

## MECHANICAL PROPERTIES ACCORDING TO SPECIAL ALLOYS USED TO CASTING

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### Abstract

This article is focus on different alloys used to casting same part „COVER” 5 different aluminum alloys were studied for the best mechanical properties. Mechanical properties were evaluated in the same place from casting. Customer had special requirements on mechanical test. Suitable product was not governed by the mechanical properties obtained from standard tensile test. This special test was determined about correct or non-correct product. Mechanical properties were studied for better information about alloys for manufacturer. Measured mechanical properties were verified on tensile test similar as customer test.

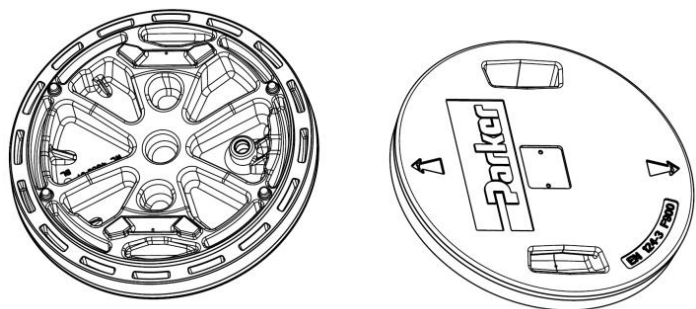
**Keywords:** Aluminum alloy, AlZn10Si8Mg, AlCu5NiCoSbZr , mechanical properties, tensile test.

### 1. INTRODUCTION

Everything was started with customer’s question: What we can do for bigger strength of this casting? Technology was got documentations for casting and requirements on mechanical properties. The first idea was changed topological shape of casting. Calculation was showed problem after change shape of casting. Construction of casting was stayed the same during test of different alloys in this experiment. The second idea was tested different types of alloy.

#### 1.1. Type of casting

The casting was constructed as shaft cover on airport area. Cover must be resisted extremely strength conditions. Design of cover is showed on picture **Figure 1**. Customer had very specific requirements for ductility and on the other hand high strength by standard EN124-3-F900. [1] This combination of features was not easy. The strength was increasing with decreasing ductility and conversely. Casting was designed with AlSi7Mg0.3 T6 in the beginning. Specific requirements were for safety during heavy load. 90 tones was critical value for safe in short time. Large number of destroyed casting during test was the reason for something change. Manipulation in production was not easy with weight around 20 kilos. Checking to inside defects on X-ray was not possible. Problem was in massive thickness of casting. Attempt to change of shape was not successful with help by topological optimization. Foundry feasibility was evaluated with MAGMA software. The easiest way for the better mechanical properties was found the alloy with the best result during testing.



**Figure 1** Design of casting „COVER”

## 2. EXPERIMENT

Basic alloy of casting „COVER”, was changed during same optimalization production parameters. „COVER”, was prepared for test as standard production process. Castings were casted and heat treatment was happened after finishing of parts. Different alloys had different heat treatments than standard was recommended. Test groups were elected for better comparing between alloys.

- AlSi7Mg0.3 T5,
- AlSi7Mg0.6 T6,
- AC-AlZn10Si8Mg F,
- AC-AlCu5NiCoSbZr T5,
- AC-AlCu5NiCoSbZr T6.

Types of alloy were chosen with suitable for low pressure die casting technology. Basic choice was aluminum alloy. One of alloy was chosen for its mechanical properties. Alloys on base AlSi and AlZn were often used in foundry. Theoretical mechanical properties by standard ČSN EN 1706 for casting produced by LPDC technology are showed in **Table 1**.

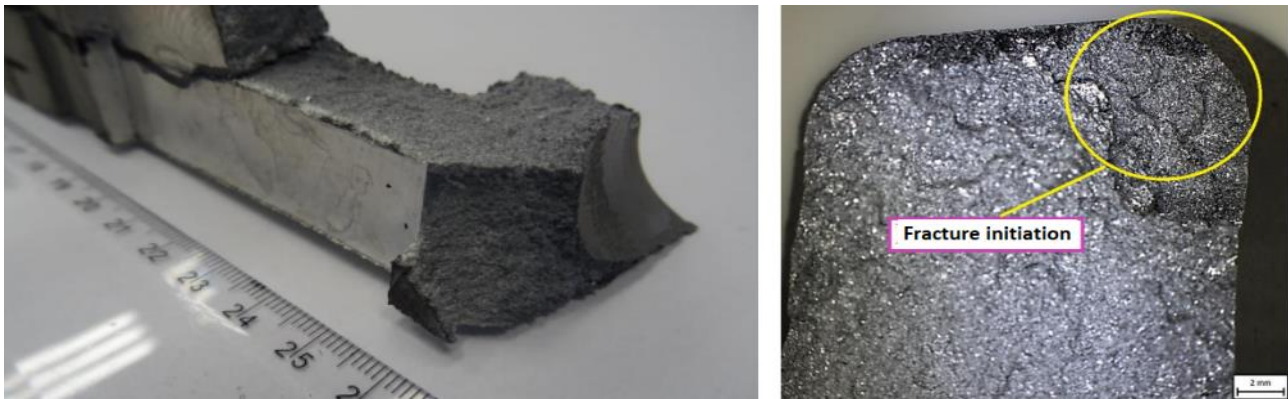
**Table 1** Mechanical properties of alloys [2,3]

Alloys	Treatment	<i>R<sub>m</sub></i> (MPa)	<i>R<sub>p0.2</sub></i> (MPa)	A (%)	HBW
EN AC-AlSi7Mg0.3	T6	290	210	4	90
EN AC- AlSi7Mg0.6	T6	320	240	3	100
EN AC-AlZn10Si8Mg	T1	230	200	1	90
EN AC-AlCu5NiCoSbZr	O	180	200	1.5	90

Treatment T1 means cooling and nature aged. T6 means dissolution at high temperature and artificial age. T7 means dissolution at high temperatures overage artificial age. Specific value could be affected by design of casting and clearing alloy purity. Value could be different between this standard. Castings had different treatment in this experimental. Treatments T1 and T7 were not performed. Castings from AlZn10Si8Mg were without heat treatment and castings from AlCu5NiCoSbZr was with T5 and T6 treatment. AlSi7Mg0.3 was very popular alloy for LPDC and these mechanical properties were very interesting after heat treatment. AlSi7Mg0.3 with T5 was the first choice. AlZn10Si8Mg was tried for its good mechanical properties *R<sub>p0.2</sub>* after crash casting from AlSi7Mg0.3 T5. AlZn10Si8Mg was standard used in our foundry too. This type of alloy did not have as good casting properties as AlSi7Mg0.3. The production of the casting was without a problem. This standard alloy had not good result after special test of strength. Big experiment for production was used to new alloy EN AC-AlCu5NiCoSbZr for LPDC technology. This alloy was contained high percentages of copper compared with other alloys. High content of copper was caused to volume loss. Casting was OK after technological changes. Experience was used this new alloy in our casting process. Castings from this material did not have good result on special test. AlSi7Mg0.6 was chosen for better mechanical properties than AlSi7Mg0.3. This alloy had added magnesium for higher value of *R<sub>m</sub>* and *R<sub>p0.2</sub>* after heat treatment. On the other side ductility was reduced.

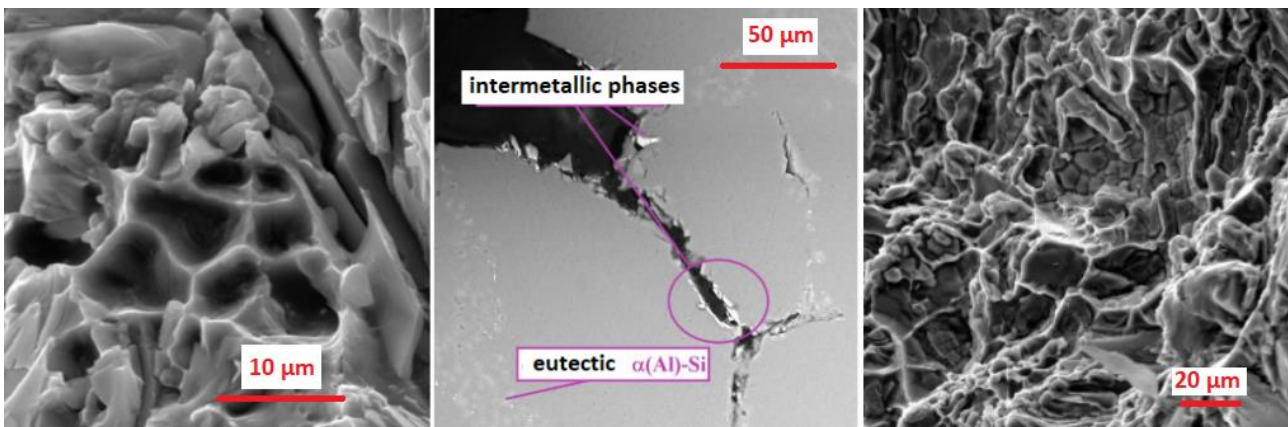
### 2.1. Fractography

Analysis of cracks was made on the start production by alloy AlSi7Mg0.3 with T6. It was done for exclusion defect with alloy and inside impurities. Sample **Figure 2** was evaluated in cooperation with the university. Fracture initiation was showed there. Sample was without essential impurities which could caused to fracture.



**Figure 2** Sample for analysis

This was constituted fracture, probably initiated by a higher value of the internal stress in the casting. Several defects **Figure 3** were observed on the fracture surface by Electron microscope TESCAN VEGA 3 with detector BSE.



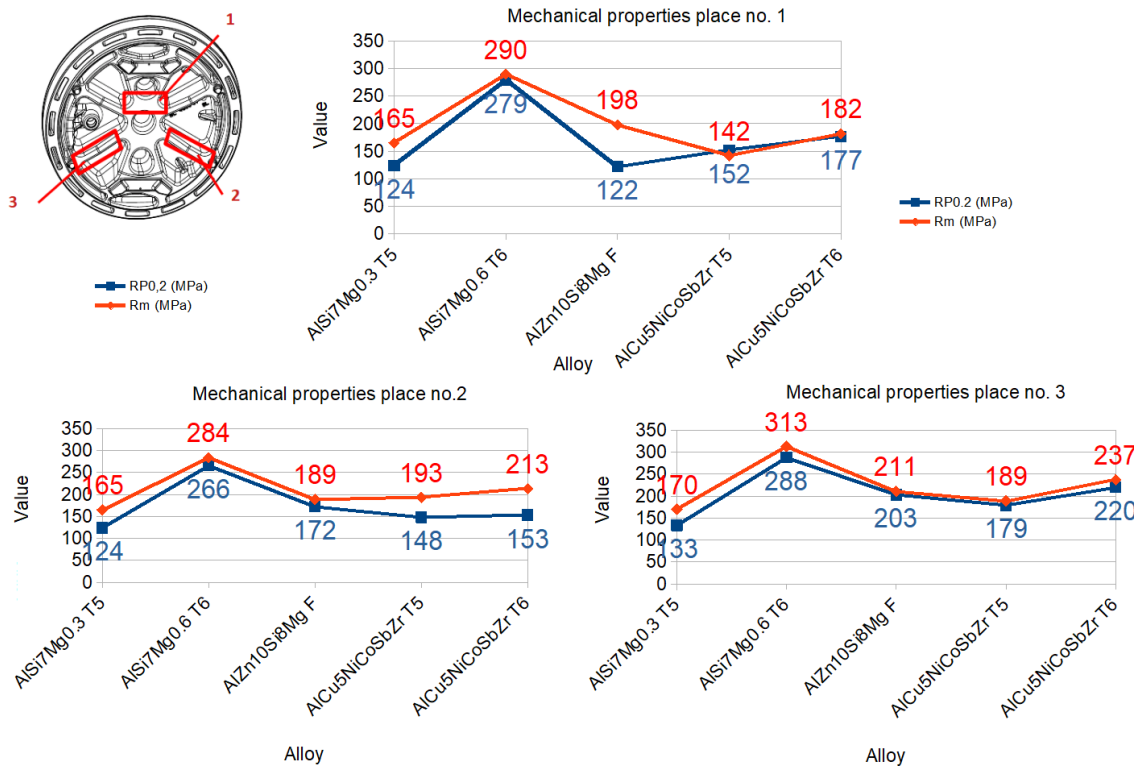
**Figure 3** Ductile fracture with part of brittle fracture of intermetallic particles

The fracture was ductile of eutectic  $\alpha(\text{Al})\text{-Si}$  with part of brittle fracture of intermetallic particles  $\alpha(\text{Al})\text{FeMgSi}$  and  $\alpha(\text{Al})\text{FeMnSi}$  by SEM and EDS analysis. This particles were not initiation of fracture. The fracture was passed through the area of the radius. Combinations of radius and high surface roughness could caused to contributed to the formation of cracks and fracture.

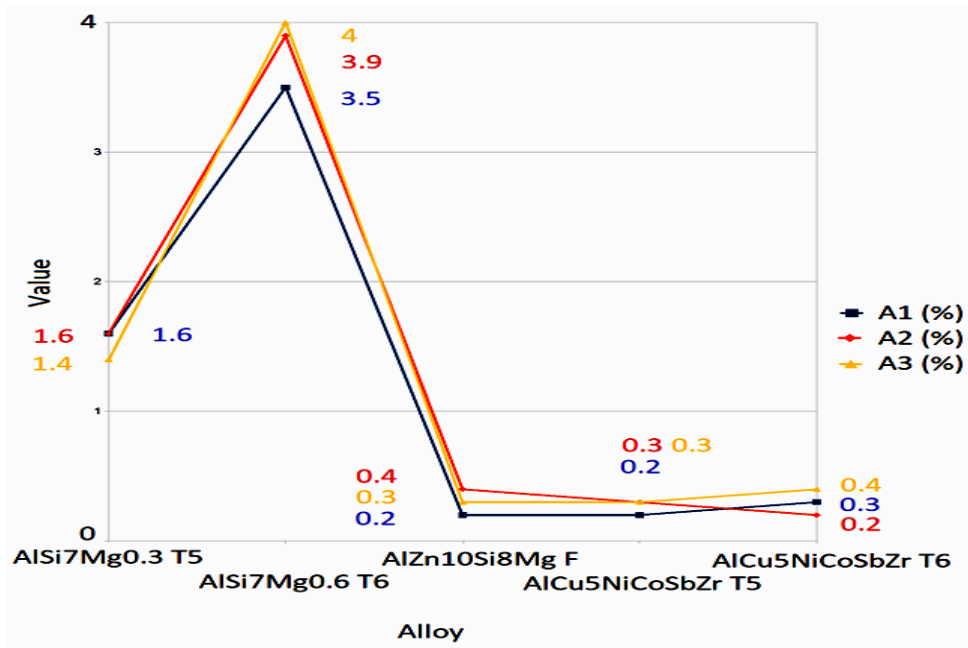
## 2.2. Tensile test

Test group had 3 casting. Each casting has 3 samples for standard tensile test. Test result was evaluated in graphs. Average values were showed for one type of alloy and heat treatment. Visible was that the best results had  $\text{AlSi7Mg0.6}$ . Very interesting was compare different place on casting. Place no. 3 had the highest values of mechanical properties  $R_m$  and  $R_{p0.2}$ .

Test specimens was removed from 3 different places of casting **Figure 4**. Places for samples were elected with casting options. It was not easy because „COVER”, had thin-walled ribs. Specimens were machining according to standard  $\text{ČSN EN ISO 6892-1}$ . [4] Samples were sent to acreditate testing laboratory. Measure machine was Zwick/Roell Z250 with loadcell 150 kN and extensometer - MultiXtens.



**Figure 4** Image place of sample and graphs with obtained mechanical properties  $R_{p0.2}$  and  $R_m$



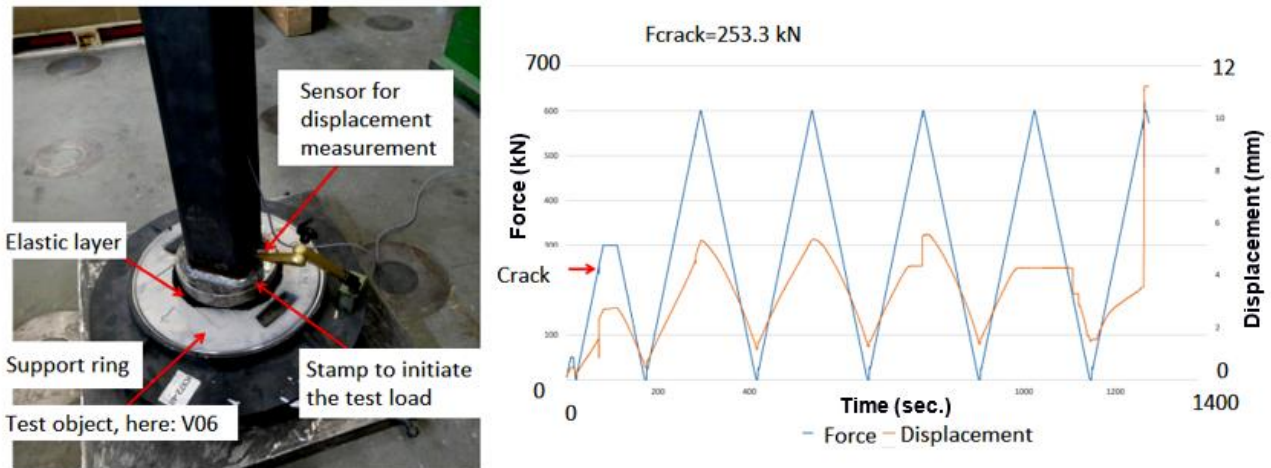
**Figure 5** Depending ductility on different alloys and heat treatments in another place of casting

Values of ductility were on different chart for better presentation **Figure 5**. AlSi7Mg0.6 with T6 had very good mechanical properties for success customers test.

Very surprising was result ductility alloy AlZn10Si8Mg. Alloy by standard had value around 6 %, but tensile test was showed very low values of ductility. It could be caused to some defects in specimens. Other values were more or less corresponded with standard.

**2.3. Special customers test**

Mechanical properties by the tensile test were information for foundry. Other castings, which were produced in this experiment were tested on special customer machine for approval for use. It was very easy test. Finish parts were saved into pressure machine **Figure 6** and were tested with measurement reports. The final strength was 600 kN during 200 seconds on the testing part.



**Figure 6** Customer testing machine and measurement report on alloy AlCu5NiCoSbZr T6

Result could be only correct or non-correct. Correct part is showed on the right side **Figure 7**. Non-correct part is on left side. AISi7Mg0.6 with T6 heat treatment had the best result on customer test. All of parts from different alloys had larger or smaller cracks.



**Figure 7** Non correct part and correct part after customer test

**3. CONCLUSIONS**

This article was focused on change type of alloys and influence on mechanical properties. Four different alloys was tested. Mechanical properties on standard tensile test were appropriated by standard in most alloy. Big experience for foundry was used to new alloy EN AC-AlCu5NiCoSbZr for LPDC. This alloy could be used for this casting with a little bit change of technology, but mechanical properties were not good for this application. Customer did not have specified requirements on values of mechanical properties. A suitable product did have to priority passed customer test with load of 90 tons.

AlSi7Mg0.6 with T6 heat treatment had the best result on standard tensile test and customer test too. Mechanical properties were nearly correspond by standard. Specific values on „Cover”, were obtained around  $R_m = 300$  MPa,  $R_{p0.2} = 270$  MPa and  $A = 4$  %. Producing alloy was changed from AlSi7Mg0.3 with T6 on AlSi7Mg0.6 with T6 on the basis of this experiment. The number of non-correct products were decreased.

## REFERENCES

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