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Self-Hardening AlZn10Si8Mg Aluminium Alloy as an Alternative Replacement for AlSi7Mg0.3 Aluminium Alloy

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Abstract

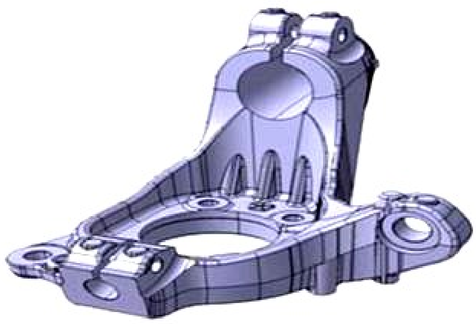
This article deals with the fatigue properties of newly used AlZn10Si8Mg aluminium alloy where the main aim was to determine the fatigue strength and compare it with the fatigue strength of AlSi7Mg0.3 secondary aluminium alloys which is used in the automotive industry for cyclically loaded components. AlZn10Si8Mg aluminium alloy, also called UNIFONT 90, is self-hardening (without heat treatments), which contributes to economic efficiency. This is one of the main reasons why is compared, and may be an alternative replacement for AlSi7Mg0.3 alloy which is heat treated to achieve required mechanical properties. The experiment results show that the fatigue properties of AlZn10Si8Mg alloy are comparable, if not better, than AlSi7Mg0.3 alloy. Fatigue properties of AlZn10Si8Mg alloy are achieved after seven days of natural ageing, immediately after casting and achieving value of fatigue strength is caused by structural components formed during solidification of the melt.

Keywords: Secondary AlSi7Mg0.3 alloy, AlZn10Si8Mg alloy, Heat treatment of Al-alloys

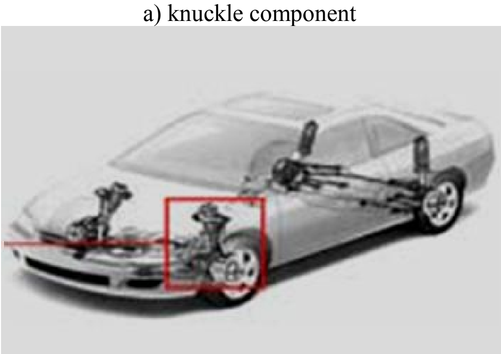
1. Introduction

Aluminum alloy AlZn10Si8Mg that began to use in the automotive industry to cyclic stress components, are increasingly appearing in practice, this is the main reason why doing research and development on this newly used alloy [1].

In the Fig. 1a is shown knuckle component used in cars. Considering complexity of the shape, this knuckle component is produced by casting from aluminum alloy AlSi7Mg0.3 and then machined. AlSi7Mg0.3 has excellent foundry properties and therefore is often used on castings for the automotive industry. After cast and machining of knuckle component followed heat treatment. The mode of heat treatment is selected T6, which consists of solution annealing, quickly cooling in water and artificial aging. If would be possible production of this knuckle components from AlZn10Si8Mg alloy, which is self-hardening, without heat treatment, it would be achieve reduce of production costs. Before converting confusion is necessary to find out, whether AlZn10Si8Mg alloy has conditions for particular use. These material must have high fatigue lifetime and good other mechanical properties for example tensile strength, yield strength and hardness [1 - 3].



a) knuckle component



b) location of component

Fig. 1. Example of using AlSi7Mg0.3 alloy in cars [2]

2. Experiment

The aim of the experiment was to perform fatigue test on self-hardening AlZn10Si8Mg aluminum alloy. To determine fatigue strength of this alloy and compare it with the fatigue strength of the alloy AlSi7Mg0.3 (A356).

2.1. Experimental material

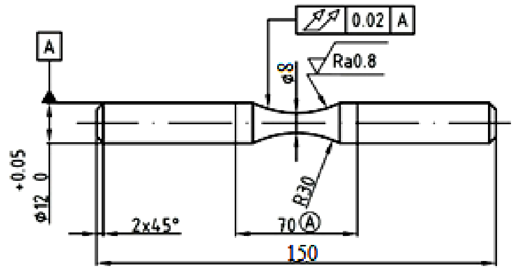
As experimental material was used secondary AlZn10Si8Mg (UNIFONT 90) aluminum alloy with chemical composition shown in Table 1. The alloy is based on aluminum, zinc and silicon and further additives and supporting elements, wherein the zinc content is between 1 -10 mass %. Despite of high zinc content, this alloy belongs to the typical Al-Si alloys, because it has similar structure than hypoeutectic Al-Si alloys [7, 8].
The experimental material has been casted into a sand mold. According to requirements, the material is not modified and inoculated. The rod with diameter of 20 mm and 280 – 300 mm length was used for the preparation of the samples for fatigue test [1, 9].

Table 1.
Chemical composition of AlZn10Si8Mg alloy (mass %)

Zn	Si	Cu	Fe	Mn	Mg	Ti
9.6	8.46	0.005	0.1143	0.181	0.452	0.0622
Ni	Cr	Ca	Cd	P	Sb	Al
0.0022	0.0014	0.0002	0.0001	0.0001	0.0007	balance

2.2. Experiment methodology

Fatigue tests were carried out in accordance with standard STN 42 0363, which prescribes a methodology for testing. The aim of fatigue test was detect fatigue strength of experimental alloy AlZn10Si8Mg. Fatigue tests were carried out on 11 rods test with diameter 8 mm in the working part (Fig. 2). They were implemented high-cycle fatigue tests at frequency f = 30 Hz, temperature of test T = 20 ± 5 °C, coefficient of cycle asymmetry R = -1. Test equipment was adjusted on the number of cycles $3 \bullet 10^6$ and if the test rod withstand this number of cycles, test was stopped and test rod was good. The number of good test rods was 5, when 3 was not failure by stress amplitude 60 MPa [4 - 6].



a) scheme

b) sample after fatigue test

Fig. 2. Shape and dimensions of test rods before and after fatigue test

3. Results

The results of fatigue test are shown in Table 2 and graphically illustrated in Fig. 3.

3.1. Achieved results of fatigue test

It was stated that fatigue strength was **σ_c= 60 MPa,** this value was determined on the basis 3 test rods, which were not failure by this stress amplitude. It is necessary that fatigue strength was determined on samples without heat treatment. The value of the fatigue strength is higher than value, which was found out Boromei et al. (2010) in experimental work on alloy AlSi7Mg0.3 what is common Al-Si-Mg alloy typical for castings with fatigue strength σ_c=50 MPa. This alloy was heat treatment. The fatigue strength found out by Panuska (2006) was σ_c=70 MPa on heat treatment AlSi9Cu alloy.

Table 2.
Parameters of fatigue test and results

no. samples	Stress amplitude - MPa	Number of cycles	failure/ run out
1	100	282000	failure
2	70	2608000	failure
3	60	2521000	run out
4	90	553000	failure
5	80	982000	failure
6	100	437000	failure
7	90	457000	failure
8	70	3000000	run out
9	80	3000000	run out
10	60	3000000	run out
11	60	3211000	run out

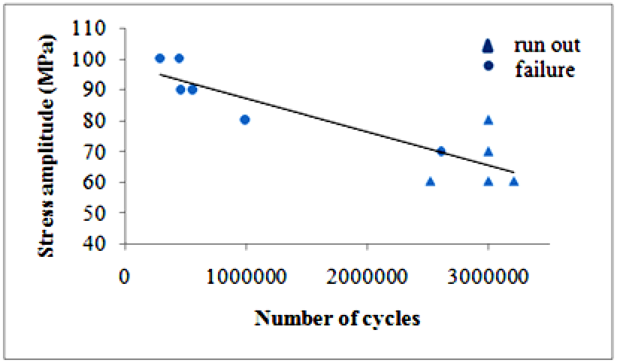
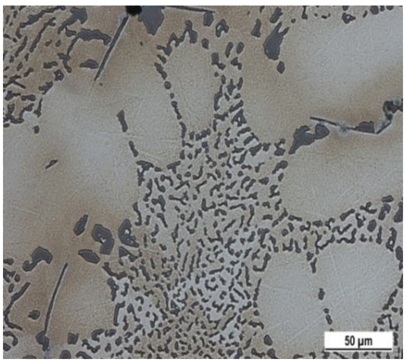


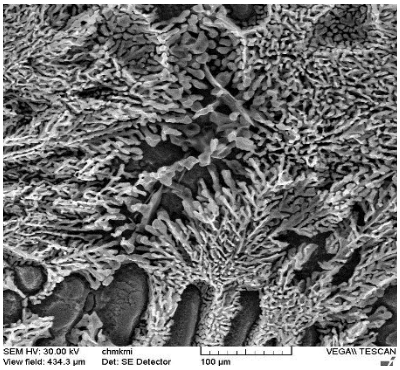
Fig. 3. Wöhler curve

3.2. Structural analysis

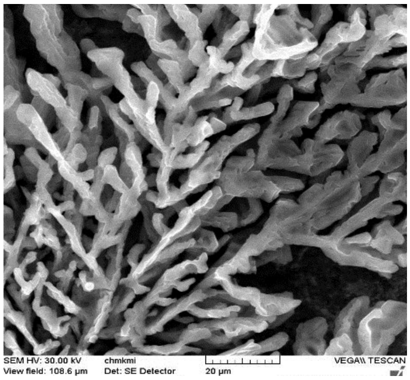
In the Fig. 4 is shows shape of eutectic silicon AlZn10Si8Mg alloy. Eutectic silicon has shape of imperfectly rounded grains in the plane of metallographic section (Fig. 4a) and in space the shape of rods (Fig. 4b, c).



a) imperfectly rounded grains, etch. 0,5 % HF



b) rod-shape of silicon, etch. HCl, REM



c) detail of rod-shape of silicon, etch. HCl, REM

Fig. 4. Morphology of eutectic silicon AlZn10Si8Mg alloy

Rod shape is acceptable because it increases the mechanical properties and in particular the fatigue resistance. This shape do not cause such stress concentration to fatigue cracking like hexagonal shape that in space of metallographic section is observed as needles. Rod shape of eutectic silicon in AlZn10Si8Mg alloy has been achieved without modifying and heat treatment. This shape probably depends on some elements such which appeared in the alloy. This is one of the reasons why this type of alloy is suitable for industrial applications [8 and 9].

4. Conclusion

The aim of the experiment was to carry out fatigue tests at room temperature at AlZn10Si8Mg self-hardening aluminum alloy, determine the fatigue strength and compare it with the fatigue strength of the AlSi7Mg0.3 alloy. It was stated that fatigue strength of AlZn10Si8Mg is σ_c= 60 MPa, this fatigue strength is higher than fatigue strength of AlSi7Mg0.3 alloy. One of the main reasons why AlZn10Si8Mg self-hardening aluminum alloy achieves this fatigue strength is due to structural components, such as shape of eutectic silicon. Shape of eutectic silicon of AlZn10Si8Mg alloy has in space rod shape (Fig. 4), which is achieves without heat treatment and modification. From the results obtained stated that the AlZn10Si8Mg alloy is suitable for cyclically loaded components and it is a possible alternative for AlSi7Mg0.3 alloy.

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References

[1] Panušková, M. (2006). Improve the performance of selected aluminum alloys for castings, Dissertation project, University of Zilina, 62 p.

[2] Castella, CH. (2015). Self hardening aluminum alloys for automotive applications, PhD thesis. Politecnico di Torino, 2015. 136 p.

[3] Boromei, I. et al. (2010). Influence of the solidification microstructure and porosity on the fatigue strength of Al-Si-Mg casting alloys. *Metallurgical Science and Technology*. 28(2), 18-24.

[4] Tillová, E., Chalupová, M. (2009). *Structural analysis of Al-Si alloys*. Zilina, 191 p. ISBN 978-80-554-0088-4.

[5] Ďuriníková, E. (2012). The effect of selected factors on the structure and properties of the secondary aluminum alloy AlZn10Si8Mg, dissertation, University of Zilina, 125 p.

[6] Brezinová, J., Draganovská, D., Guzanová, A., Vojtko, M. (2014). The Wear Evaluation of Blasting Machine's Blades, In Key Engineering Materials, Vol. 635, p. 190-193, ISBN 978-3-03835-344-7, ISSN 1662-9795.

[7] Pastirčák, R. (2014). Effect of low pressure application during solidification on microstructure of AlSi alloys. In Manufacturing technology. *Journal for Science, Research and Production*. 14(3), 397-402. ISSN 1213-2489.

[8] Bolibruchová, D., Macko, J. & Brůna, M. (2014). Elimination of negative effect of Fe in secondary alloys AlSi6Cu4 (EN AC 45 000, A 319) by nickel. *Archives of Metallurgy and Materials*. 59(2), 717-721. ISSN 1733-3490.

[9] Nigrovič, R., Meško, J. & Zrak, A. (2016). The Influence of Laser Beam on the Surface Integrity of Cutting Edge, In Manufacturing technology. *Journal for Science, Research and Production*. 16(6), 1332-1336. ISSN 1213-2489.