Material Engineering Practice IX

Edited by
Mária Mihaliková and Pavol Zubko

TRANS TECH PUBLICATIONS

Material Engineering Practice IX

Selected, peer reviewed papers from the
9th International Conference on
Material in Engineering Practice IX,
June 12-13, 2014, Herľany, Slovak Republic

Edited by

Mária Mihaliková and Pavol Zubko

TTP

Trans Tech Publications Ltd
Churerstrasse 20
CH-8808 Pfaffikon
Switzerland
http://www.ttp.net

Volume 635 of
Key Engineering Materials
ISSN print 1013-9826
ISSN cd 1662-9809
ISSN web 1662-9795

Full text available online at *http://www.scientific.net*

***Distributed** worldwide by*

Trans Tech Publications Ltd
Churerstrasse 20
CH-8808 Pfaffikon
Switzerland

Fax: +41 (44) 922 10 33
e-mail: sales@ttp.net

and in the Americas by

Trans Tech Publications Inc.
PO Box 699, May Street
Enfield, NH 03748
USA

Phone: +1 (603) 632-7377
Fax: +1 (603) 632-5611
e-mail: sales-usa@ttp.net

printed in Germany

Material Engineering Practice IX

Edited by
Mária Mihaliková
Pavol Zubko

PREFACE

9. Scientific-Technical Conference "Material in engineering practice, 2014". Its content was intended for the presentation of innovative materials on the possibility of improving the properties of materials on the effects of intrinsic and extrinsic properties on the quality of the material, but also on the degradation of properties during the operation. Attention was paid to the prediction of mechanical and technology materials properties as well as modern methods for testing the characteristics of materials.

The scientific-technical conference "Material in engineering practice, 2014" was held after the ninth time since 1984. So far, eight scientific and technical conferences and their findings confirm that the idea of the exchange of experience and personnel of the technical practice of researchers is necessary and beneficial for both sides. It can be concluded that personnel from practice need not only to solve acute material problems but also to know the new solutions of material products and parts for facility reconstructions.

The knowledge about the material mechanisms of degradation during actual conditions as well as their evaluation methodology is required for safe operation and the residual life of the device currently.

The 9^{th} conference was attended by 48 experts from practice and education. The participants were from Slovakia, Poland and Croatia. The conference took place in Herľany TUKE.

The organizers of the conference are convinced the main objective of the conference as the exchange of knowledge in the field of materials engineering has been fulfilled.

Mária Mihaliková and Ján Micheľ
Chair of the Conference

COMMITTEES

ORGANIZED BY

Faculty of Metallurgy

Technical University of Košice

Slovac Republic

CHAIR OF THE CONFERENCE

prof. Ing. Ján Micheľ, CSc.

doc. Ing. Mária Mihaliková, PhD.

prof. Ing. Marián Buršák, PhD.

LOCAL ORGANIZING COMMITTEE

doc. Ing. Mária Mihaliková, PhD.

prof. Ing. Marián Buršák, PhD.

Ing. Petra Lacková

Ing. Miroslav Német

SCIENTIFIC BOARD

prof.Ing. Emil Spišák, PhD.

prof.Ing. Peter Palček, PhD.

prof.Ing. Eva Tillová, PhD.

Acad. prof. Ing. Ilija Mamuzič, PhD.

prof.Ing. Marián Buršák, PhD.

prof.Ing. Ján Micheľ, CSc.

doc.Dr.Ing. Peter Horňák

Table of Contents

Key Engineering Materials Vol. 635 (2015) pp 1-4
© (2015) Trans Tech Publications, Switzerland
doi:10.4028/www.scientific.net/KEM.635.1

Submitted: 10.07.2014
Revised: 06.10.2014
Accepted: 16.10.2014

Changes of Mechanical Properties of AlSi7Mg0.3 Cast Alloy through Filtration

Eva Tillová[1, a], Mária Chalupová[1, b] and Lenka Hurtalová[1, c]

[1]University of Žilina, Faculty of Mechanical Engineering, Department of Material Engineering, Univerzitná 8215/1, 010 26 Žilina, Slovak Republic

[a]eva.tillova@fstroj.uniza.sk, [b]maria.chalupova@fstroj.uniza.sk, [c]lenka.hurtalova@fstroj.uniza.sk

Keywords: aluminium alloys, filtration, ceramic filters, mechanical properties, porosity

Abstract. Molten aluminium alloy is so active that it an easily chemically react with O_2 and H_2O to form Al_2O_3 inclusions and H during melting practice. However, some other inclusions form by process. Under turbulent flow conditions, the inclusions are distributed unevenly in molten aluminium alloy. They may associate with crack or by the location of crack initiation in solidified casting. Castings containing these inclusions will probably exhibit poor ductility or toughness. Therefore, the purification of the molten aluminium alloy is one of the most important processes for improving the quality of Al-products. The inclusions in molten secondary AlSi7Mg0.3 cast alloy (without refining or modification; grain refined with 55 ppm AlTi5B1 and modified with 20, 40 and 60 ppm AlSr10) were removed using depth filtration by ceramic foam and pressed filter. The results showed that the mechanical properties through filtration changes. Ductility and UTS of the filtered tensile specimens increases. The better mechanical properties were measured by the using of pressed ceramic filter. Highest UTS and ductility was observed for samples modified with 40 ppm of Sr. Filtration with ceramic filters have very significant influence on the porosity decreasing; in the process the better effect has a pressed filter. In samples modified with 60 ppm of Sr were observed effect of over modification (mechanical properties decreased; porosity increased).

Introduction

Al-Si alloys are well-known casting alloys with high wear resistance, low thermal-expansion coefficient, good corrosion resistance, and it can improve mechanical properties at a wide range of temperatures. These properties led to the application of Al-Si alloys in the automotive industry, especially for cylinder blocks, cylinder heads, pistons, and valve lifters [1].

To produce a high-quality product, it is necessary to produce an Al-Si casting that has the prescribed shape and dimensions, without any external/internal defects, including all the required mechanical, technological, structural, and other properties [2]. As the use of cast aluminium has increased, so have the mechanical property requirements. Because the molten aluminium alloy has a great influence on the final microstructure and, hence, the mechanical properties, aluminium foundries are devoting an increased amount of effort and attention towards improving the molten metal quality. A number of techniques exist for the improving the cleanliness of the melt, including sedimentation, fluxing, degassing, and filtration of the melt prior to casting. In all of these techniques, the aim is to remove impurities that can adversely affect the physical integrity and mechanical properties of the casting [2 - 4].

Filters have been used for many years in order to improve the quality of castings [5]. Filtration is the process of separating solid particles from the melt, with the solid particles being captured on the filter and the liquid phase passing through the filter. In addition to solid particles, there are also semi-liquid phases of high viscosity in molten metals; this fraction is captured by the adhesion mechanism, i.e. the particles stick to the filter walls [2, 6 - 8].

Generally, there are two mechanisms by which filtration are accomplished - deep bed filtration and cake filtration. Cake filtration is the most familiar mechanism, where the filter acts as a sieve, and retains particles larger than its pore size on the surface of the filter. Deep bed filtration occurs within the body of the filter medium as the metal flows through the pores of the filter. Particles are trapped and held by electrostatic forces as they contact the pore walls. Trapped particles are usually significantly smaller than the filter pore size [2 - 3].

Another effect of using filters that not all users consider is the possibility to control the mould filling and the turbulence of the melt [5 - 8].

The present study is a part of larger research project, which was conducted to investigate and to provide better understanding properties of secondary Al-cast alloys. This work is focused on the filtration effect on mechanical properties of secondary (recycled) Al-Si cast alloy.

Experimental

A secondary (scrap-based - recycled) AlSi7Mg0.3 cast alloy (in wt. %: 7.1 % Si - 0.38 % Mg - 0.42 % Fe - 0.025 % Sr - 0.095 % Ti - 0.005 % Mn - 0.001 % Cu - base Al) was used. AlSi7Mg0.3 alloy be used for high temperature casting (e.g. engine, pistons). This alloy was melted in a high frequency electric furnace at melting temperature of 760 °C. The melt was grain refined with AlTi5B1 and modified with AlSr10 (Table 1).

Table 1 Amount of additives in individual melts

Melt number	AlTi5B1 (ppm)	AlSr10 (ppm)
1	-	-
2	55	20
3	55	40
4	55	60

Four different melts (Table 1) were cast in to metallic mould without the using of ceramic filter and with the using of ceramic pressed and foam filter (Figure 1). The filters were located in a casts hollow in front of entrance of melt to the mould (Figure 2). The experimental casts (bars ϕ 18 x 155 mm) were heat treated - hardened (solution heat treatment at 535 °C/8 hours, quenching in warm water and the ageing at 170 °C/8 hours, free air quenching). From the castings were made specimens for tensile test according to standard STN EN 10002-1 and samples for the evaluation of porosity. The tensile test was performed on a tensile machine ZDM 30 at 21 °C. Values of ultimate tensile strength (UTS) were determined by the average of value of three test bars.

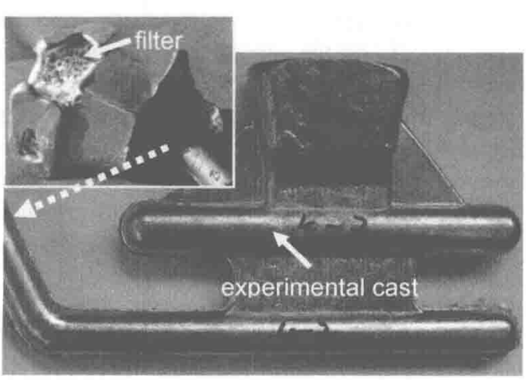
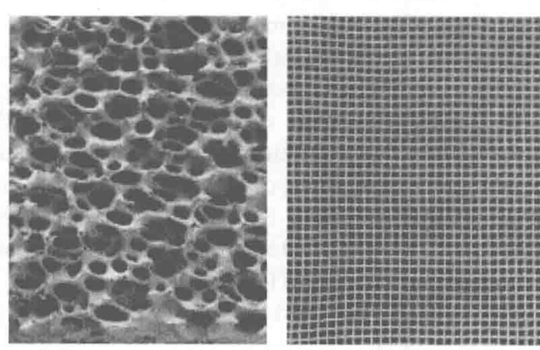


Fig. 1 Location of ceramics filter



a) ceramic foam filter b) ceramic pressed filter

Fig. 2 Morphology of ceramic filters

Metallographic samples were prepared from selected tensile specimens (after testing) and the microstructures were examined by optical (Neophot 32) microscopy. Specimens were sectioned and prepared by standards metallographic procedures including etching by 0.5 % HF [9].

Results and Discussion

Test results are showed in the Figures 3 - 5. Highest UTS in melt without filter was measured in melt 3 (298 MPa) probably after optimal modification (40 ppm Sr). Ultimate tensile strength in filtrated melt was changed from approximate 260 to 312 MPa. Highest UTS was observed for modified samples with 40 ppm of Sr too. After over modification (60 ppm Sr) was measured decreasing of values of ultimate tensile strength.

Ductility was very variable as shows Figure 4, but it may be write that the ductility significantly increased after filtration. The highest values of ductility were measured for pressed filtered and modifier samples with 40 ppm of Sr (13.6 %).

It appears then that in the case where the filter print is empty, the metal is just going down under the action of gravity. In the case of the pressed ceramic filter, as the metal is flowing in the direction of the filter, the metal stream is just going through the filter. In the case of the foam filter, a large quantity of metal is stopped by the filter, which seems to be gradually filled and probably a large amount of liquid start to fill the cavity above the filter. That may explain less filtration efficiency of foam filter beside pressed filter and lower mechanical properties.

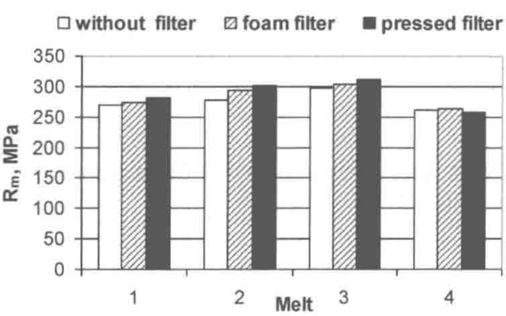


Fig. 3 Effect of filtration on UTS

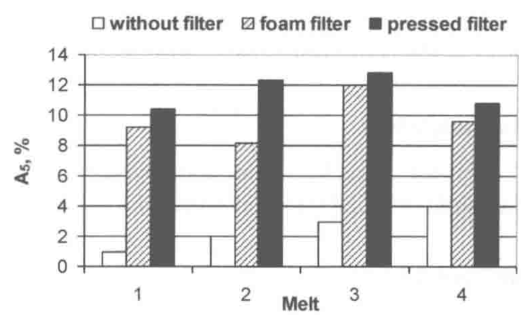


Fig. 4 Effect of filtration on ductility

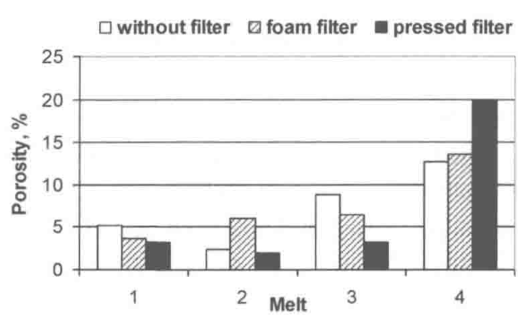
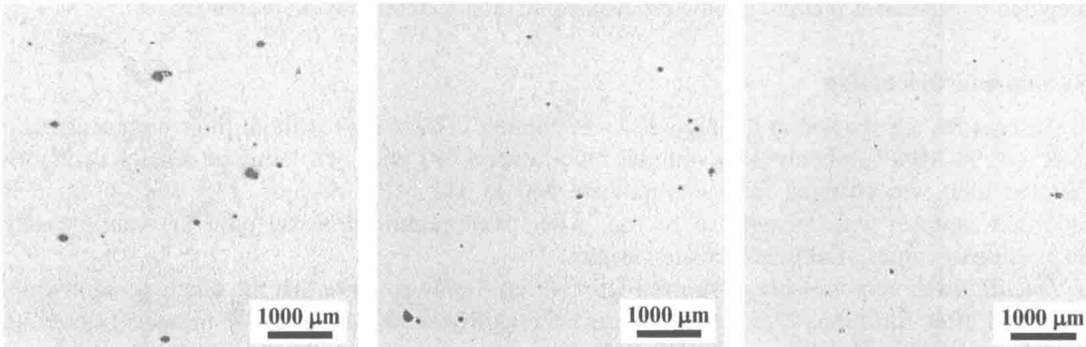


Fig. 5 Effect of filtration on porosity

Porosity was evaluated by quantitative metallography (software NIS Elements) [9], as the area share of pores on one section by 25 x magnification (Figures 5 and 6). With the exception of melt 4, using of ceramic filters makes lower porosity and the better values were reached by the using of pressed filter. At the Figure 6 is comparison of porosity in the melt 3 (40 ppm Sr) without and by the using of individual ceramic filters.

In melt 4 porosity increases probably after over modification by 60 ppm Sr.



a) without filter b) with the foam filter c) with the pressed filter

Fig. 6 Effect of filtration on porosity - macrostructure of AlSi7Mg0.3, etch. 0.5 HF

Summary

The experiments with filtration of secondary AlSi7Mg0.3 cast alloy showed that the ductility of the filtered tensile specimens increases. The better mechanical properties (UTS and ductility) were measured by the using of pressed ceramic filter independently on the quantum of modifiers element. Highest UTS and ductility were observed for samples modified with 40 ppm of Sr.

Filtration with ceramic filters has very significant influence on the porosity decreasing; in the process the better effect has a pressed filter.

Acknowledgements

This work has been supported by the Scientific Grant Agency of Ministry of Education of Slovak Republic N°1/0841/11 and project EÚ - ITMS: 26110230117.

References

[1] Y. Shufang et al., Application of CX-type modifiers in Al-Si alloys. J. Univ. Sci. Technol. Beijing, 10, 2 (2003) 34-38.

[2] J. Roučka et al., Casting Alloy Filtration. Czech Foundry Society, Brno, (2000).

[3] E. Tillová et al., Quality control of microstructure in recycled Al-Si cast alloys. Manufacturing Technology, 11 (2011) 70-76.

[4] J. Adler, Ceramic Diesel Particulate Filters. Int. J. Appl. Ceram. Technol., 2, 6 (2005) 429-439.

[5] M. Di. Sabatino et al., The influence of oxide inclusions on the fluidity of Al-wt. % Si alloy. Materials Science and Engineering A, 413-414 (2005) 272-276.

[6] M. Zhou et al., Deep filtration of Molten Aluminium using Ceramic Foam Filters and Ceramic Particles with Active Coatings. Metallurgical and Materials Transactions A, 34A (2003) 1183-1191.

[7] L. Liu, F. H. Samuel, Assessment of melt cleanliness in A356.2 aluminium casting alloy using the porous disc filtration apparatus technique. Journal of Materials Science, 32 (1997) 5927-5944.

[8] H. L. de Moraes et al., Removal of Iron from molten recycled Aluminium through Intermediate Phase Filtration. Materials Transactions, 27, 7 (2006) 1731-1736.

[9] E. Tillová, M. Chalupová, Structural analysis of Al-Si cast alloy (in Slovak). EDIS ŽU, Žilina, (2009).

Key Engineering Materials Vol. 635 (2015) pp 5-8
© (2015) Trans Tech Publications, Switzerland
doi:10.4028/www.scientific.net/KEM.635.5

Submitted: 09.07.2014
Revised: 24.09.2014
Accepted: 16.10.2014

Fatigue Properties of Synthetic Nodular Cast Irons

Alan Vaško[1, a *]

[1] University of Žilina, Faculty of Mechanical Engineering, Department of Materials Engineering, Univerzitná 8215/1, 010 26 ŽILINA, Slovakia

[a] alan.vasko@fstroj.uniza.sk

Keywords: nodular cast iron, synthetic melts, silicon carbide, microstructure, fatigue tests

Abstract. The contribution deals with comparison of microstructure, mechanical properties and fatigue properties of synthetic nodular cast irons with a different ratio of steel scrap in a charge. Chemical composition of individual melts was regulated alternatively by ferrosilicon (FeSi) and carburizer or metallurgical silicon carbide (SiC). The paper shows positive influence of SiC additive on the microstructure, mechanical properties as well as fatigue properties of nodular cast iron. The additive of metallurgical silicon carbide in analysed specimens increases the content of ferrite in the matrix, decreases the size of graphite and increases the average count of graphitic nodules per unit of area. Consequently, the mechanical and fatigue properties of nodular cast iron are improved.

Introduction

The fatigue has been a predominating fracture mode of load-bearing machine members. Therefore, through the years its prevention has become a fundamental design criterion. Although fatigue has been studied extensively over many years and excellent reference books are now available, further study is warranted because the knowledge base, although large, is partly obsolete and new materials and treatments are continuously being developed. Fatigue testing is usually performed to estimate the relationship between the amplitude of stress and the number of cycles to failure for a particular material or component. Fatigue testing is also conducted to compare the fatigue properties of two or more materials or components [1].

Nodular cast iron is a group of cast structural materials with a wide application in engineering practice (especially in the automotive industry). It combines high tensile strength and plasticity with high fatigue strength. Nodular cast iron can be produced according to the classical or synthetic casting procedure, which is more economical because cheaper steel scrap is added to the charge instead of more expensive pig iron [2]. The transition from the traditional use of pig iron to synthetic nodular cast iron prepared from steel scrap requires the regulation of chemical composition of melt. It is advantageous to use the metallurgical silicon carbide (SiC) as a siliconizing and carburizing additive instead of the ferrosilicon (FeSi).

Experimental material and methods

The specimens from four melts of nodular cast iron were used for experiments. The melts were different by charge composition (Table 1). The basic charge of individual melts was formed by different ratio of pig iron and steel scrap and by different additive for the regulation of chemical composition (metallurgical silicon carbide or ferrosilicon). The content of these additives was chosen to achieve approximately the same resultant chemical composition of the melts. For modification the FeSiMg7 modifier was used and for inoculation the FeSi75 inoculant was used.

Experimental bars (diameter 32 mm and length 350 mm) were cast from all the melts and consequently experimental specimens for tensile test, impact bending test, hardness test and fatigue tests were made.

Table 1 Charge composition of experimental melts

Melt number	pig iron [%]	steel scrap [%]	additive	modification & inoculation
3	40	60	SiC90	FeSiMg7 + FeSi75
5	0	100		
8	40	60	FeSi75 + carburizer	
10	0	100		

The metallographic analysis of specimens from experimental melts was made by the light metallographic microscope Neophot 32. The microstructure of specimens was evaluated according to STN EN ISO 945 (STN 42 0461) and by automatical image analysis (using NIS Elements software) [3,4].

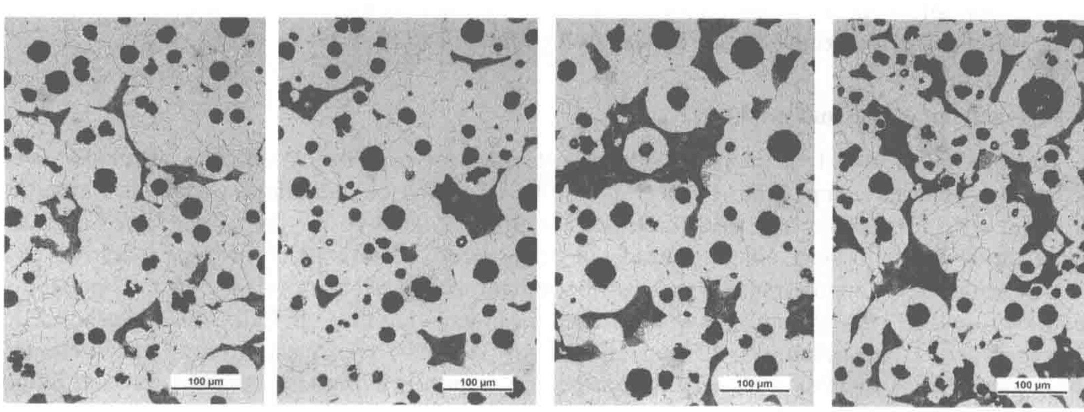
The tensile test was made according to STN EN 10002-1 by means of the testing equipment ZDM 30 with a loading range F = 0 to 50 kN. The impact bending test was made according to STN EN 10045-1 by means of the Charpy hammer PSW 300 with a nominal energy of 300 J. The Brinell hardness test was made according to STN EN ISO 6506-1 by means of the testing equipment CV-3000 LDB with a hardmetal ball of diameter D = 10 mm forced into specimens under the load F = 29 430 N (3000 kp). The fatigue tests were made according to STN 42 0362 at high-frequency sinusoidal cyclic push-pull loading (frequency $f \approx 20$ kHz, stress ratio $R = -1$, temperature $T = 20 \pm 5$ °C) using the ultrasonic testing equipment KAUP-ZU [5].

The microfractographic analysis was made by the scanning electron microscope VEGA II LMU on fracture surfaces of the specimens from experimental bars fractured by fatigue tests.

Experimental results and discussion

From a microstructural point of view, the specimens from all the melts are ferrite-pearlitic nodular cast irons with different content of ferrite and pearlite in the matrix, different size of graphite and count of graphitic nodules (Fig. 1). Different content of ferrite and pearlite in the matrix as well as different size of graphite and count of graphitic nodules in the individual specimens are caused by different ratio of steel scrap in the charge and kind of additive for the regulation of chemical composition (SiC or FeSi).

The results of the evaluation of the microstructure of the specimens from the cast bars by STN EN ISO 945 (STN 42 0461) and by image analysis (content of ferrite and count of graphitic nodules) are presented in Table 2.



a) melt 3 (with SiC additive) b) melt 5 (with SiC additive) c) melt 8 (with FeSi additive) d) melt 10 (with FeSi additive)

Fig. 1 Microstructure of the specimens from cast bars, etched 1% Nital