Optifine brings Turkish delight

UK-based MQP carried out a series of tests at Eti Aluminyum in Turkey to demonstrate the ability of its Optifine product to achieve a minimum 50% reduction in grain refiner addition compared with the use of standard TiBAl grain refiner. A second objective was to reduce consumption by 70%.

By **Michael Bryant***

UK-based MQP claims that its Opticast technology makes it possible to study and quantify all the factors affecting grain refinement, including grain refiner potency, melt nucleation level, growth restriction factors, grain refiner recovery and in line treatments. According to the company, it allows rapid and reliable results to be generated so that accurate conclusions can be made regarding implementation of optimised grain refining practice.

Grain refiner variability is an important factor in achieving a fully optimised practice and this has led to the development of Optifine, which is a grain refiner.

Integrated aluminium production

Eti Aluminyum, a member of Cenzig Holding, is located at Seydisehir in Turkey, and is one of a very small number of aluminium producing facilities in the world that is fully integrated. It has its own bauxite mines near to its factory and this is the starting point for a total process of ore extraction, primary aluminium smelting and casthouse processing to billet.

The casthouse at Seydisehir produces around 65kt/yr of 6063 billet. Casting equipment comprises two 45Mt holders, an Alpur inline degasser, a filter box with 40ppi ceramic foam filters and a Wagstaff billet casting table. The majority of the furnace charges contain a large proportion of its own primary aluminium and the current grain refinement is with 2.2kg/tonne of standard commercial 5/1 TiBAl.

Casthouse trials

A series of trials was carried out in the Seydisehir casthouse by MQP. The first objective was to demonstrate the ability of Optifine to achieve a minimum 50% reduction in grain refiner addition compared with the standard TiBAl grain refiner being used. A second objective was to reduce consumption by 70%. These objectives would mean initially reducing addition rates from 2.2kg/tonne down to 1.1kg/tonne and then down to 0.65kg/tonne.

The work began by taking samples of metal from the furnace spout and carrying out Opticast crucible tests with standard 5/1 TiBAl grain refiner and Optifine added at 0.5kg/tonne,1.0kg/tonne and 2kg/tonne.

The aim was to establish that it was possible to reduce the addition rate to 1.1kg/tonne using Optifine and still meet the required grain size specification.

The Opticast curves, which resulted from the trial, revealed a large difference in efficiency between the standard commercial TiBAl grain refiner (blue line) and Optifine (red line) as shown in **Fig 1**.

The horizontal hatched line at 146 μm indicates the grain size obtained in samples taken in the launder when the standard TiBAl grain refiner was used at an addition rate of 2.2 kg/tonne. The red curve for Optifine additions indicates that the same grain size can be achieved with an addition of 0.5 kg/t of Optifine.

Based on these results it was decided to carry out a second trial with Optifine at an addition rate of 1.1 kg/tonne. The results from this showed an average grain size measured at 135 μm in the Opticast samples, which confirmed the prediction made in the first trial.

After homogenisation, a billet slice from this trial was examined and the grain structure was as shown in **Fig 2**.

The next step was to produce five production casts with a 50% reduction in the addition rate down to 1.1kg/tonne. The normal practice at Eti is to assure a titanium level of 50 ppm in the furnace before casting in order to assure a high enough growth restriction. The base level of titanium in charges may vary from as low as 5 ppm to 100 ppm in the furnace, depending on the ratio between pure metal and scrap. This means that if the analysis shows less than 50 ppm, Ti waffles

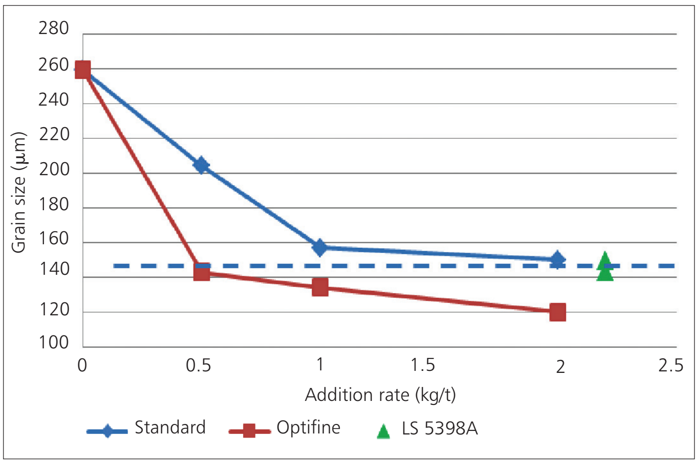

Fig1 Opticast grain refinement curves from the first trial

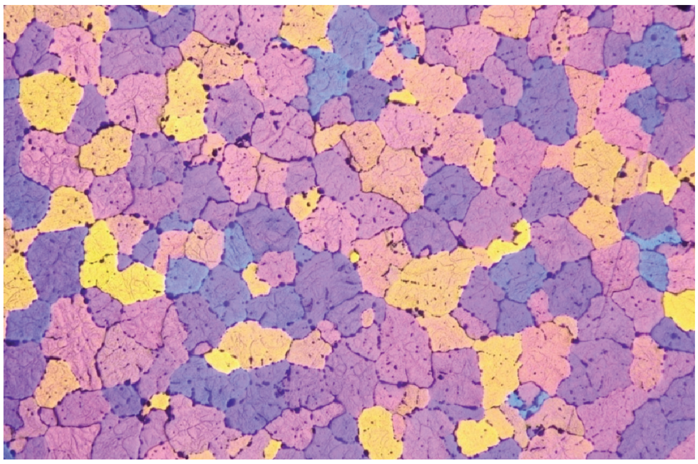

Fig 2 Micrograph of billet cast from second trial with Optifine added at 1.1kg/tonne. Grain size after homogenisation was 65 μm compared to the 135 μm measured in the Opticast samples

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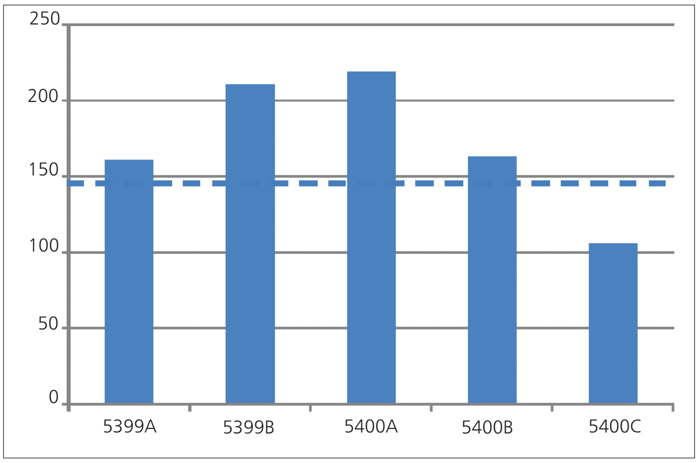

Fig 3 Grain sizes in Opticast samples for five production casts with Optifine addition rate of 1.1 g/t

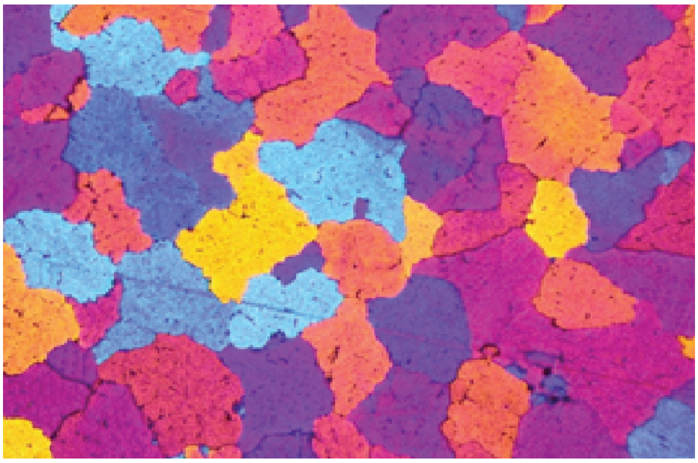

Fig 4 Billet micrograph from cast with Optifine added at 0.65 kg/t

are added to increase the concentration to 50 ppm.

In two of the production casts, the titanium content was increased by Ti addition, but in the other three casts no titanium additions were made as a means of evaluating if Optifine could perform acceptably even if the growth restriction conditions were not optimised. The results from the tests are shown in **Fig 3**.

The Opticast results indicate that to ensure a small grain size an adequate Ti level is essential to provide optimum growth restriction conditions. The two casts without Ti addition had extraordinarily low Ti levels of roughly 2 ppm, which resulted in grain sizes around 210 μm. Two other casts to which Ti had been added to around 20-30 ppm produced grain sizes just above 160 μm. The other cast without a Ti addition, but a base Ti concentration well above 50 ppm due to a large proportion of scrap in the charge, showed a very small grain size of 110 μm.

Having determined that a satisfactory grain size can be produced with an Optifine addition of 1.1kg/tonne, provided that the Ti content is adequate, a further production cast was made with a lower Optifine addition in conjunction with a Ti level adjusted to 50 ppm. Crucible tests were made with Optifine additions ranging from 0.86kg/tonne down to 0.56kg/tonne.

The results showed that grain size prediction works well when the Ti level in the furnace is adjusted to 50 ppm. It also indicates that it would be possible to cast this alloy with an Optifine addition even as low as 0.56 kg/tonne, a decrease of 75 % from the original level of 2.2 kg/tonne. A billet slice from this cast with a 0.65kg/tonne Optifine addition showed, after homogenisation, a grain size 110 μm as in **Fig 4**.

It is worth noting that in these trials, none of the 6063 billets cast from metal treated with Optifine experienced cracking, even when the measured grain size in the Opticast samples was over 200μm. In fact a 200μm grain size in an Opticast sample corresponds to about a 100μm grain size in a billet. This puts it well within the allowable maximum 176μm grain size corresponding to ASTM Grade 2.0, which Eti Aluminium uses to avoid billet cracking.

The results have confirmed that although in the case of smelter metal the growth restriction factor is substantially less than in a remelt operation, this can be overcome by increasing titanium levels to 0.005%. Optifine was successfully used for the casting of 6063 billets on a production basis with the addition rate being reduced by 70% compared to standard grain refining practice – provided the titanium level was increased to 0.005%.

The Seydisehir casthouse is now in the process of converting its grain refining practice to Optifine. This will involve production of 6063 billet and an anticipated production of rolling slab. ■

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ETI ALUMINYUM

Eti Aluminyum, located at Seydisehir, is Turkey's only producer of liquid aluminium and it is the country's only fully integrated producer, which takes in untreated ore downstream and then has the capacity to fulfil every process requirement to the finished product. The company has its own bauxite mines located 20km from the factory and this is the starting point of its operations.

ETI's level of integration gives it the advantage of better control of raw material quality, cost and supply. The company holds only minimal raw material stocks, which makes it easier to forecast raw material and final product costs.

However, there are disadvantages. "There are more inputs and factors affecting our profitability in this style of operation. As we have seen recently, energy costs have spiralled and so have some vital raw material costs, like caustic soda, petroleum coke, natural gas, and electricity. To manage such a highly integrated plant with its many processes requires a bigger and more complex organisation. Today more than 1,300 people work here," a company spokesman said.

Producing aluminium is an energy-intensive process and many plants have been brought to the brink by rising energy costs – it is estimated that around a third of plants around the world are operating at a loss – but Eti Aluminyum has avoided the full impact of these increases by using its own hydro-electric power plant.

The plant in question has the capacity to process 460kt of bauxite annually and currently produces 60kt of aluminium per year. There is also an on-site casting facility with a capacity of 75kt/yr.

Eti Aluminyum produces primary and cast aluminium products as well as wet and dry aluminium hydroxide, calcined alumina and a small quantity of high Mg-alloyed plates.

MQP is grateful to Eti Aluminyum for its co-operation in this work at the Seydisehir plant and for its permission to publish the results. Special thanks to Bader Saglam for her participation in the programme.