# Melt treatment of aluminium alloys in channel induction furnaces

**The use of aluminium alloys in extremely demanding areas of application, such as the aerospace and automotive industries, requires a high degree of sheet and plate product quality. A prerequisite for the related production process is the use of rolled ingots with excellent casting quality as an initial material.**

**Innovation team**

## High melt standards as a precondition for casting quality

Ingot quality of the highest standard is characterised by their cast structure and the melt quality of the cast liquid metal. Above all, the melt quality is responsible for ensuring the provision of the strength, viscosity, surface and processing characteristics demanded by the customer. Melt quality can be defined by the amount of dissolved hydrogen in the liquid metal, the alkaline and alkaline earth metal content, as well as the inclusion content (metallic and non-metallic). All these factors have to be reduced to a minimum by the use of innovative melt treatment techniques. Increasing quality requirements make it essential that in addition to standardised melt refining during casting, every effort is made to enhance melt quality in the holding furnace.

## Melt treatment in the casting furnace

At present, salt, holding and gas purging treatments are available for liquid melt treatment in the casting and holding furnaces. In combination with reactive gases (e.g. $Cl_2$) circulation gas treatments using nitrogen or argon generally lead to a marked improvement in melt quality. The reactive components reduce the level of alkaline and alkaline earth metals and raise the performance of inclusion removal. Inclusions are reduced by means of their flotation using gas bubbles and efficiency can be assessed directly via the size of the bubbles introduced. The smaller these are, the greater the reaction area and hence the effectiveness of the treatment. Gas can be introduced via lances, graphite impellers, porous plugs, or nozzles. However, the smallest gas bubbles and thus the highest melt qualities can only be attained using impeller systems.

## Channel induction furnaces on two AMAG casting lines

At AMAG casting GmbH two different casting lines are fitted with tiltable channel induction furnaces with capacities of approximately 33 mt. These furnaces are used for casting and the gas purging treatment is carried out with an impeller using a mixture gas of chlorine and nitrogen. In order to attain maximum melt treatment success, the rotor blade of the impeller must be precisely matched to the furnace dimensions and its geometry. For this reason, within the scope of a thesis, a tailor-made rotor geometry was developed and the results of this work published in numerous media and international conferences [1-4].

## Simulation model

A simulation model was created in order to adjudge the operational behaviour of differing rotor types. This model was based on a 1:1 image of our channel induction furnace. The simulation was aimed at allowing the comparison of differing rotor types with regard to the resulting size and distribution of the gas bubbles, the stationary flow condition and melt homogenisation. Using the results from existing impeller geometries, aspects for the adaptation of rotor geometries can then be derived and a new rotor blade developed.

## Simulation results

Exemplary gas bubble behaviour and distribution in the melt for two differing rotors are shown in Fig. 1. In comparison both demonstrate unsatisfactory gas bubble size and distribution within the liquid metal. In the case of Rotor I, a gas flow develops, which moves along the shaft to the surface of the bath. This is due to the lack of geometric elements for the reduction of the size of the gas bubbles (Fig.1).

For this purpose, Rotor II has specially arranged recesses in the upper part of the rotor blade, which creates smaller gas bubbles, which spread out in a funnel formation.

The results shown by the simulation work were also found during investigations on

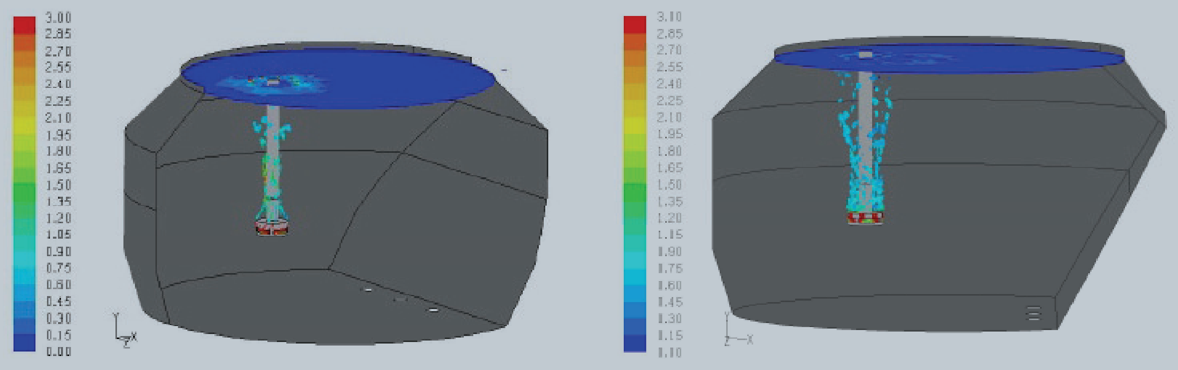


**Fig. 1:** Gas bubble formation during melt treatment with rotor geometry I (left) and gas bubble formation during melt treatment with rotor geometry II (right)

the real furnace and are entirely unsatisfactory. An impeller functioning in an optimum manner must be able to produce markedly smaller gas bubbles and distribute them throughout the entire furnace vessel.

The resulting stationary flow conditions were also used to adjudge the degree of melt homogenisation, the reduction in alkaline and alkaline earth metals, and the removal of both the dissolved hydrogen and the inclusions in the melt. This approach derives from the fact that the liquid metal must come into contact with the gas bubbles, which means that sufficient bath movement is an essential requirement. Rotor I attained the highest flow speeds in this area as a result of the gas flow, starting with gas outflow to the surface of the bath (see Fig. 2 left). At this point, a slight eddy effect is created in the upper part of the furnace, but virtually no movement in the lower half. Therefore, comprehensive melt movement is not given. By contrast to rotor I, geometry III provides sufficient melt movement (see Fig.2). In addition, this impeller creates the appropriate formation of flow eddies in the bottom half of the furnace, which can result in the greatly improved transport of contaminated melts to the reaction zone of the gas bubbles.

## Optimised rotor geometry

If one combines the positive characteristics of all the rotors examined and classifies them in line with their geometry, it is possible to create the ideal rotor geometry for the chlorination treatment. On this basis, a new impeller was developed (see Fig. 3) and is currently in use in the AMAG casting GmbH production process.

The lower half, the rotor star, transports the melt to and from the rotor blade thus allowing the desired melt exchange. In addition, this leads to the enhanced distribution of the gas bubbles along the rotor shaft. The input of the reaction gas takes place via specially arranged perforations on the rotor blade, the gas being transported by the rotary motion on the outer edge of the rotor. In the upper half, special noses, lead to a further reduction in gas bubble. The positive effect of the new PRI impeller on the quality of the melt forecast by means of simulation was clearly proven with the help of experimental testing.

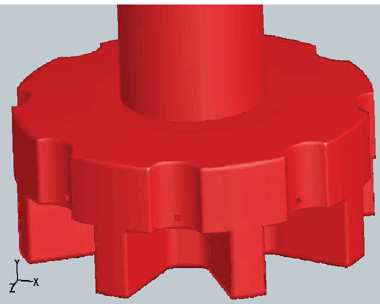

**Fig. 3:** The newly developed geometry of the AMAG casting GmbH PRI rotor.

As a result of the inventive geometry of the impeller, a highly innovative phase was added to the process sequence in our casthouse. This means that the company can now respond to still higher customer demands and underline even more clearly its role as a premium supplier.

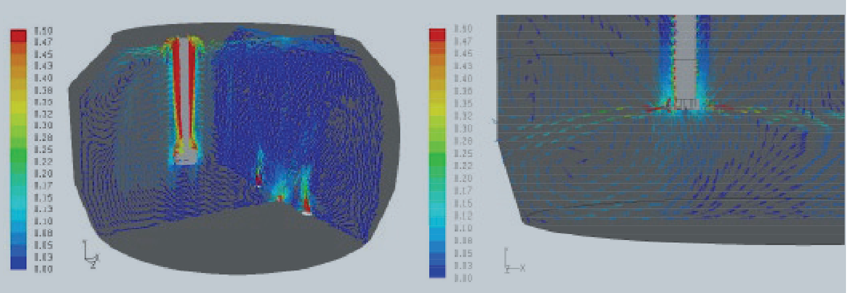

**Fig. 2:** Flow formation in a stationary condition using rotor I (vectors in [m/s], left) and rotor II (vectors in [m/s], right.

**References:**

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[2] B. Prillhofer, H. Antrekowitsch and H. Böttcher: Improving melt quality in casting furnaces by a gas purging treatment. Aluminium Alloys (Proceedings of the 11th International Conference on Aluminium Alloys), Wiley-VCH, Volume 1, (2008), p. 517-522.

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