Available online at www.sciencedirect.com
ScienceDirect
Trans. Nonferrous Met. Soc. China 24(2014) 1346−1351

Transactions of
Nonferrous Metals
Society of China

www.tnmsc.cn

Melting purification process and refining effect of 5083 Al−Mg alloy

Cheng-guo MA, Shu-yan QI, Shuang LI, Huan-yan XU, Xiu-lan HE

School of Materials Science and Engineering, Harbin University of Science and Technology, Harbin 150040, China

Received 28 January 2013; accepted 7 July 2013

Abstract: To improve the poor stability of casting process of Al alloy with high Mg content, which leads to poor final product quality, the melting purification process and the influences of the refiner on the microstructure and defect of 5083 alloy were studied. The results show that the optimized process for the rotary impeller degassing of 5083 alloy is as follows: a rotary speed of 250−400 r/min; a gas flow of 1.2−2.0 L/s, a refining time of 10−15 min. This optimized process can reduce the gas content in the solid alloy to 2×10^{-3} mL/g or lower. Due to the addition of grain refiner, the cast microstructure of 5083 alloy is refined. The Al−5Ti−1B wire shows the best refining effect among all the refiners. The refining effect is improved with the increase of grain refiner addition amount. And the refinement effects become stable when Ti content reaches 0.1% or higher. The surface crinkling defect of the billet can be easily found in the alloy refined with Al−5Ti−1B wire compared with the alloys refined with other refiners.

Key words: Al−Mg alloy; melting; purification process; grain refiner

1 Introduction

5xxx series aluminum alloys are widely used due to their low density, good corrosion resistance, weldability, and plasticity, as well as a moderate tensile strength [1−3]. However, a number of defects such as inclusions, coarse grain, severe surface crinkles present during the melt processing and casting of flat ingot for most of aluminum alloy enterprises. These defects induce the metallurgical defects and cracking, which decrease the quality of finished products, and slow down the popularity of the 5xxx alloy in the market [4−7].

Coarse grains are easily formed during the last crystallization stage for 5083 alloy. The coarse grains with low melting point distribute inhomogeneously among grain boundaries and dendrite boundaries, which lead to a poor performance for plasticity and tensile strength, as well as a high risk of cracking. When the grain and dendrite are refined, the low melting point phases distribute inhomogeneously among grain boundaries and dendrite boundaries, which lead to a good performance for plasticity and tensile strength, as well as a low risk of cracking [8−10]. The grain size and the state of dendrite phase are highly dependent on the quality of grain refiner.

Harmful elements and impurities in the melts are mainly eliminated by solvent purifying, online degassing and filtering. A number of techniques have been proposed in foreign countries, including the process in-furnace standing and solvent treatment, N_2+Cl treatment, Ar+Cl treatment, N_2+Cl+CO treatment, out-furnace online SNIF treatment, Alpur method, and MINT method. Purifying methods for degassing hydrogen mainly include bubbles floatation method, vacuum treatment, and ultrasonic treatment. Vacuum degassing method performs advantages over other methods, such as good eliminating performance and no pollution, while the cost is much higher than that of the others. Bubble floatation method, as a gas purifying technique, becomes more and more popular. As one of the most promising method, online degassing gains great amount of interests from aluminum melting furnace industry. Typical online degassing methods include MINT method with fixing nozzle, SNIF and Alpur method with rotary impeller.

Some critical issues for the fabrication of large-size Al alloy with high Mg ingot include poor stability of casting process, uncertainties of melt treatment and homogenization process. At present, the key techniques of melt treatment and casting for 5083 alloy are investigated to improve the quality and the yield, and

---

Foundation item: Project (12511075) supported by the Foundation of Heilongjiang Education Committee, China
Corresponding author: Cheng-guo MA; Tel: +86-451-86392501; E-mail: 88528367@163.com
DOI: 10.1016/S1003-6326(14)63198-8

reduce the manufacturing cost [11−13].

2 Experimental

2.1 Melting process

5083 aluminum alloy used in this work was fabricated using fresh aluminum and recycled aluminum. The mass fraction of fresh and recycle aluminum was equal. The purity of fresh aluminum is 99.92%, while the recycled aluminum was composed of 99.95% Cu, 99.96% Mg and some other elements added in master alloy. Melting process was conducted in an electric furnace at the temperature of 700−750 °C. Stirring and refining were conducted for 10 min before furnace import. JRJ_2 solvent protection and no stirring were required during melting process. The melt was refined with Ar for 15 min in static furnace. The melt was soaked with solvent protection for 30 min. Hydrogen content was tested after soaking for 10 min. Casting was performed when the hydrogen content was up to the standard. The casting parameters were as follows: ingot specifications of 255 mm×1500 mm, casting speed of 90−95 mm/min, casting temperature of 695−710 °C, water pressure of 0.08−0.15 MPa. 40ppi ceramic filters and ceramic filter tube were used for purifying.

The degassing and purifying parameters for 5083 melt were as follows: melt mass of 50 kg, gas type of N_2 (99.9%); gas flow of 1.0, 1.2, 1.5, 2.0 L/s; rotary velocity of 100, 150, 200, 300, 450 r/min; degassing period 5, 10, 15, 20, 25 min.

2.2 Grain refining process

To investigate the effect of types and addition content of grain refiner on grain refinement, Al−Ti master alloy bulk, Al−Ti wires, Al−Ti−B wires and Al−Ti−C wires were selected as grain refiners. The influences of refiner type and its adding amount on grain size were studied. Casting was conducted according to the following parameters: ingot size of 255 mm×1500 mm, casting temperature of 715 °C, starting period for casting of 30 min, casting time of 102 min and cooling water pressure of 0.08 MPa. The microstructures of samples were analysed by Neophot-2 optical microscopy. The content of hydrogen in Al liquid was tested by JR-CQ apparatus.

3 Results and discussion

3.1 Effect of processing parameter on melt purification of Al alloy

Figure 1(a) shows the effect of degassing time on gas content of the melt with rotary speed of 300 r/min and gas flow of 1.5 mL/min. It indicates that as degassing time increase, the hydrogen content of alloy decreases significantly. The hydrogen content decreases rapidly during the first 10 min degassing period. Longer degassing period brings very little effects after 10 min. Hence actual degassing period is normally 10−15 min [14,15].

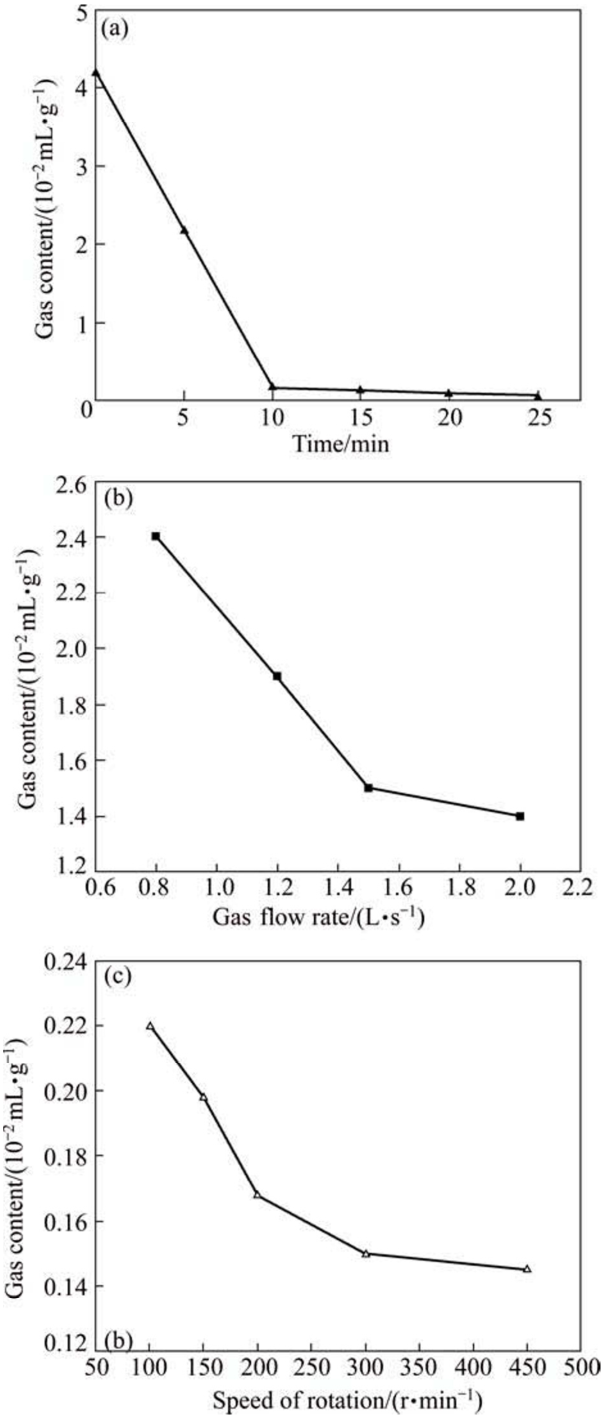

Fig. 1 Influence of parameters on gas content: (a) Degassing period; (b) Gas flow; (c) Rotary speed

Figure 1(b) shows the influence of gas flow on degassing performance with fixed rotary speed of 300 r/min for 15 min. It indicates that the hydrogen content of alloy decreases significantly with the increase of gas flow. When the gas flow increases to 1.5 L/s, the