Conversion to Fully Automatic Operation at a Major Hot Strip Mill Slab Yard

Cesare Corti, General Manager, and Leonardo Speranza, Control Systems Manager, ILVA SpA, Taranto, Italy
David Stocker, Senior Systems Engineer, TMEIC Corporation, Salem, Virginia, USA

A project to fully automate the operation of the slab yard that feeds ILVA SpA Hot Strip Mill #2 in Taranto, Italy, is nearing completion. The new automation and control system was retrofitted onto the existing cranes, and includes an interface with the existing Level 3 enterprise system. The remote and unmanned crane operation provided by the new system offers several major benefits, including significantly reduced operating costs.

ILVA SpA, part of the Riva Group, a major European steel producer, is currently finalizing automation of the slab yard at the Hot Strip Mill #2 in Taranto, Italy. This yard utilizes ten overhead bridge cranes organized in five bays for slab storage. To date, three of the five bays have been automated, while the remainder will be upgraded on a rotating outage schedule.

The project scope includes mechanical refurbishment and complete electrical retrofit of each crane, as well as the addition of a new slab tracking and inventory system. The crane retrofit includes the conversion to variable speed AC drives, PLC control, wireless network communications and web cameras for remote monitoring and operation. Each crane was also fitted with a laser-based system for automatic slab pick-up and landing of slabs, including the automatic pick-up of slabs loosely piled on railcars.

The benefits realized by this project include reduced labor costs, increased operational flexibility, improved utilization of the yard assets, and higher quality in the delivery of slabs to the furnace.

Figure 1 – One of Five Bays in the Slab Yard

This paper includes an overview of the project scope, goals, benefits, the technology employed, and discussion of some of the “real world” issues and lessons learned during the planning and implementation of the project.

Basis for Undertaking Project

Prior to this project, the cranes were operated manually. Access to the Level 3 yard planning system was via a terminal in the central pulpit, and work instructions for crane movements were transferred between the supervisors in the pulpit and the crane operators via radio.

In an effort to improve the efficiency of the overall operation of the rolling mill, ILVA recognized the following problems in the slab yard operation:

- High labor cost – approximately 40 crane operators were on staff in the slab yard,
- High maintenance costs due to poor operator skill or diligence resulting in damage to the crane,
- Poor product tracking due to verbal data transfer between the pulpit and the crane operators,
- The crane cab is a hot, dirty work environment, with limited ability to handle hotter slabs directly from the caster.

ILVA management realized that each of these problems could be addressed by automation of the crane system in the yard. The goals for such an undertaking included:

- Labor savings due to crane automation,
- Reduced mechanical wear and tear due to reduced operational variability,
- Improved material and asset tracking,
• Potential for higher throughput due to reduction in process variation caused by human errors and behavior,
• Increased yard storage capacity due to closer stacking, achieved through the higher accuracy of the variable speed drives and automation,
• Reduced variation in delivery of slabs to the furnace.

After analysis of the costs and benefits, ILVA let contracts for the project late in 2001. The major suppliers included TMEIC Corporation for the crane control and automation upgrades, and Carpenteria Meccanica Almici SpA for full mechanical refurbishment of the existing cranes. PRISMA Impianti Srl provided installation services as a subcontractor to both ILVA and TMEIC Corporation.

Yard Overview

The yard is separated into five bays, each containing two overhead bridge cranes, as shown in Figure 2. All new slabs enter the yard via rail (left). Slab delivery is onto a common delivery table that serves all hot mill furnaces (right). A transfer table is available for exchange of slabs between the bays.

The yard holds a wide range of slabs of various widths, thicknesses, lengths and steel grades. Slabs are piled up to eleven high in the yard. The tong-style lifting device on each crane can lift a single slab.

Major Features of New System

The major features of the new automation system, as proposed by the selected suppliers, include:

• **Unmanned Crane Operation** - Each crane executes Work Instructions, which are generated either automatically by the Level 3 enterprise system or manually by the operator in the central pulpit.
• **Remote Crane Operation** - In order to handle exception conditions, all motions for a selected crane can be made directly by the operator from either of two remote operation stations located in the central pulpit.
• **Automatic Slab Tracking & Inventory** – All slab movements are tracked and stored in a central database.
• **Slab Position Sensor** – Laser based slab recognition and position measurement system enabled automatic pick-up of slabs from railcars and tables, and provides consistent and safe yard handling practice.
• **Variable Speed Drives for Improved Crane Performance and Control** – Provides more accurate and consistent stacking, and a reduction in mechanical damage.
• **Integrated Crane and Roller Table Control** – Table motion is interlocked with crane motion to enhance safety and reduce equipment damage.
• **Modern Diagnostic System** – Based on the latest Human Machine Interface (HMI) technology.

Automation Project Scope

The automation project scope included the following major elements.

Mechanical Refurbishment of each Crane

• This task included the installation of new variable speed AC motors and drives, and simplified drive trains.

Crane Control Upgrades

• Replaced the AC contactors for fixed speed motor control of the bridge, trolley and hoist motions with variable speed AC drives.
• Converted the relay vintage crane control to PLC control.
• Added a modern HMI and Diagnostic System.
• Provided for remote operation from the central pulpit.
• Added absolute position measurement for the bridge, trolley and hoist motions.
• Added a Crane-to-Crane Anti-Collision System.

Communication Network Upgrades
• Deployed a Radio Frequency (RF) Ethernet network for remote crane control and monitoring.
• Installed a wireless digital video system for remote crane monitoring and operation from the central pulpit. Communication between the cameras on the crane and the displays in the pulpit is via the RF Ethernet.

New Automation Modules
• Slab Position Sensor (SPS) System for automatic slab recognition and handling,
• Yard Inventory and Tracking Database,
• EDI Interface to Level 3 Enterprise System,
• Automatic Transfer and Delivery Table Control.

Control and Automation System Architecture
Figure 3 is an overview of the control and automation system. Each crane was retrofitted with a VME®-based Innovation Series® Controller system supplied by TMEIC Corporation. This VME rack hosts all crane control functions, including the Slab Position Sensor interface and slab detection and measurement software engine.

Communication between the cranes and the central pulpit is via RF Ethernet. EDI\(^3\) with the existing Level 3 enterprise system is via wired Ethernet with an appropriate interface driver.

The central database for storage of the slab inventory and all other system data is hosted in a Microsoft SQL Server package running in Microsoft Windows®-compatible PC’s. The database itself is stored in a RAID array to assure data integrity and security.

The Human Machine Interface (HMI) is hosted in a variety of Windows-compatible computers, mostly with flat panel/touch-panel type displays.

Slab Position Sensor
A Slab Position Sensor (SPS) system was installed on the trolley of each crane to support the automatic operation. The primary sensors are a pair of laser scanners (LIDAR\(^5\) technology) that provide a three-dimensional profile of the slabs and other objects under the crane. Figure 4 and Figure 5 illustrate the arrangement of the sensors.

Figure 3 - Control System Architecture

Communications between the cranes and the central pulpit is via RF Ethernet. EDI\(^3\) with the existing Level 3 enterprise system is via wired Ethernet with an appropriate interface driver.

\(^1\) VME is a registered trademark of the Motorola Company
\(^2\) Innovation Series is a registered trademark of the General Electric Company.
\(^3\) EDI – Electronic Data Interchange

TMEIC Corporation
The SPS measurements are also used to confirm the geometry of slabs handled in the yard or picked up from the railcars or tables.

The SPS also provides a limited ability to detect improperly handled slabs, so that the crane motion can be automatically stopped before mechanical damage occurs.

Figure 6 shows an example of a slab pile on a railcar. The yellow dots indicate the individual scan points that make up the profile of the slab objects in view – in this case the tops of slab piles on railcars.

Any future upgrade to the Level 3 system will include ODBC 6 compliance such that the new system will be able to directly access the SQL database without a gateway module.

Interface to Existing Level 3 System

The existing Level 3 enterprise system generates Work Instructions (WI’s) to move slabs in the yard, based on the yard inventory and rolling schedule.

Each Work Instruction contains put and get information to move a slab from one predefined location to another within the yard. Examples include:

- Railcar to Yard
- Yard to Yard
- Yard to Furnace Delivery Table

Although all Work Instructions are typically generated by the Level 3 system, they can also be created by the operator via the HMI system. Most manual slab moves are made this way.

The Work Instructions are exchanged with the crane control via the SQL database. The Level 1 and Level 2 systems have direct access to this database.

System Operation

Figure 8 shows an automatic pick up of a slab from a railcar. For this operation the Slab Position Sensor system provides the exact bridge and trolley position feedback of the target slab.

Any future upgrade to the Level 3 system will include ODBC 6 compliance such that the new system will be able to directly access the SQL database without a gateway module.

6 Open Database Connectivity – a standard database access method developed by Microsoft Corporation.
the slab pile within one half of a bay along the railroad track. In addition, there is no structure in place to force side-to-side slab position on the railcar.

Figure 9 shows the automatic stacking of slabs in the yard. The stacking is more consistent versus manual operation due to the reduced variation in performance of the automation system. Yard capacity was therefore increased due to closer stacking of slabs in the yard.

Figure 9 - Automatic Stacking of Slabs in the Yard

The refurbished and automated cranes have been in service for approximately 60 crane-months. Through this period, these cranes have executed well over 100,000 Work Instructions. To date, the system has met or outperformed all expectations.

Realized Project Benefits

Reduced Labor Costs

The number of crane operators in the yard has already been reduced by 50%. The current expectation is that after project completion, two operators on duty will operate all ten cranes, which will result in an ultimate labor cost reduction of approximately 75%.

Improved Yard and Asset Utilization

Crane availability has increased and crane maintenance costs have been significantly reduced. In particular, damage to the pincer assemblies has gone down sharply. Also, damage to the yard infrastructure, such as the table rolls and motors, the railcars, and the building structure itself is notably lower.

The yard layout has been reconfigured with an increase of more than 10% in total storage capacity. The new layout also provides more unobstructed access to key equipment, such as the roller tables. In addition, storage flexibility was improved due to greater homogenization of the storage locations.

Higher Quality

Delays and errors in slab delivery to the furnace have been reduced.

Open Issues & Lessons Learned

Crane Cycle Time

A skilled human operator has intimate knowledge of the process at hand, and a keen ability to adapt as required to meet operational goals given an infinitely variable set of circumstances. Therefore, it is critical in the design and implementation of any automation system to assure that impact on the overall production rate of the system is minimized.

For this reason, special attention has been given to the optimization of the crane movements required to carry out each type of Work Instruction. This effort has been undertaken jointly by ILVA and the suppliers, resulting in continuous improvement in the crane cycle time.

Project Status

To date, six of the ten cranes in the yard have been fully refurbished and converted to automatic operation. The four remaining cranes will be converted on a rotating schedule.
Remote Operation

The original system design included two remote operator stations in the central pulpit. However, the operators have insisted on simultaneously monitoring the motions of all cranes. Therefore, a project is currently underway to add additional video monitors such that the digital video images from each of the ten cranes are available in the central pulpit at the same time.

Operational Interface with Level 3 Enterprise System

Another area that required special attention was the interface between the existing Level 3 enterprise system and the new yard inventory database. The existing enterprise system spans multiple operations within the facility, and therefore could not be replaced within the scope of this project. However, since the existing enterprise system does not have direct access to the new slab inventory database, and because it runs infrequently (only when the rolling schedule is updated), it is apt to produce Work Instruction lists that are based on out-of-date information. Several design compromises have been made and may be made in the near future been as “work-arounds” for this issue.

Impracticality of a 100% Automation Solution

It is not reasonable or even feasible to expect full automation of the entire operation. For example, the pick-up of trapezoidal shaped slabs made during width changes in the caster is best made by the human operator. Although it is theoretically possible to automate these operations, they form only a small percentage of the total, and the cost of implementation and related system maintenance would likely outweigh any savings.

Summary

The project to fully automate the operation of the slab yard that feeds ILVA SpA Hot Strip Mill #2 in Taranto, Italy, is nearing completion. The new automation and control system was retrofitted onto the existing cranes, and includes an interface with the existing Level 3 system. The demonstrated benefits realized by this project include reduced labor costs, improved utilization of the yard assets, and higher quality in the delivery of slabs to the furnace.