Automation and Drive Replacement for the CSN LLC 2-Stand Reversing Cold Mill

Abstract

CSN LLC renovated its 2-stand reversing cold mill in Terre Haute, Ind. This paper describes the new and improved functionality, strategy for implementation with minimal downtime, buy-in from project stakeholders, and results and benefits.

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Beginning in the midst of the 2009 economic downturn, CSN LLC boldly began a major renovation of its 2-stand reversing cold mill in Terre Haute, Ind. This work was based on a study of the mill performed in 2008 by TMEIC Corp. The scope included replacement of level 1, level 2, HMI, process models, two flatness rolls, coolant headers and selective spot cooling sprays. CSN obtained approval for the replacement automation system in early 2009, and the main drive replacement was added to the scope in March 2010 due to a surprise unavailability of main drive spares. The shutdown for installation of the new automation equipment and main drives took place in October 2010. This work includes descriptions of new and improved functionality, the strategy for implementation with minimal downtime, buy-in by project stakeholders, and results and benefits to date.

Discussion

Project Background — CSN LLC was formed in 2001 when Companhia Siderúrgica Nacional (CSN) acquired the assets of Heartland Steel. CSN, the first integrated flat steel producer in Brazil, is one of the largest integrated steel producers in Latin America, with annual production of 5.8 million tons per year. CSN LLC is an independent steel processing facility incorporated in the U.S., with a capacity of 1 million tons per year of flat rolled products.

The 2-stand reversing cold mill is a key asset for CSN LLC (CSN). Every coil processed by the facility is cold reduced by this reversing mill. Although the mill is not that old, limitations

Figure 1

CSN LLC is a 1-million-ton-per-year independent steel processing facility located in Terre Haute, Ind.

Figure 2

CSN 2-stand reversing cold mill.

from the original start-up in December 1999 hindered it from reaching its intended design potential. CSN had invested in mechanical and sensor upgrades, but the automation and drive system were as originally installed. Obsolescence, together with limitations of the equipment, provided sufficient reasons for CSN to consider a modernization.

Two-Stand Mill Arrangement — Coils are first loaded onto a payoff reel. On the first pass, the coil is reduced by each of two stands before it is coiled on the exit tension reel. On the second pass, the coil is again reduced by each of two stands before being coiled on the entry tension reel. One, two, three or four passes are possible, since a coil may be delivered from either side of the mill.

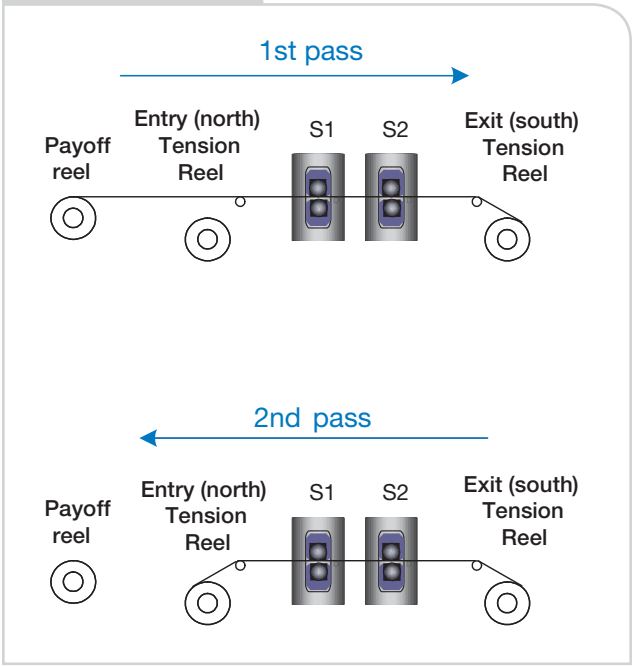
Mill Study — In mid-2008, CSN commissioned a mill study. TMEIC was selected to undertake the mill study. The objectives of the mill study were:

- To investigate mill capabilities for thin products requiring up to 85% reduction.
- To identify any yield gains that could be achieved by upgrading the automation system.

The results of the mill study were:

- Identified the capabilities of the mill for products requiring up to 85% reduction.

Figure 3



CSN 2-stand mill arrangement.

- Identified potential yield gains in reduced head and tail lengths that could be realized with replacement of the automation system.

- Identified potential improvement in flatness performance that could be realized with replacement of the shape rolls, new coolant headers and new spot cooling headers.
- Identified business risks due to obsolescence and the lack of single-stand operation capability.
- Identified limitations in level 1, level 2 and the main drives.
- Identified additional opportunities for cost savings.

Define Project Scope — CSN utilized the results of the mill study to generate an inquiry document to solicit bids for replacement of the automation system. The requested scope included:

- Replacement of level 1, level 2, process models, HMI, both shape rolls, mill coolant headers and spot cooling headers.
- Interface to the existing drives and most of the existing I/O and operator stations.
- Retain most field I/O and replacement of the MCC-related I/O.
- Incorporation of the roll coolant and oil-air PLC functionality into the new automation system where previously it had been standalone.
- New operator desk in main rolling pulpit.
- Capability for single-stand operation.

CSN's rationale for retaining the main drives was both cost and the ability of a new automation system to mitigate any major main drive problems with single-stand operation.

Request for Quote and Proposal Evaluation — CSN invited several well-known vendors to bid the project. Proposals and presentations were prepared and submitted to CSN. CSN's selection process included review and evaluation of the proposed technologies, visits to reference sites and contacting other references.

Project Begins — In April 2009, CSN and TMEIC signed a contract to begin the modernization of the 2-stand reversing mill based on the above scope. TMEIC quickly sent experienced project people to the site to begin the detailed planning for the project:

- Detailed information was gathered and available space identified for placement of new equipment.
- Identification of the existing CSN plant communications networks.
- Preliminary discussions regarding the L2/L3 interface, including how it works now and how CSN wants it to work after the modernization.
- Preliminary discussions with the operations people on how to lay out the new pulpit desk for optimal operation.
- Key subvendors for the new shape rolls (ABB) and coolant spray system (Lechler) were chosen.

Heat Study — A heat study was performed on the mill early on in the project by Lechler, the cooling spray vendor. The results of the heat study were used to confirm the proposed design of the new coolant headers and spot coolant sprays.

Buy-In From Project Stakeholders — CSN made a decision to commit key resources as needed during the design phase. This included spending time consulting with TMEIC engineers at the site, as well as multiple visits to TMEIC's Roanoke, Va., facility for the following activities:

- Detailed discussions with project team members.
- Review of preliminary hardware designs.
- Review of current operational procedures and the goals for improved functionality.
- Review of main desk layouts with the mill operators.
- Review of preliminary screens and reports with the CSN mill operators, maintenance and engineering team.
- CSN operators, maintenance and engineers frequently tested functionality with TMEIC engineers during development.
- CSN Information Technology (IT) team tested new database connections, data transfer and table structures.
- Technical training.
- Operator training.

Allowing the maintenance and operating personnel to participate with input and review of the design created a "buy-in" from these stakeholders. This made for a better overall design that addressed previous operational issues. As an example, the previous main desk had a larger "wingspan" distance, which forced a seated operator to "roll" back and forth while operating the mill. The new desk is more compact and, therefore, more convenient to perform the same tasks.

Main Drive Surprise — The initial planning called for the new automation equipment to be installed in June 2010. Shortly after the work on the automation project began, CSN was informed by their original main drive vendor that supplies of the GTOs were completely exhausted and no longer available for the mill stand drives. The main drive replacement had been considered initially, but was considered less urgent because the new automation system would allow single-stand operation. With the news of the spare's unavailability, the main drive replacement became more urgent. The original main drive vendor offered an experimental IGCT replacement. With no other short-term options and high failure rates, CSN purchased the first experimental unit. Initial trials with this first unit at the site were not promising, so CSN began looking at other options.

Main Drive Replacement — In March 2010, CSN and TMEIC signed another contract for replacement of

the main drives (two stands and two tension reels) with new TMEIC TMdrive-70 drives. The TMdrive-70 features the latest injection enhanced gate transistor (IEGT) voltage source inverter technology for AC main drives. It was agreed that a single shutdown would be employed for replacement of the main drive and automation equipment. This shutdown was scheduled for October 2010. CSN chose the TMdrive-70 for the following reasons:

- Compatibility with cylindrical rotor motors.
- Operation to the originally promised 75 Hz motor frequency.
- Latest IEGT technology.
- Outstanding reliability (MTBF exceeds 30 years).
- Highest efficiency.
- Less sensitivity to power dips.
- Best integration solution for new automation system.
- Simplicity of design and hardware relative to other options.

The original decision to retain the existing payoff reel, entry flattener and shape roll drives was not changed.

Design Phase and System Test — A robust design is important for any large automation project, and it is even more critical for a producing mill. This was especially true for this project, where there was no possibility of returning to the old system. The following techniques were applied during the design phase:

- Detailed review of existing documentation.
- Sent designers to site to observe operation and discuss any problems with the current implementation.
- Prepare a written functional requirements document.
- Review of functional requirements with the customer.

System test is a process in which the system automation hardware (including communication networks) and automation software are integrated. TMEIC applied the following techniques for software system test:

- Dedicated system engineer responsible for the system test.
- System engineer prepares the formal system test plan, which is reviewed with the customer prior to the system test.
- System test plan includes a functional checklist, which must be approved by the system engineer.
- Parts of the system that are not present are simulated.
- The idea is to exercise all possible software paths, including abnormal conditions.
  - Utilize actual customer PDI.
  - Generate model references.
  - Roll hundreds of coils.
    - Using actual HMI.
    - Simulated operator pushbuttons.
  - Generate reports.
  - Check all events and alarms.

Commissioning Strategy — The major goals of commissioning for this project were to:

- Minimize length of final outage.
- Minimize time to full production.

The strategy to accomplish these goals included doing things early whenever possible to minimize the work needed during the final outage. TMEIC requested three mini-outages during the summer of 2010. Each mini-outage was planned in detail to allow particular areas of the mill to be I/O checked to the new software and then functionally commissioned as much as possible. Since the bulk of the existing Profibus I/O networks were reused, the I/O to be tested was disconnected from the existing controllers and reconnected to the new controllers during each mini-outage. Following the mini-outage, the I/O was reconnected to the existing controllers and functionally checked that everything was OK prior to restarting the mill. Mini-outages were planned and executed as shown in Table 1.

In addition to the mini-outages, all new I/O was checked prior to the main shutdown.

Main Shutdown — The main shutdown began on 18 November 2010. Two shifts of craft labor and technical

Table 1

Outage and Pre-Commissioning Activities

Outage	Pre-commissioning activities
Mini-outage #1	• Medium-pressure hydraulics
	• High-pressure hydraulics
	• All lube systems
	• Fume exhaust
	• All operator station I/O
	• X-ray gauge host interfacing
	• Spray solenoid cabinets (pre-install)
	• New pulpit operator desk (pre-install)
Mini-outage #2	• Entry coil handling
	• Payoff reel sequence
	• Roll change sequence
	• Exit coil handling
Mini-outage #3	• Hydraulic cylinder control
	• Roll bending control
	• Commissioning of the new water cooling system for the TM70 main drives

Figure 4

Removal of main drive equipment from drive room during shutdown.

Figure 5

Main pulpit was stripped in preparation for new main operator desk.

supervisors were utilized for round-the-clock coverage. The scope of the main shutdown began with the removal of the following equipment:

- Main drive equipment.
- Pulpit operator desks and controls.
- Both shape rolls.
- Spray headers.
- Spray solenoid cabinets.
- Speed sensors on the main drive motors.
- Entry and exit roller box assemblies.

Removal of the main drives (Figure 4) required partial removal of one wall of the drive room and temporary removal of the stairwell leading to the second story control room. A temporary stairwell to the second story control room was constructed in another location for the shutdown period.

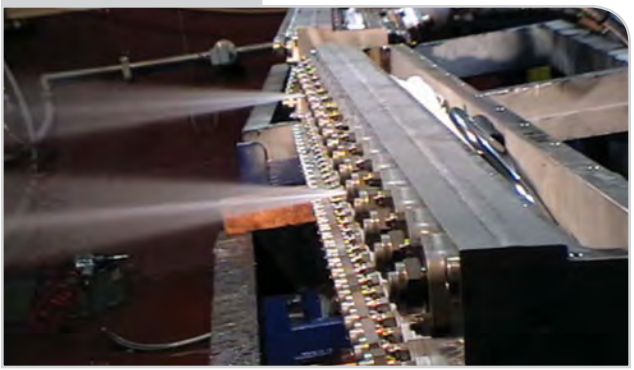
Following removal of the above equipment, installation of the following equipment commenced:

- New TMEIC main drive equipment.
- New pulpit desk, computer cabinets and overhead monitors.
- Two new ABB shape rolls.
- Eight new Lechler spray headers.
- Two new Lechler spray solenoid cabinets.
- New entry and exit strip presses (CSN, supplied by SES).
- New entry and exit shears (CSN, supplied by SES).
- Four new main drive speed sensors.
- New high-definition video system (cameras, monitors and network recorder).

While the new main drive equipment was being installed, the new main drive speed sensors were installed. Existing main drive transformers and transformer cables were reused. Close cooperation between CSN and the equipment designers during the design stage made the reuse of these cables possible. The new drive room I/O panels facilitated the integration of the existing drive interfaces to the new automation system. Following the initial checks, the drives were first tested uncoupled from the motors.

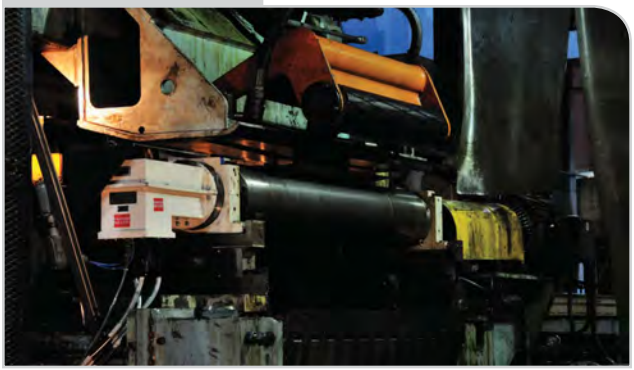
The new shape rolls were installed, and preliminary tests and verification with the electronics were done. I/O checks with the new sprays were reconfirmed following installation of the new spray headers and

Figure 6



New selective cooling spray headers.

Figure 7



New shape rolls were installed on both north and south (shown) sides.

solenoid panels. Operational testing of the entry and exit shears was performed in addition to the regulated control of the entry and exit strip press assemblies.

The existing main pulpit desk and HMI were removed and replaced with the new equipment. Operation of the new devices was confirmed with the automation system. The existing floor operator station HMI units were removed, and the new HMI touch screens were installed. The existing analog video system was removed, and the new digital video system, along with the new high-definition cameras, was commissioned.

The new MCC I/O and modifications to the oil/air I/O were checked with the new controllers. All functions that had been pre-commissioned during the mini-outage were confirmed.

After the mill was ready to accept rolls, the mill coolant system was checked and final tuning for the work roll bending and hydraulic gap control was performed. The coupled test of the main drives and the mill was also completed.

Start-Up With the New System — The first few coils were utilized for tuning of the tension regulators and initial automatic gauge control (AGC) commissioning. AGC loops were commissioned one function at a time. Automatic flatness control was started with limited authority at first, beginning with work roll bending corrections. Bending range was gradually increased and tilting and spot cooling corrections were phased in one at a time. Operators were "doubled" so as to improve their initial familiarity with the system. Round-the-clock coverage for the automation system during the first few days of rolling allowed quick resolution of any issues and also helped the operators to become comfortable with the new system. In less than 1 week, CSN was able to run the mill during night shift without commissioning engineer support. This allowed commissioning to continue during the day and production during the nights.

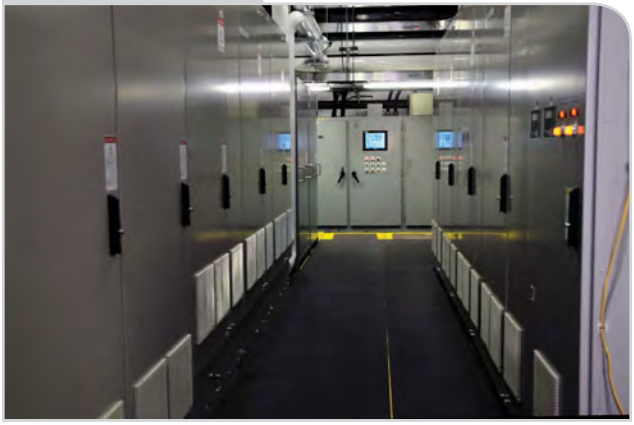
Results

CSN's 2-stand reversing cold mill is now in full production. Both thickness and flatness quality are excellent. Head plus tail off-gauge length has improved and recent monthly averages consistently set new records. The new main drives have not experienced any failures and have demonstrated the ability to ride through power events which certainly would have tripped the previous system and sometimes failed GTOs. The utility savings have been greater than expected. The new operator desk, controls and widescreen HMI displays have been well received by the operators. Multiple production records have been set for both tonnage and footage. Mill utilization percentage (monthly) has reached an all-time high. Even though the mill has been operating at record levels, the CSN team has been able to utilize the new system capabilities to continue their upward monthly performance trends.

Figure 8

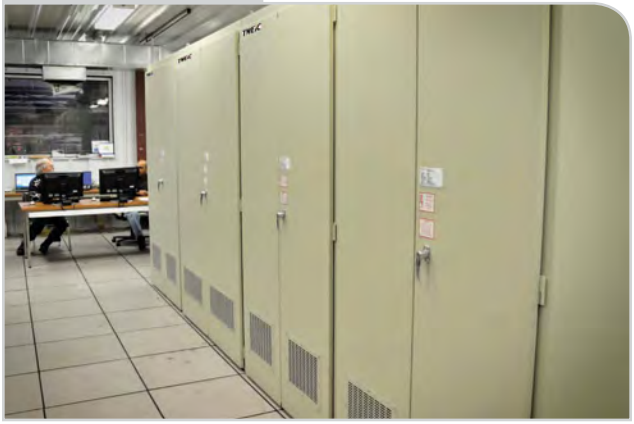
New wraparound operator desk and HMI arrangement.

Figure 9



Drive room following installation of new main drive equipment.

Figure 10



New level 1 automation equipment installed in control room directly above main drive room.

Table 2

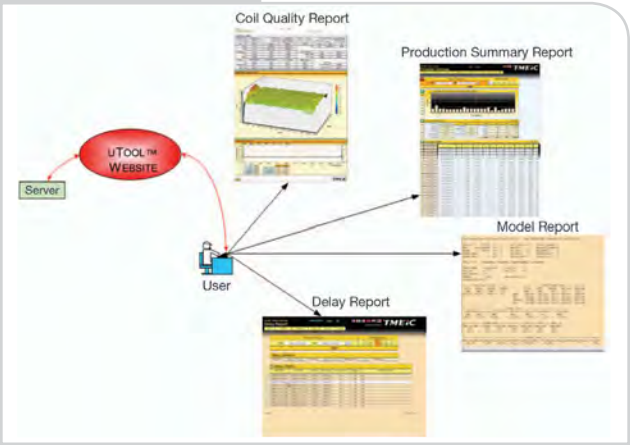
Main Shutdown Activities

Equipment	New	Reused	Removed old/ replaced	Modified	Commissioned	Confirmed only
Main drives	X		X		X	
Pulpit operator desks	X		X		X	
Shape rolls (2)	X		X		X	
Spray headers	X		X		X	
Spray solenoid panels	X		X		X	
Speed sensors on the main drive motors	X		X		X	
Entry and exit strip presses	X		X		X	
Entry and exit shears	X				X	
Existing I/O		X				X
New I/O	X				X	X
High-definition video	X		X		X	
Instrumentation		X				X
Floor touchscreens	X		X		X	
Floor operator panels		X				
Coil handling software	X		X			X
Roll change software	X		X			X
Fluids software	X		X			X
HMI software	X		X			X
Hydraulic cylinder control	X		X			X
Thread/de-thread sequence	X		X		X	
Flatness control	X		X		X	
AGC control	X		X		X	
Level 2/models	X		X		X	
Level 3 interface	X		X		X	
Master control	X		X		X	

Figure 11

New pulpit operator desk and HMI.

Figure 12



Web reports provide near-real-time production and quality information.

Table 3

Features and Benefits

New feature	Specific benefit
New spray headers, shape rolls and integrated flatness control	• Improved flatness performance
	• Ability to produce lighter gauge material than before
New models and AGC	• Improved head and tail performance
	• Improved thickness performance
	• Higher run speed
	• Ability to produce lighter gauge material than before
	• Obsolescence fully addressed
New level 1 control	• Auto sequences more reliable
	• Time between coils and passes greatly reduced
	• Ability to produce lighter gauge material than before
	• More information and control available to operators
	• Obsolescence fully addressed
New main drives	• Improved reliability
	• Less sensitive to power events
	• Improved efficiency and energy savings
	• Obsolescence fully addressed
	• Significantly lower maintenance costs
	• Higher run speed
Stand dummy mode	• Can still roll if 1-stand disabled
Embedded permissive diagnostics	• Operators can quickly determine reason why mill stopped or will not run
	• Maintenance time to find source of problem greatly reduced (go right to repair)
Integrated L1 and L2 HMI	• More information available to operators
	• Now available at all operator stations (single monitor)
Web reports (Figure 12)	• More detailed data than previous reports
	• Available to the entire plant
	• Graphics including 3D flatness
	• Rolling model reports are easily accessed by mill engineers to better analyze mill and products
Rolling schedule tools	• Cold mill operating personnel now have tools that allow them to quickly and easily generate a rolling schedule lineup from an available population of coils

Summary

The major renovation of the CSN 2-stand reversing cold mill automation and main drives has been completed. Pre-commissioning of key subsystems in advance helped to minimize downtime. Quality and yield have been improved. New production records have been set. Mill utilization is at an all-time high. Obsolescence issues have been fully addressed. Reliability of main drive equipment has been significantly improved. Information available to the operators, including diagnostic information, is much improved. Near-real-time quality and production information, including three-dimensional graphics generated by the system, are convenient to access throughout the plant via a Web browser. ✦

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