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Total Plant Monitoring for an Integrated Steel Plant

WHITE PAPER

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HCL

TABLE OF CONTENTS

In an integrated steel plant, there are many systems monitoring and controlling each of the unit operations, but there are not many system applications available that can be used for total plant monitoring.

Abstract

Steel making processes are highly energy intensive and comprised of many complex unit operations. Iron ore and coal need preprocessing before feeding into a reactor, and molten metal from different reactors needs to be carefully drawn into a solid metal and then rolled into sheets. Each of these operations has a stake in the quality of steel produced, and needs constant monitoring.

There are many systems monitoring and controlling each unit operation, but there are not many system applications available that can be used for total integrated monitoring of plant operations that includes energy optimization across plants, production scheduling and a plant-wide comprehensive reporting system that users can view on computers, tablets or smart phones.

This paper discusses the actual realities and how integrated reporting can benefit steel manufactures.

Abbreviations

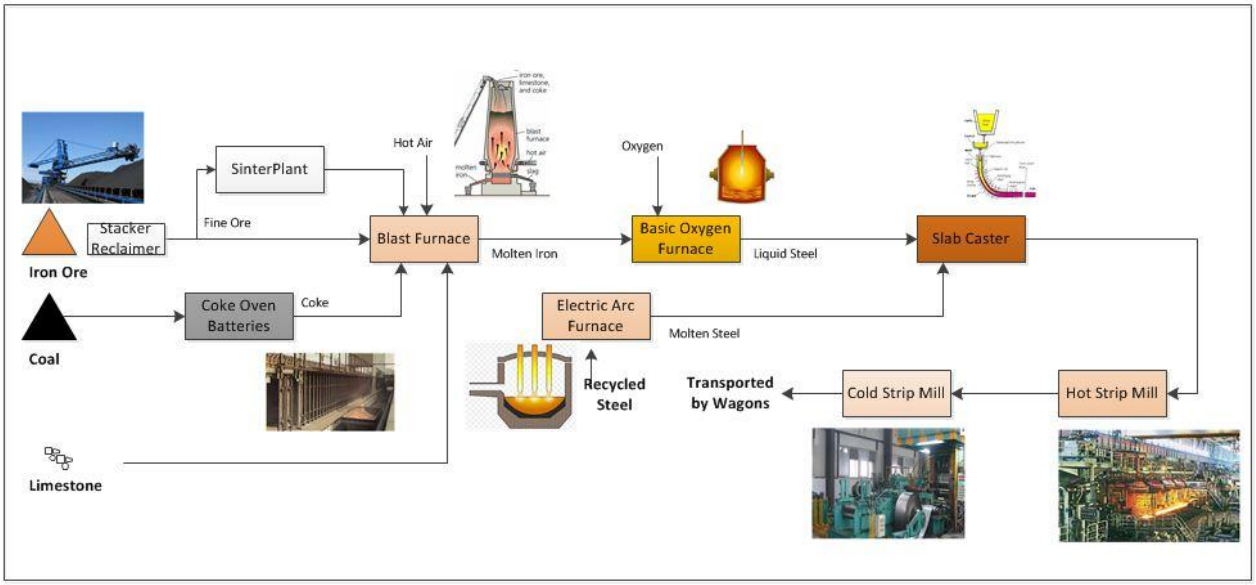
Sl. No.	Acronym	Full Form
1	BOF/LD	Basic Oxygen Furnace – Used in converting molten iron to steel. Also called a Linz-DonaWitz furnace
2	DCS	Distributed Control System
3	KPI	Key Performance Indicators
4	Hadoop	Hadoop is a data storage and handling system for very large databases, on the order of terabytes
5	PLC	Programmable Logic Controller
6	MES	Manufacturing Execution System
7	SCADA	Supervisory Control and Data Acquisition system - similar to DCS

Steel Manufacturing and Automation

Automation in steel manufacturing is complex and varied as there are many operations to be monitored. Here is a brief description of the process flow and automation involved in steel manufacturing.

Steel Plant Operations

The diagram represents a simplified flow diagram in steel manufacturing.

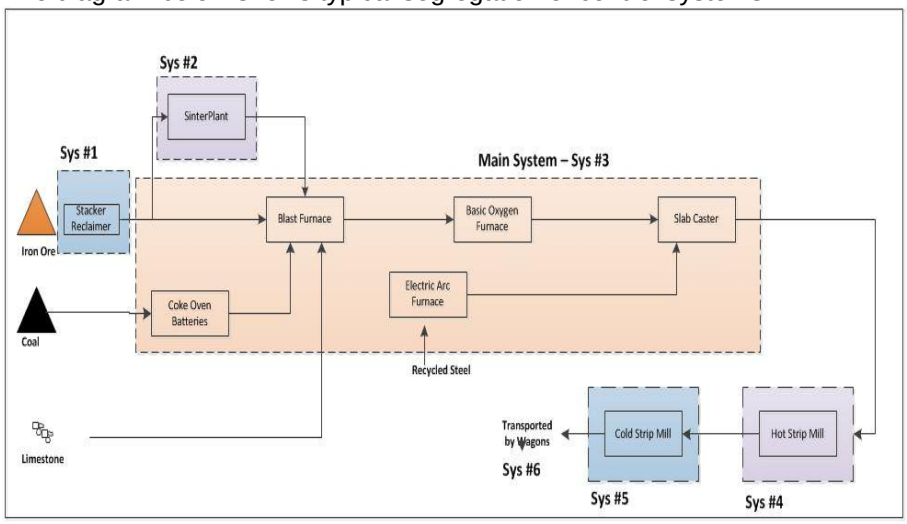


- Crushed iron, coal and limestone from respective mines are brought to the plant by wagons /ships
- A stacker helps in piling the ore and the bucket wheel reclaimer reclaims the ore and puts it onto conveyor belts that transport the ore to the plant area
- Iron ore fines are agglomerated into lumps in a sinter plant
- As raw coal has poor crushing strength and is volatile matter, the coal is baked in the absence of air in coke oven batteries to produce Coke
- Iron ore, coke and limestone are fed into a blast furnace, and hot air from the stoves reduces iron ore to molten iron
- Molten iron is sent to a Basic Oxygen Furnace or LD furnace to reduce the carbon content by treating with pure oxygen. Excess carbon goes out as carbon monoxide, and molten steel is born.
- Molten steel is slowly rolled and cooled to a solid slab in a slab caster or continuous caster
- Slabs are taken to the hot roll ,ill where they are reheated to bring them to a correct temperature for rolling. They are then rolled to smaller thickness by passing over a series of rolls, and finally made into a rolled coil of steel. The coil is shipped or sent to a cold mill.
- The cold roll mill reduces the thickness further. Annealing and galvanizing is done on the steel to meet the specifications of its intended use.
- Recycled steel or scrap steel is melted in an electric arc furnace, and joins the processes as molten steel.

Stacker Reclaimer, Sinter Plant, Blast Furnace, Hot Strip Mill and Cold Mill all have individual control systems monitoring their operations

Automation Systems in an Integrated Steel Plant

As there are many operations in steel making, there are many control systems deployed, each for a specific or group of operations. The diagram below shows typical segregation of control systems



- The Stacker Reclaimer is controlled by a separate PLC system (Sys #1 in the diagram). Stacker movement, like luffing, travelling and slewing, are controlled by the PLC
- The Sinter plant is controlled by a separate distributed control system that primarily does water addition and sinter mix moisture control, surge hopper level control, sinter mix charging control and air- and gas flow control
- The Coke oven, blast furnace, stoves, BOF, and slab caster are controlled by the main control system (sys #3)
- As hot and cold strip mills are driven by variable speed drives, a separate SCADA system is used in hot strip and cold mill respectively (sys # 4 & 5).
- Wagon movement and scheduling are handled by the wagon monitoring system

Other than these field-based systems, there are other operational systems such as:

- Production planning and control are handled by a separate system to optimize the production schedule

With many control systems, there is a necessity to collect, analyze and view data across plants.

Challenges in Steel Plant Automation

As there many control systems in play in a steel plant, getting a complete view of the entire plant operations from ore handling to the transportation of finished steel requires a supervisory system like a Manufacturing Execution System (MES). In plants that do not have an MES, data consolidation is done manually is some form, leading to error and inconsistencies. There are obvious disadvantages in these, such as:

- It becomes difficult for operators to collate information from all these different sources
- Operators lose track of productivity improvement measures and efficiency monitoring
- Key performance indicators across the plant are cumbersome to calculate, and many times are done manually
- Synchronized archival and playback of past data from different units cannot be done for the complete plant, and moreover, not all individual systems support archival and playback features

Solution - Maqplex in an Integrated Steel Plant

HCL's Maqplex is a cloud-based framework for data collection, data analytics and reporting.

A common reporting framework that would interface to all data sources, i.e. from different control systems, in the plant, collect and archive data with the facility to perform advanced data analytics, and with an easy interface to mobile devices like tablets and smartphones is required. The framework with an option of using the cloud (as it offers the highest scalability for the future at the most optimal cost) would be an ideal choice. HCL's Maqplex M2M framework is best suited for this application.

Benefits of Using Maqplex

Data collected from different sources is time stamped and stored in a central database. The Maqplex dashboard uses the data to present reports, plots and predictions. Some of typical dashboard presentations include:

- Real-time and archived graphical data plotting
- KPI indicators from sinter, blast furnace, basic oxygen furnace and mills
- Energy and mass balance for each unit operation
- Inventory management and waste tracking
- Condition monitoring of equipment
- Video analytics using thermal imaging
- Analytics with Hadoop
- Data/graphics on mobile platforms

Here is brief description of these features.

Maqplex has adapters to collect data from PLC, DCS, LIMS and Asset management systems

Energy & Material Balance help to reduce energy consumption

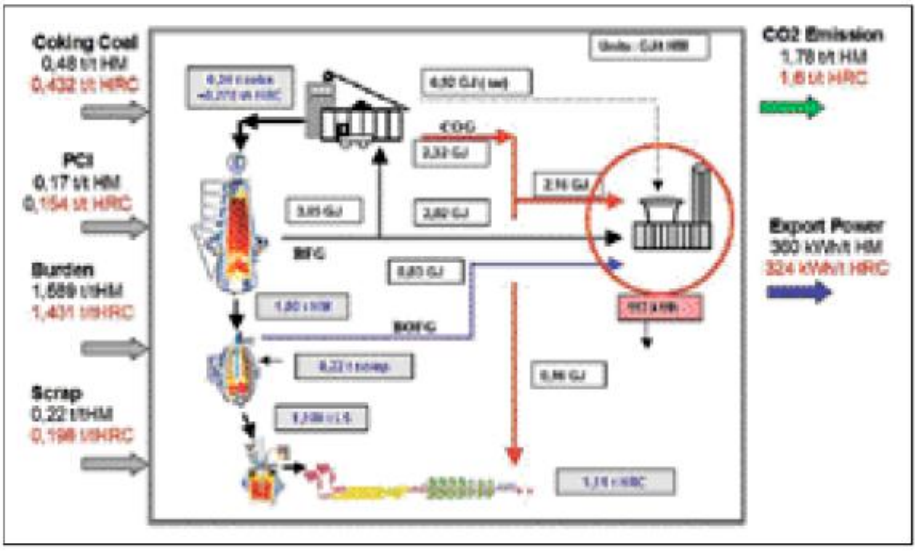
a. Plant-Wide Data Collection

Maqplex has data adapters to collect data from PLC, control systems and even directly from wireless devices or Ethernet networks. Data from the stacker reclaimer to the cold mill and wagon tracking system can be archived on Maqplex.

b. Energy and Material Balance

As 6 million Kcal are used to produce 1 ton of steel, energy conservation plays a very important role in steel manufacturing. As process data across the plant is collected, energy and material balance, especially where gaseous fuels are used, can be computed for:

- Coke oven heating
- Blast furnace stoves
- Soaking pits
- Reheating furnace in hot strip mill



Energy Balance

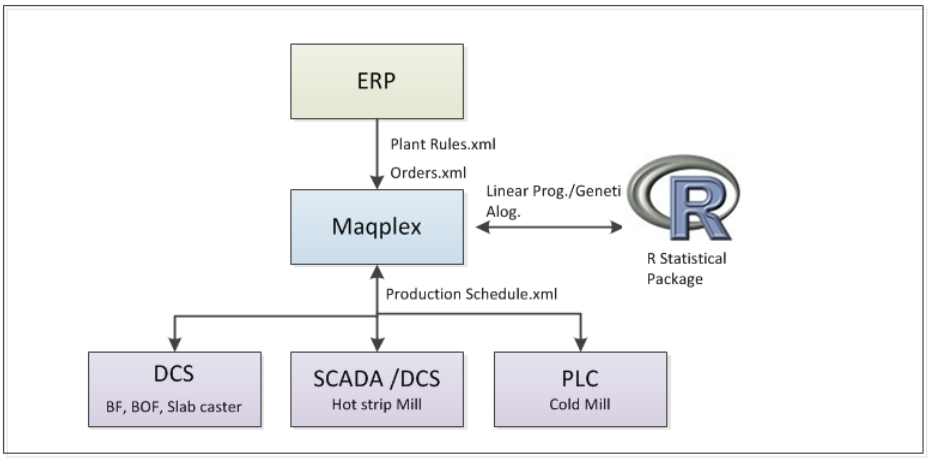
- Reveals actual energy consumption by allocation of the actual use of energy in each of the unit operations
- Identifies areas in which waste heat or gas are not harnessed.
- Generates energy consumption forecasts that can be used when integrated to smart grid

c. Scheduling

Scheduling of production is challenging in a steel plant with many dependent unit operations. Steel plant operation is a batch process – coke oven batteries operate in cycles, blast furnace and BOF furnaces operate in batches. So it is important that the batch production cycle is optimized to ensure there is continuous output of finished steel with minimal latency time.

Scheduling of molten iron operations, hot strip mill and cold mill can be done by Maqplex

The solution fills a critical gap between the company's enterprise resource planning (ERP) system and the plant's real-time production control system (DCS) by optimizing the daily production process.



Maqplex is seamlessly interfaced with 'R' – an open source statistical package that has over 3,000 built-in algorithms. The library of R algorithms gets updated periodically as they become proven.

Maqplex is integrated with the RsStatistical package that has more than 3,000 algorithms in its library

Scheduling can be performed at three levels:

- Hot molten steel – Blast furnace, BOF and slab caster constraints are considered to guarantee continuous supply of hot metal to slab casters.
- The hot strip mill scheduler considers the activities of the slab yard, reheating furnaces and rolling mills to optimize the production schedule
- The finishing mills scheduler optimizes the resource utilization required for annealing and galvanization to meet requirements of the end customer required output

d. Condition Monitoring of Equipment

Online vibration analysis can be performed on drive trains in hot strip and cold rolling mills. Pattern recognition algorithms are used to detect any deviation from normal vibration levels to alert operators

e. Thermal Imaging

Maqplex can display thermal images sent from fixed thermal cameras and perform video analytics to detect abnormalities. Typical locations for thermal imaging include:

Condition monitoring and preventive maintenance is simplified using Hadoop and R statistical packages

Maqplex provides the option of storing non-sensitive data on cloud servers

- Steel from slab caster to hot strip mill is monitored on a thermal camera to compare the actual temperature with the computed, pre-scheduled temperature at various points to optimise the process
- Exterior refractory inspections locate "hot spots" in furnaces and process vessels, indicating thinning or missing refractory lining or insulation

f. Analytics with Hadoop

Maqplex is integrated with Hadoop. Real-time data collected from hundreds of sensors can be archived in distributed servers and effectively analysed for potential breakdown of equipment, pattern matching to compare current plant data with past data to check how plant upsets were handled. As Maqplex can be integrated with the cloud, performing data analytics with Hadoop and the cloud becomes a very cost-effective and feature-rich solution

g. Data on Mobile Platforms

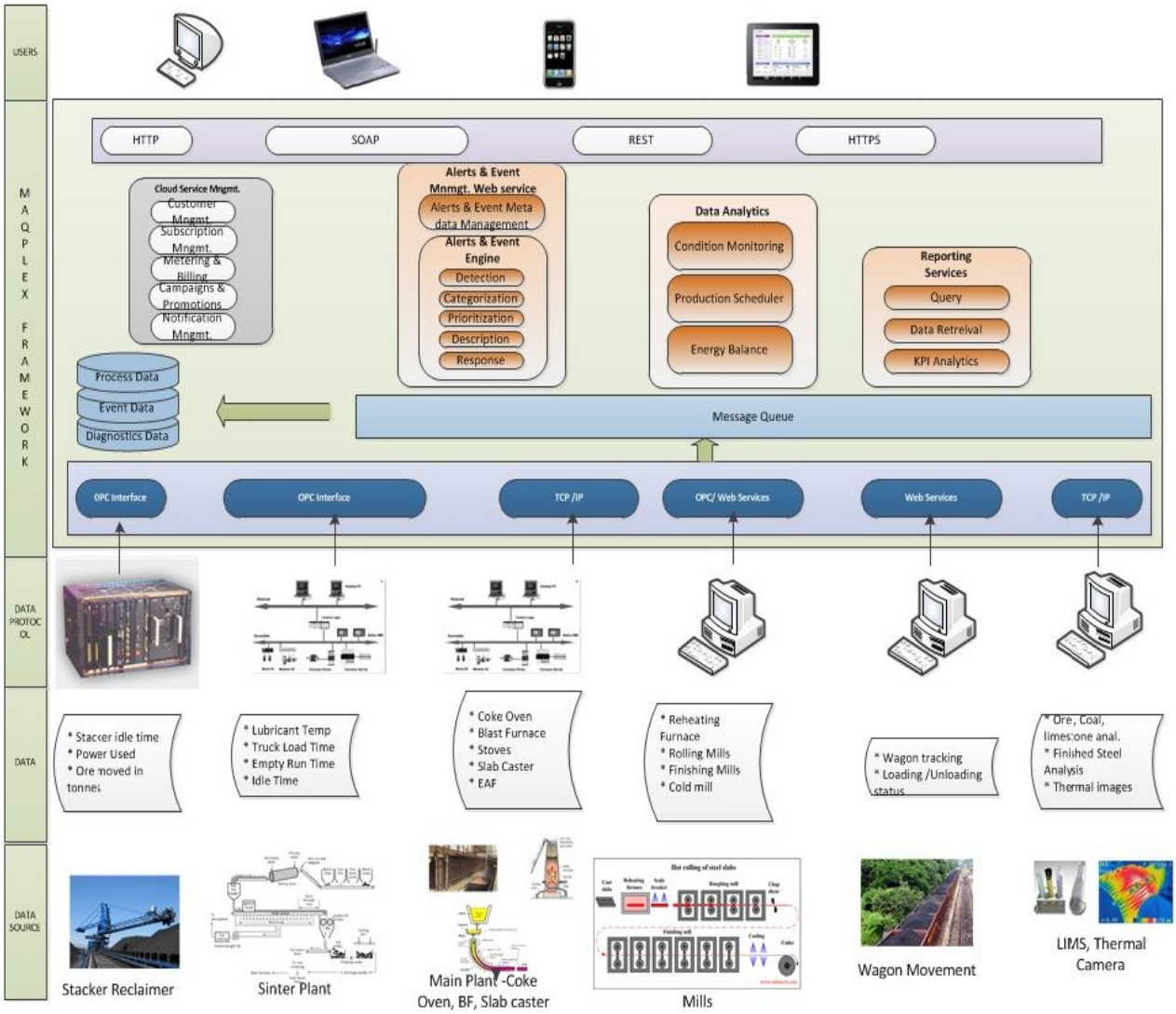
Maqplex has a ready interface to mobile devices like tablets and smart phones. Graphics and plant data can be viewed, and if need be, also controlled from mobile devices.

Application on the Cloud

Maqplex is an M2M framework that uses the cloud infrastructure for hosting the application, computing and for the database. The cloud is the ideal backbone for this application, offering many benefits such as:

- The application can be split into many services – data monitoring services, analytics services, optimization services, etc., and can be offered to customers
- End users pay only for the services used, and only for the time used
- Scalable to cater to any number of end users with performance and response time guaranteed
- Analytics can be expanded in the future to include more proven optimization applications for mines
- Option of remote monitoring by experts in another part of world
- All the above at the least possible cost

Here is architecture diagram of a Maqplex framework as envisaged in a steel plant.



Maqplex consolidates data from systems supplied by different OEM

A Typical Use Case

In the past, an integrated steel plant had different control systems for each of their plants, starting from ore handling to loading finished steel to wagons. There was no system integrating data across all plant,s and that led to many operational issues.

- It was not possible to compare steam , power and green gas emission efficiencies across each plant at same instant
- Scheduling of hot metal operation was not possible, and done only for hot and cold mills
- Each plant had their own supervisory controls from a range of vendors while they performed very similar functions. Maintaining the application required system knowledge of that application.
- It was not possible to correlate important parameters from other plants when there was upset in one section of a plant

Maqplex is an ideal application to solve these operation issues.

- With Maqplex dashboards, all unit operations and equipment performance are available in easy visual formats
  - A user-friendly query engine can compare present data with past data as graphs or tabular formats. Any abnormal increase in fuel or power can easily be identified and root causes determined.
  - Powerful analytics using R statistical packages helped engineers try different types of schedulers
  - Energy balances ensure there is no waste or energy leakage, thereby reducing the carbon footprint and making a greener plant
  - Maqplex is a cloud-based application that requires nominal IT infrastructure cost by end users. All data that were not considered sensitive were moved to the cloud, and more IP related data could be retained on servers within the plant premises. A services subscription can be on a monthly basis, and more importantly, users pay only for what is used.

HCL's Maqplex is ideally suited for steel with adapters to get data from a system that interfaces with real-time sensors combined with powerful analytics

Conclusion

As steel manufacturing extends from ore handling to tracking wagon movement carrying finished steel, operations are complex and there is no single control system deployed to control the entire integrated plant. A comprehensive framework that can integrate with control systems, lab information systems, wagon movement systems or asset management systems is certainly a must.

HCL's Maqplex is ideally suited for the steel industry, with adapters to receive data from any system that interfaces to real-time sensors. Its strong analytics framework is an ideal platform to execute optimization applications like scheduler, energy balances or condition monitoring, and above all, Maqplex is cloud-enabled so it can deliver all the features at a reduced cost with easy integration to smartphones and tablet computers.

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