Mining BestPractices Plant-Wide Assessment Case Study

Industrial Technologies Program

Kennecott Utah Copper Corporation: Facility Utilizes Energy Assessments to Identify $930,000 in Potential Annual Savings

Benefits

- Identified potential annual cost savings of $930,000
- Identified potential annual savings of 452,000 MMBtu in natural gas
- Found opportunities to reduce maintenance, repair costs, waste, and environmental emissions
- Found opportunities to improve industrial hygiene and safety
- Identified ways to improve process throughput
- Identified a potential payback period of less than 1 year for all projects combined

Application

Kennecott Utah Copper Corporation used targeted energy assessments at a smelter and refinery to help identify opportunities for energy efficiency and process improvements, and to examine use of alternative or waste fuels. These types of assessments can be conducted at any industrial facility, and the projects identified during the assessments may be employed at other copper mining and smelting facilities.

Summary

Kennecott Utah Copper Corporation (KUCC) used targeted energy assessments in the smelter and refinery at its Bingham Canyon Mine, near Salt Lake City, Utah, to identify projects to conserve energy and improve production processes. By implementing the projects identified during the assessment, KUCC could realize annual cost savings of $930,000 and annual energy savings of 452,000 million British thermal units (MMBtu). The copper smelting and refining facilities were selected for the energy assessments because of their energy-intensive processes. Implementing the projects identified in the assessments would also reduce maintenance, repair costs, waste, and environmental emissions. One project would use methane gas from an adjacent municipal dump to replace natural gas used to heat the refinery electrolyte.

Public-Private Partnership

The U.S. Department of Energy's (DOE) Industrial Technologies Program (ITP) cosponsored the assessment. 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 $225,000 assessment cost.

Plant Description

The Bingham Canyon Mine is one of the world's largest open pit copper mines. Processing facilities include a concentrator, a 175-megawatt (MW) coal-fired power plant, a copper smelter, and a copper refinery. The operation produces 300,000 tons of refined copper per year plus significant quantities of gold, silver, and molybdenum. The mine employs approximately 1,600 people. Revenue from metal sales is approximately $600 million annually. KUCC recently celebrated 100 years of open pit mining at the Bingham Canyon Mine.

The Kennecott smelter and refinery are modern, energy-intensive metal production facilities constructed in the mid-1990s. The design includes state-of-the-art energy recovery and efficiency. The smelting process is based on multiple oxygen-fired furnaces operating at high temperature. A unique aspect of the smelting process is that most of the energy for smelting the copper is provided by the oxidation of iron and sulfur in the feed materials. In spite of this energy efficiency, the smelter still requires large quantities of fossil fuel and electric power.

Kennecott has installed the most advanced emission control systems available, and the smelter is the cleanest in the world. The copper refinery is a modern electrolytic refinery where pure copper is electroplated onto stainless steel sheets to produce 200-pound pure-copper sheets known as cathodes.

The copper smelting and refining plants were selected for the plant-wide assessment (PWA) because of their energy-intensive processes. These processes use oxygen, natural gas, and a mix of self-generated and purchased electricity as the primary sources of energy. Each year, the smelter and refinery plants use approximately 2.8 billion cubic feet of natural gas, 200 gigawatt-hours (GWh) of electric power and 450,000 tons of oxygen. The smelter recovers energy from both the smelting furnaces and the sulfuric acid plant by cooling process gases and hot sulfuric acid to produce steam used to generate about 60% of the total smelter electrical energy requirement. Major energy-consuming equipment includes process-heating equipment such as dryers, copper matte grinding and drying mills, smelting and refining furnaces, steam generators (boilers), pumps, air compressors and electric motors, the sulfuric acid plant, and extensive emission control facilities.

Assessment Approach

Although Kennecott is one of the most modern and energy-efficient mining operations in the world, low metals prices and international competition necessitate a continuing search for improved efficiencies and ways to reduce operating costs. Energy is a major element in the cost of copper production. The goal of KUCC's energy-efficiency enhancement program is to reduce energy consumption by 10% per unit of product.

Experts from DOE's national laboratories conducted preliminary targeted assessments of the plant. These assessments focus on identifying a facility's large energy consumers and finding opportunities for preventive maintenance, cost reduction, and performance improvement. The assessments identified opportunities for saving energy in process heating, steam systems, pumping systems, compressed air, and insulation. The assessment team also identified other areas for potential improvement, including operating practices, energy substitution, maintenance, and modifying plant equipment.

Following the initial assessments, a team from Oregon State University conducted a broad site review to identify and quantify additional high-potential energy-saving opportunities.

The assessments also employed a multidiscipline team from Kennecott with support from outside engineering and technology firms to perform specialized design calculations.

To provide a cross section of potential energy and process efficiency improvement opportunities for Kennecott, the assessment team identified six areas for further review:

1. Energy use minimization through major technological change
2. Optimization of an existing thermal drying process
3. Optimization of an existing thermal process
4. Maximizing thermal efficiency
5. Use of alternative or waste fuels
6. Substitution of energy sources and thermal optimization.

Mickey Prim, Manley-Prim Photography, Inc.

Kennecott Utah Copper Corporation smelter

Results and Projects Identified

Three projects were selected for detailed analysis and implementation based on the assessments. These projects are listed in Table 1 and subsequently discussed in detail.

Table 1. Projects Identified during the Kennecott Plant-Wide Energy Assessment

	Annual Projected Energy Savings	Annual Projected Economic Impact		
Project Description	**Natural Gas (MMBtu)**	**Annual Savings ($)**	**Capital Cost ($)**	**Payback Period (yr)**
Replace heated matte launders with unheated water-cooled launders	100,000	600,000 (including maintenance savings)	1,000,000	1.5
Optimize concentrate dryer	22,000	80,000	0	N/A
Use landfill gas for heating refinery electrolyte	330,000	250,000	0	N/A
Total	**452,000**	**930,000**	**1,000,000**	**0.9 aggregate average**

Replace heated matte launders with unheated water-cooled launders

Summary. Replacing heated matte launders with new water-cooled copper launders has the potential to save 100,000 MMBtu per year (MMBtu/yr) in energy and to reduce operating costs by more than $600,000 per year, including reduced maintenance costs.

Study results and conclusions. Molten copper matte (liquid copper sulfide at 2,300°F) is transported from the smelting furnace to water granulation using heated, refractory-lined troughs known as "launders." In 2002, the total natural gas consumed to heat the launders was approximately 100,000 MMBtu, resulting in an operating cost of approximately $365,000. Additional costs are incurred to maintain the refractory lining.

Technology has been developed to use unheated water-cooled launders to transport the molten matte. The concept is based on freezing a thin insulating and protective layer of matte in the launder to prevent excessive heat loss and to protect the copper launder. Heat fluxes are very high and failure or burn-through of the launder could cause an explosion.

KUCC required detailed engineering assessments to resolve significant uncertainties regarding the design. The first used finite element analysis to define the cooling system design and explore options to make the launders more resistant to burn-through and failure. The second assessment developed the detailed engineering design sufficient to allow a +/-20% accuracy cost estimate and to provide the basis for performing a risk analysis. Total savings are estimated to be more than $600,000 per year, including $365,000 in fuel savings, plus reduced materials and repair costs.

Additional benefits include:

- Reduced maintenance and repair costs
- Improved hygiene and reduced workplace temperature
- Improved safety through the elimination of heated surfaces
- Reduced generation of industrial waste refractory.

Optimize concentrate dryer

Summary. Three recommendations were developed to improve the thermal efficiency of the rotary concentrate dryer. The use of higher dryer inlet temperatures was tested and successfully implemented to realize a 4% thermal efficiency improvement. The use of quenching water to temper the burner inlet flame was evaluated, but significant technical issues remain unresolved. Attempts to reduce the moisture content of the feed material were found to be technically feasible but not economically attractive. Additional optimization work (including using steam for preheating dryer air) is under evaluation. The fuel savings realized to date is $80,000 per year.

Study results and conclusions. More than 4,000 tons per day of wet copper concentrate feed to the smelter is dried in a large rotary kiln. The dryer is heated by natural gas and consumes more than 800,000 MMBtu/yr, or 30% of the smelter's total fuel consumption. The combustion gases blown into the dryer must be as hot as possible to maximize thermal efficiency, but must not exceed the ignition temperature of the metal sulfide copper concentrates.

Nitrogen gas is used to cool the combustion gases to minimize oxidation and ignition.

Inlet gas temperature was increased incrementally from 1,100°F to 1,350°F. It now appears that the maximum operating temperature in the summer, when the feed has lower moisture content, is 1,350°F. At higher temperatures, sulfur dioxide generation increases rapidly, which increases the cost for gas scrubbing. During winter months when the feed moisture is higher, there is still potential to increase inlet gas temperatures.

Using water sprays to replace nitrogen-blanketing gas seemed promising, but improved availability of nitrogen and optimization of the inlet temperature make it unattractive at this time.

The assessment team evaluated several techniques to reduce the feed moisture to the dryer, including the use of steam heating to reduce water viscosity, acidification of the slurry feed to the filters, and use of commercial drying aids (organic compounds to improve water removal). While technically successful, none of the approaches was more economically attractive than thermal drying.

Alternative sources of low-cost steam to preheat the dryer combustion air and nitrogen (e.g., from the Kennecott coal-fired Utah Power Plant) are currently under study.

Additional benefits of optimizing the concentrate dryer include:

- Improved dryer throughput
- Reduced off-gas volume and lower dusting rate
- Reduced costs for emission control.

Use landfill methane gas for heating refinery electrolyte

Summary. KUCC has an opportunity to utilize landfill gas (LFG) from an adjacent municipal waste dump to replace natural gas used to heat the refinery electrolyte. The potential energy content is approximately 330,000 MMBtu/yr. The LFG is currently collected but flared onsite. The project is technically feasible and appears to be financially attractive. The net cost savings will be about $250,000 per year in natural gas if a suitable commercial arrangement can be finalized. Kennecott has applied to the State of Utah for air quality permit changes to allow LFG use.

Study results and conclusions. The use of LFG to replace natural gas is gaining acceptance throughout the United States in locations where large industrial natural gas consumers are located near municipal landfills. LFG is best used in process-heating applications where the gas consumption is steady and continuous year-round. The two steam boilers at the Kennecott refinery are ideally suited for LFG.

Kennecott and DTE Biomass Energy have entered into an agreement to assess the technical and commercial feasibility of utilizing the LFG from the local landfill. A key step in the process is developing a capital cost estimate for the gas-processing facility, pipeline, and boiler adaptations.

Additional benefits include:

- Reduced greenhouse gas emissions
- Projects are consistent with KUCC's corporate sustainable development initiative.

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

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