Stirring Efficiency Generated by Electromagnetic Stirring vs. Bottom Gas Stirring for a Giant Electric Arc Furnace — Numerical Simulation Results




On the road to sustainable steelmaking, replacing the blast furnace route with the electric arc furnace (EAF) is considered one of the most viable solutions to achieving carbon-neutral steel production. The proposed charge mix in this kind of EAF will ideally be hydrogen-based direct reduced iron combined with scrap. The furnace capacity is normally in the range of 200–500 tons. Due to the high temperature gradient within the giant EAF bath and lack of CO bubbling in the melt, bottom stirring is highly appreciated from a metallurgical process perspective. The stirring efficiency generated by electromagnetic stirring (EMS) versus bottom gas stirring (BGS) has been investigated for a 450-ton-capacity EAF with the help of numerical simulations and some industrial performance test results. Melt flow pattern, velocity distribution, stirring energy and bath temperature homogenization have been compared directly for these two stirring technologies. Preliminary results show that the stirring power induced by EMS is several times higher than by BGS. The pros and cons of EMS versus BGS in terms of equipment installation, lifespan, operation safety and reliability issues will be discussed in this article.

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Introduction

Today's electric arc furnace (EAF) normally operates with a large heat size, ultrahigh-power input and short tap-to-tap time, and therefore relies heavily on the bath stirring capacity to improve the heat and mass transfer in the furnace. For the future hydrogen-based zero-carbon direct reduced iron (DRI) melting in an EAF to replace the blast furnace route, the heat size is normally in the range of 200–500 tons. Due to the high temperature gradient within the giant EAF bath and less CO bubbling in the melt, bottom stirring is very much required from a metallurgical process perspective.[1] A lack of stirring in the bath could create several process problems, such as:

- High bath temperature gradient both in vertical and horizontal directions during power-on period.
- Difficulties with melting large pieces of scrap, pig iron and carbon-free DRI or hot briquetted iron (HBI) in a short time frame.
- Lower iron yield due to weak metal-slag reaction.
- Limited power input and excess slag line refractory wearing due to excessive superheat on the bath surface.
- Broad variation in tapping temperature and tapping weight, and problems for downstream operations.

There are two main stirring technologies available for electric arc furnaces: bottom gas stirring (BGS) and electromagnetic stirring (EMS). A number of investigations have been published regarding the effect of bottom gas stirring on the metallurgical process in the electric arc furnace.[2–6] The effect of electromagnetic stirring on the EAF metallurgical process has also been applied and studied by ABB Metallurgy on an industrial scale.[7–10] In the present article, the stirring efficiency generated by EMS versus