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

Benefits

- 55 percent energy savings in copper anode furnaces
- Substantially reduces NOx emissions
- Reduces maintenance costs

Applications

Experience has shown that retrofitting copper smelting anode furnaces from air-fuel to oxy-fuel burners typically results in substantially reduced NOx emissions as well as 50 to 60 percent fuel savings from eliminating the large nitrogen load associated with air-fired combustion. Low-NOx oxy-fuel burners have also been commercially demonstrated in steel reheating furnaces.

Kennecott Utah Copper Retrofits Smelting Applications from Air-Fuel to Oxy-Fuel Burners

Summary

Retrofitting copper smelting applications from air-fuel to oxy-fuel has been shown to lower fuel and plant operating costs and reduce emissions. In 1988, Kennecott Utah Copper upgraded its air-fuel burners to low NOx oxy-fuel burners in its Utah Copper smelter-copper anode furnaces. This project resulted in energy savings of about 55 percent and substantial NOx emission reductions. When Kennecott designed its new, state-of-the-art smelter in the early 1990s, it selected oxy-fuel burners for the anode furnaces to achieve low NOx emissions and high energy efficiency. When oxy-fuel burner technology improvements became available in April 2000, Kennecott initiated another project to upgrade to a new design. Switching to Dilute Oxygen Combustion (DOC) burners resulted in an additional 80 percent reduction in NOx emissions, and improved maintenance costs for the two anode furnaces.

Plant/Company Overview

Kennecott Utah Copper, a subsidiary of the international mining and processing corporation Rio Tinto, produces approximately 320,000 tons of copper cathode

Smelter at Kennecott Utah Copper

Photograph courtesy of Manley Prim Photography, Tucson, AZ

per year. Kennecott's Bingham Canyon Mine near Salt Lake City is one of the largest and longest-running mines in the world; open pit mining began there in 1906. The mine operates state-of-the-art smelting/refining facilities recognized for their environmental protection practice and achievement. Kennecott Utah Copper is the third largest copper producer in the United States, accounting for about 15 percent of the nation's supply. Copper ore is mined and concentrated at the Bingham Canyon facility. The smelter converts the copper concentrates into impure molten copper that is further refined in two large anode furnaces. The smelter then prepares it for casting into anodes, large metal plates that are used in the final electro-refining process.

Project Overview

Experience in the late-1980s at Kennecott has shown that retrofitting copper anode furnace applications from air-fuel to oxy-fuel typically results in reduced NOx emissions as well as a 50 to 60 percent fuel savings from eliminating the large nitrogen load associated with air-fired combustion. To optimize the design of low NOx oxy-fuel burners for the anode furnaces in the new copper smelter, Kennecott worked with Praxair, Inc., an oxy-fuel combustion pioneer and the largest industrial gas producer in North and South America, and North American Manufacturing, Ltd., one of the world's largest suppliers of industrial combustion systems. This project resulted in energy savings of about 55 percent, and substantial NOx emission reductions compared to the conventional air-fuel burners.

After several years of successful operation with the oxy-fuel burners, Kennecott decided to undertake another upgrade project when burner technology improvements became available. This improved technology, called Dilute Oxygen Combustion (DOC), uses separate high-velocity fuel and oxygen jets to generate strong in-furnace gas recirculation, producing combustion between the fuel and a highly diluted oxygen and furnace-gas mixture. These low-NOx oxy-fuel burners had already been commercially demonstrated in steel reheating furnaces and copper smelting anode furnaces. The burner design meets industry needs for increased productivity, lower NOx emissions, and reduced fuel and operating costs, while keeping capital expense and maintenance low. Kennecott sought to gain these benefits by switching to DOC in their two anode furnaces. Maintaining product purity and improving plant productivity were additional goals.

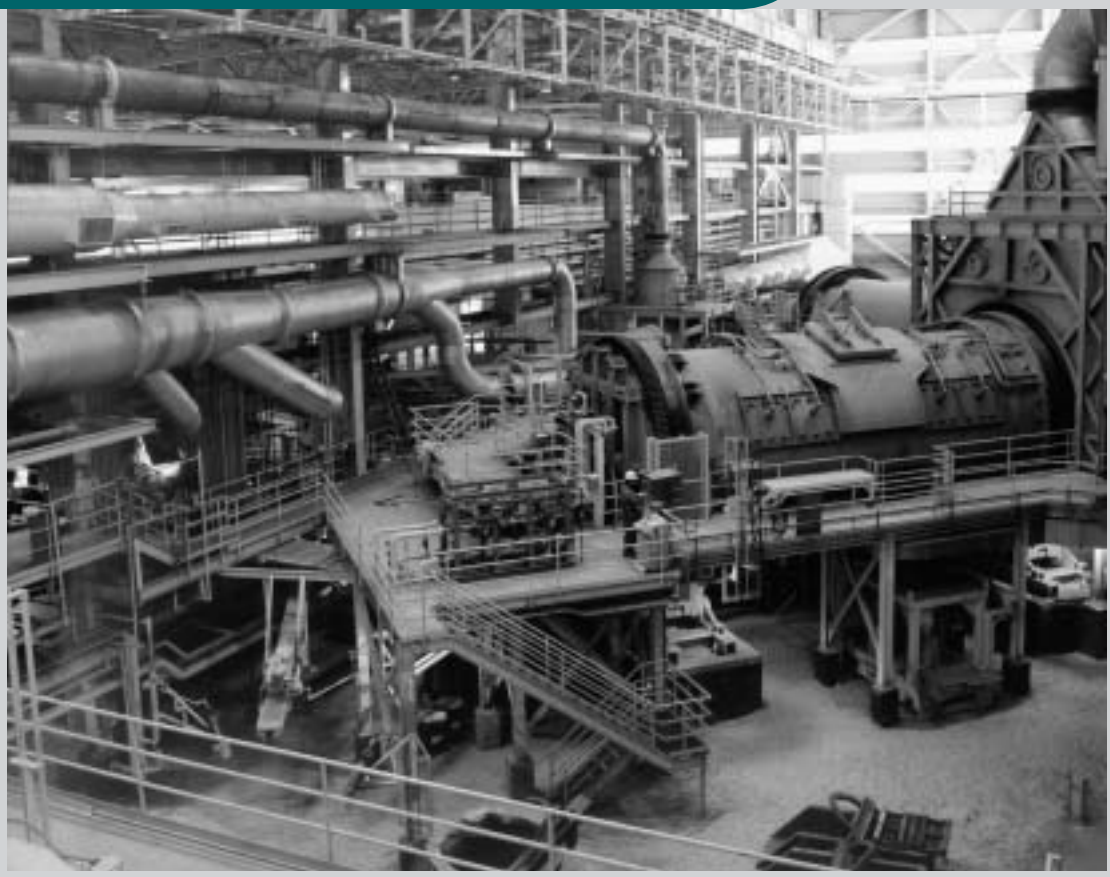
Project Implementation

The two copper anode furnaces were originally installed with Praxair/North American Manufacturing stabilized jet (SJ) oxy-fuel burners. The burners had historically performed well; however, they used water for cooling and the oxygen nozzle design was complex and susceptible to plugging from copper splash. In April 2000, each furnace was retrofitted with jet lance burners based on the concept of Dilute Oxygen Combustion. The cooling water was no longer required with this design. The same SJ burner port opening was used to install the DOC burner. There was minimal work required to make the change and the startup went smoothly.

Results

The benefits of installing the SJ burners first, rather than using the more traditional air burners, were a 50 percent reduction in thermal NOx emissions and a 55 percent improvement in fuel savings. The subsequent installation of the DOC burners resulted in maintenance savings, and in an additional 80 percent reduction in thermal NOx emissions by the anode furnaces. However, since both the new and original burners were oxy-fuel models, the retrofit did not lead to additional fuel savings.

Anode Furnace with New Oxy-Fuel Burner System



Photograph courtesy of Manley Prim Photography, Tucson, AZ

Lessons Learned

One of Kennecott's original objectives was to lower energy costs for the anode furnaces. With potential energy savings of up to 55 percent, or the equivalent of 15 million Btu saved per ton of oxygen used, Kennecott felt that this was sufficient incentive to select low NOx oxy-fuel burners in 1993. After operating the low NOx burners for several years, managers at Kennecott Copper remained receptive to examining continuing improvements to the technology. They were able to realize further reductions in NOx emissions and decreases in maintenance costs by switching to the DOC burner technology in 2000.

Industry of the Future—Mining

In mid-1998, the National Mining Association reached an agreement with the U.S. Department of Energy's Industries of the Future Program to join in creating research and development partnerships to develop and deploy new technologies that will improve environmental performance and enable the industry to meet increased global competition. The mining industry supplies the minerals and coal essential to the infrastructure of virtually the entire U.S. economy: glass, ceramics, metals; cement for buildings, bridges, roads, and equipment; and coal or uranium to generate more than 70% of the nation's electricity.

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BestPractices is part of the Office of Industrial Technologies' (OIT's) Industries of the Future strategy, which helps the country's most energy-intensive industries improve their competitiveness. BestPractices brings together the best-available and emerging technologies and practices to help companies begin improving energy efficiency, environmental performance, and productivity right now.

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Project Partners

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