The heating of road transport ladles by means of gas burners

Influence of heating technology on melt quality in liquid metal transportation ladles

Precisely at a time of increased competition, efforts are being made to achieve sustainable reductions in process and material costs. In this connection, with its liquid aluminium deliveries, AMAG casting, which for thirty years has enjoyed a reputation as a competent and reliable supplier of cast aluminium alloys, offers its customers a first class solution.

The economic advantages of liquid aluminium deliveries

This product not only includes the supply of the liquid aluminium itself, but also the technical and logistical advice of the customer. In this connection care must be taken that the high quality of the liquid metal in the transport ladle when it leaves the remelting plant is retained until it reaches the customer and is converted into the end product. A central premise in customer decisions for this product is the quantifiable economic advantage. This derives from a massive reduction in metal losses and decisive savings with regard to energy, logistics and current assets. In addition, short-term changes in customer needs can be covered in a targeted manner using liquid aluminium, which results in corresponding increases in productivity in combination with lower costs.

Initial study of heating methods and related quality factors

Long distance transportation of liquid metal alloys requires superheating to compensate temperature loss and to avoid any solidification. At the customer, the transport ladles sometimes replace holding furnaces or have to wait for metal transfer into the holding furnace. Therefore, the liquid metal must be heated at its destination. Foundry managers can choose between direct heating gas burners or indirect heating ceramic immersion heaters.

The type of heating technology for holding of the liquid aluminium in the transport ladle is addressed as an important process parameter with an influence on melt quality. So far, there hasn't been found a detailed investigation of the influence of both heating technologies on melt quality, by the authors. Therefore, AMAG casting examined the effects of both technologies on melt quality (hydrogen and inclusion content, as well as density index) using different measurement techniques (Table 1) and subsequently produced a summary of the results using the example of AlSi7Mg(Cu). Detailed results from studies on different alloys will be presented in specialist journals and at international conferences during 2010 [1, 2].

Heating technologies for liquid metal transportion ladles

Refiners and the foundry industry use gas burners (direct heating) as well as submerged immersion heaters (indirect heating) to operate ladles for road transportation. The advantages and disadvantages of both technologies are compared in Table 2 and usual application fields for these technologies are:

- preheating before filling (refiner)
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- holding before casting (foundry)

Subsequently, the density index as a function of holding time for the alloy AlSi7Mg(Cu) will be discussed in detail for both heating technologies.

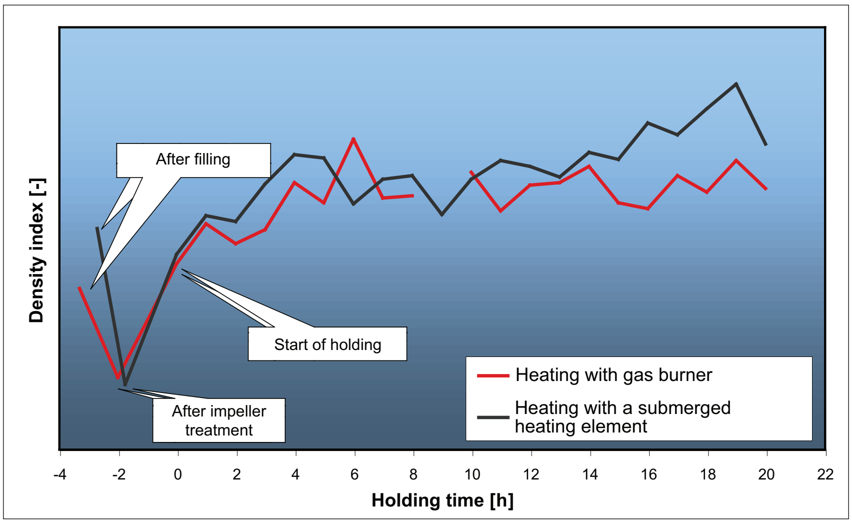

Fig. 1: Density index as a function of holding time for the alloy AlSi7Mg(Cu)

Influence of the heating process on the density index

The density index is a standard quality figure of aluminium foundry alloys and gives information about the gas and oxide film content of the liquid metal. Fig. 1 shows the density index as a function of holding time for one test series relating to the two differing heating technologies. Both test series demonstrate identical parameters with regard to the filling and the holding temperature, magnesium content, furnace treatment, etc., which makes them highly comparable. After the filling process, the pattern of the curves shows a differing density index, which in the course of impeller treatment (gas purging treatment with a graphite rotor) falls to the same level. As a result of the dependency of the density index on the amount of dissolved hydrogen in the melt, a gas purging treatment leads to a reduction in both melt quality parameters to a level below the system equilibrium concentration. Hence, the momentum to reach the system equilibrium is highly increased, which leads to another rise of both figures (the increase in the density index is presented in graphic terms in Fig. 1). This system equilibrium is achieved after a heating period of around 5 hours and is then retained. As a result of the constant oxide film concentrations, the related progression of the dissolved hydrogen in the liquid metal demonstrates similar behaviour. Therefore, on the basis of the test results presented it can be clearly shown that heating technology has virtually no effect on melt quality. ■

	Overview of melt quality figures and common evaluation methods		
	Hydrogen content	Density index	Inclusion content
AlSCAN	x		
1st bubble method	x		
Reduced pressure test		x	
PreFil®			x
PoDFA			x

Table 1: Overview of the methods used for the determination of melt quality

	Direct heating using a gas burner	Indirect heating using a submerged immersion heater
Pro	• Proven technology • Simple handling • Low maintenance efforts • Gas generally available • Tilting possible with fitted burners and therefore no energy losses	• Low temperature stratification in the ladle • No exhaust required with submerged electrical heating elements • Superior heat transfer
Contra	• H_2 absorption in the melt should the burners be incorrectly set • N_2 purging lance required in order to compensate for temperature stratification • Waste gases	• Complex mechanical engineering • Tilting only possible when the heating system is de-mounted • Submerged immersion heaters are extremely sensitive to mechanical loads • Risk related to the rupture of the submerged immersion heaters • Limited life of the electrical heating element

Table 2: The advantages and disadvantages of direct and indirect heating

Summary of the study results

No negative effects on the inclusion content
Both heating technologies (gas burner and submerged heating elements) have no negative effect on the inclusion content. Hence, melt quality has to be ensured by refiners before filling the transportation ladles.

Gas purging treatment prior to the casting process is of decisive importance
Impeller treatment in the remelting plants prior to the holding process leads to a marked reduction in hydrogen content. Afterwards, independent of the heating systems, the liquid metal picks up the hydrogen very quickly due to high momentum to reach system equilibrium concentration again. Therefore, it can be concluded that the gas purging treatment in the remelting plant is only of secondary importance. A low amount of dissolved hydrogen in the castings can only be guaranteed if the melt is impeller treated by the customer immediately prior to the casting process.

Influence on the density index
The density index shows the same behaviour due to its dependency on the hydrogen content. Again, it is absolutely essential to treat the melt before casting (impeller treatment) to ensure a low density index.

Quality, cost-efficiency and safety are arguments in favour of heating using gas burners
The employment of submerged heating elements carries an increased risk due to the danger of a rupture in the ceramic protective pipe. The usage of gas burners combined with nitrogen purging lances can be rated as being operationally safe and also guarantees uniform melt quality in tandem with low investment and maintenance costs.

Bibliography

[1] B. Prillhofer and J. Knaack: "Influence of heating technology on melt quality in ladles for road transportation of liquid aluminium casting alloys during holding", Light Metals 2010 (The Minerals, Metals & Materials Society), Seattle, USA, (2010), in print.

[2] B. Prillhofer, J. Knaack, H. Böttcher, H.. Suppan und H. Kaufmann, „Einfluss der Heiztechnologie auf die Schmelzequalität der Aluminiumgusslegierung AlSi9Cu3(Fe) beim Warmhalten in Straßentransporttiegeln", Giesserei, 1, (2010), in print