The Real Cost of Maintenance: Production Quality and Output Yield
Enhancements of Industrial Laser Metrology for Continuous Process Lines

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Abstract

ArcelorMittal Burns Harbor utilized 3D laser tracking and 3D laser scanning technologies during the recent upgrade of the Continuous Heat Treatment Line (CHTL). This paper outlines the economical and operational benefits realized by employing industrial laser metrology for both new equipment installation and verification of existing process capability. During the upgrade, ArcelorMittal engineers quickly identified and corrected misaligned equipment and process roll configurations, verified new equipment installation accuracy, performed clash detection of new equipment placement, defined tolerances, and designed the appropriate placement of operator control rooms using the real-time measurements provided.

Importance of Alignment for Continuous Process Lines

The primary performance metrics for all world-class steel manufacturing facilities are safety, productivity, quality, cost, employee motivation, environmental compliance and customer satisfaction. In order to be competitive and profitable, equipment capabilities are constantly pushed to exceed the engineering design. Operating and maintenance teams struggle to assure that the hundreds of mechanical and electrical devices work in harmony under the dynamic operating environment to continuously produce miles of steel strip at high process speeds. Precise machine alignment is a critical factor in maintenance and production capability. Proper equipment alignment helps extend equipment reliability and usage, markedly improves product quality, enables faster process speeds, lengthens equipment life, reduces delays, and product rework resulting in operating cost savings and sustainable operations.

ArcelorMittal Burns Harbor Continuous Heat Treatment Line consists of ten main operating sections and hundreds of process rolls. Equipment alignment dramatically affects the lines product and process capability also imperative to new installations and facility upgrade capital expenditures. Operating
facilities are constantly pushed to run faster, lighter gauges, wider widths and higher strengths; challenging the intended design capabilities of the line. The ability to stabilize the coil strip length down the centerline of the process line and control the opposing forces allows for smooth product flow. Operational value of properly aligned machine systems is critical to proper coil tracking thus maintaining process speeds, product flatness quality, development of new products and extended equipment life.

Figure 1. Continuous Heat Treatment Line (CHTL) Schematic, Burns Harbor Plant

Laser Tracking and Laser Scanning

Laser trackers and laser scanners are extremely accurate, versatile and adaptable coordinate measurement devices. The laser tracker is the most exact and precise portable coordinate measurement machine (CMM) in the metrology industry for determining geometric characteristics in demanding industrial environments. The tracker combines two techniques; a laser interferometer or absolute distance meter (ADM) to measure relative distance and two optical encoders to measure the horizontal and vertical angle to a spherically mounted retro-reflector (SMR) target. The horizontal location and elevation of the SMR are then calculated. The tracker sends a laser beam to SMR held against the object to be measured. The light reflected off the SMR retraces its path, re-entering the
tracker at the same position that it left. The interferometer or ADM measures the distance between the tracker and the target (spherically mounted retro-reflectors) as light re-enters the tracker. The laser tracker measures 10,000 observations per second. The internal software provides instantaneous statistical analysis using least squares algorithms resulting in an accuracy of 0.001 inches (0.025mm) over a 250 foot diameter measurement range (76m). The laser tracker provides a high level of accuracy and detail while removing the human factor.

Figure 2. Laser Tracker

The laser scanner quickly and accurately analyzes a physical object and environment to digitally capture the precise shape using a line of laser light. The data collected create “point clouds” of an object’s surface characteristics to produce 3-dimensional models. Data is collected at a rate of 960,000 measurement points per second. The resulting image is an exact digital reproduction of existing conditions based on millions of 3-dimensional measurement points. A scan of a complex production area can be completed in several hours with a dimensional accuracy of +/- 2mm (+/- 0.08 in) and translated to CAD for reverse engineering and design enhancements.
**Continuous Heat Treatment Line (CHTL) Upgrade**

The operational and engineering design value of utilizing 3D laser tracking and 3D laser scanning technology is highlighted with examples collected from ArcelorMittal Burns Harbor’s capital project to improve the continuous heat treatment line (CHTL). The primary objective of the continuous annealing line upgrade was to enhance production capability and equipment reliability broadening the product mix to include additional advanced high strength steels (AHSS) and increase prime coil widths from 52 inches to nearly 60 inches. ArcelorMittal USA has differentiated itself as a pioneer in the development of the dual phase steels to meet the automotive OEM demands for AHSS products. Prior to the CHTL upgrade, the capability to produce advanced high strength steel products was limited due to equipment restrictions. The main operating areas requiring improvement were the entry end welder, furnace control, cooling control and material tracking capability.

Prior to the installation of new equipment, many process sections of the line were precision measured to acquire a baseline strategy for alignment. In order to establish control, the Falk team utilizes the brass monuments installed in the floor slab and installs additional temporary target “nests” on building support columns and the line itself to aid in quick laser equipment set-up and calibration. The more “nests” established improve the measurement accuracy as well as shortens the time and cost for future outages streamlining the alignment process. Verifying the brass in-floor tracker control network and mounting multiple temporary target “nests” on building support columns insured coordinate accuracy and quick set-up as the tracker was moved to various measurement heights.

On the entry end, the welder rails were laser tracker measured to insure precise installation of the new equipment and entry-end operating pulpit area laser scanned for safe placement and optimal design. Another key area emphasized is the alignment of the entry accumulation looping tower rolls. Many furnace rolls, process rolls, steering rolls, bridle rolls and the two belt wrappers on the exit reels were laser tracked to check installation and insure precise coil strip tracking under operating conditions. Utilizing the 3D laser tracking and 3D laser scanning technologies, ArcelorMittal engineers in conjunction with Falk-PLI were quickly able to identify and correct misaligned equipment and process roll configurations, verify new equipment installation tolerances and accuracy, and design the appropriate placement of the entry end operator pulpit.
Operating Efficiency – Eliminating Coil Tracking Issues

Entry Looping Accumulation Tower

One of the main problems affecting the CHTL’s capability to produce increased coil widths and AHSS grades was due to coil tracking and steering limitations. The entry accumulation tower rolls were laser tracked, the data obtained was particularly interesting in understanding coil tracking issues. Figure 3 outlines the data generated for the “as found” roll configurations.

Figure 3. CHTL Entry Tower Rolls – Initial “as found” condition

The “as found” entry accumulation tower roll number 2 was out of level by as much as 0.378” as compared to the operator and drive side of the line. The variation from roll to roll was alarming. Figure
4 outlines the “as left” tower accumulator roll configurations where adjustments were made to better align this process section.

Figure 4. Entry Tower Rolls – Final “as left” condition

Overage Furnace

The overage furnace section was measured due to operating coil tracking concerns and the inability to run cold overage dual phase cycles and wider products. Prior to the upgrade the harder products tended to encounter shape problems and tracked off, generally due to the required colder temperatures facilitating the strip “walking” off the furnace rolls. The main drivers for this problem were inadequate roll alignment and insufficient steering capability. Strip breaks or track-offs in the furnace due to coil tracking problems were experienced 2-3 times per quarter. Each occurrence was very costly with 30 hours of unexpected down-time interrupting the process and affecting customer shipments. The evaluation and re-alignment efforts have eliminated coil tracking issues over a three year period.
The furnace rolls were measured at various locations. Understanding the forces that affect the strip tracking through the furnace and how proper equipment alignment affects product and process quality are critical. Obtaining accurate measurements with optical surveying methods or piano wire is challenging and time consuming when comparing roll configurations that are 76 feet apart vertically.

The laser tracker enabled quicker measurements of the bottom and top furnace rolls to be obtained. Laser tacking technology allowed fifty-nine furnace rolls to be measured, adjusted and re-measured in a matter of 36 hours. Traditional optical methods would require more time and man-hours at a lower level of statistical confidence. The use of laser tracking allows a minimum 50% reduction in outage time allocated to roll alignment as compared to optical surveying methods amounting to a savings of $23,000 in maintenance man-hours costs. Figure 5 outlines the “as-found” and “as-left” survey depicting how the top drive support pedestals in the jet gas cool and overage sections were corrected back to the centerline of the strip.

Figure 5. CHTL Overage Furnace “as-found” and “as-left” Reports
The improved coil tracking and steering has enabled the CHTL to benefit by:

- Expanding product widths from 52” prior to the upgrade to nearly 60”.
- No track offs or strip breaks encountered since the line started up.
- The delays encountered due to coil tracking issues prior to the adjustments and improvements have been ELIMINATED.
- Decreased “wear and tear” on the rolls, roll bearings and housings result in lower maintenance costs and longer roll life.
- Capability to produce the advanced high strength steels at wider widths allows ArcelorMittal to expand product offering to meet customer product demands.

These laser tracking measurement campaigns performed by Falk-PLI enabled the CHTL maintenance to correct misaligned roll configurations to improve overall line speeds, process reliability, production costs, coil shape and product mix capability. Another huge benefit to the realignment was the
confidence boost it gave the line operators to run product requiring the colder temperature cycles in the overage furnace.

**Engineering Design - Laser Metrology Applications**

*3D Laser Scan Entry End Operating Pulpit*

The 3-dimensional laser scan results of the CHTL entry end operator pulpit allowed the engineering team to visualize and optimize the design prior to fabrication and installation. The laser scanner obtained the images and dimensions of the existing conditions (Figure 6) producing an “augmented reality” for the design team. Using the measurement data and 3-dimensional “augmented reality”; unsafe walkway angles and obstructed operator views were recognized. The laser scanner data allowed the design engineers to easily view clash detection and manipulate the CAD files to optimize the entry end design and operator pulpit placement by:

- Soliciting operator feedback of possible pulpit design and positioning.
- Identifying the size and placement of the window mullions to avoid obstructed views of critical processes.
- Quickly defining the exact spatial dimensions between the line and pulpit.
- Routing electrical cables safely.
- Eliminating unsafe walkways and locating ships ladders correctly.
- Locating an inspection station
- Verifying foundation of welder and anchor bolt designs.
Figure 6. “As Found” 3D laser scan view of CHTL entry end before upgrade.

Figure 7. Original pulpit design with optimized location based on 3D scan data.
Figure 8. Original Pulpit Design – Operator view

Figure 9. New Pulpit Design – Modified door and windows design in adjusted location allow operator view of welder.
3D Laser Tracking For Welder Placement Verification

Laser tracking technology was used to aid with the installation of the new welder. Optical measurement was initially employed to define the pre-project condition of the welder and installation area. However, the existing survey monuments were not properly defined resulting in incorrect coordinate measurements. In order to gain a high degree of confidence, laser technology was employed to re-define the facility centerline and tracker monuments installed. Monuments and equipment on different foundations do not maintain consistent relationship over time. The welder was found to be producing out-of-square welds, tight welds on the drive side progressing to a looser weld on the operator side contributing to possible weld breaks and increased tracking difficulties due to the skew; resulting in unnecessary costs and delays.

Summary

Misaligned equipment leads to reduced process speeds, decreased yield, increased scrap, and re-work rates for continuous production operations. Capital project line improvements are insured accurate and precise equipment installation, upgrade schedule reduction times and optimal design with the use of laser metrology technologies. The table below summarizes several benefits ArcelorMittal Burns Harbor experienced with the use of 3D laser tracking and 3D laser scanning data:

Table 1. Laser Tracking and 3D Laser Scanning Operating and Engineering Design Advantages

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<thead>
<tr>
<th>Operating Enhancements</th>
<th>Before Upgrade</th>
<th>After Upgrade</th>
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<tbody>
<tr>
<td>Coil Width Capability</td>
<td>52”</td>
<td>59 5/16”</td>
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<tr>
<td>Improved Product Capability</td>
<td>9%</td>
<td>43%</td>
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<tr>
<td>- % AHSS Grades Produced</td>
<td></td>
<td></td>
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<tr>
<td>Downtime Due to Coil Tracking Issues</td>
<td>10 occurrences (300+ hours) annually</td>
<td>0</td>
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World class manufacturing facilities are continuously improving their key operating metrics to sustain and grow business. The capital improvements have allowed ArcelorMittal to develop additional AHSS products in wider widths while achieving better process speeds and yields. The return on investment of precise equipment and process roll alignment is realized immediately. Reducing operating delays by just 100 hours would avoid losing production capacity of 7000-8000 tons and millions of dollars in lost revenue.
References

2. Bridges, Bob, PhD; “Laser trackers”; www.faro.com/site/resources; retrieved 2/24/2011