Multi stage filtration incorporating TiBAl grain refinement

Michael Bryant of MQP Ltd gives a special review of recent high efficiency XC filter production trials in a secondary melting environment to be presented in detail at TMS 2011 in February.

The aluminium casthouse industry wants to see a filter developed that can deliver the high efficiency performance of a deep bed filter but with low hold up volume, low floor space requirement and the ability to be used economically in conjunction with frequent alloy changes (1). Multi stage filtration technology based on the principle of using a three stage process is currently being evaluated in two alternative systems.

Three stage alternatives

The common starting point is the observation that the addition of TiBAl grain refiner in front of a ceramic foam filter (CFF) reduces filtration efficiency (2). The likely cause is TiB2 particles which prevent the formation of bridges at the top surface of the filter acting to form a filter cake. This fundamentally changes the filtration mode from cake to the less effective depth filtration (3).

In both cases a ceramic foam filter is the first stage, TiBAl grain refiner is added in a second stage and a further filtration means is used in the third stage to ensure that no oxide stringers or boride agglomerates from the grain refiner can pass from the filter to the casting table. In one system, the XC filter, the third stage filtration is achieved with a small deep bed filter (DBF) employed in the final chamber. In the alternative system, the Optifilter, the third stage filtration is achieved with a cyclone deployed in the final chamber.

In 2005, Instone (4) described the XC filter, which gave superior filtration efficiency achieved by the combination of ceramic foam filtration and deep bed filtration. The design comprised a three chamber unit with a CFF in the first chamber, grain refiner addition in the second chamber and a small DBF in the third chamber. Several prototypes of this filter were built and tested at the pilot DC casting centre at the Rheinwerk smelter in Neuss, Germany. The results of more than eighty evaluation casts compiled using LiMCA and PoDFA measurement techniques showed that excellent filtration efficiency could be achieved.

This programme of work has been extended to demonstrate the long term stability of the technology under production conditions and to establish the various scale-up parameters required for a production unit. Unlike earlier trials conducted using pot room metal, these trials were performed using metal prepared from recycled foil scrap or processed dross and delivered to the furnace as molten pre-alloyed metal.

Details of the casting programme and parameters were as follows:

- Flow rate 10 t/h
- Casting speed 62 mm/min
- 30 ppi CFF – 3 suppliers
- 5-layer deep bed filter
- Grain refinement, after CFF and before DBF (LSM 3:1 TiBAl rod at 0.6 kg/mt).
- Casting layout and location of measurement equipment (fig. 1)

XC filter production trial

During a production trial campaign involving the casting of 37 heats in sequence over a three week period a consistently high metal quality for the filtered metal was achieved throughout and the prototype system functioned satisfactorily. The metal quality (LiMCA N20) after filtration averaged 400 counts per kg and consistently bettered the target value of < 1,000 counts per kg. The results in terms of filtration efficiency were also excellent with efficiencies of 97 per cent for inclusion sizes over 50 microns together with an average LiMCA N20 counts of 400 per kg.

The Optifilter

The design of the Optifilter comprises a first chamber containing a ceramic foam filter, a second chamber for the addition of grain refiner, and a third chamber containing a cyclone. A system utilising a cyclone in the third chamber has the potential benefit of permitting frequent alloy changes.

The effectiveness of a cyclone concept has been proven by numerical and water modelling experiments. These showed an expected removal efficiency of approximately 50 per cent for particles >60 micron with a flow velocity of 0.5 m/s rising to 80 per cent for particles >100 microns. However, the true removal efficiency can only be determined by actual operation of the unit.

The Optifilter system prototype is ready for production trials but practical difficulties have been encountered with priming the cyclone chamber. Casting trials demonstrated that a head height difference of approximately 150 mm will be required between the inlet and outlet levels to drive...
metal through the cyclone at a sufficient rate to achieve the required flow rate for casting. Further filtration efficiency measurement trials are planned with a modified prototype with a 150 mm head height difference.

The ability of the XC filter to deliver ultra-high efficiency is now proven under production conditions. The system will be suitable for application where either long runs of the same alloy are made or were it is possible to flush through the relatively small hold up volume to allow a number of alloy changes to be made in sequence without the need to drain the bed.

If eventually successful the Optifilter system will provide a similar high efficiency filtration solution for frequent alloy changes or low volume operations where it is necessary to fully drain the filtration unit.

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Bibliography

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