The Change in the Porosity Distribution with Hydrogen Content of A357

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Abstract

ETIAL 177 (A357) was used in this work to cast T shape geometry where deliberate hot spot was generated to check porosity formation and distribution. Casting were made before and after degassing. Hydrogen level of the melt was measured by AlSPEK and found to be 0.12 and 0.30 mL/100g respectively. The hot spot region was slip into four parts and porosity measurements were made by using Clemex image analysis software. Reduced pressure test (RPT) samples were collected to quantify the melt quality by means of measuring bifilm index.

Keywords: Casting, Porosity, Casting quality, A357, Hydrogen

Özet

Bu çalışmada, A357 alaşımının gaz gidermeli ve gidermesiz dökümleri yapılmıştır. Dökümlerde sıcak yırtılma testi kokil kalıpları kullanılmıştır. Döküm öncesi sıvı metalde AlSPEK marka cihaz ile hidrojen içeriği ölçümü yapılmıştır. Kalıplardan elden edilen her parçanın muhtemel sıcak yırtılma oluşabilecek noktanın dört farklı bölgesinden mikroyapısal porozite ölçümü yapılmıştır. Gaz giderme işleminin etkinliğini ölçmek amacı ile de her dökümden RPT (Reduced Pressure Test) numuneleri alınmıştır. Sonuç olarak, gaz giderilmiş dökümler hidrojen içeriği ortalama 0,12 ml/100gr elde edilirken gaz giderilmemiş dökümlerde ortalama 0,30 ml/100gr olarak elde edilmiştir. RPT numunelerinde bifilm indeksleri çıkarılmıştır. Kokil kalıp dökümleri için porozite dağılımları ilişkisi çıkarılmıştır. Döküm kalitesi ile porozite ilişkisi ayrıca incelenmiştir.

Anahtar Kelimeler: Döküm, Porozite, Döküm Kalitesi, A357, Hidrojen

1. Introduction

Almost 90% of the Al-Si alloys cast are used in automotive industry. The main reason is the weight over strength ratio of these alloys. In addition, Al-Si alloys provide high impact strength, excellent castability, low thermal expansion and good corrosion resistance. One of the commonly used alloy group is Al-7Si alloys which find applications such as wheels, engine block and covers. In order to produce castings with minimized defects, many parameters need to be controlled [1].

Porosity has been held as the major defect that causes rejection of cast parts. Campbell and Dispinar has shown that porosity is formed only in the presence of bifilms regardless of hydrogen content. Solidification shrinkage and inadequate feeding causes the bifilms to open (i.e. unravel)

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to form porosity. However, in the literature, hydrogen has always been blamed for the porosity formation simply because the solubility of hydrogen is high at temperature above melting point and very low at solid aluminum [2]. Thus, it is suggested that hydrogen is released from the solidifying front to form porosity [3].

Dispinar [4] has carried out an extensive study with reduced pressure test (RPT) and showed that hydrogen was not the major source of porosity. He proposed an index that could be used to quantify aluminium melt quality by measuring the sum of maximum length of pores and called it bifilm index [5].

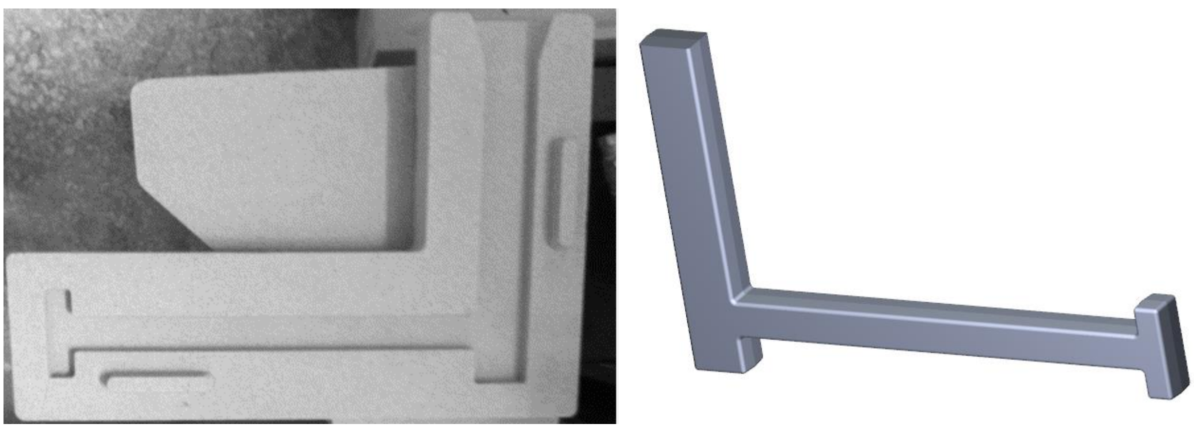
2. Experimental work

The composition of A357 used in this study is given in Table 1. The melting procedure was carried out in a resistance furnace in SiC crucible with 20 kg of charge melted melted at 750 ^{o}C.

Table 1. Chemical composition of A357

Si	Fe	Cu	Mn	Mg	Zn	Ti	Al
6,60-7,40	0,20	0,02	0,03	0,30-0,45	0,04	0,08-0,14	Rem

Figure 1 shows the dimension of the cast part produced in the experiments.



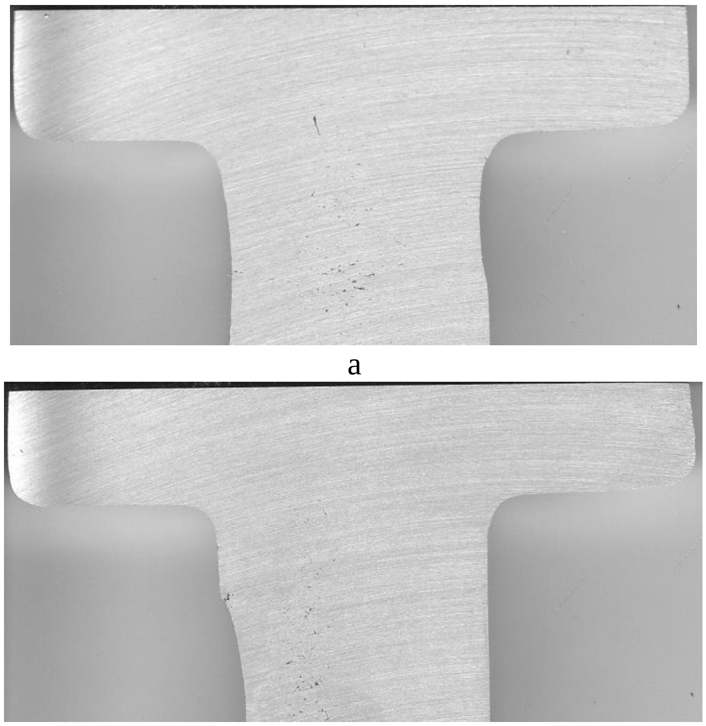
a) b)

Figure 1. a) Sand mould used in the castings, b) dimension of the cast part that is produced

Degassing was carried out for 20 minutes with Ar. AlSPEK was used to measure the hydrogen content of the melt. The samples were sectioned to the half and subjected to metallographical examination. Then, Clemex image analysis software was used to measure porosity size, area and distribution.

3. Results

Three casting were made to produce reproducible results. One of the selected images is given in Figure 2.



a

b

Figure 2. Cross section of samples cast
a) Untreated melt, b) degassed melt

The image analysis was carried out by splitting the cast parts into four regions as seen in Figure 3.

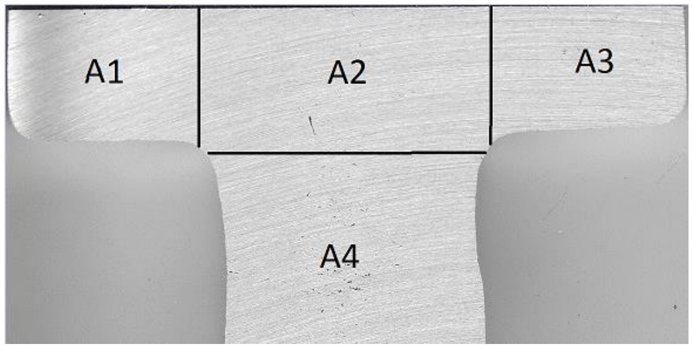


Figure 3. Sectioned areas of pore analysis

The bifilm index measurements were made in a reduced pressure test (Figure 4a) on the samples solidified in sand mould under 80 mbar vacuum.

Figure 4a. Reduced pressure test machine

Cross sections of RPT samples before and after degassing is given in Figure 4b.

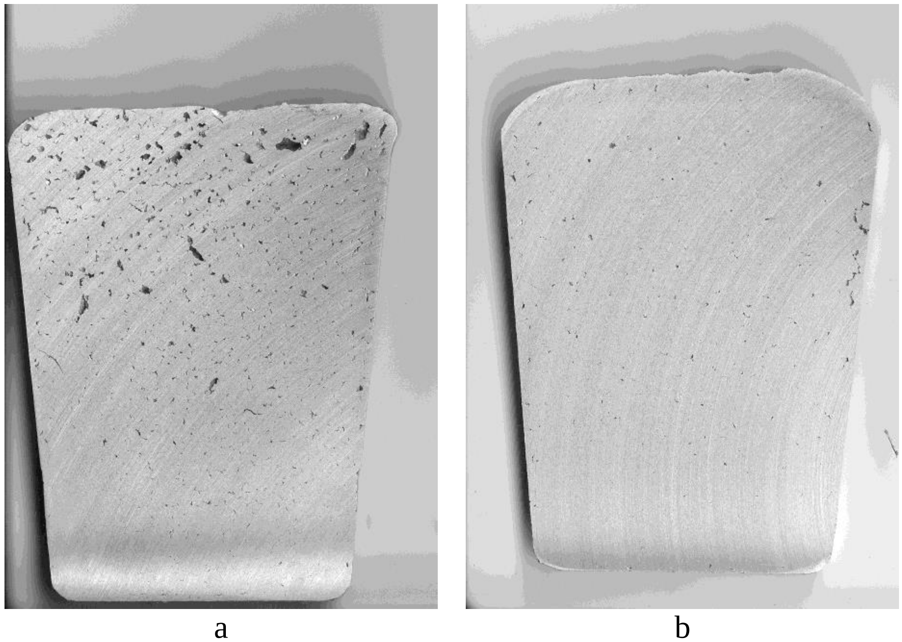


Figure 4b. Cross section of RPT samples
a) Untreated melt, b) degassed melt

The bifilm index measurements were made from the average of 6 samples and the results are given in Figure 5.

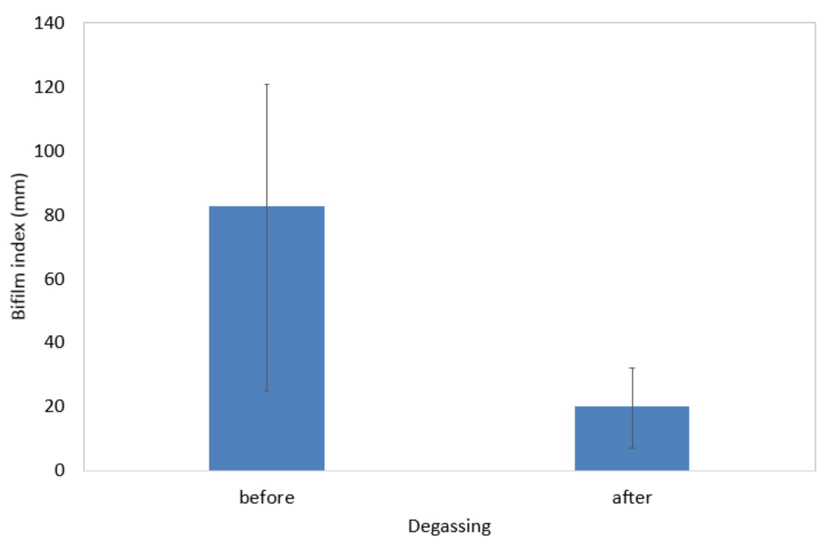


Figure5. Bifilm index measurements

The average porosity area per different sections of the cast part is summarized in Figure 6.

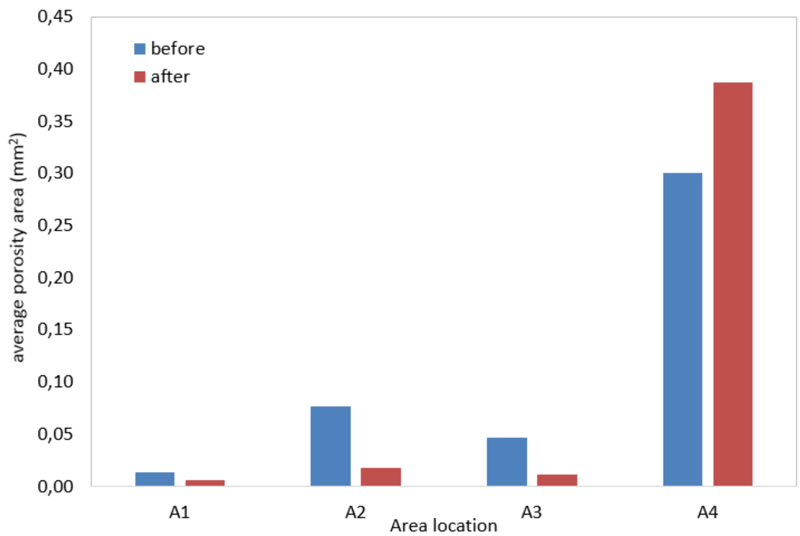
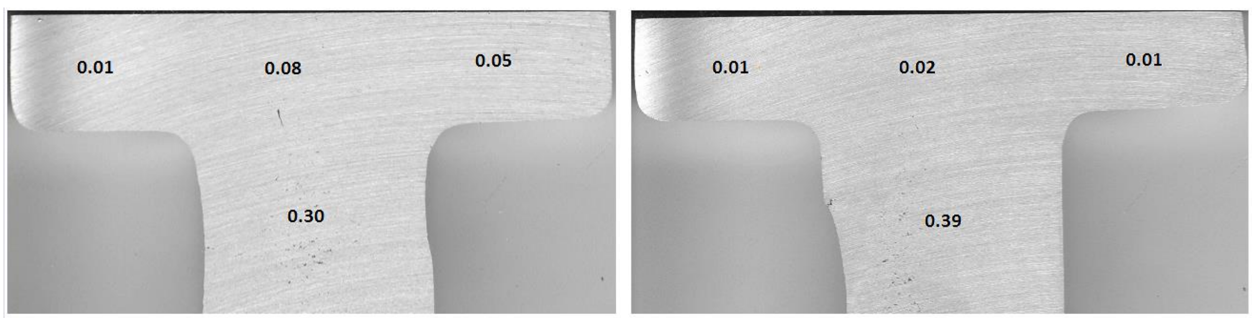


Figure 6. Average pore area distribution



a b

Figure 7. Distribution of pores along the sectioned areas of the cast part
a) Untreated melt, b) degassed melt

4. Discussion

Degassing of aluminium melts has been known to be beneficial particularly reducing the porosity formation. However, Dispinar had shown that uncontrolled and vigorous stirring of the melt may lead to porosity formation even in the low hydrogen contents. The reason was explained by the entrainment of surface oxide films in the form of bifilms into the melt. Bifilms are folded oxides which has no bonding between the films. Thus, they can be easily opened during solidification and form porosity. Dispinar had proposed bifilm index as a measure of aluminum melt quality which is calculated by the sum of maximum length of pores on the cross section of RPT samples. Since all pores are initiated by bifilms, an additional parameter was also used. This parameter was the number of pores. In this work, the bifilm index of the untreated melt was 80 mm and after degassing, the value was dropped down to 20 mm. However, as seen on the cross sections of RPT samples in Figure 4b, the number of the pores appear to be close to each other. Only the sizes were reduced. Therefore, as seen in Figure 6 and 7, the number of pores and the average area of pores for the untreated and degassed melt are close to each other. The hydrogen level of the untreated and degassed melt were measured to be 0.3 and 0.12 mL/100g respectively. Although, the area of pores are relatively higher in the untreated melt, yet, both castings revealed similar number of pores in the hot spot region.

Conclusion

Bifilm index can be used to quantify aluminium melt quality. In addition, the number of pores need to be included in the results.

Lower the hydrogen content do not imply a decrease in the porosity. It is the number of bifilms that need to be considered.

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