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OFFICE OF INDUSTRIAL TECHNOLOGIES
ENERGY EFFICIENCY AND RENEWABLE ENERGY, U.S. DEPARTMENT OF ENERGY

BENEFITS

- Saves an estimated \$528,400 annually in operating and energy costs
- Reduces natural gas use by 50,070 million British thermal units (MMBtu) per year
- Reduces electrical use by 329,400 kWh per year

APPLICATIONS

Metlab uses large amounts of natural gas and electricity for process heating and process services. The significant results of Metlab's plant-wide assessment may encourage other industries with similar equipment and process lines to seek opportunities to save energy and cut costs.

Metlab Plant-Wide Assessment

Summary

The plant-wide assessment of energy efficiency, emissions, and productivity was performed in 2001 at Metlab in Wyndmoor, Pennsylvania. Metlab uses large gas-fired furnaces to perform metal heat-treating operations such as surface hardening, surface coatings, tempering, and annealing on many critical parts used by the commercial and defense sectors. The assessment included a comprehensive survey and assessment of energy use, emissions, and production practices at the plant. Based on the results of this study, Metlab plant management has set goals to reduce energy use and associated emissions by 20 to 30 percent, reduce plant discharges by 50 percent, and increase productivity by 10 to 20 percent. To achieve these goals, Metlab has prepared a plan that will produce an annual savings of approximately \$528,400; with a capital cost of \$820,000, the plan will pay for itself in 1.8 years.



FIGURE 1. 20,000-POUND PINION SHAFT



Company Background

Metlab was founded in 1928 as a manufacturer of aircraft components. As part of its early manufacturing process, Metlab invented and patented the first “drop-bottom” furnace that allowed parts to be lowered into a quench tank directly under the furnace in a matter of seconds, preventing the manufactured parts from cooling and distorting during the transfer. This furnace design was a forerunner of today’s furnaces that are used to heat-treat aluminum as well as aircraft landing gear. Metlab discontinued its fabrication operation in the 1930s because of a slump in the aircraft manufacturing industry and devoted its efforts solely to commercial heat-treating. In January 2001, Metlab purchased J.V. Potero, Inc., a 48-year-old commercial heat-treating company specializing in induction hardening, black oxide processing, and atmospheric heat-treating of small- to medium-sized batches.

Metlab currently occupies an 80,000-square-foot facility and performs a wide variety of heat-treating processing including normalizing, hardening and tempering, atmosphere annealing, stress relieving, age hardening, carburizing, and nitriding. Metlab can process very large parts (the largest has weighed 43,000 pounds), and has furnaces ranging in size from 2 feet (ft) in diameter by 3 ft long, to 15 ft in diameter by 16 ft long. The photographs on pages 1 and 2 show the types of parts that Metlab can process in its facility.

Metlab services industrial and defense customers both in the United States and abroad. The company is a member of the Metal Treating Institute (MTI), the American Society of Metals International (ASMI), and the standards group of the aerospace industry.

FIGURE 2. LARGE-DIAMETER GEAR



Assessment Overview

Metlab scrutinized the amount and cost of natural gas and electricity consumed during the years 1999 and 2000 and found that cost and consumption for both energy sources rose during the 2-year period. The increase in the cost of natural gas was especially high, providing Metlab with an incentive to find ways to reduce its fuel use and costs.

Metlab's goal in performing the assessment was to identify ways that the company might improve productivity and at the same time reduce energy consumption, waste, and greenhouse gas emissions such as carbon dioxide (CO₂) and nitrogen oxides (NO_x). The assessment was structured to include a comprehensive survey and assessment of energy use, emissions, and production practices at the plant, with special emphasis placed on the large gas-fired furnaces Metlab uses to perform metal heat-treating operations. The plan for performing the assessment included:

- An inventory of all energy-consuming equipment in the plant, including furnaces, Black Oxide Coating System, plant water system, plant compressor system, and the endothermic gas generator station
- An examination of the use of plant-wide electricity, natural gas, water, compressed air, emissions, discharges, and other plant services
- An analysis of selected furnaces' performance measurements including energy use for critical process cycles, emissions, and energy efficiency.

Metlab managed the assessment with support from Energy Research Company, CSGI, Inc., and the Pennsylvania Department of Environmental Protection. Energy Research Company collected data and analyzed the thermal performance of the two pit furnaces (the "two major furnaces" mentioned below under "Assessment Implementation"). CSGI, Inc. wrote the report and did the bulk of the assessment. The Pennsylvania Department of Environmental Protection provided energy-saving related assistance. Each of these entities and the U.S. Department of Energy's Office of Industrial Technology (OIT) shared assessment costs with Metlab. OIT's contribution was \$100,000, or about 42% of the total assessment cost. OIT supports plant-wide energy efficiency assessments that will lead to improvements in industrial efficiency, waste and emissions reduction, productivity, and global competitiveness in OIT's Industries of the Future.

Assessment Implementation

An inventory of all the furnaces was conducted and data were gathered concerning loading capacity, natural gas use, frequency of operation, and magnitude of use during a typical production cycle. Assessment personnel used the data to identify the major energy users in the plant. The units that used a cumulative 85 percent of the total amount of natural gas per month were selected for the detailed assessment analysis.

The assessment team estimated that the plant emitted 121,000 pounds of flue gases per year, of which 12 percent was CO₂. The flue gases also included a small amount of NO_x. Furthermore,

the plant purchased approximately 8 million gallons of city water per year that was used primarily to cool furnace components, quench heated parts, and fill five rinse tanks. All this process water was used once and discharged directly into the sanitary sewer system. Metlab determined that a significant amount of the discharged water could be recycled and reused.

Extensive testing measured the energy consumption in two major furnaces. The testing measured heat input, flue gas losses, wall and other heat losses, heat stored in the furnace, and heat delivered to the load. Measurements were made for several loads and cycles. Next, a process model was developed to optimize the loading and heating/soak time for the heat-treating operations, leading to shorter heating/soak times, improved productivity, and cost savings.

Overview of Specific Actions Identified in Assessment

The assessment revealed several specific actions that Metlab can undertake to reduce energy use, increase savings, and reduce emissions. For example, to reduce the energy that the furnaces use by 25 to 35 percent, the following actions could be taken:

- Reduce the excess air to the burners and the excess air infiltrating the furnaces
- Install recuperative or regenerative devices on the furnaces to use recovered heat to preheat combustion air in the furnaces
- Improve the heating system controls.

These actions will also decrease the amount of CO₂ and NO_x that the furnaces emit.

Water from a nearby natural aquifer could be used as process cooling water, thus reducing the amount of water Metlab must purchase from the city. The amount of water discharged from the plant could be reduced by more than 75 percent by collecting and recycling cooling water. The amount of compressed air used by the plant could be reduced by 15 to 25 percent by fixing leaks in the system and optimizing the compressor's operations. A 10- to 15-percent reduction in the use and emission of process atmospheres and purge gases such as methane and nitrogen could be achieved by proper gas flow control during heat-treating operations.

A process model was developed during the assessment that could optimize the heating/soak time for the heat-treating operations, resulting in shorter heating/soak times, improved productivity, and cost savings. The exact savings that using the new model could achieve depends on the production cycle and customer approval. Testing will be required to ensure the suitability of changes in the heat-treating cycle, as will customer education and acceptance. This option offers the most attractive economic return for the heat-treater and the customer.

Results

Table 1 lists several heat-treating process improvements that Metlab plans to implement to meet its goals for energy and cost savings, reduced emissions, and improved productivity. The company hopes to use existing and emerging technologies in this effort. Some emerging technologies that Metlab is considering include:

TABLE 1. SUMMARY OF RECOMMENDATIONS AND AREAS OF IMPROVEMENTS

No.	Identified Opportunity	Suggested Actions	Projected Annual Savings			Projected Economic Impact	
			Natural gas (MMBtu/year)	Electricity (kWh/year)	Financial (\$/year)	Capital Cost (\$)	Payback Period (years)
1	Optimize furnace loading	Select proper furnace, use proper loading and scheduling	2,160		126,000	25,000	0.20
	Reduce holding times	Re-evaluate soak times for heat-treating process for long cycles					
2	Implement changes in compressed air supply and distribution system	Fix leaks, change compressor operations		329,400	27,000	60,000	2.20
3	Implement changes to plant nitrogen supply and distribution system	Repair leaks, install smaller supply line to furnaces and proper regulation of nitrogen pressure supply			15,000	20,000	0.75
4	Modify plant water distribution and supply system	Install flow regulators for all furnaces			15,000	10,000	0.67
		Install water recirculation system and consider using water seepage in the plant			Approx. 10,000	50,000	5.00
5	Reduce purging time	Reduce purge time to meet safety requirements	2,400		16,800	5,000	0.30
6	Reduce wall losses	Maintain and upgrade insulation for furnaces	7,585		53,100	200,000	3.80
7	Recover waste heat by using preheated combustion air	Install heat recovery equipment (recuperators or regenerators) for furnaces	15,170		106,200	250,000	2.40
8	Modify combustion controls	Eliminate use of on/off control and high excess air by installing proportional or high/low control to ensure appropriate excess air at all firing rates	15,170		106,200	150,000	1.40
9	Furnace seals	Install and maintain proper furnace seals	7,585		53,100	50,000	0.90
Totals			50,070	329,400	528,400	820,000	1.8 (average)

- On- or off-line models to estimate true heating and soak times
- Air-fuel ratio control systems on furnace burners
- Air preheating devices on furnaces
- Single-ended recuperative radiant tubes (ceramic or high-temperature alloy) to replace furnace retorts
- Energy-efficient motors and compressors.

Plant managers have established a goal of reducing energy consumption by a minimum of 20 percent, along with a 50-percent reduction in plant discharges and a 10- to 20-percent gain in productivity. This plan will produce an annual savings of about \$528,400. The capital cost is \$820,000; therefore the plan will have a payback of 1.8 years.

Metlab is willing to share the assessment results with the nation-wide commercial and captive heat-treating community as well as the broader materials community. It is also recommended that the results be communicated to the various heat-treat societies and the industry standards groups to encourage re-examination of the “rule of thumb” heating parameters contained in the standards’ generalized specifications.



BestPractices is part of the Office of Industrial Technologies Industries of the Future strategy, which helps the country’s most energy-intensive industries improve their competitiveness. BestPractices brings together emerging technologies and best energy-management 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.

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