

ArcelorMittal Burns Harbor Hot Strip Mill Achieves Nearly \$2.3 Million in Savings Through the World-Class Equipment Reliability Program

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This project won the AIST Maintenance & Reliability Technology Committee's 2010 Silver Reliability Achievement Award, which recognizes iron and steel producing companies for reliability improvements and achievements.

ArcelorMittal operates 21 facilities across the United States employing more than 20,000 people. During

This work provides an overview of the ArcelorMittal Burns Harbor world-class equipment reliability program, an effort to make equipment assets more reliable. The program yielded millions of dollars in savings, increased safety and ultimately changed the culture at the plant's hot strip mill.

2008, ArcelorMittal senior leadership determined that, in addition to investing capital in production equipment replacements and upgrades, a complete and

Figure 1



The ArcelorMittal Burns Harbor hot strip mill.

consistent reliability business process would be developed and implemented using world-class reliability practices and tools to reap the full benefits of the company's critical equipment assets. ArcelorMittal leadership decided to launch a world-class equipment reliability (WCER) effort to focus on making



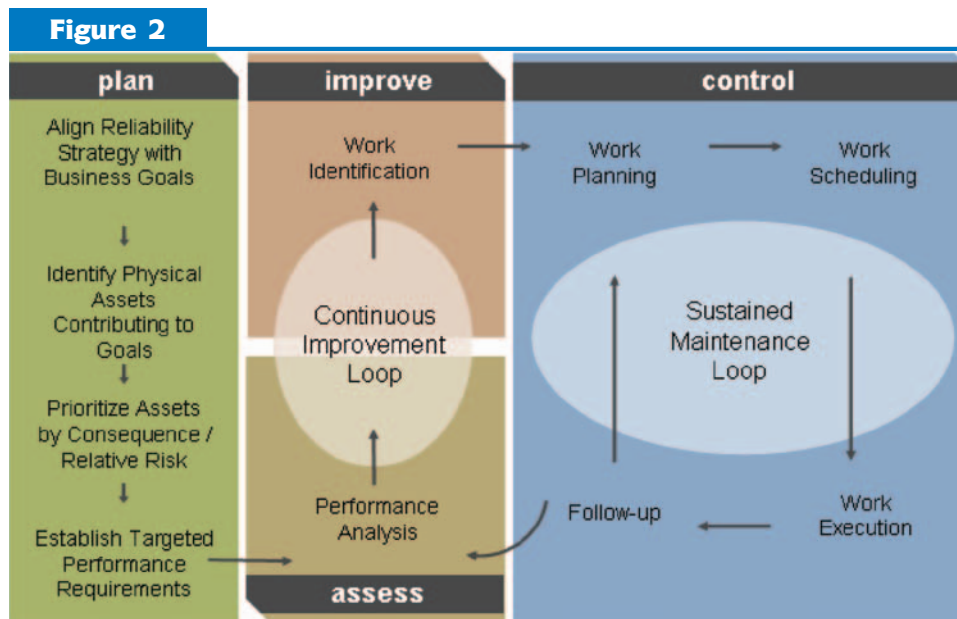
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these key equipment assets more reliable. A central team from the key operating facilities was formed to drive the effort. The central teams were comprised of a number of individuals from each operating facility who were trained in reliability principles, methodologies and implementation. These team members were then deployed on their respective plant sites to launch the WCER initiative within specific business units. One of the specific areas targeted at the ArcelorMittal Burns Harbor plant was the hot strip mill. The WCER team at the ArcelorMittal Burns Harbor hot strip mill achieved very dramatic results in a one-year period. Total savings in 2010 were nearly US\$2.3 million. Other positive benefits include increased safety, a cleaner work environment, increased awareness of proactive equipment maintenance and changing the reactive “firefighting” culture at the hot strip mill.

World-Class Equipment Reliability Implementation

In 2008, ArcelorMittal USA decided to have third-party subject matter experts conduct an assessment of the current state of its maintenance practices and systems. The results of the audits confirmed that maintenance practices were not at world-class levels. The WCER program was developed at ArcelorMittal to increase equipment reliability through the WCER business process. Ivara EXP Enterprise software was selected as a tool to support the ArcelorMittal WCER implementation. The software was installed on corporate servers using a single database for all U.S. operations. In order to effectively manage the full scope of the WCER business process, a custom interface to the existing Tabware computerized maintenance management system (CMMS) was designed, tested and implemented. ArcelorMittal central team members were trained and coached to be the internal WCER trainers and coaches for personnel throughout their plants. The training and coaching development effort was completed in 2009, leaving each plant site with a central WCER team of internal reliability practitioners to drive and support reliability improvement activities.



The ArcelorMittal WCER asset management business process.

In 2009, the Burns Harbor hot strip mill (HSM) operation was identified as a high-priority candidate for WCER implementation. It experienced an average delay rate of greater than 22%. In order to achieve the 2010 business plan of a 17.58% average delay rate, significant improvements in production equipment reliability were necessary. Through much of 2010, the hot mill was not operating at full capacity. However, as economic conditions have improved, the production requirements for the facility have increased significantly. This opportunity was another reason to take action to reduce the high delay rate for the HSM in a sustainable manner.

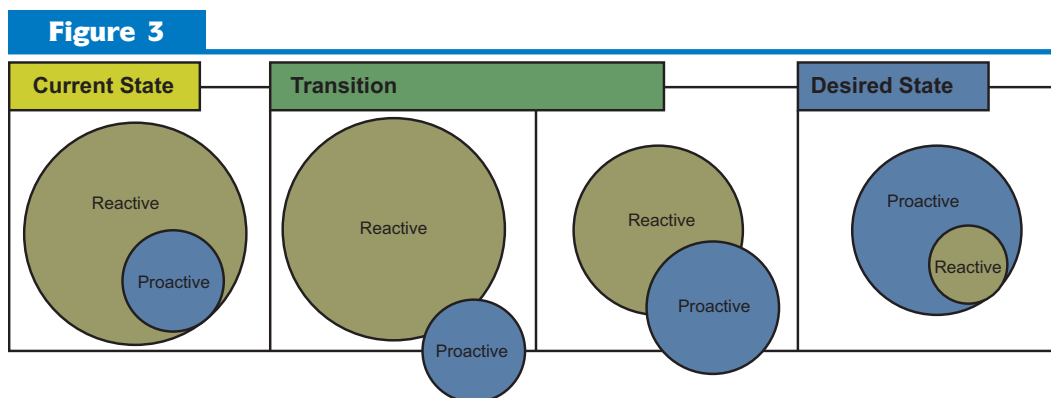
The Beginnings of Change

To begin addressing the reliability issues within the hot strip mill at Burns Harbor, a team was assembled to focus exclusively on applying the WCER approach and methodologies within this business unit. This began with the implementation of a proactive asset management business process. The initial area of focus was the finishing mill, which consistently experienced the highest delay rates for the entire hot strip mill.

Critical to success of the program was ensuring that the HSM WCER team, which represented 6% of the total maintenance workforce, be able to focus exclusively on proactive activities and not be pulled away to deal with day-to-day reactive duties. Jay Koch, hot strip mill division manager, demonstrated his support of the improvement effort by dedicating a total of 10 full-time resources from within the hot strip mill to the WCER effort. These resources included seven individuals from the HSM maintenance group, one from operations and two from the operations technology group. In addition, an external resource was brought in to lead the effort in the role of asset coach.

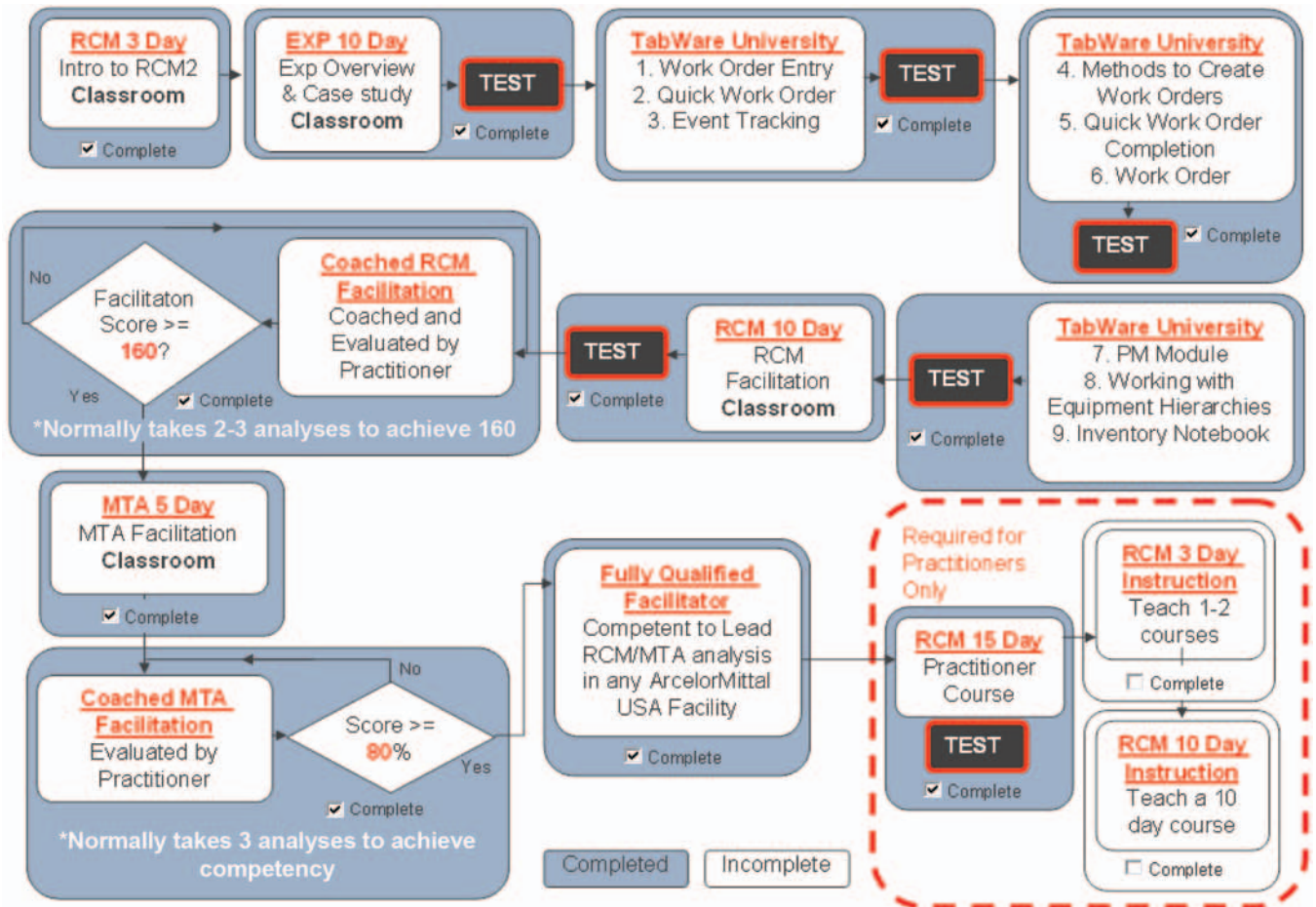
The Burns Harbor central reliability team provided WCER skills training and coaching to the HSM team members and ensured that the improvement effort was performed in accordance with the overall ArcelorMittal USA WCER standards.

In preparation for the effort, training profiles were developed to support all of the key roles within the WCER organization. Whenever possible, computer-based training that incorporated knowledge testing was used to deliver the skills training. This was supplemented



The process of moving from reactive to proactive — how ArcelorMittal successfully made the transition.

Figure 4



Example of formal training and certification needed for WCER reliability engineers.

with classroom training as needed to fulfill role requirements. All personnel within the HSM WCER team have a competency profile that identifies the training they have completed and the certifications they have attained in their development. Providing comprehensive skills training followed by field coaching has effectively prepared this team to deliver strong results while also enabling them to educate other personnel in the hot strip mill on the value of a proactive approach.

HSM WCER Team Members and Their Roles and Responsibilities

The HSM WCER team was built to ensure the delivery of all elements of a world-class equipment reliability business process. Team members and their role responsibilities are as follows:

- **Asset Coach: Scott Piech.** Responsible for coordinating overall WCER development and implementation effort for HSM.
- **Equipment Specialist — Electrical: Cameron Perryman, and Equipment Specialist — Mechanical: John Bussema, PE.** Accountable for discipline-specific asset performance (equipment depth, craft breadth). Implement the action plans developed with reliability-centered maintenance (RCM)/maintenance task analysis (MTA). Manage inspector resources daily and work execution on major outages. Also responsible for the acknowledgment of

indicator alarms, continuous reliability improvement, and asset cost performance and maintenance budget of area assets.

- **Reliability Practitioners: Nick Burlingham and Jeff Gill.** Responsible for facilitating all of the work identification activities (RCM, MTA, current inspection implementation (CII) and root cause failure analysis (RCFA)) used to build technically valid maintenance programs for production equipment.
- **Equipment Inspector — Mechanical: Mike Hattabaugh, and Equipment Inspector — Electrical: Gary Bretz.** Responsible for providing feedback to the equipment specialists to improve asset performance and further develop the quality of the indicators and routes. Responsible for performing the equipment inspections following inspection routes and entering the equipment conditions into hand-held inspection devices.
- **Lead Planner/Scheduler: Nate Lappin.** Responsible for planning and scheduling proactive inspection and corrective activities to address abnormal equipment conditions. This role is critical to the weekly downtime planning/scheduling activities which now incorporate much more proactive work.
- **Planner — Mechanical: Jim Johnson, and Planner — Electrical: Joe Tyilizs.** Responsible for the detailed planning of inspection and corrective maintenance jobs within the Tabware CMMS. This includes the identification of all parts, materials, manpower,

Figure 5



Work ID — RCM/MTA — Identify on-condition and scheduled tasks to be performed.



Implementation — Develop and validate on-condition indicators and scheduled tasks and create routes.



Inspections — Perform inspections. Write work orders for equipment issues. Provide feedback for analysis and route validation. Interface with operations on day-to-day issues.



Planning and Scheduling — Plan and schedule proactive work generated from inspections as well as daily generated work from operations.

The WCER group is actively engaged in all aspects of WCER.

procedures, safety information, permits, tools, etc., required to perform corrective maintenance work efficiently, effectively and safely.

- **Operator: Jerry Splitgerber.** Responsible for performing operator inspections of equipment and providing operator input to the work identification analyses.

HSM Asset Risk Prioritization

To determine the order in which production equipment would undergo work identification, an asset prioritization analysis was conducted on the finishing mill systems within the HSM. The output of this analysis is a relative risk number assigned to each system identified. The relative risk number is the sum of the magnitude of consequences of failure of the system in terms of a number of criteria (including safety, environment, quality, throughput, cost and customer service) multiplied by the likelihood of failure of the system. The relative risk list was used as a starting point for the WCER team to develop their work identification plan for the HSM. However, relative risk was not the only parameter considered in the development of the work identification analysis plan.

Templating for Similar Asset Types

Another key factor used in determining the sequence of analyses was the potential that an analysis had to be applied to multiple assets. The team identified those systems that were similar to others within the HSM, as these offered the opportunity to fast-track both the analyses and their implementation. In this manner, failure modes and the associated action plans developed through the formal work identification analysis for one asset are templated to another asset, taking along all the detail of the indicators built to inspect for asset condition and the corrective tasks required when an indicator condition is found to be abnormal. Efforts by Nick Burlingham and Jeff Gill to efficiently template similar assets allowed for rapid deployment on similar assets within the finishing mill. The strategy to employ templates and analysis copying enabled the HSM WCER team to rapidly implement 13,586 indicators within 12 months.

Work Identification

ArcelorMittal WCER leadership identified four options to be used for formal work identification, including RCM, MTA, CII and RCFA. These approaches vary in their level of rigor from the very detailed analysis of RCM to the less rigorous approach of CII. The approach selected depends on a number of factors, including the complexity and criticality of the equipment, availability of knowledgeable resources, current and targeted performance of the equipment, and the current level of knowledge of the equipment operation and its performance. The BH-HSM WCER

team chose to focus on MTA and RCM for most of their analyses. Key reasons for this decision included:

1. Thorough program documentation was identified as a requirement of the effort.
2. Sufficient resources were available to support all elements of work identification performance and implementation.
3. RCM and MTA offered the potential for rapid program implementation within the reliability software, and therefore rapid deployment of the improved proactive inspection activities.

Work identification analyses were conducted with the participation of trades and operating personnel from the finishing mill area. Once analyses were completed, the results were compiled into summary reports for review and approval by the HSM management.

Implementing Maintenance Inspection Routes

Following approval, equipment specialists implemented the action plans through the creation of indicators within the reliability software. An indicator is defined as a point of inspection for an asset that highlights whether or not a specific failure mode is developing, which could potentially lead to a subsequent asset failure. The indicators were organized into groupings called routes, which are all of the indicators to be inspected at a specific frequency for a given asset operating condition. New inspection routes are validated by the equipment specialist working with an inspector to complete the route to identify any changes to indicators or their sequencing that would improve inspection quality and effectiveness. Once validated, the routes are activated and data collection and analysis commences. The 13,586 indicators implemented in 2010 have been organized into 311 separate inspection routes for operating and maintenance personnel. Of these routes, 45% are performed when the equipment is running, while 55% must be performed during a shutdown. Inspection route compliance for 2010 was 95%.

Use of Predictive Technologies

The HSM WCER team aimed to maximize the effectiveness of their reliability program through the use of

predictive technologies for asset inspection whenever possible and practical. This has resulted in the extensive use of vibration, thermographic, ultrasonic and oil analysis techniques throughout the program. Predictive technologies have already proved highly successful in identifying abnormal asset conditions for follow-up.

In order to monitor how effectively the WCER business process is executed, the HSM WCER team built key performance indicators to track and report on all aspects of WCER, including strategy development, program implementation, performance management and work management. This information provides personnel involved in WCER the means to quickly see how well they are executing their business process activities and highlights any issues well before they negatively impact equipment performance.

Results

Over a period of 12 months since the launch of the WCER program in the Burns Harbor hot strip mill, a total savings of \$2.3 million has been realized. These savings have come from several areas, including:

- Avoidance of unplanned downtime of production assets through equipment inspections aimed at identifying potential failure conditions and through the modification of production equipment to eliminate specific failure modes. The abnormal conditions were addressed with appropriate corrective action prior to failure. These improvements resulted in a savings of US\$1,282,500 due to avoided equipment failure.
- Improved efficiency of corrective work performed during scheduled plant shutdowns due to information provided from equipment inspections, coupled with improved planning and scheduling practices.

Schedule compliance for shutdowns has increased from 65 to 80%, resulting in a manpower savings of US\$556,800 on an annual basis.

- An improvement in HSM work ratio due to reduced asset downtime that translates to a savings in energy (gas/electric) consumption of US\$450,000.
- Total savings in 2010 of US\$2,289,300.

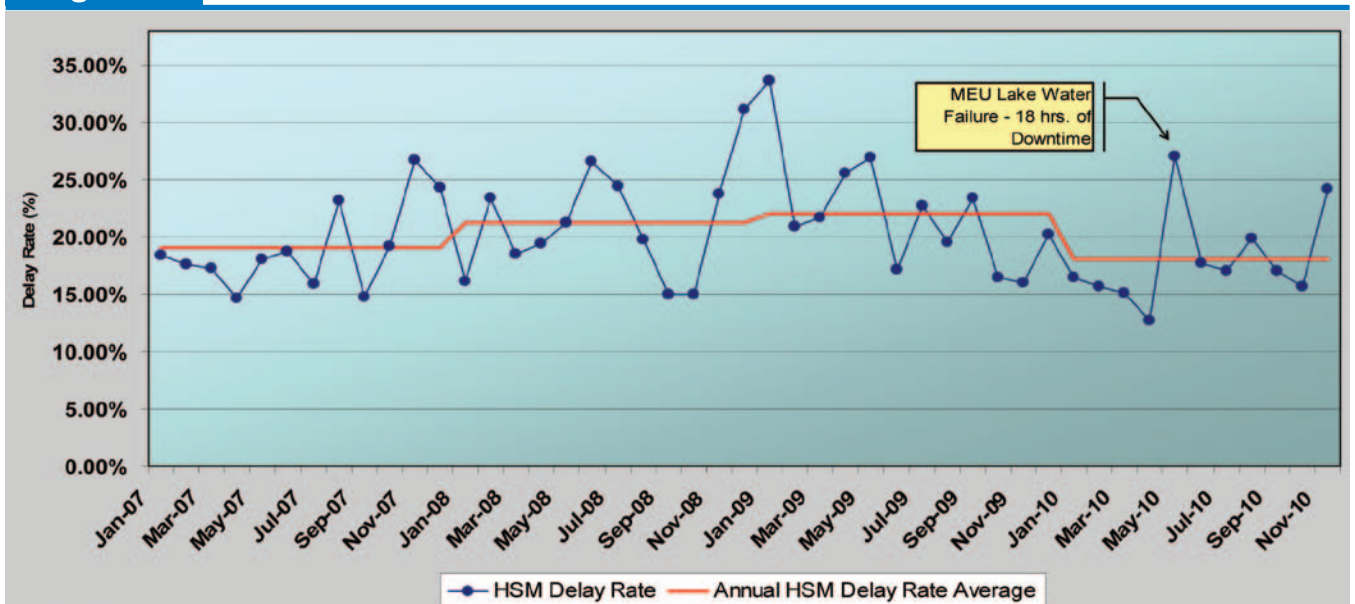
Significant Costs Avoided

Some specific examples of unplanned downtime of production equipment that was avoided through the identification and correction of abnormal equipment conditions or redesign of the equipment are the following:

Single Modification Saves \$200,000 per Year by Avoiding Unnecessary Bearing Failures — During the analysis of the finishing mill stands, it was identified that there was an average of four backup roll bearing failures per year at a cost of US\$50,000 per bearing. These failures were determined to be caused by problems with the lubrication delivery and recovery system. The WCER analysis team recommended that the system be redesigned. John Bussema led a fully integrated approach to gain buy-in at all levels and achieve rapid, accurate results from engineering to installation, drawing on vendor, engineering and craft resources. This redesign has been completed, and no backup roll bearing failures have occurred since the change. This single modification saves US\$200,000 per year by avoiding unnecessary bearing failures.

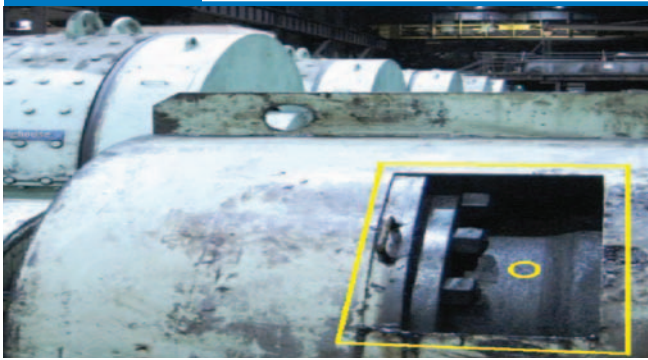
Vibration Inspection of Finishing Mill No. 6 — A vibration inspection of the main gearbox of finishing mill No. 6 was identified through formal analysis and implemented on this equipment. Routine performance of the

Figure 6



Improvement in Burns Harbor hot strip mill delays.

Figure 7



High vibration readings were discovered in the main gearbox, which resulted in cost avoidance of \$385,000.

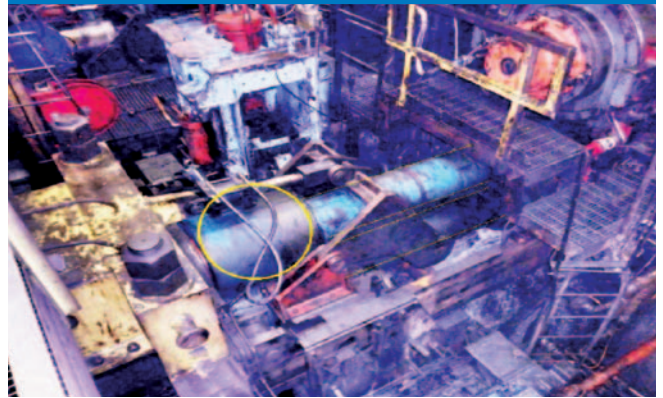
inspection highlighted a high vibration condition of the gearbox.

Through further investigation, inspector Mike Hattabaugh identified the likely cause to be a lack of coupling lubrication. The coupling was properly lubricated and another vibration reading taken, which was found to be normal.

If the coupling had failed, the corrective action would be to change the set of main drive reduction gears on which the coupling is press-fit. The cost to recondition the gear set and coupling is US\$385,000, which is the cost avoided due to taking corrective action when this abnormal condition was detected.

Infrared Thermographic Inspection — An infrared thermographic inspection of the main drive spindles on the finishing mills showed the temperature of four of the spindles to be excessively high. Investigation revealed that grease fittings on these spindles had failed and, as a result, proper lubrication was not being supplied. On the next shutdown, the grease fittings were

Figure 8



Mechanical inspections: high average temperatures were discovered using an infrared camera, which resulted in cost avoidance of \$480,000.

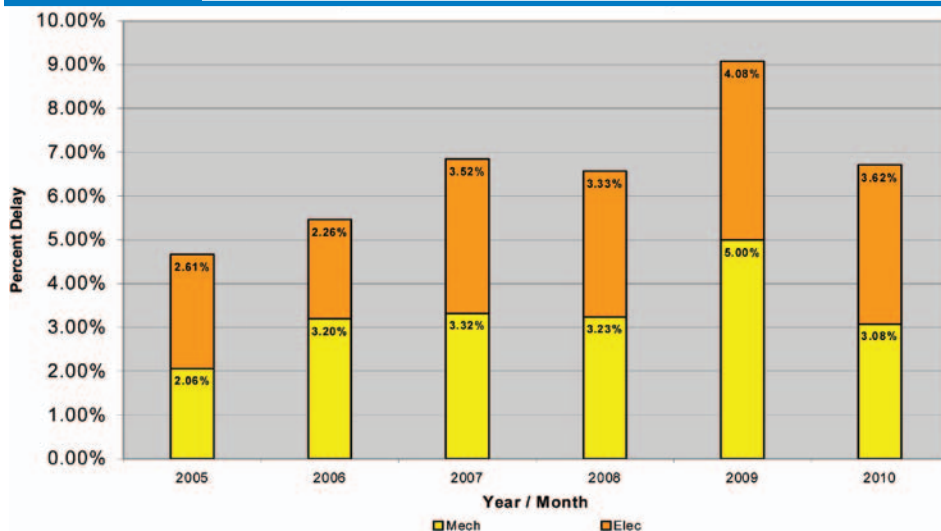
changed and the spindles greased. Subsequent infrared inspection showed the spindles to be running at normal operating temperatures. Each unexpected spindle failure would have cost US\$120,000; therefore, detecting and correcting this abnormal temperature on four units represents an avoided cost of US\$480,000.

Thermography on Electrical Equipment — Electrical inspections using infrared thermography revealed six finishing mill main drive blower motor circuits with hot connections. The function of each blower is to cool four power trays. Also found were four power trays that had hot internal connections that were not evident without thermography. Of the 28 power trays affected by these findings, it is believed that approximately 14 would have failed had corrective action not been taken. The cost to send a tray for rebuild is US\$5,250, and the inspection resulted in an avoided cost of US\$73,500. Thanks to efforts of Cameron Perryman and Gary Bretz, this potential failure was avoided.

Oil Analysis — A lubrication oil analysis task was identified for the ram gearbox on each finishing stand. On the first inspection, three of the seven gearboxes were found to have extremely low oil levels, triggering critical alarms in the reliability software. The gearboxes were drained and refilled with lubricating oil. A failure of any one of these gearboxes would cost US\$38,000, and therefore this inspection finding represents an avoided cost of US\$114,000.

Effective Use of Craftsmen During Weekly Scheduled Shutdowns — The HSM WCER effort has also driven a significant improvement in effective use of craftsmen

Figure 9



A 26% decrease in overall hot strip mill maintenance delays in 2010 vs. 2009.

during weekly scheduled shutdowns. In the past, shutdown work schedule compliance averaged only 65%. This was due to the large amount of reactive work identified during the shutdown. Much of this reactive work was critical enough that it had to be repaired before returning the mill to operation. This meant that some of the planned and scheduled work was delayed to a later time. The manpower applied to the newly found reactive work was not efficiently used because the work they were performing was not planned in advance. Much of their time was spent searching for parts and tools to complete the reactive jobs.

Equipment inspections developed and implemented through WCER have ensured that more of the critical corrective work is identified in advance, allowing the jobs to be fully planned and scheduled prior to the shutdown. Thanks to persistent efforts by Nathan Lappin, Jim Johnson and Joe Tylisz, the manpower available on shutdowns is now more efficiently utilized on planned activities, and the work schedule compliance for shutdowns is now 80% every week. This increase in the efficiency of shutdown manpower utilization translates to a savings of US\$11,600 per shutdown or US\$556,800 on an annual basis.

Gas/Fuel Energy Savings — The average production equipment delay rate in the HSM in 2008 and 2009 was more than 20%, with 2009 averaging 22% (78% working ratio). Since starting the WCER in the HSM, the average delay rate for 2010 has dropped to 18%, which is a working ratio of 82%. Though this improvement has not translated into additional profit at this time, due to the current economic conditions, it has resulted in significant energy savings (gas/electric only) in the amount of US\$400,000 year to date. Once economic conditions improve and markets return, the increased working ratio will deliver a significantly higher profit to the organization through increased production capability.

Additional Benefits

Additional benefits of the Burns Harbor HSM WCER effort, which cannot be quantified in terms of cost savings, include:

- A 26% decrease in overall maintenance delays in 2010 vs. 2009.
- Increased focus on effective planning of shutdown corrective work has resulted in improved safety for work crews.

- In order to perform more effective inspections, the WCER team has focused on cleaning up the entire finishing mill area. Due to great effort by Jerry Splitgerber, working conditions and safety for area personnel have greatly improved.
- With the exception of one position that was filled from outside, the entire WCER team was formed from existing HSM personnel without increasing the labor budget. Therefore, this improvement effort came at little additional cost to the business unit and yet has already delivered a significant savings.

Future Direction

As a result of the improvements made in the finishing mill area of the HSM, the WCER team has now been expanded to implement a proactive maintenance program for the runout table and coiler area. The additional resources needed for this work will be drawn from the existing HSM workforce and also new hires. With this increased scope of work, the WCER team will now be responsible for equipment reliability for 50% of the HSM assets. The team will continue their work in the same manner until all HSM critical assets have been addressed. It is clear that by taking a very focused approach to reliability improvement, providing team members with the essential skills, tools and information to be effective and looking for opportunities to fully leverage all of the work done, the WCER team at the Burns Harbor hot strip mill have achieved very dramatic results in a one-year period.

Acknowledgments

The author would like to thank hot strip mill division manager Jay Koch and maintenance manager Sam Totten for their leadership and support. The author would also like to thank Gino Palarchio from ArcelorMittal and Larry Frey, Tim Shelton and Tim Stickland for their central team support to the HSM. In addition, the author would like to thank Ivara for their case study of the WCER team. Most of all, the author thanks all of the ArcelorMittal Burns Harbor hot strip mill WCER team: Cam Perryman, John Bussema, Nick Burlingham, Jeff Gill, Nate Lappin, Mike Hattabaugh, Gary Bretz, Jim Johnson, Joe Tylisz, Jerry Splitgerber and Dave Sherwood, for the privilege of working with them. ♦

This paper was presented at AISTech 2011 — The Iron & Steel Technology Conference and Exposition, Indianapolis, Ind., and published in the Conference Proceedings.



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