Higher-Quality Electric-Arc Furnace Steel

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Steelmakers have traditionally viewed electric arc furnaces (EAFs) as unsuitable for producing steel with the highest-quality surface finish because the process uses recycled steel instead of fresh iron. With over 100 years of processing improvements, however, EAFs have become an efficient and reliable steelmaking alternative to integrated steelmaking. In fact, steel produced in a modern-day EAF is often indistinguishable from what is produced with the integrated blast-furnace/oxygen-steelmaking route. Improvements in design, coupled with research developments in metallurgy, mean high-quality steel produced quickly and energy-efficiently.

Not Your (Great-) Grandparent's EAF

Especially since the mid-1990s, there have been significant improvements in the design of EAFs, which allow for better-functioning burners and a more energy-efficient process. Now, EAFs often utilize as much oxygen per ton of steel as does "oxygen steelmaking." The unique design of the burners in an EAF increases throughput of the process, improves heat transfer and protects the steel against contamination from elements in the air. These burners evenly supply most of the energy requirements of melting down recycled steel by injecting oxygen and fuel to create combustion energy.

Practically speaking, this means that steelmakers using EAFs have seen a big shift in productivity. Now, using the same amount of electrical power, much less time is needed to produce one heat of steel. Processing time has been cut to around 40 minutes, which is an hour less than the same process in the mid-1980s.

By Alfred T. Palmer - Library of Congress Prints and Photographs Division, Farm Security Administration - Office of War Information Collection.

Research Continues to Improve the Quality of Steel

Even with continued improvements to the design of steelmaking processes, the steelmaking research community has focused their attention on the fundamental materials used in steelmaking in order to improve the quality of steel. In my lab at Carnegie Mellon University, we have several research projects that deal with controlling the impurity concentration and chemical quality of steel produced in EAFs.

For example, we recently used mathematical modeling to explore ways to control phosphorus. Careful regulation of temperature, slag and stirring are needed to produce low-phosphorus steel. We analyzed data from operating furnaces and found that, in many cases, the phosphorus removal reaction could proceed further. This explained why better stirring in the furnace helps. On the other hand, lower nitrogen levels can be obtained by dissolving more carbon into the metal bath. Carbon-rich direct-reduced iron (DRI) is one good way to deliver carbon to the metal.

These examples show that while phosphorus and nitrogen are both detrimental to the mechanical properties of steel, each is controlled using different chemical and processing principles. Such increased understanding of chemical and heat-transfer principles allows continued improvement of EAF steelmaking.

Full findings of this research can be found in "Dephosphorization model for a continuous DRI-EAF process[1]" and "Carbon transfer during melting of direct reduced iron.[2]" For more information on Pistorius' research, visit his website or view a short video at www.industrialheating.com/Pistorius.

References:

1. MA Tayeb, R Fruehan, S Sridhar, PC Pistorius; "Dephosphorization model for a continuous DRI-EAF process," *Materials Science and Technology Conference and Exhibition* 2014, v. 1, p. 143-151, (2014)
2. Y He, PC Pistorius; "Carbon transfer during melting of direct reduced iron," *AISTech 2016–The Iron & Steel Technology Conference and Exposition* (2016)