EMS INTENSITY

Question

In the technical literature, there is a considerable amount of information about the effect of EMS on segregation ratio, pinhole reduction etc in billet cast steels with various carbon contents. However, there is very little information about how to calculate the optimum EMS parameters for any given billet size. How can steelmaking technologists calculate the optimum frequency, voltage and amperage for any given billet size? What is meant by the term "stirring intensity", often expressed as a decimal or percentage. S.G., Australia

Answer

In spite of the fact that stirring intensity is most critical factor affecting the as-cast product it is rarely quantified in universal units, which would allow comparing stirring performance of different EMS installations. Stirring intensity expressed through electric current or magnetic flux density, absolute values or as a percentage of some reference value, provides only a relative comparison of stirring intensity change for the given EMS arrangement.

Velocity of stirring motion can be accepted as a universal quantitative measure of stirring intensity. Stirring velocity is derived from electromagnetic torque produced by a stirrer and will depend on its magnitude and spatial distribution within the melt. Numerical computations, typically 3D, are required to determine magnetic torque and stirring velocity. However, a simple analytical expression can also be used for assessing stirring velocity within the molds or strands of axisymmetrical geometry, such as those of square and round cross sections.(1) This expression was originally developed by Davidson of Cambridge University and extensively verified by us with measurements of stirring velocity in the columns of mercury and a low melting point alloy.(1) Stirring velocity is commonly cited in the literature as linear velocity (m/s) but it can also be expressed as rotational velocity (rad/s). The conversion of one velocity into another for any given radius of stirring pool can be performed in accordance with equation:

$$U = \Omega \bullet R$$

Where U is the linear velocity, m/s
Ω is the rotational velocity, rad/s
R is the stirring pool radius, m

It has been established that the effect of EMS on solidification structure, i.e. formation of equiaxed crystals and their size, central soundness and segregation, depends in a great part on steel chemical composition, mainly carbon content. High carbon and alloy grades require higher stirring intensity in order to achieve good metallurgical results.[2] Therefore EMS design and operating parameters are optimized on the basis of steel grades to be cast, casting practice (i.e. with metering nozzle or submerged pouring) and mold size and cross sectional geometry.

The steel grade will influence the selection of stirring intensity level. The casting practice will be considered in determining stirrer position with respect to the meniscus or type of the stirrer, i.e. single-coil EMS vs dual-coil EMS. The mold size and geometry will affect assessment of optimal operating frequency and power input.

Due to attenuation of magnetic flux density by the copper alloy mold, for any given mold size (cross sectional) and mold alloy type, there is a frequency at which the maximum magnetic torque can be delivered to the melt. Figure 1 illustrates this point. As seen, a lower optimal frequency is needed for a larger mold. Magnetic torque and rotational velocity will be also reduced with mold size increase and/or a greater value of electrical conductivity of the mold material. This effect can be compensated for by using mold material with a lower electrical conductivity. The details of the above relationships are discussed in the reference literature.[1]

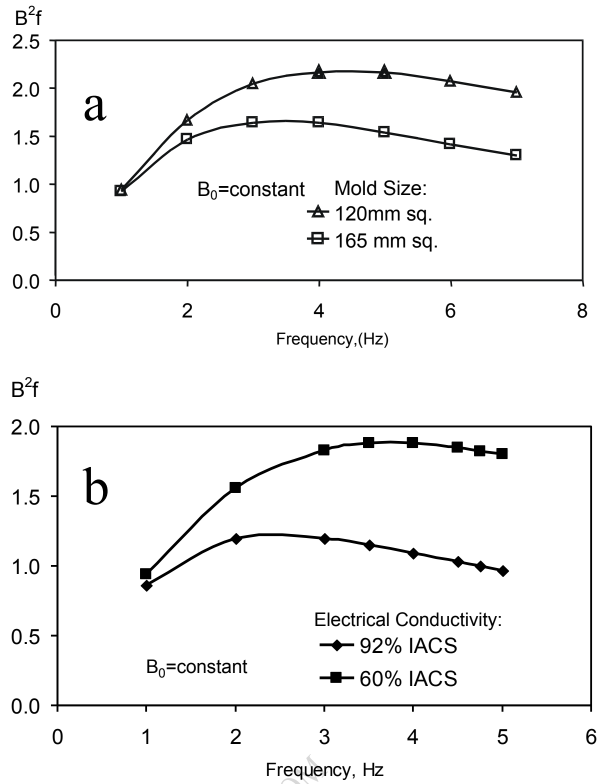

Fig 1. Effect of the mold size (a) and electrical conductivity (b) on magnetic torque.

References:

1. L. Beitelman, Electric Furnace Conference Proceedings, Vol. 55, Chicago 1997, pp. 333-340.

2. K. Ayata, T. Fujimoto, T. Onoe, Trans. ISIJ, Vol. 26, No. 10 1986, B-311.

Answer provided courtesy of Len Beitelman, ABB Inc., JME Division, 1450 Hopkins Street, Suite 105, Whitby, Ontario, Canada L1N 2C3 who can be contacted directly at len.s.beitelman@ca.abb.com or via phone at +1 (905) 666-2251 or fax at +1 (905) 266-2266.