:

- Maximise the furnace throughput
- Maximise the power input to the furnace through each electrode.
- Operate the electrode to penetrate automatically and uniformly
- Implementation of furnace safety interlocks
- Auto–manual control of electrode slipping (time based or consumption based)
- Real time data logging

Ferro-alloys production technology has undergone continuous development with respect to equipment design as well as process automation and control.. The modern smelters continuously face the challenge of upgrading and controlling the raw material feeding system and furnace power system. The significant improvement in this field are automatic feeding of raw materials and power. The feed control requires ore chemistry, the batching technique with very high accuracy and very precise feed distribution. This is accomplished by using high precision load cells, radar/laser based systems, fast response gas analysis systems as well as programmable multi-transducer, harmonic analyzers etc.

The Furnace Process Controller which is predictive in nature, calculates on the basis of the ore chemistry, furnace power level etc. which are interlinked over a series of empirical equations, set points for the batching of raw materials with different other furnace parameters as variable. These equations are now-a-days best implemented through PC based dedicated control system using high level programming language which dynamically generates set points for the batching of new material ingredients.

With selected raw material composition, the batch condition in the furnace depends on:

- Ore composition, ultimately affecting slag resistivity
- Charge cover over submerged areas
- Electrode tip position

When all of these factors are simultaneously controlled, thermal equilibrium conditions are maintained, which helps in regulating the bath temperature. Controlled bath temperatures, in turn maintain the stability of the furnace operation and also ensures maximum stability of smelting energy (kwh/Ton) requirement. Furthermore, near consistent bath temperatures also simplify tapping operations and slag handling operations.

The furnace operation and control including automatic batching/feeding of raw materials are now commonly executed through Programmable Logic Controller (PLC) based automation system. The measuring instruments (sensors, transducers etc.) as required for various process measurements that support the realisation of the above factors (e.g. electrode tip position measurements etc.) are now available with very high accuracy and reliability. The accurate measurements together with the digital control, implemented in the Programmable Logic Controller (PLC) along with PC based HMI stations satisfies the increasing need of high productivity with quality control through single window.

All the electrical as well as process parameters including those for cooling water and hydraulics are being measured using suitable sensors, transmitters and integrated with the PLC based automation system complete with HMI stations for centralised monitoring and controlling of the furnace.

The important features of the automation system that are attributed to the selection of furnace control system are:

- Availability of single window plant informations

- Vastness of data base
- High degree of predictivity
- High speed of response
- Availability of the system

A typical PLC based automation system architecture for modern ferro–alloys plant is shown in Figure-1.

3. BENEFITS ACHIEVED

The benefits for adoption of such modern automation system are:

- Increased throughput due to improved furnace efficiency when the active power input through the electrode is close to maximum.
- Consistent quality of end products, energy saving, electrode life improvement etc due to uniform penetration of electrodes.
- Reduction in man–power and availability of complete plant information centrally for efficient decision making for plant operation.
- Automatic furnace startup and shut down operations.
- Optimisation of the furnace operating point.
- Improved furnace life due to safe operation through interlock.
- Reduction in operating cost (Rs/Ton).
- Improved return on investment (ROI).
- Adherence to the International Safety Norms.

4. IMPORTANT FUNCTIONS REALISED THROUGH AUTOMATION SYSTEM IN MODERN FERRO-ALLOYS PLANT

4.1 Supervisory Control and Data Acquisition System

While the main control functions are realized through the furnace control unit, the most modern supervisory control and data acquisition system for the entire plant provides a single window for the complete plant including incoming raw materials handling system, gas cleaning plant, water system, product handling system etc. The quality of the functions of the system is much enhanced by the modern measurement technology/ techniques with very high reliability and accuracy concerning parameters like “Power including harmonics and flickers, Electrode position, electrode slip, furnace temperatures, waste gas analysis etc “ This provides a unique solution for integrated major interlocking and interface among the different units with the help of following tools:

- Process variable related diagnostic facility.
- Internal data traffic diagnostic facility.
- Application specific data e.g. help screens, decision making support system.
- Remote availability of plant information over Internet.

4.2 Lining Management System

The smooth operation of submerged arc furnace necessitates a clear knowledge of the furnace lining. This requirement is enhanced when “Freeze Lining” is used in place of conventional lining.

Using dual thermocouple at all different zones of the furnace and using a “Heat Transfer Algorithm”, approximate freeze lining width, an actual wear isotherm, heat losses etc. are calculated. This system also involves a strategy for repair of lining to ensure maximum lining life at the desired load levels.

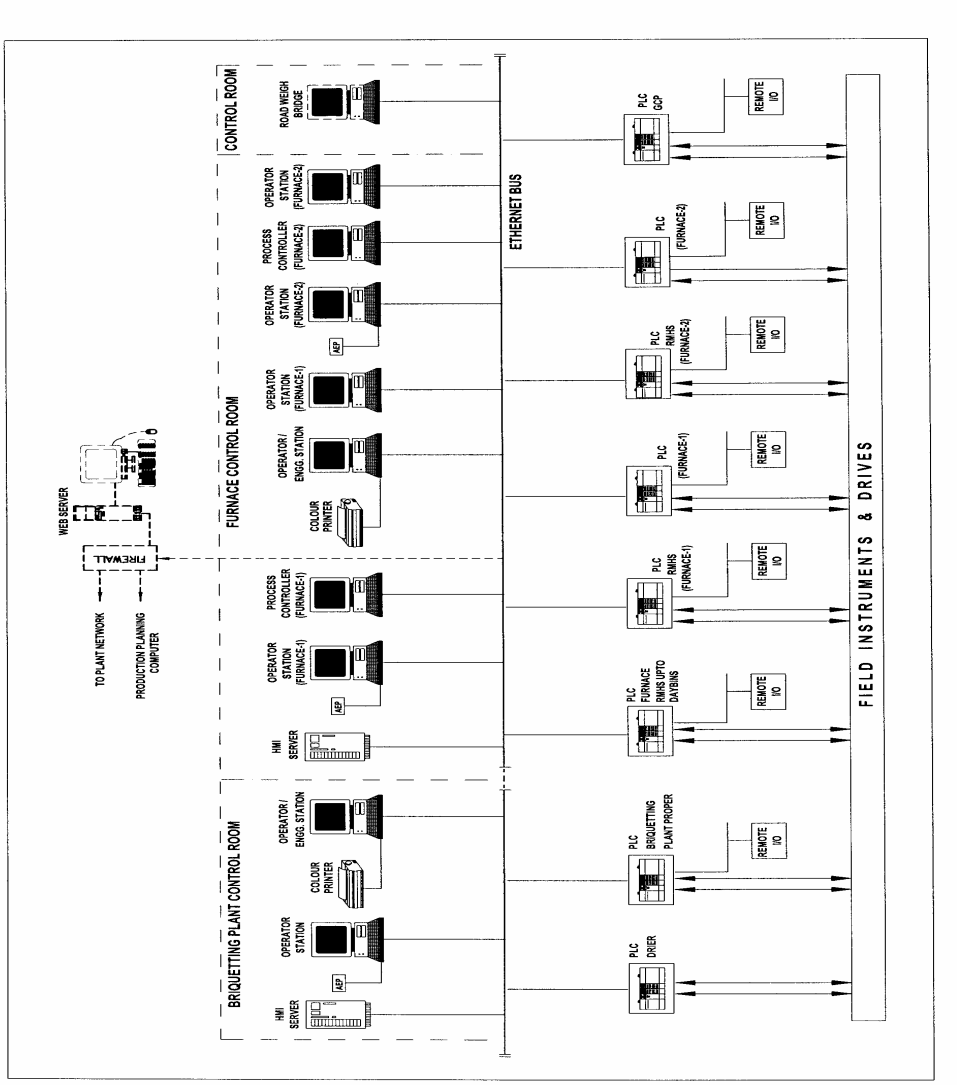

Figure 1: Typical Architecture of Automation System for Ferro-Alloy Plant

4.3 Electrode Management System

The submerged arc furnace's smooth operation necessitates a clear knowledge of the detail status of the electrodes in terms of slipping, baking and their interrelated strategies.

Using a predefined software as well as very accurate measurement and control of slip, the total optimization of electrode management system is achieved.

4.4 Maximum Demand Control System

The submerged arc furnace process, as applicable for ferro-alloys plant, is a power intensive process and one of its most important function is the maximum power demand control function. With the help of the modern and accurate measuring techniques for electrical parameters as well as the built-in intelligence, very high quality of maximum power demand control can be maintained.

4.5 Pollution Control System

Like in any modern plant, irrespective of the type of product, their quality and quantity, the ferro-alloys plants also need to ensure adherence to the statutory pollution norms of the country, which is becoming more stringent day by day. Modern instrumentation with very accurate on-line measurement of the dust content and other poisonous gases like SOx, NOx etc in the flue gas are used for continuous monitoring of the pollutants and taking necessary corrective actions to meet the requirements.

5. CONCLUSION

From the above, it may be concluded that the instrumentation and automation system plays a very important role for the safe and efficient running of the modern Ferro-Alloys plant. The overall aim is to integrate operation of all sections of the plant together using intelligent systems and to overlap technical and business management decisions in order to achieve economic, efficient and quality production. The unprecedented development in automation systems products with diminishing trend of their cost has resulted in a bright situation to implement the latest available technology for new plants/modernised plants. Further, it is worth mentioning here that the development in the field of instrumentation and automation system/products is an ongoing process resulting in fast obsolense of the products which may lead to a situation of non-availability of spare part/software supports from the automation system vendor.