RECENT IMPROVEMENTS IN WROUGHT RAILROAD WHEEL PRODUCTION AT STANDARD STEEL

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ABSTRACT

This paper describes recent manufacturing modernization efforts and technical progress at the production facility of a major North American wrought railroad wheel manufacturer. Improvements to forging and rolling processes are discussed, with special emphasis on the new computer-controlled, vertical wheel rolling mill. Also described are upgrades to forging and dishing presses, the rotary heating furnace, automated wheel stamping equipment and a hot in-process laser inspection system. Finally, the installation of a new phased array ultrasonic inspection system for wheels is reviewed. Quality and productivity benefits of the new equipment are discussed throughout the paper.

INTRODUCTION

Standard Steel of Burnham, Pennsylvania, has been a leading supplier to the railroad industry since 1856 when the first ring mill was installed to produce 2000 locomotive tires per year. In 1895, the first bolted and steel tired railroad wheel was designed and introduced by the company, and in 1898 axle production began. The forged and rolled railroad wheel was developed in 1904, a new wheel mill was added in 1917, and the first heat-treated wheel followed in 1930.

Although the wheel shop had been modernized in 1982 when the “S-plate wheel” was introduced, it was decided to replace the vintage 1917 wheel mill with more modern technology. Despite numerous upgrades, the old wheel mill, which had successfully produced wheels for more 80 years, was well beyond the end of its engineering life and was no longer efficient. A detailed modernization project was started to completely upgrade the wheel manufacturing process. The important goals of the wheel process modernization project were as follows:

1. Reduce manufacturing cost

2. Improve wheel quality

3. Increase capacity

Equipment vendors and major wheel manufacturers from around the world were consulted during the course of the project. This paper describes improvements to the wheel manufacturing process modernization effort in the order of process flow sequence.

SAWING AREA

Cylindrical bottom pour steel ingots are sent from the melt shop to the wheel forging shop and arrive in the sawing area. There are ten Behringer band saws in the sawing area, making it the largest band saw shop in North America. The saws cut the 20 feet long ingots into very precise wheel blocks to designated weights. The scale at the saw table insures that blocks are cut to the proper weight for the wheel design being produced. For example, blocks for H36 one-wear freight car wheels weigh 970 pounds, ± 10 pounds. Before the installation of band saws ingots were torch cut into blocks and H36 weight was 1,020 pounds, ± 30 pounds. The new saws have thus improved yield and allow for production of a more precise, consistent forged wheel.

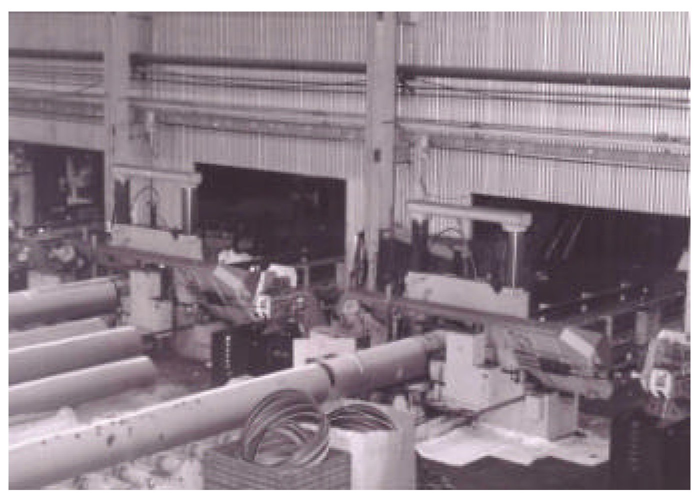

Figure 1. An overview of the Saw Shop showing the cutting of ingots into wheel blanks.

Figure 2. A close-up view of a saw cutting a wheel block.

ROTARY FURNACE

After cutting and weighing, blocks are segregated by heat numbers and are charged into the rotary hearth furnace. The furnace burns natural gas, with oil as a backup alternative, to heat the wheel blanks to the required forging temperature. The furnace has five sequential heating zones, starting at 1600°F and graduating to 2300°F in the final zone before forging. This new computer controlled, state-of-the-art furnace has regenerative burners that provide improved efficiency.

DESCALER

The blocks are removed from the rotary heating furnace at a temperature of 2300°F and are placed on top of the descaler unit. An elevator lowers the block into the descaler and the block is blasted with high-pressure water to remove the iron oxide scale before forging. This process step is performed to prevent the occurrence of entrapped scale on the final forged surface. Once the mult has been descaled, the robot manipulator grips the block and places it on the table of the 10,000-ton forging press.

10,000 TON FORGING PRESS

When the manipulator releases the block on the first operation table, computer control of the two stage forging operation begins. The 10,000-ton forging press provides the pre-form shape for later rolling and begins the transformation into the more recognizable finished product, the railroad wheel. The first operation of the press uses a flat bottom die and only the top of the block is shaped. After the first operation is completed, the bottom table slides to locate the second operation die in position for the second forge hit. This second operation provides for shaping of the pre-form bottom. The 10,000-ton forging press was completely refurbished as part of the wheel mill modernization project. Hydraulics and structural components were rebuilt and press control systems were updated. After the pre-form is completed on the 10,000 ton forging press, the piece is removed from the press with a robot manipulator, and passed to a second robot manipulator for insertion into the new Wagner vertical wheel rolling mill.

Figure 3. A robot manipulator transferring a wheel pre-form from the 10,000 ton forging press to the rolling mill.

WAGNER VERTICAL WHEEL ROLLING MILL

The new rolling mill is the most modern in the world and is capable of producing the world's most precise forged railroad wheel. The state-of-the-art, computer controlled, rolling mill continues the transformation process by means of various rollers. Web rolls, which perform the driving function to rotate the wheel during rolling, contact the pre-form in the plate area. The mill back roll, in combination with other tooling such as web rolls, upper and lower centering rolls, conical edging rolls and guide rolls, provides the forces responsible for shaping the pre-form into a wheel. Wheel rolling is now accomplished without a mandrel through the center of the wheel.

The computer controls on the rolling mill ensure that a consistent rolled product is produced. However, extensive effort went into the initial set-up process of the mill for each of the many different wheel designs produced by Standard Steel. Rolling mill computers were adjusted to insure dimensional quality and numerous trial production runs were conducted following mill installation and shake-down. All wheel designs have been converted to the new process.

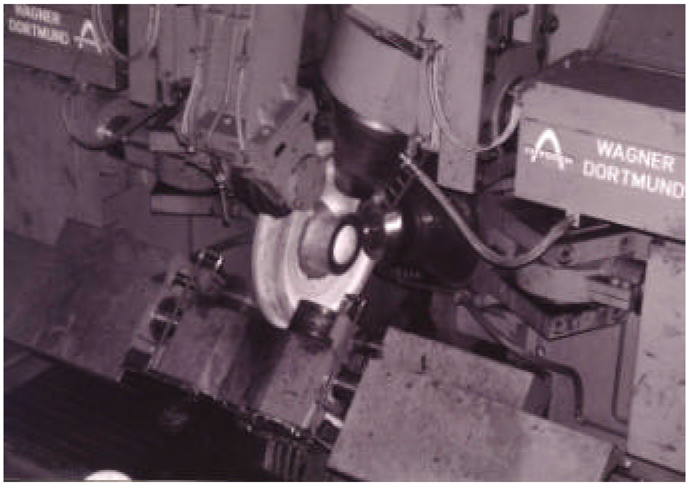

Figure 4. A wheel is rolled in the new vertical wheel rolling mill. Note that there is no mandrel.

The diameter of the pre-form is expanded significantly during the rolling process and the diameter is monitored using a laser measuring system that is focused on the tread. In addition to the laser, there are thirteen position control indicators and twenty-six pressure transducers involved in controlling the mill tooling to obtain correct rolled dimensions in the finished product. When the wheel reaches the values specified for the wheel design being produced, rolling automatically stops. The mill edging rolls, side rolls and centering rolls insure that a uniform, concentric wheel with the required flange is produced. Rolling time is less than one minute per wheel. Following rolling, the wheel is inserted into the 4,000 ton dishing and punching press by a robot manipulator, as shown in Figure 5.

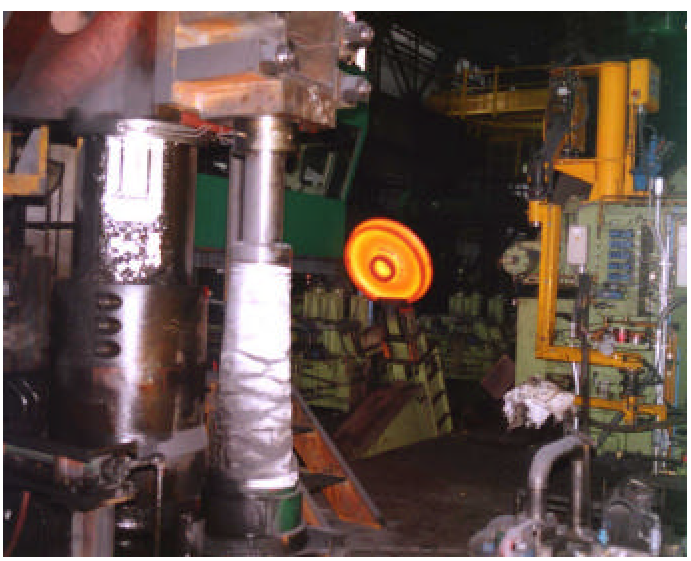

Figure 5. A robot manipulator passes a wheel from the rolling mill to the dishing and punching press.

DISHING AND PUNCHING

This two-stage operation forges the final wheel shape. The first operation, known as dishing, provides the wheel the modern "S" plate design shape. This design provides much lower thermal stresses in railroad service than the older, straight plate wheel design. The second operation is punching, which produces a center hole for mounting the wheel on the axle. Hydraulic and mechanical systems on this press were also upgraded to insure a consistent final wheel product.

AUTOMATED STAMPING

Following the dishing and punching operations the wheel is transferred by robot manipulator for automated stamping of manufacturing identification information on the wheel hub. The stamping machine automatically indexes to the next serial number and provides for consistency in stamping. Previously, hub stamping was done manually and workers changed stamping dies between each wheel.

HOT LASER INSPECTION

This new device will measure various critical parameters on the wheel after it leaves the dishing and punching press and will serve as a valuable in-process check. The laser system will be able to detect variations from empirically established process dimensions and provide feedback to wheel mill personnel. If measurements vary from established values, process changes can be made promptly. Currently, such measurements are taken manually by employees using hand tools. The laser measuring system therefore will provide better accuracy, consistency and safety. After measuring, and while still hot, the wheels are transferred to cooling pits by conveyor and stacker crane to ensure controlled cooling.

ULTRASONIC INSPECTION - BACKGROUND

Recent notable problems with in-service wheel failures on North American railways have led to substantial interest in wheel ultrasonic testing by railroads and the Association of American Railroads (AAR). These service failures were the primary impetus for creation of an AAR Technical Advisory Group (TAG) charged with updating and re-writing the portion of the AAR Wheel and Axle Manual devoted to ultrasonic testing of newly manufactured wheels. The specification, which had not been significantly changed in nearly 30 years, requires that wheels be scanned axially (across the rim) and radially (from the tread surface). Major changes to the ultrasonic specification include the following points:

- Tightening of the indication rejection criteria
- Requiring use of a distance amplitude correction (DAC)
- Additional reference holes to insure better volumetric coverage

Standard Steel also realizes that wheels are being exposed to more demanding service conditions on North American freight railroads. Higher axle loads, a greater incidence of shelling and spalling resulting in larger and more frequent wheel impact loads, better car utilization leading to more fatigue cycles per unit of time, and higher braking loads needed to stop heavier trains all are being imposed upon today's railroad wheels. High speed passenger operations are another very demanding application for wheels. Wheel product quality requirements have thus progressively increased. To further insure the reliability of Standard Steel wheels in service, a new ultrasonic testing system was installed at the Burnham, PA, plant. This system uses phased array technology to more precisely verify wheel rim integrity during final inspection.

PHASED ARRAY ULTRASONIC INSPECTION

Krautkramer-Branson Inc., of Lewistown, PA produced the world's first phased array ultrasonic inspection system for Standard Steel's railroad wheel rims. Phased array technology has been used successfully for medical applications and for inspection of welded pipe. Multiple transducers are contained in a single housing and the transducers are electronically fired in sequence to facilitate ultrasonic inspection. The dimensional data set for each wheel rim design is programmed into the system computer so that scanning is accomplished on the desired rim section. The following are benefits of the new inspection system:

- Computer controlled
- Faster inspection
- Flexible, easy to make changes
- System security with tiered access
- Improved inspection sensitivity
- Improved inspection volumetric coverage
- No need for employees to manually adjust sensors
- Ability to "steer" and "focus" ultrasonic beams

CONCLUDING REMARKS

The many improvements made by Standard Steel in recent years demonstrate the firm's commitment to production of quality railroad wheels. With increasing service demands in a cost-competitive marketplace, modernization and product improvements are clearly essential. Other modernization projects, in areas such as steel melting and heat treating, are scheduled for the near future.

ACKNOWLEDGEMENTS

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