CMP TECHAPPLICATION

Plasma Tundish Heating

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Improving Casting Productivity At Chaparral Steel

After many experiments on the one-strand caster, Chaparral Steel found that utilizing a plasma torch tundish heating system, to add energy to the steel in the ladle or tundish, prevented premature solidification and allowed almost unlimited casting time. The plasma torch was so successful that it was incorporated into the design of the tundish for Chaparral's new two-strand horizontal billet caster which began operation in August of 1988. Early trials by Chaparral on a one-strand horizontal billet caster at its melt shop in Midlothian, Texas revealed problems with heat loss in the ladle and tundish system. Excessive heat loss resulted in premature solidification of the steel in the tundish requiring termination of the cast. Casting time, therefore, was limited and prevented Chaparral, a producer of special bar quality steels, from casting the entire capacity of their 150-ton ladles.

Plasma tundish heating offers key benefits to the steel industry. Photo courtesy of Plasma Energy Corp.

Background

The continuous caster is the initial forming operation under which steel is processed. Liquid steel is poured from a ladle into a tundish. The steel then flows through the tundish to the mold where solidification begins. Having taken its shape in the mold, the solid steel shell with a liquid core is continuously extracted from the mold and cooled, usually by water sprays, until it is completely solidified. The continuous strand is then cut into lengths and sent on to the rolling operation.

While the ladle functions as a material handling device to contain the steel as it is moved from the melting furnace to the caster, the tundish serves several purposes. First, it acts as a distributor by transferring the steel from a single ladle to the mold(s) of the casting machine. The caster has one mold for each strand and may have as many as six strands. The tundish also serves to reduce and equalize the ferrostatic pressure of the steel as it enters the mold, reducing unwanted turbulence in the mold. And finally, it acts as a quality control device allowing non-metallic inclusions to float to the surface and become trapped in the slag rather than flowing into the mold where they would become part of the solidifying strand.

Maintaining proper steel temperature in the tundish is imperative to produce high quality steel at maximum productivity — too cold and the steel will solidify too early, too hot and casting speed may have to be reduced.

Due to excessive heat losses in the ladle/tundish system on their original one-strand caster, Chaparral found they were limited to a total casting time of one hour. Casting for longer periods of time greatly increased the risk of steel freezing in the tundish. At their nominal casting rate, Chaparral was only capable of casting 20 tons of the 150-ton capacity ladle.

The Plasma Solution

Initial trials with a plasma torch located in the ladle of the one-strand machine, increased casting time to 5 hours which greatly increased productivity. Chaparral was so impressed with the results of the initial trials that they incorporated a plasma torch into the design of the tundish for their two-strand caster, designed by Steel Casting Engineering. The torch location was moved from the ladle to the tundish to provide better, more responsive, process control. The 2MW plasma torch, supplied by Plasma Energy Corporation, is mounted so that it extends through a hole in the cover of the 27-ton tundish. Designed to operate in a transferred or non-transferred mode, the torch can be raised or lowered to maintain the proper gap with the surface of the steel as the level varies. The torch can also swing out of the way to allow removal of the tundish. Liquid steel in the tundish is stirred to improve heat transfer and homogenize its temperature by bubbling argon through porous plugs located in the bottom of the tundish. The dc torch, rated at 1000 volts and 2000 amps, can use either nitrogen or argon gas depending on economics and metallurgical considerations. Torch cooling is supplied by a closed-loop watercooling system and the return electrode is located in the side-wall of the tundish.

Operation

After the tundish has been filled with steel, the plasma torch is lowered into the tundish and the plasma arc is initiated. Power input is regulated to maintain the desired steel temperature to prevent premature solidification and allow maximum casting speeds. Temperatures of the liquid steel in the tundish are taken every 10-20 minutes with an immersion thermocouple.

Benefits of Tundish Heating

Numerous benefits have been realized by Chaparral Steel from heating the steel while it is in the tundish. They include:

- Prevention of premature solidification causing strand freeze-offs. This decreased downtime, increased productivity, and provided a smoother operation of the continuous casting process.
- Tap temperatures at the melting operation can be reduced since heat loss can now be compensated for. This reduced energy and refractory costs in the melting furnace and ladle.
- Longer casting time allows the casting of larger heat sizes, further increasing produotivity.
- With better control over temperature in the tundish, and the ability to maintain it at the most desirable level, more uniform quality throughout the cast and from heat to heat is observed. (See Fig. 1)

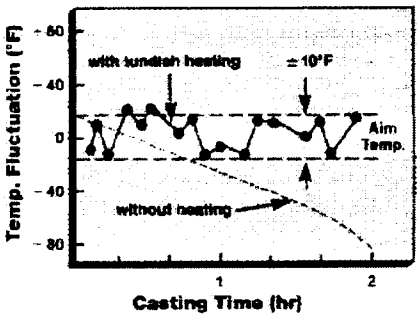

Figure 1 *Tundish heating can closely control casting temperature and eliminate the need for using extra energy in melting.*

Advantages of Plasma

Several energy sources could be used to supply heat to the steel in the tundish but plasma has some unique advantages:

- The torch can be mounted independently from the tundish or casting machine requiring only minor modifications to the tundish.
- The use of electrical energy provides for accurate control of power input to the system, and allows for an easy upgrade to automatic process control.
- Many different gases can be used to accommodate the desired results and prevent yield loss due to oxidation.
- The small physical size of the torch permits it to be used even in confined spaces.

Chaparral Pleased with Results

Duff Hunt, Superintendent-Steelmaking Technology at Chaparral Steel made the following endorsement, "The tundish plasma torch provides Chaparral the flexibility of casting to completion 150-ton heats on a single strand of our horizontal caster. Without the torch this would be impossible due to excessive thermal loss from the liquid steel in the tundish/ladle system. In addition, the torch is a tool which provides a means to control the tundish temperature accurately while casting on two strands in excess of 3 hours."

Other Advantages

Plasma tundish heating has additional advantages.

- On multi-strand billet casters, the loss of production on one strand due to a breakout will greatly increase the casting time on the remaining strands. The risk of freeze-off in this circumstance is eliminated by using the plasma torch.
- Plasma torch installations in Japan reported that tundish temperature can be controlled to ± 10°F compared to temperature fluctuations of 60-70° F in unheated tundishes. This produces higher quality steel with more uniform microstructure, and reduced inclusion and porosity levels.
- Keeping the tundish slag hot and fluid can improve its ability to trap non-metallic inclusions and produce cleaner steels.
- Cold ladies of steel that would normally have to be returned to the melting furnace or ladle furnace to add more heat can be safely cast, increasing productivity,
- With energy efficiencies of 70-80 percent, the plasma torch is one of the most efficient means of adding energy to liquid steel.
- The caster operator has the ability to make small ferroalloy trim additions in the tundish to reduce the amount of off-grade steel produced.

Other Plasma Tundish Heating Developments

While the installation at Chaparral is the only use of plasma tundish heating in the U. S., there are several commercial installations in Japan and Europe. In Japan, Nippon Steel is using a 1 MW Tetronics dc transferred-arc plasma torch on a 14-tonne tundish to provide a clean, high-efficiency energy source to minimize steel temperature variations. Aichi Steel is now using a Tetronics system. Plasma tundish heating is also reportedly used at NKK and Kobe Steel. At Deltasider in Aosta, Italy, a Krupp three-phase ac plasma system has been installed on a 15-tonne tundish. The ac system requires no return electrode in the tundish.

The use of a plasma torch for tundish heating is a unique use of this technology. It allows steelmakers to insure the production of a high and consistent quality product at maximum productivity.

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EPRI
Robert Jeffress
Project Manager

CMP
Joseph E. Goodwill
Director

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This TechApplication was prepared by Gary Walzer, Manager of Special Projects. Technical review was provided by Libor Rostik, Chaparral Steel and Tom Gahagan, Plasma Energy Corporation. Edited by John Kollar, Manager of Communications.

Center for Metals Production
Mellon Institute •4400 Fifth Avenue
Pittsburgh, Pennsylvania 15213-2683
412-268-3243

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