Optifine potent grain refiner reduces risk of cracked ingots and billet

Full scale production trials show that Optifine is a very potent grain refiner which allows reduction in rates of addition of 62-89% compared to conventional refiners and has the accompanying benefits of lower cost and better quality. Since the Optifine master alloy has a consistently high efficiency, and the grain refinement process can be closely monitored with the Opticast system, the risk of cracking of ingots and billet is avoided. **By Rein Vainik*, Gus Hornsby**, John Courtenay*** and Michael Bryant*****

A paper was presented at the 2009 TMS Conference[1] describing laboratory and Casthouse trials with *Optifine*, a new, high efficiency, TiBAl (3%, 1% bal) grain refining rod.

The programme of work has continued with full scale trials at Hulamin, South Africa, involving a number of alloys and optimisation using the Opticast method. This sampling technique has been designed to give a slow solidification rate in order to exaggerate grain size differences, ie as compared to rapidly cooled samples. (See *AIT March/April 2009 p26-28)*.

Results have confirmed the earlier findings that Optifine is at least twice as efficient as standard grain refiners and that addition rates can be reduced to extremely low levels without risk of cracking of ingots and billets.

The low level of additions brings major cost savings and metal cleanliness benefits especially in respect of the amount of hard boride particles present.

The sole purpose of grain refinement is to obtain a grain size in the final slab or billet that prevents the cast from cracking during casting and subsequent treatment, eg rolling or extrusion. This should be done with as small amount of grain refiner as possible. There are two reasons for this:

– to minimise the cost of grain refinement;
– to minimise the amount of impurities added to the melt consisting of boride particles derived from the TiBAl rod which degrade the surface quality in bright trim and foil and can-stock.
– Boride particles may also migrate to grain boundaries and have a harmful effect on mechanical properties.

The Opticast system[2] has been successfully applied as a production tool at Hulamin since 2005 and is a means to decrease master alloy additions in a controlled way. The aim is to optimise each cast by adjusting the master alloy addition rate so that a minimum amount of grain refiner is added, but sufficient to prevent cracking.

The experience from the use of Opticast optimisation at casthouses around the world has shown that to achieve this objective there are three important steps:

- Improve the growth restriction conditions in the melt – this is essentially a function of the melt composition, the higher the concentration of alloying elements the larger the growth restriction. Ti has a much higher growth restriction effect than any other element and can easily be added to melts to increase growth restriction without affecting other properties.

- Choose the most efficient grain refiner – in a highly efficient grain refiner the borides are ideally confined to a very narrow size range[3].

Alloy	No of Casts	Av reduction of addition (%)
AA3000-series		
Alloy 1	2	74
AA6000-series		
Alloy 2	2	62
Alloy 3	2	89
AA5000-series		
Alloy 4	13	65
Alloy 5	12	56
Alloy 6	1	62
Alloy 7	1	76

Table 1 Reduction in master alloy addition for the alloys tested in the full scale casts (%)

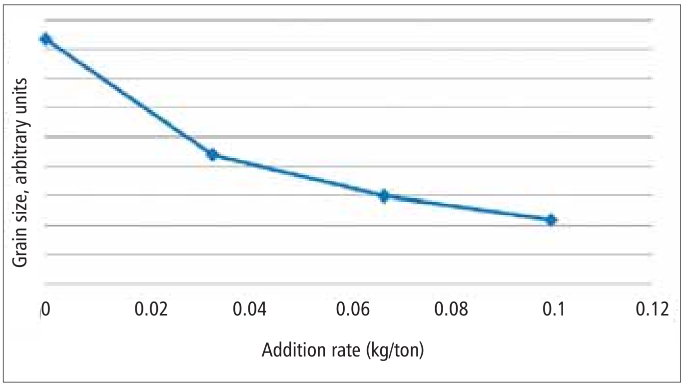

Fig 1 Grain refinement curve for Optifine in a charge of alloy 1, AA3000 series

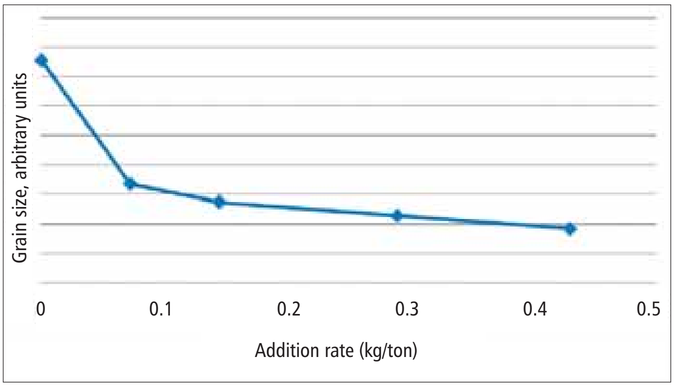

Fig 2 Grain refinement curve for Optifine in a charge of alloy 2, AA6000 series

*Opticast Aluminium AB, Junkergatan 3,SE-126 53 Hagersten, Sweden.
**Hulamin Rolled Products, Moses Mabhida Rd, Pietermaritzburg 3200, South Africa. ***MQP Limited, 6 Hallcroft Way, Knowle, Solihull B93 9EW UK

- Choose the optimum position to add the refiner – the grain refiner can be added at various points in a casting system, before or after a degasser, and before or after a filter. Each casting line should be evaluated in order to find an optimum addition position.

Summing up, the ideal situation is a rapidly dissolving, clean grain refiner which allows a fast dispersion of equally sized boride particles. This could then be added after the filter. The Optifine grain refiner has been developed with these considerations in mind.

For production trials, Optifine coils were mounted on two casting lines and the necessary addition rates were measured by taking Opticast samples during the casts. The samples reflected the grain size close to centre of DC cast 400mm thick ingots.

On each casting line the total amount in each cast is about 60 to 80t to produce five ingots. The ingot sizes during the casts ranged from 1360 to 1700mm wide with a thickness of 630mm. The casting speeds were between 50 to 60mm/min.

The rod feeding rates ranged from 35 to 85cm/min, depending on ingot size, casting speed and master alloy addition rate.

Results

The reductions in addition levels achieved with Optifine are shown in **Table 1**.

In some of the casts crucible tests were performed to determine the grain refinement curves for the alloys 1-5 in **Table 1**. Two examples of these curves, for alloys of AA3000 series and AA6000 series, are shown in **Figs 1** and **2**.

These curves show that the grain size is progressively reduced by very small additions of the Optifine rod and particularly in the case of the AA3000 series alloy that a fine grain size can be achieved by extremely small additions.

It would be very valuable to know for a particular alloy the precise grain size needed to avoid cracks. However there is no direct way to do this by calculation as grain size depends on a number of parameters, including ingot size, casting speed, cooling rate and seasonal variations. In the development of the Opticast method the approach has been to evaluate each Casthouse individually and to set the grain size limit to a safe level, which will cope with the possible fluctuation in production parameters and seasonal variations.

In Hulamin Casthouse, most of the grain sizes achieved during the trials are considered to be able to effectively stop the propagation of cracks in the ingots. There is also a possibility to further decrease the addition levels since it is likely that grain sizes of up to approximately 200μm may be allowed for some of the alloys. It appears that less than 0.03kg/t would be sufficient for some of the alloys, and about 0.07kg/t would be able to give a grain size in the order of 200μm for other groups of alloys. The results also indicate, that even for some of the crack sensitive alloys a very fine grain size can be obtained with as little as 0.1kg/t, using Optifine. ■

References

1 R Vainik and J Courtenay 'Optifine-a grain refiner with maximised efficiency' Light Metals 2009

2 L Backerud and R Vainik, Method for Optimised Aluminum Grain Refinement, Light Metals 2001, 951-954

3 A I Greer, A M Bunn, A Tronche, P V Evans and D J Bristow, Modelling of Inoculation of Metallic Melts: Application to Grain Refinement of Aluminium by Al-Ti-B, Acta Materialia, 48 (2000) 2823-2835

Contact:
MQP Ltd, 6 Hallcroft Way, Knowle,
Solihull B93 9EW UK. Tel +44 (0) 1564 20043
Fax +44 (0) 778 606 2474
E-mail john.courtnay@mqpltd.com
www.mqplimited.co.uk