XC Filter and Optifilter: Two three stage filtration systems compared
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Background
Within the aluminum casthouse industry there is a need to develop a filtration system that can:
(a) deliver the high efficiency performance of a deep bed filter
(b) requires low hold up volume, minimal floor space and the ability to be used economically
in conjunction with frequent alloy changes.

In an effort to achieve these objectives multi stage filtration technology based on the principle of a
three stage process is currently being evaluated in two alternative systems.

The two alternative technologies both stem from a common starting point namely that the addition
of TiBAI grain refiner in front of a CFF reduces its filtration efficiency (Fig.1 and Ref.2).

It is suggested that the cause is TiB2 particles, arising from the grain refiner, which prevent the
formation of bridges at the top surface of the filter. This fundamentally changes the filtration mode
from cake mode filtration to the less effective depth filtration.

![Figure 1. Influence of TiBAI grain refiner on efficiency of ceramic foam filters](image-url)
Systems being compared
In the two systems being evaluated a ceramic foam filter (CFF) 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.

The XC Filter
In 2005 Instone (4) described a new design of filter unit named the XC filter which gave superior filtration efficiency achieved by the combination of ceramic foam filtration and deep bed filtration. Importantly this design comprised a three chamber unit with a ceramic foam filter in the first chamber, grain refiner addition in the second chamber and a small bed filter in the third chamber.

Several prototypes of this filter were built and tested at the pilot DC casting center 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 program of work has now 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 the earlier trials which were 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.

A schematic of the XC Filter design used in these trials is shown in Fig 2 and a photograph of the prototype unit in Fig.3.

Figure 2. XC Filter Design
Figure 3. Industrial prototype XC Filter use in these trials

Trial Details
Details of the casting program and parameters were as follows:

- A total of 37 casting trials were carried out with a total of seven CFF’s.
- Mould Size- 1750mm x 600mm
- Flow rate-10t/h
- Casting speed- 62 mm/min
- 30ppi CFF – 3 suppliers
- 5-layer Deep Bed Filter
- Grain refinement- after CFF and before DBF (LSM 3:1 TiBAl rod at 0.6kg/mt)
- Casting Layout and location of measurement equipment as shown below
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 through out and the prototype system functioned satisfactorily. The metal quality (LiMCA N20) after filtration averaged 0.4k counts/kg and consistently bettered the target value of <1k counts/kg. The results in terms of filtration efficiency were also excellent with efficiencies of 97% for inclusion sizes over 50 microns together with average N-20 LiMCA counts of 400/kg.

Stirring of the melt in the furnace increased the total number of inclusions as well as the number of larger inclusions reaching the filter from the furnace. The metal quality of the filtered metal leaving the XC-Filter was independent of variations in the level of incoming inclusions. Consequently higher filtration efficiencies were achieved for high inclusion loading situations. These results are illustrated in the LiMCA plots of Figures 4 and 5.

Overall the conclusion is that these trials have proved the operational robustness and the usability of the XC-Filter concept. No major change in concept is considered necessary for the industrial version of the XC-Filter.
Figure 4. XC Filter - N20 values measured at the two LiMCA positions before and after stirring of the melt in the furnace
Figure 5. XC Filter – Inclusion size distribution for stirred and settled melts measured at the two LiMCA positions

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

The Optifilter system has now been developed to the stage of providing a prototype for production trials but practical difficulties were at first encountered with priming the cyclone chamber. It was thought that the problem was one of head height difference between the inlet and outlet levels. In a further trial, on a sow casting station, this was increased to 150mm and molten aluminium was passed successfully through the reactor at a flow rate of 325kg/min. It seems however that the ability to prime the cyclone was due to furnace tilt rate rather than to head height difference.

Further trials are planned and the next target will be to cast successfully on a DC casting pit and explore filtration efficiency.

To conclude
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.

On the other hand the Optifilter system, if eventually proven to match modeling predictions, will provide a similar high efficiency filtration solution for frequent alloy changes or low volume operations where it is necessary to drain fully the filtration unit.

Acknowledgement
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Literature References
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