

Production trials at Hulamin with Optifine

Rein Vainik, Gus Hornsby, John Courtenay and Michael Bryant* describe full-scale trials in the Hulamin casthouse in South Africa, using Optifine, a high-efficiency TiBAl grain refining rod. The potency of the product is such that additions can be reduced to very low levels, with both cost and quality benefits.

A paper was presented at the 2009 TMS Conference (1) describing laboratory and casthouse trials with Optifine, a new, high efficiency, TiBAl 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 methodology.

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 after grain refinement.

Background

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 and extrusion. This should be done with as small amount of grain refiner as possible. There are two reasons for this:

- 1 To decrease the cost for grain refinement
- 2 To minimise the amount of impurities added to the melt. Boride particles derived from TiBAl rod degrade 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 without risk for cracking.

The experience from Opticast optimisation work 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 the other properties of the alloy.
- Choose the most efficient grain refiner — in a highly efficient grain refiner the borides are ideally confined to a very narrow size range.(3)
- 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.

*Of the Authors, Rein Vainik is associated with Opticast Aluminium AB; Gus Hornsby is with Hulamin Rolled products, and John Courtenay and Michael Bryant with MQP, Limited.

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.

Production trials at Hulamin

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 400-mm thick ingots.

On each casting line, the total amount in each cast is about 60 to 80 tonnes to produce five ingots. The sizes during the casts ranged from 1,360 to 1,700 mm width with a thickness of 630 mm. The casting speeds were between 50 to 60 mm per min.

The rod feeding rates ranged from 350 to 850 mm per 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 in order to determine the grain refinement curves for the alloys shown in Table 1.

Two examples of these curves, for alloys of AA3000 series and AA6000 series, are shown in Fig 1 and 2.

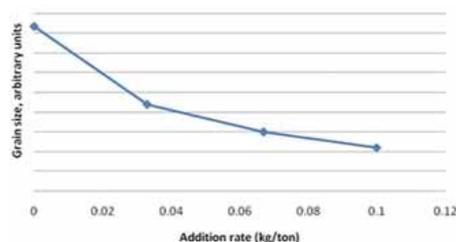


Fig 1. Grain refinement curve for Optifine in a charge of alloy 1, AA3000 series.

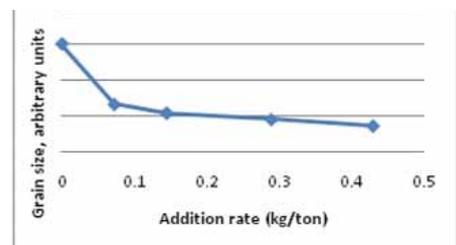


Fig 2. Grain refinement curve for Optifine in a charge of alloy 2, AA6000 series.

Discussion

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 of grain refiner.

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 calcu-

Alloy	No of Casts	Average reduction in 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: Reductions in master alloy addition for the alloys tested in the full scale casts.

lation, 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 the Hulamin casthouse, most of the grain sizes achieved during the trials are considered to be able to stop the propagation of cracks in the ingots in an effective manner. There is also a possibility to further decrease the addition levels, since it is likely that grain sizes of up to approximately 200 µm may be allowed for some of the alloys. It appears that less than 0.03 kg per tonne would be sufficient for some of the alloys, and about 0.07 kg per tonne would be able to give a grain size in the order of 200 µm 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 0.1 kg per tonne, using Optifine.

Conclusion

The full-scale production trials reported of in this report clearly show that Optifine is a very potent grain refiner which allows reduction of addition rates to extremely low levels with the accompanying benefits of cost and 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 billets is avoided.

References

- 1 R.Vainik and J.Courtenay "Optifine – a grain refiner with maximized efficiency" *Light Metals* 2009.
- 2 L. Backerud and R. Vainik, "Method for Optimized Aluminium Grain Refinement", *Light Metals* 2001, 951-954.
- 3 A.I. Greer, A.M.Burn, A. Tronche, P.V. Evans and D.J. Bristow", Modelling of of Inoculation of Metallic Melts: Application to Grain Refinement Aluminium" by Al-Ti-B, *Acta Materialia*, 48 (2000) 2823-2835.

Reader Reply No.85