Jernberg Industries, Inc.: Forging Facility Uses Plant-Wide Energy Assessment to Aid Conversion to Lean Manufacturing

Summary

In an effort to streamline its manufacturing processes at its Chicago, Illinois, forging plant, Jernberg chose to convert from its traditional batch methods to lean manufacturing. The company had already begun the conversion, so the plant-wide assessment (PWA) was well-timed to best address energy-intensive processes that would probably need to be changed. The assessment team also evaluated the efficiencies of the primary support systems (e.g., compressed air, cooling water). The team used a process simulation model to evaluate the impacts of converting existing batch production to a lean manufacturing operation and employed a systems approach to identify trends and energy use distribution for plant equipment. Seven projects were identified that together could save Jernberg about $791,000 per year in costs, more than 64,000 MMBtu per year (MMBtu/yr) in fuel and more than 6 million kWh per year (kWh/yr) in electricity.

Public-Private Partnership

The U. S. Department of Energy's (DOE) Industrial Technologies Program (ITP) cosponsored the assessment through a competitive process. DOE promotes plant-wide energy-efficiency assessments that will lead to improvements in industrial energy efficiency, productivity, and global competitiveness, while reducing waste and environmental emissions. In this case, DOE contributed $100,000 of the total $212,000 assessment cost.

Plant Description

Jernberg was founded in 1937, and was the country's first independent press forging company. The company's forging campus, located on the south side of Chicago, produces 170 million pounds of forged parts annually. Jernberg produces a wide variety of gears, yokes, hubs, and other parts for the automobile and motorcycle industries.

The primary raw material used in the forging operations is steel bar. The bar stock is often preheated with a natural gas-fired burner to drive off moisture and to facilitate shearing. The heated bar stock is fed into one of seven shear presses or saws, where it is cut into billets of 6- to 15-inch lengths. The billets are automatically deposited into metal boxes as they leave the shear press.

The billets are transported via forklift to one of 10 forging lines. Here the billets are manually fed (charged) into a conveyor that feeds the billets into a pass-through induction furnace. The heater rapidly increases the billet temperature to 2,200°F to 2,300°F. The heated billet is ejected from the furnace discharge and drops down a feed chute that serves the forging press. At the bottom of the chute, a worker lifts the billet from the chute and places it on the bottom die. The forging

Benefits

- Identified potential annual energy savings of more than 64,000 MMBtu/yr in fuel and more than 6 million kWh/yr in electricity
- Identified potential annual cost savings of about $791,000
- Found ways to reduce inventory, improve product quality, improve equipment reliability, and more efficiently utilize plant resources (e.g., increased waste heat recovery)

Application

Jernberg had begun a conversion from its traditional batch forging and finishing processes to a lean manufacturing operation (where forging is accomplished in a continuous process) when management decided to conduct a plant-wide energy assessment. The assessment targeted processes that are energy-intensive in nature and would likely have been changed anyway because of the conversion. Many of the recommendations that resulted from the assessment could also be implemented in a facility without converting to lean manufacturing. Lean principles are not specific to forging and finishing, and can be applied to any manufacturing process.

ram is activated and compresses the billet. Another worker then lifts the pressed billet and places it on the second stage die where it is rammed into its final shape. Once the billet has been forged, the part is ejected from the press and is conveyed to a trim press where flash is removed from the hot part.

Approximately half of the parts that are produced are also heat-treated; this is accomplished in one of five batch-style heat treat furnaces. Jernberg employs several heat treat methods, including water-quench, oil-quench, normalizing, and annealing. Many parts undergo finishing operations, including shot blasting, drilling, grinding, magnaflux testing, dimensional testing, and ultrasonic testing.

Assessment Approach

The lean manufacturing approach optimizes equipment utilization, maintenance programs, information flow through the plant, and workplace organization. Lean manufacturing also requires plant personnel to assess ways to eliminate waste, including work-in-process inventory, unnecessary movement of parts throughout the plant, over-production, machine downtime, etc. The primary benefits of lean manufacturing include more efficient overall utilization of the plant, reduced inventory (and associated carrying costs), improved product quality, and improved equipment reliability.

Jernberg, like most industrial facilities, has traditionally produced parts using batch processes, which can lengthen a production cycle time by three to five times or longer. The assessment team performed a process simulation to evaluate the impacts of converting existing batch production to a lean manufacturing operation. The team used the simulation to determine whether such models could predict the energy-related impacts of modifying manufacturing processes, as well as to identify additional potential savings that might be achieved by eliminating production bottlenecks. In this case, the heat treating department was identified as a significant bottleneck, but using controlled cooling instead of batch heat treating would largely eliminate the problem as well as save significant amounts of energy.

The assessment team used a systems approach to evaluate the plant's energy consumption. The team evaluated historical data for a 2-year period to identify trends and energy use distribution for plant equipment. This allowed the team to identify systems to be targeted for further evaluation. Once systems and equipment were identified and targeted, recommendations were developed that would be both technically and economically viable. These included recommendations that supported the conversion to lean manufacturing. The team also considered projects that would be applicable to conventional manufacturing operations.

In addition to targeting energy-intensive processes, the PWA also evaluated the efficiencies of the primary support systems, such as compressed air and the cooling water loop.

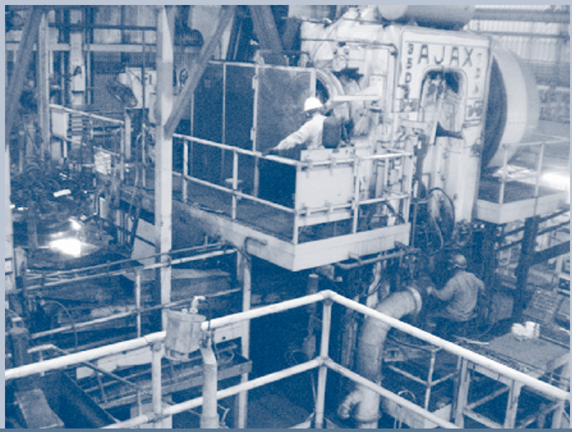
Results and Projects Identified

The assessment team identified seven projects during the Jernberg PWA. If all projects were implemented, Jernberg could save more than 64,000 MMBtu/yr in fuel and more than 6 million kWh/yr in electricity. Total annual cost savings would be about $791,000. Total implementation costs would be about $2 million for all projects.

The team identified the following specific projects.

Repair recuperator

The existing recuperator on heat treat furnace No. 5 is not being used. It appears to have been taken out of service during a previous furnace rebuild. As a result, 1,400°F air is exiting the stack during furnace operation. By repairing the recuperator and returning it to service, the stack exit temperature could be reduced to 400°F, and the recovered heat could be used to preheat the combustion air in the furnace. This project would save an estimated 1,812 MMBtu/yr. The team estimated that the implementation cost for this project would be $25,000, assuming that the recuperator will need to be repaired before returning it to service. This project would yield an annual cost savings of $9,400; the resulting simple payback period would be 2.7 years.



Prototype of lean manufacturing forging cell

Recover waste heat from cooling tower loop

There are 14 cooling towers that provide process cooling for the induction heating furnaces, air compressors, and hydraulic systems on each forging line. Jernberg uses approximately 12,000 MMBtu of natural gas for space heating each year. Most areas of the plant require space heating, except for the forging department, which relies primarily on waste heat from the process to warm the area during the winter. Of the many cooling loops used in the plant, only the loop that serves the north air compressors is used consistently enough to provide a steady source of heat for the plant. This loop currently rejects 3,650 MMBtu of heat from two Ingersoll-Rand compressors. By using this waste heat to warm the final processing department and displacing the existing gas-fired unit heaters that are only 80% efficient, 4,652 MMBtu/yr of natural gas can be saved. The annual savings would be $23,700. The estimated cost to implement this recommendation is $25,000, with a simple payback of 1.1 years.

Eliminate billet reheats

The induction heaters operate on an open-loop control basis to take room-temperature billets and heat them to 2,300°F before delivering them to the forging press. When a downstream process (such as the forging press) goes down, the heated billet stock is diverted to totes, where it is allowed to cool to room temperature before being reheated. The furnace has no automated controls, so an operator must shut down the charging system that feeds the billet stock into the furnace to reduce waste heating of billets when the line goes down. Therefore, the assessment team proposed a closed-loop control system for each line. This control system would allow the induction furnaces to react to downstream variations and speed up or slow down as needed to match production requirements more closely. This type of control would fit with the lean manufacturing process very well, because it allows all processes in the forging cell to balance. Because billet heating is by far the most energy-intensive step in the manufacturing process, eliminating these reheats would have a significant impact on energy consumption. This recommendation would save the company about 4.1 million kWh/yr of electricity, with an annual cost savings of $247,700. The cost to retrofit all 10 lines would be $500,000. This cost includes the installation of controls and queue sensors as well as programming logic to operate the furnaces. The simple payback for this recommendation would be 2 years.

Install air compressor controls

Currently, the Ingersoll-Rand compressors are base loaded while the Fuller rotary vane compressors operate partially loaded in throttle modulation. Like rotary screw compressors, throttle modulation of vane compressors is an inefficient method of control. Plant personnel turn compressors on and off as needed. In most cases, this causes more compressors to be on than needed, particularly during shift change and when process lines are shut down early. An integrated control system would remove the human factor from compressor control, and ensure that the vane compressors are base loaded when they are online, using the reciprocating compressors as swing machines. These electronic controls would also allow the compressors to maintain system pressure at +/- 1 psig, which allows the compressor pressure setpoint to be reduced safely to within 2 psig of the plant's minimum pressure requirement. The combined savings associated with pressure reduction and capacity control would be about 1.8 million kWh/yr with a cost savings of $76,900 per year. Based on an implementation cost of $270,000, the simple payback for this project would be 3.5 years.

Convert heat treat process to controlled cooling

Currently, forged parts are allowed to cool for a minimum of 24 to 48 hours, and then reheated to 1,500°F in the heat treat furnaces. Controlled cooling would take the hot forged parts and carefully cool them in a closed chamber. The cooling profile would be designed to make certain the parts' microstructure is properly developed to ensure proper hardness. This would be accomplished using the residual heat from the forge process. Jernberg currently uses a type of controlled cooling on some of its parts by utilizing vanadium alloyed steels. Implementing controlled cooling on other parts would require significant research and development to model and develop a normalizing chamber to achieve desired results. Such a system could save Jernberg 57,700 MMBtu/yr by utilizing the process heat that is currently wasted for heat treating of parts. This system would also fit well with lean manufacturing, because the forged parts would be fed via conveyor directly through the cooling chamber. The estimated cost for this project is $1.1 million. This includes approximately $600,000 to model the cooling profiles for the parts plus $500,000 to construct two chambers that would provide the cooling process. Based on an annual natural gas savings of $352,000, the simple payback for this project would be 3.2 years. Installation of this system would remove a production bottleneck in the heat treat department and would increase the plant's capability such that raw materials could be converted into finished product in only one workday.

Replace air compressors

The four existing Fuller compressors are at their end of service life. These machines are two-stage rotary vane compressors that are controlled much like a rotary screw compressor. Because of the age and wear on the compressors, the maintenance costs are high (approximately $10,000 per year for materials only), and the machines' capacity has degraded because of increased blowby between the vanes and the chamber wall. The compressors are also water cooled, and there are water costs associated with cooling tower evaporation and drift. By replacing the machines with new, two-stage rotary screw compressors, compressor specific power (measured in cubic feet per minute per brake horsepower [cfm/bhp]) could be increased from the current 4.3 cfm/bhp to 5.3 cfm/bhp at the application conditions. This improvement in efficacy would save Jernberg 143,100 kWh/yr with a cost savings of $74,000 per year. The cost of four new compressors would be approximately $280,000; therefore, the simple payback associated with this recommendation would be 3.8 years.

Jernberg has already started to replace two air compressors. The new compressors are also being relocated to further optimize the air system in conjunction with plant layout changes associated with lean manufacturing.

Reduce forge press downtime

When dies are changed on the forge presses, the new dies are heated using a natural gas torch that is sandwiched between the die cavities for approximately 20 minutes. When die changes are required during production hours, this time represents lost productivity. By installing an infrared die heating station, the same die heating process could be accomplished in 4 to 5 minutes, allowing the crew to change a die and return the press to production more quickly. While some energy savings would be realized by eliminating the torch, the primary savings would occur because less press downtime would reduce billet heater losses. This savings would be approximately $7,200 per year. An infrared die heat station could be purchased for $5,000, yielding a simple payback of 0.7 years.

BestPractices is part of the Industrial Technologies Program, and it supports the Industries of the Future strategy. This strategy helps the country's most energy-intensive industries improve their competitiveness. BestPractices brings together emerging technologies and energy-management best practices to help companies begin improving energy efficiency, environmental performance, and productivity right now.

BestPractices emphasizes plant systems, where significant efficiency improvements and savings can be achieved. Industry gains easy access to near-term and long-term solutions for improving the performance of motor, steam, compressed air, and process heating systems. In addition, the Industrial Assessment Centers provide comprehensive industrial energy evaluations to small- and medium-size manufacturers.

Project Partners

Jernberg Industries
Chicago, IL

ComEd
Oakbrook Terrace, IL

Taratec Corporation
Columbus, OH

Additional assistance was provided by the Forging Institute of America and the City of Chicago – Department of Environment.

For Additional Information, Please Contact:

EERE Information Center
1-877-EERE-INF
(1-877-337-3463)
www.eere.energy.gov

Visit our home page at
www.eere.energy.gov/industry

Industrial Technologies Program
Energy Efficiency and Renewable Energy
U.S. Department of Energy
Washington, DC 20585-0121

A Strong Energy Portfolio for a Strong America

Energy efficiency and clean, renewable energy will mean a stronger economy, a cleaner environment, and greater energy independence for America. Working with a wide array of state, community, industry, and university partners, the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy invests in a diverse portfolio of energy technologies.

DOE/GO-102004-2007
October 2004