Use of Grain Refiner Flux in Wheel Castings

Hayati Sahin[1], Kerem Can Dizdar[2], Derya Dispinar[1*]
1. Vesuvius Foseco R&D, Enschede, The Netherlands
2. NTNU, Trondheim, Norway
*Corresponding address: e-mail: derya.dispinar@vesuvius.com

Abstract: Al5TiB is the most common grain refiner master alloy used in aluminum castings. The low efficiency, heterogeneity and fading of Ti rods have been a great concern. In this work, 25 wheels were cast (Al11Si alloy) with two grain refiners: Al5Ti1B in the form of rod, and Nucleant 1582 in the form of flux. The wheels were sectioned into three parts: bore, spoke and rim. Samples were machined to check the mechanical properties and grain size measurements. It was found that both Al5Ti1B rods and Nucleant 1582 had revealed quite similar results, although the addition ratio of flux was half of the Ti rod addition. In the case of use of Ti rod, a cleaning flux was also used. By the use of Nucleant 1582, reduction of consumables from 2 to 1 was achieved, because the flux had both cleaning and grain refinement features at the same time.

Keywords: Al11Si; Grain refinement; Flux

1 Introduction

Achievement of finer grains in casting of aluminum alloys known to have positive effects such as increased fluidity, increased feedability, decreased shrinkage, decreased porosity and increased mechanical properties. The process of grain refinement is the heterogeneous nucleation initiation by Al_3Ti, TiB_2 and AlB_2 intermetallic phases peritectically nucleates the α-dendrites. Due to the fundamentals of a peritectic reaction, the solid particles present in the liquid melt have the tendency to settle at the bottom of the crucible during casting operations known as the fading effect [1-2]. In foundries, the economical way is to melt large quantities and cast as many parts as possible. Therefore, the liquid metal is kept for long durations until the castings are complete. It was shown that 20 minutes was enough to start the settlement process of TiB_2 and $TiAl_3$ [3]. Thus, the grain refinement efficiency decreases.

Began [4] on the other hand introduced chemical grain refiner. It was in the form of granulates which was added to the melt during degassing operations. TiB_2 phases were formed in-situ which eliminated the requirement of surface energy and wettability. The risk of presence of possible oxides and impurities as in the case rods or waffles (i.e. quality) were no longer an issue in these fluxes. Additionally, since it was added in the form of flux (Nucleant 1582), it had the advantage of both cleaning the melt and grain refine simultaneously.

2 Experimental procedure

In this work, the effect of two different grain refiners on the microstructure and mechanical properties of Al11Si alloy was investigated. Al5Ti1B rod were added in the ratio of 1 kg/1 ton melt. On the other hand, from the family of Nucleant 158X grain refiner fluxes, Nucleant 1582 was selected for these trials and 0.55 kg/1 ton was added to melt during treatment. Degassing was carried out for 10 minutes with Foseco MTS 1500 system in 900 kg capacity transfer crucible. The chemical composition of the starting melt is given in Table 1. 25 wheels were collected in the sequence of 5 parts. Baker test samples were collected for grain size measurements. Wheels were heat treated for the conditions of 540 °C solutionizing for 6 hours, quenched in water and aged at 145°C for 4 hours. Samples were collected from three regions: bore, spoke and rim; and subjected to tensile testing.

Table 1. Composition of Alloy

Si	Fe	Cu	Mn	Mg	Sr	Ti
10.8	0.13	0.003	0.003	0.14	0.03	0.09

3 Result and discussion

The grain size measurements showed that Al5Ti1B rod added and Nucleant 1582 flux treated melt had quite similar grain size which was 291 and 276 μm, respectively (Fig 1).

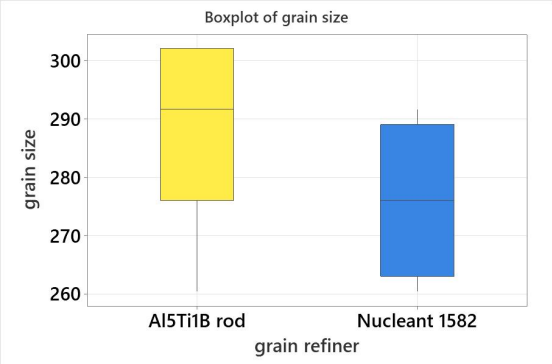

Figure 1. Grain size change with different grain refiners

The strength of Ti-rod and Nucleant 1582 flux treated melts revealed similar values in the different sections of the wheel as seen in Figure 2a. Same scenario and findings were observed for the elongation at fracture values which can be seen in Figure 2b.

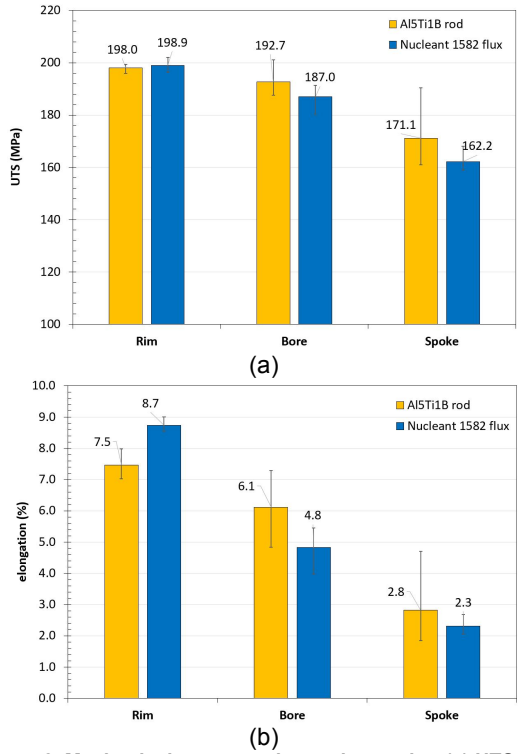

Figure 2. Mechanical property change by section (a) UTS, (b) elongation at fracture

One of the interesting observations was the change in Ti content of the melt by the casting sequence. At every 5th wheel, an OES sample was collected from the furnace and the results are presented for all three grain refiners in Figure 3. It can be seen that Ti content was decreasing towards the end of the melt when Ti rod was added to melt. On the other hand, when Nucleant 1582 flux was used, the Ti level was not changing and had remained constant through the casting process.

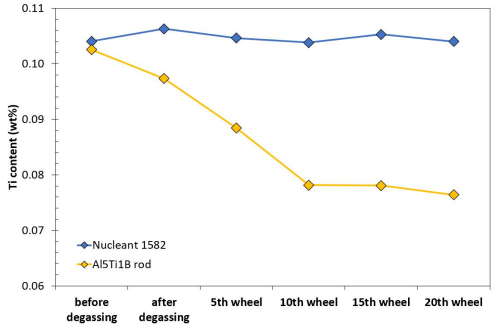

Figure 3. Ti wt% change by duration

4 Conclusion

There is no significant difference between Ti rod and Nucleant 1582 flux treatment of Al11Si alloy on the microstructure and mechanical properties of cast wheels. The addition ratio of the flux is half of the Ti rod addition, and the consumption of products was decreased to 1, instead of two when Ti rod was used (because no extra cleaning flux was added to melt as in Ti rod use). No fading effect was observed when flux was used compared to Ti rod added trials.

Acknowledgments

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