North Star Steel Company: Iowa Mini-Mill Conducts Plant-Wide Energy Assessment Using a Total Assessment Audit

Benefits

- Identified potential annual cost savings of $2.6 million
- Identified potential annual energy savings of 140,000 MMBtu in natural gas and 39 million kWh in electricity
- Found ways to reduce waste and improve productivity

Application

An assessment team combined the Iowa Energy Center's Total Assessment Audit methodology and a plant-wide assessment strategy to evaluate the Wilton plant's focus areas. This evaluation helped the team to find ways to optimize energy savings and waste reduction, and improve productivity. Focus areas were electric arc furnace dust reduction, motors and pumps, melting and reheat process upgrades, heat recovery measures, and energy management. The assessment techniques and results can also be applied to other mini-mills.

Summary

North Star Steel's Wilton, Iowa plant completed a plant-wide energy assessment designed to examine potential process changes and technologies that could improve energy efficiency. The assessment team performed a Total Assessment Audit (TAA) to evaluate the Wilton plant's focus areas for energy savings, waste reduction, and improved productivity. TAA is a synergistic and integrated approach to identify ways to optimize energy use, decrease waste, and improve productivity. The assessment techniques, data gathered during the assessment, and technical solution options will be shared with North Star Steel's other mini-mills, where similar evaluations and energy/waste reduction improvement projects can be employed. If all projects identified during the Wilton plant study were implemented, the assessment team estimated that total annual energy savings would be about 140,000 MMBtu in natural gas and nearly 39 million kWh in electricity. Total annual cost savings would be more than $2.6 million.

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 $79,000 of the total $169,000 assessment cost.

Plant Description

North Star Steel Company was founded in October 1965 in St. Paul, Minnesota, and began steel scrap recycling operations at the St. Paul mini-mill in 1967. Cargill, Inc. acquired the company in February 1974. North Star's operations currently include electric-arc furnace mini-mills in Beaumont, Texas; St. Paul, Minnesota; and Wilton, Iowa. North Star also has a steel rolling mill in Calvert City, Kentucky; a grinding-ball plant in Duluth, Minnesota; and a joint venture (North Star/Bluescope Steel) with Bluescope Steel of Australia. North Star/Bluescope Steel operates a 1.5 million ton-per-year flat-rolled steel mini-mill near Delta, Ohio. Since 1974, North Star's annual steel-production capacity has risen from 300,000 tons to its current level of 3.5 million tons, and employment increased from 600 to more than 3,000.

The Wilton plant is a steel mini-mill that uses an electric arc furnace (EAF) for steelmaking and 100% recycled steel scrap to manufacture steel products. The recycled steel scrap is melted in the EAF and refined by adding alloys, carbon, and other materials. The molten steel is tapped into a preheated ladle and transferred to the tundish at the billet caster. From the tundish, the molten steel flows into molds that make square billets that are then cooled, solidified, and cut to length. The billets are stored until needed, then fed into the reheat furnace and brought to a temperature of about 2,200ºF. When the correct rolling temperature is reached, the billet is passed through water-cooled roll stands where the steel is formed and shaped. The final step involves shearing the steel products into custom lengths, which are bundled together for storage. The Wilton plant produces structural steel products including flats, angles, rebar, and round-cornered squares.


Electric arc furnace

Cargill, Inc. has embarked on a corporate-wide goal to reduce waste by 30% and reduce energy use by 10% by 2005. The North Star Steel plants have also adopted this goal. Total energy costs at the Wilton plant were $8.73 million for fiscal year 2000-2001. By reducing energy consumption to match its strategic goals, Cargill would save an average of $873,000 annually.

Assessment Approach

The assessment team used a Total Assessment Audit (TAA) to evaluate the Wilton plant's five focus areas for energy savings, waste reduction, and improved productivity. TAA is a synergistic and integrated energy, waste, and productivity study implemented by a team of experts chosen specifically for a particular manufacturing facility. The Iowa Energy Center (IEC) developed the TAA methodology, and the Iowa Manufacturing Extension Partnership (IMEP) deployed TAA under an IEC grant. Both IEC and IMEP, along with MidAmerican Energy Co., were partners in the assessment.

TAA team members were asked to assess the plant's chances of achieving its efficiency goal of 10% energy reduction and 30% waste reduction by 2005. The team consensus was that there was a high probability of achieving the goals. North Star Steel and the TAA team members identified five areas for improvement based on pre-assessment findings:

- EAF dust reduction
- Melting and reheat process upgrades
- Energy management
- Motor and pump improvements
- Heat recovery measures

These five areas were then closely scrutinized for ways to cut energy use, reduce waste, and improve productivity. In addition to identifying projects to meet these goals, the team studied the benefits and costs of possible technological solutions or improvements.

Results and Projects Identified

Table 1 lists the projects identified during the assessment that could produce the desired energy, waste, and productivity benefits. A discussion of these projects follows.

EAF Dust Reduction

Handling EAF dust is an expensive process at North Star's Wilton plant. Three options for dust reduction were examined:

1. Recycle all the dust through the EAF.
2. Recycle a fixed quantity of dust through the EAF.
3. Process the dust onsite.

The energy assessment team determined that none of these options was economically feasible because of increased zinc buildup in the furnace and other issues. These options will not, therefore, be pursued further.

Table 1. Summary of Energy Conservation Opportunities				
	Annual Energy Savings		Economic Impact	
	Fuel (MMBtu)	Electricity (kWh)	Annual Savings	Capital Cost
EAF Dust Reduction				
Recycle or process EAF dust onsite	NA	NA	Negligible	NA
Motor and Pump Improvements				
East tower	NA	735,000	$ 32,000	$ 20,000
Clean water system	NA	1,341,000	$ 59,000	$ 35,000
Mill cooling water system	NA	1,068,000	$ 47,000	$ 5,000
Melting and Reheat Furnace Process Upgrades				
Improve EAF energy efficiency	-48,000	19,800,000	$ 675,000	$ 1,800,000
Upgrade reheat furnace	26,000	NA	$ 341,000	$ 3,000,000
Install recuperators for ladle and tundish heating systems	1,000	NA	$ 5,000	$ 45,000
Modify air preheating system for ladles	14,000	NA	$ 61,000	70,000
Preheat billets	14,000	NA	$ 63,000	$ 50,000
Heat Recovery				
Modify reheat furnace discharge skid base design	18,000	NA	$ 18,000	$ 100,000
Improve reheat furnace oxygen monitoring and control	21,000	NA	$ 81,000	$ 50,000
Increase combustion air preheat temperature	62,000	NA	$ 278,000	$ 150,000
Construct a combined heat/power system	21,000	16,000,000	$ 856,000	$ 2,745,000
Recover waste heat from air compressors	11,000	NA	$ 48,000	$ 50,000
Energy Management				
Expand scope of strategic utility metering	TBD[a]	TBD	TBD	$ 80,000
Improve fire watch program	TBD	TBD	TBD	TBD
Correct compressed air system imbalances	TBD	TBD	TBD	TBD
Optimize ventilation and emissions control in the melt shop	TBD	TBD	TBD	TBD
Total	140,000	38,944,000	$2,564,000	$ 8,200,000

[a] To be determined.

Motor and Pump Improvements

The assessment team identified three areas of opportunity for energy efficiency improvement related to motors and pumps:

- East tower: Repair or replace east tower water pumps and motors or use the existing pump with a larger motor.
- Clean water system: Modify suction geometry to reduce head losses. Reduce process system flow rates to selected loads. Segregate rolling mill and melt furnace-cooling systems to allow one pump to be turned off.
- Mill cooling water system: Replace discharge header basket strainer. Reduce flow rate delivered to rolling mill stands by 20%.

Melting and Reheat Furnace Process Upgrades

Significant projects related to upgrade of the melting and reheat furnace processes included the following.

Improve EAF energy efficiency. Several potential ways to improve the energy efficiency of the electric arc melting furnace were identified for further investigation.

- Use more powerful transformers and long arcs, which are efficient when a foamy slag practice is used to envelop the arc (thus minimizing heat losses and arc flare damage).[1]
- Increase productivity by minimizing power-on time.
- Identify bottlenecks in scrap-charging efficiency and caster productivity. Install larger magnets and/or increase the power to reduce the number of lifts per bucket. Increase tundish size.
- Install a More´ lance system to permit carbon injection (to promote slag foaming), which would increase the electrical efficiency of the furnace.
- Increase casting speed by using longer molds and/or molds of different designs.

Upgrade reheat furnace. The assessment team found that potential upgrades to the rolling mill billet reheat furnace include the following.

- Add a bottom preheat zone, a top preheat zone, and replace heat zone burners with lower-capacity ultra-low NOx burners.
- Install a new control system.
- Replace a natural draft stack with an ejector stack.
- Relocate furnace controls for the charge end of the furnace to a new control area (pulpit).
- Relocate controls for the initial rolling operation (rougher controls) to the main pulpit.

Heat Recovery

Significant potential projects related to heat recovery include those listed below.

Increase combustion air preheat temperature. Increasing the combustion air preheat temperature from 600°F to 900°F in the reheat furnace would increase efficiency and reduce energy consumption by about 10%. The recuperator would be modified to handle more heat volume from exhaust gases from the reheat furnace so that the air passing through the recuperator would be heated to 900°F, rather than the current operating temperature of 600°F. Reduc-tion of heat input for increasing the combustion air temperature would save fuel.

Construct a combined heat and power system. In situations where the electric power cost is volatile, using a combined heat and power system to produce electric power while supplying heat to the reheating furnaces could be economical.

Energy Management

The assessment team reviewed options for improvements to North Star Steel's existing energy management program. These included expanding the scope of strategic utilities metering, enhancing the fire watch program (to turn off equipment, check for cold weather operability, identify leaks, etc.), correcting imbalances in the compressed air system, and optimizing ventilation and emissions controls in the melt shop. Specific energy and cost savings for each of these improvements will be evaluated later by North Star Steel.

[1] "Enveloping the arc" means to have the electrodes submerged and arcing through a layer of foamy slag. This focuses the direction of the arc, thus shielding the rest of the furnace from damaging stray arcs and transfers the maximum amount of heat from the arc to the molten bath rather than to the surrounding furnace walls and roof.

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