APPLICATION

Plasma Cupola Iron Melting

The EPRI Center for Materials Production *Industrial and Agricultural Technologies and Services CMP-111*

THE CHALLENGE:

Produce High Quality Iron, Increase Productivity, and Reduce Operating Costs

Background

Automotive foundries produce a large number of castings for cars and trucks. These include engine blocks, crankshafts, brake components, etc. The castings are made of gray or nodular iron which is mainly produced by melting scrap in high volume furnaces called cupolas. These are large vertical shafts that are filled with steel and iron scrap and foundry coke. Combustion occurs when hot air is blown into the bottom of the shaft through tuyeres. A typical automotive foundry cupola can produce up to 100 tons per hour of molten iron.

Problem

The energy needed for melting in a conventional cupola comes from burning coke which allows little control over gas volume and metal chemistry. As a result, the scrap feed material has to meet tight specifications on size, density, and oxide content; and the foundry coke must be of high quality and proper size. Low-cost scrap such as iron borings and steel turnings cannot be fed directly into a conventional cupola as they will be blown out of the stack due to high blast air rates intrinsic to the operation. In addition, expensive alloy additions, such as Ferrosilicon, have to be added to the charge to guarantee that the iron meets chemistry specifications.

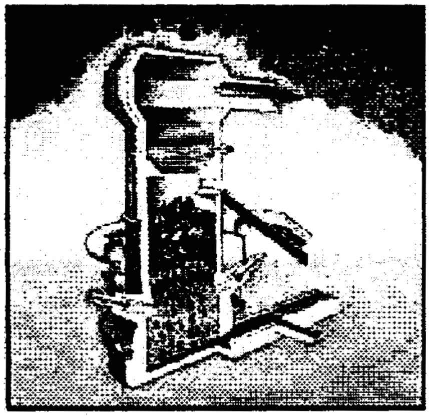

Figure 1
Schematic of Plasma Cupola

Solution

In October 1983, Westinghouse Electric Corp., the Electric Power Research Institute, Modern Equipment Company, and General Motors (GM) Central Foundry Division initiated a collaborative project to develop a plasma cupola that would allow melting of lower cost scrap, reduce coke consumption, increase productivity, and improve process flexibility. The 36-month, $3 million project involved design, fabrication, installation, and testing of a 2.5 tons per hour pilot cupola. Impressed with the results of this project, General Motors installed a plasma cupola at the General Motors Powertrain (GMPT) Group's Defiance, Ohio foundry, in the service territory of Toledo Edison.an operating company of Centerior Energy. The utility played an active role in convincing the customer to adopt the new technology as it both meant new load and helped ensure the competitiveness of a major customer.

The plasma cupola, see Figure 1, is run on a three-shift operation. It can produce up to 50 tons per hour of molten iron, when loose cast iron borings (up to 70% of the charge) are fed directly to the cupola. Hot blast air is injected into the cupola through six tuyeres located near the bottom of the melter. A Westinghouse 2-megawatt Marc-11 plasma torch, see Figure 2, is mounted onto the end of each of the six tuyeres to heat the blast air. Water constantly flows down the outside of the shell to cool the cupola.

In the control room, the operator is able to monitor cupola operations including feed mix, torch power, iron composition, etc. If deviations from preset ranges occur, corrective action can be taken quickly and efficiently. Both GMPT-Defiance foundry and their customers have evaluated castings made from iron produced by the plasma cupola and concluded that the established quality standards are met.

The plasma torches can be operated in a manual mode from an individual torch control panel or in a fully automatic mode from a master station. During normal operation, the operator starts all six torches by pressing one button on the master panel. Also, the power levels are changed by operating a single control. Normal maintenance consists of replacing the torch electrodes, which takes place every 750 to 1000 hours of operation, and can be accomplished in less than 30 minutes. Spare torches are maintained and kept ready for on-line replacement if required. A torch can be replaced on the tuyere in less than 15 minutes. Overall operating experience with the plasma cupola at GMPT-Defiance foundry shows that plasma systems can be operated with a high degree of reliability. Based on six years of operating experience, it can be concluded that plasma technology is a cost effective means for the production of molten iron.

Benefits

Low-cost scrap usage. Loose cast iron borings and steel turnings, at up to 70% of the charge, can be used. Also, highly oxidized scrap can be used. The iron oxide is reduced to iron in the cupola adding to the metallic yield.

Low-grade coke usage. 100% of expensive foundry-grade coke can be replaced by low-grade metallurgical coke. Also, coals can be mixed with the coke to reduce the cost of fuel.

Increased productivity. The melt rate can be increased by more than 50% over the same sized conventional cupola by installing the plasma torches. Melt rates as high as 150 tons per hour can be achieved in a plasma-fired cupola.

Figure 2
Westinghouse Marc-11 Plasma Torch

Excellent metal chemistry control. The hot-metal chemistry can be controlled by tuyere injection and/or adjustment of torch power. Silicon can be produced by injecting sand in front of the plasma torch at the tuyeres.

Reduced environmental impact. Since part of the coke requirement is replaced by plasma power, the volume of gases exiting the cupola is significantly reduced which results in lower costs for air pollution control equipment.

Lower operating costs. Even for the same charge material, the plasma cupola operating costs are 10% to 15% lower than the costs for a conventional cupola due to a more efficient use of coke and higher productivity. Operating costs can be lowered further if low-cost iron units, such as borings and turnings, are used.

Company Profile

General Motors Powertrain (GMPT)-Defiance foundry is located in Defiance, Ohio, and until November 1991, was part of GM Central Foundry. The GMPT-foundry is the world's largest automotive foundry and manufactures gray and nodular iron castings for GM and other auto manufacturers. They employ approximately 4300 people and operate 3 shifts to produce engine blocks, cylinder heads, crankshafts, differential carriers, and steering knuckles. Major production processes include induction melting; plasma cupola and conventional cupola melting; oil, shell, hot-box and cold-box core making; conventional and flaskless green sand molding; heat treating; shot-blast casting cleaning; and grinding.

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