Remote viewing made easy

How thermal imaging cameras are helping to reduce slag carryover in steel production and improve efficiency

Steel slag, a molten liquid melt of silicates and oxides, is a by-product of the steelmaking process, which is produced during the separation of molten steel from the impurities that are found in iron ore and scrap metal. The slag solidifies upon cooling.

The reason it needs removal is that slag impurities degrade steel. For example, slag will pull phosphorus from iron and, if not removed, the phosphorus reverts back into the steel, lowering its quality. It also causes substantial wear and tear on the vessels involved. Removal of slag has involved huge effort and expense on the part of steel producers. Recent advances in detection now mean that slag can be more reliably and effectively managed.

The disadvantages of slag carryover include:
- Longer processing time
- High inclusion formation and steel cleanliness challenges
- Difficulty in ladle dephosphorisation
- Carbon oxide buildup
- Ladle refractory wear.

While slag can be used in the aftermarket for advanced applications, its presence as a result of the steelmaking process involves a great deal of time and expense to remove it. Slag can also lead to equipment damage, which can be costly.

How steel is produced

Steelmaking starts with iron in a furnace, with the two most common furnace types being a basic oxygen furnace (BOF) and an electric arc furnace (EAF). The two vary as follows:

**Basic oxygen furnace**
- A basic oxygen furnace is a refractory-lined and tiltable converter. When steel is made in a basic oxygen furnace, molten iron and scrap are heated. Oxygen is then blown through nozzles into the charge via a water-cooled oxygen lance. The BOF is able to rotate, enabling it to charge raw materials and fluxes that are used to remove impurities. That also allows it to sample the melt and pour the slag and sludge out of the furnace. The oxygen converts the pig iron, which accounts for approximately 94% of the volume. The remaining 6% is composed of impurities, including manganese, carbon, and silicon. By the end of the steelmaking process, steel made via BOF will have impurity levels of approximately 1%.

**Electric arc furnace**
- In comparison, an electric arc furnace (EAF) creates steel from scrap and direct-reduced iron (DRI). It uses three vertical graphite electrodes to charge the iron and scrap via electric current. This furnace is comparable to a wok with a lid. Metal is added, the lid is closed, and an arc is created between the electrodes. A huge amount of power is used to melt 100% of the steel scrap.

At this point, limestone flux is added. A hole in the base of the EAF, and a ladle is positioned underneath. The molten steel exits into the ladle, and the hole closes when slag is detected.

With both types of furnaces, molten iron is tapped at regular intervals. Accurate temperature monitoring ensures steel quality is consistent and improves process efficiency. While it seems that the steps are straightforward, detecting slag and keeping it from degrading the steel is an art and a science, and the detection methodology that combines with time and dolomite time, forming steel slag. At the end of the refining operation, the liquid steel is tapped (poured) into a ladle. The steel slag remains in the vessel and is subsequently tapped into a separate slag pot.

The molten steel is removed from the furnace when the steel is at its optimal consistency, through the tapping hole. During the steel manufacturing process, the tapping hole remains plugged to keep heat from escaping the furnace.

**Slag detection methods**

When slag begins to exit along with the steel, the pour is stopped. The initial process for detecting slag was visual. An operator wore thick viewing shield, or visor, to observe the colour of the pour. Since slag has higher emissivity, it looks brighter than the steel proceeding it. Once the slag was spotted, the operator signaled for the molten metal vessel to tilt, preventing it from pouring out.

There are several downsides with this method:
- A major one being safety, as the operator’s eyes could be damaged whilst observing the steel.
- A major problem was that slag detection and thermal imaging, providing an excellent computer interface for the steel industry. The system claims to offer improved operator safety, quick response times and consistent results. It is very durable and will normally be expected to last longer than the vessel. The system can result in major savings in aluminium additions, as the ladle slag heights can be reduced by 2.5cm. Phosphorous reversion is also reduced between 0.032 to 0.053%. Another benefit is reactivity and argon stirring lances can have increased lifespans of 10-20%.

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The SDS’ high-resolution thermal imaging camera detects the transition between steel and slag with a particular wavelength, reducing blackouts caused by smoke and fumes. The date it presents in real time, enables the operator to make informed decisions about the tapping process. By warning the operator in a dependable, repeatable and timely manner to stop the tap before slag is carried over, the SDS improves production yields and ensures a lower slag content, therefore improving the steel’s quality. This also reduces energy costs further along the process and lowers the overall maintenance on the furnace vessel.

Using an SDS has shown to improve operator response time and consistency at the end of each tap. This results in a typical reduction in slag depths of up to 15%, compared to traditional methods for monitoring slag.

The SDS represents a major innovation in slag detection and thermal imaging, providing an excellent computer interface for the steel industry. The system claims to offer improved operator safety, quick response times and consistent results. It is very durable and will normally be expected to last longer than the vessel. The system can result in major savings in aluminium additions, as the ladle slag heights can be reduced by 2.5cm. Phosphorous reversion is also reduced between 0.032 to 0.053%. Another benefit is reactivity and argon stirring lances can have increased lifespans of 10-20%.

**Summary**

Although measurement methods have evolved over the past few decades, the quality of metallic scrap and iron feed stocks have simultaneously deteriorated. This results in greater slag generation and slag-related challenges for the steel industry.

The existence of slag causes substantial processing time, lower steel quality, difficulty adding alloys and conditioners, plus substantially higher processing and treatment costs.

The cost of additional downstream processing time and materials can be a significant burden for an operating plant. By controlling slag carryover, this costly downstream processing can be reduced or eliminated, improving plant throughput and operating margins.

AMETEK’s Land Slag Detection System is designed to withstand the harsh conditions of continuous operation inherent in steel production. It claims to reduce slag carryover levels by 15-30%, saves money and dramatically improves operator safety.

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