Electromagnetic stirring

In today's aluminium market the demand for products that improve profitability continues to rise. Electromagnetic stirring (EMS) is a well-established method of improving furnace economy and, in some countries, is fitted as standard. By **Kristofer Malmberg, Ph.D.***

ABB is acutely aware of the continued need for EMS products which are designed with flexibility in mind. Optimum results are achieved by expertly selecting the correct product based predominantly on the individual needs of the customer. To claim that a narrow range of products and cooling systems can fulfill all possible requirements is to oversimplify matters. As such a comprehensive range of energy efficient products, that can offer truly tailored solutions, is an absolute necessity. Some form of performance guarantee, such as ABB's performance warranty, can act as an additional reassurance that the supplier has the expert knowledge and range of products necessary to deliver significant and long term benefits.

EMS installation

Any reliable conclusion regarding the advantages or disadvantages of EMS systems, cooling systems or even choice of fitting position, should be based on analysis of data from a wide range of different installations. Anything less is simply speculation. ABB's first EMS installation for aluminium was in 1968. Our conclusions are based on an exceptionally broad range of knowledge and data from 250 EMS installations for aluminium, including both liquid and air cooled, and side and bottom mounted systems, and over 2000 accumulated years of operation.

EMS can offer the following benefits:

- Increased productivity
- Lower energy consumption
- Reduced dross formation
- Higher alloy yield
- Homogeneous aluminium bath temperature and chemical composition

By providing a range of EMS systems for production capacities from 5 to over 200 tons, that can be tailored to any kind of furnace and process step, the customer doesn't need to be an expert themselves in order to choose a supplier that can provide a system that meets their needs. Most companies specialise in a certain kind of EMS system while ABB specialises only in customer solutions.

One cannot underestimate the importance of designing products that not only contribute to overall energy efficiency but are in themselves energy efficient. There is a certain misconception that larger stirrers, often with liquid cooling, are less energy efficient than their smaller, sometimes air-cooled counterparts. Figure 1 shows clearly that energy consumption as kWh/t is the same regardless of factors such as furnace size, cooling system or whether it is side or bottom mounted. Larger stirrers use more energy in order to produce more aluminium but it doesn't make them any less energy efficient than smaller stirrers.

Energy consumption does, however, fluctuate from one process step to another. See figure 2 which shows power usage by process step. Aluminium bath homogenisation in a holding furnace can be achieved using a relatively low stirring force; simply because the burners have a lower energy output compared to melting and twin chamber furnaces. A stronger stirring force is, however, required in order to increase heat transfer from the burners and roof radiation in both melting and twin furnaces. Energy consumption in this case is determined by the process step. In order to optimize both energy consumption and process benefits it is necessary to tailor a stirring profile controlling duration, intensity and direction to a customer's needs. This, as well as the choice of appropriate EMS and cooling system, requires comprehensive expertise coupled with a broad range of products to choose from.

Cooling

There is some debate as to whether air cooling or liquid cooling is best for EMS systems. Some would argue for air and others for liquid and supply only one or the other. Based on data from a total of 250 aluminium installations, where 230 are liquid cooled and 20 are air cooled, ABB can conclude that both kinds of cooling systems have their merits. Air cooled EMS systems were developed to meet the demand for electromagnetic stirring on furnaces with production capacities of up to approximately 40 tons. Typically, the financial investment

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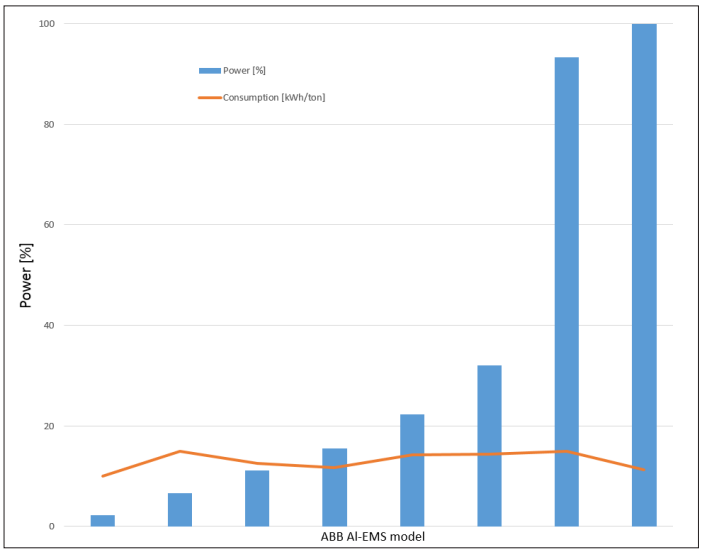

Fig 1 AI-EMS energy consumption kWh/ton

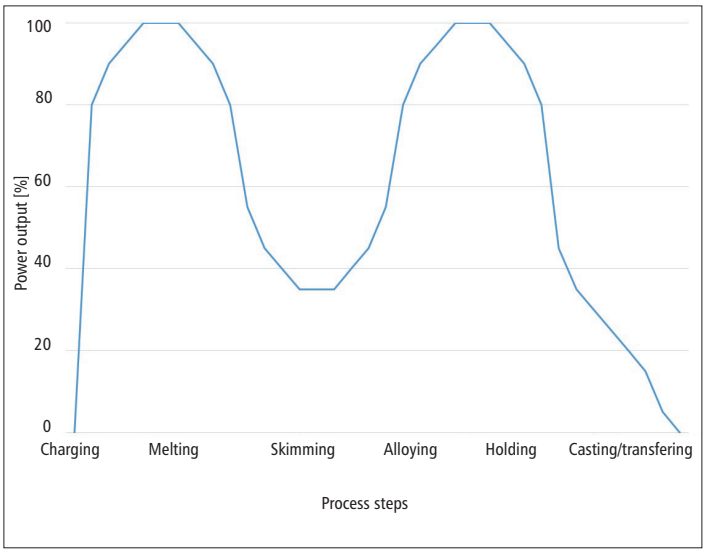

Fig 2 AI-EMS energy usage by process step

needed and resulting stirring power are more appropriate for stirrers of this size. In addition, air-cooling systems require the use of filters, which should be changed on a regular basis, resulting in a higher level of maintenance than liquid cooling systems.

For larger stirrers on furnaces producing more than around 40 tons, liquid cooling is deemed to be more appropriate. As a rule, more cooling power is required for larger EMS systems. A liquid cooled EMS is well-equipped to deal with these demands and at the same time remains compact in size. Any benefits associated with the use of a considerably larger, equally powerful air cooled EMS cannot be justified when compared to the practical difficulties involved. Since liquid cooling consists of a closed loop water circuit, there is no need for filters less maintenance is therefore required. Careful analysis of installations confirms that liquid cooling offer a superior level of reliability for more powerful EMS systems.

Fitting

Traditionally, EMS systems have been fitted to the bottom of the furnace as standard. A bottom mounted EMS benefits from being fitted on the furnace bottom where there is maximum potential for optimum stirring. Stirrers mounted on the side will usually experience a certain loss in performance compared to bottom-mounted stirrers. The side-mounted EMS was developed and patented by ABB to satisfy the need for stirring where bottom mounting is not possible, for example stationary furnaces. To ensure maximum performance the EMS should be bottom mounted where possible.

It has been said that there are less complications involved in the installation of side mounted EMS as compared to the bottom mounted variety. This may well be true. Based on our considerable experience, it must be said that the long-term benefits of bottom mounting by far outweigh the short-term inconvenience associated with installing a bottom-mounted EMS system.

For the above reasons our customers have chosen side mounted only four times out of 250 installations. ABB can conclude that bottom mounted EMS should be recommended over side mounted and side mounted should be recommended over not having EMS at all.

Process benefits are achieved through metallurgical improvements, which are driven by forced convection. When the magnetic field is introduced into the aluminium bath, an eddy current is produced, repelling the magnetic field and causing movement in the aluminium bath. The resulting rotation brings the cold bottom melt to the hot surface and the hot surface aluminium to the cold bottom. Any size of aluminium bath can, in as little as two minutes, reach a temperature homogenisation with a difference of max +-5oC. This can be compared to a typical temperature difference of 70-100oC in the absence of stirring. A lower surface temperature allows for more effective heat transfer from the burners, and furnace roof radiation is therefore increased.

Productivity is improved and dross generation decreased, which in turn leads to a higher aluminium scrap yield. An increase in productivity means that less energy is needed to reach the desired casting temperature. Moreover, the number of rejects due to faults caused by variations in casting temperature is greatly reduced. While alloying, electromagnetic stirring results in chemical homogeneity, decreased alloying time and increased alloy yield. The EMS dissolves alloys, such as Fe, Si, Cu, with a higher melting point more efficiently on account of the movement of the molten aluminium, which constantly feeds the liquid surrounding the alloy with unsaturated, hot aluminium.

Conclusion

In supplying 250 EMS systems for aluminium, ABB has gained invaluable knowledge and expertise which allows us to address the debate surrounding energy efficiency, choice of cooling system and fitting position on the furnace. As predicted, analysis of the facts confirms our original statement; a comprehensive range of energy efficient products, carefully selected on the basis of customer needs, is a prerequisite for providing customers with tailored solutions and guaranteed results. **www.abb.com/metals** ■