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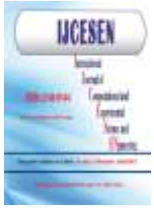



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**Research Article**

# Thermal Analysis of AlSi10Mg Alloy and Heat Treatment Hardening

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**Abstract:**

Aluminium which is considered as a metal with use and great perspective belongs to the group of non-ferrous metals due to its low density and suitable physical, mechanical and chemical properties which make its application possible in many branches of modern industry.
The mechanical and physical properties of aluminium are significantly improved by its connection with other elements such as; like, Mg, Mn, Cu etc., can be used for the production of various industrial products by moulding, lamination, pressing, stamping etc. In this paper the AlSi10Mg alloy was treated, the samples were analyzed by thermal analysis, heat treatment through hardness, the results which showed that the alloy hardness was significantly increased compared to before heat treatment. The purpose of this paper is to look closely at the stages of hardening and the change in hardness after melting and after heat treatment.
After the thermal analysis, the stages in detail of their creation in the laboratory conditions used during the experimental work with melting and the solidification process are defined.
Experimental work showed that microstructural and mechanical properties changed with heat treatments. It was observed that heat treatment has a great effect to increase hardness of AlSi10Mg. According to Optic Microscope (OM) analysis it can see formation of different phases.

## 1. Introduction

AlSi10Mg is a typical casting compound with good pouring properties and is commonly used for thin-walled castings and complex geometries. It offers good strength, toughness and dynamic properties and is therefore also used for parts that are subjected to heavy loads. The AlSi10Mg Aluminium Parts are ideal for applications that require a combination of good thermal properties and low weight. They can be machined, spark-scraped, welded, micro-washed, polished and coated if required [1,2,3,4].
Conventionally cast components in this type of aluminium alloy are often heat treated to improve mechanical properties, for example by using solution annealing, quenching and hardening of aging. The sintering process is characterized by extremely fast melting and re-hardening. This produces a metallurgy and corresponding mechanical properties in the built-in state as it is similar to heat-treated cast parts. Therefore, such hardening heat treatments are not recommended for sintered parts, but rather a relief cycle of stability of 30m at 720 ° C. Due to the linear construction method, the parts have a certain anisotropy, which can be reduced or removed with proper heat treatment - see technical data for examples [1,2,3,4,5].
The purpose of this paper is to look closely at the stages of hardening and the change in hardness after melting and after heat treatment [1,2,3,4,6].
As seen in table 1, we notice that in the AlSi10Mg compound we have several constituent elements, where we have expressed in certain percentages each of the elements which are found in.

***Table 1.*** *The chemical composition of the AlSi10Mg alloys*

| Elements | Si | Fe | Cu | Mn | Mg | Ni | Zn | Pb | Ti | Al |
|---|---|---|---|---|---|---|---|---|---|---|
| Percentage (%) | 9-11 | 0.055 | 0.10 | 0.45 | 0.45 | 0.05 | 0.1 | 0.05 | 0.15 | Bal. |

this compound. We have the highest percentage of manganese (Mg) with 5.0-6.0%, while the smallest amount is expressed in the part of copper (Cu) with 0.05% [6,7,8]. The table of chemical composition is shown in table 1.

## 2. Material and Methods

During the experimental work the process in which the metal was melted is inductive furnace, the amount of metal is 240g, and the melting was done at a temperature of 720 °C in a graphite cup, then, to measure the temperature, 735-2 thermometer was used with a thermocouple type K. Once we have completed the melting process we have continued with the solidification process in cup crowning and thermal analysis through temperature measurement using a National Instruments CompactDAQ NI 9213, connected to the Labview software. After receiving the data, their numerical and graphic processing was performed with the recorded temperatures versus the time of phase transformations. Microstructure is another special treatment throughout the experimental work. We analyzed the microstructure with a Leica DMRX optical microscope. The samples were made through sanding, where we made the sanding with sandpaper. We polished with mol and nap polishing paper, it was done with 0.5µm lubricant and 0.5µm diamond paste. Etching is performed with fluoridic acid. Another measurement we made is that of hardness measurement. Hardness is measured with Emco test durascan 10 G5 with HV1 load. In total, for the measurement of hardness, we took three calculations on average and it was performed after solidification and after artificial aging at 175 ºC.

## 3. Results and Discussions

### 3.1 Thermal Analysis

The solidification process was analysed by thermal analysis on samples poured into the crooning mould, which sample was subjected to solidification by cooling in air. The cooling and differentiated AlSi10Mg coupling curves from the pouring temperature of 720 °C in the crowning mould are shown in fig. 1. Diagram with cooling turns in fig. 2 shows significant interactive deviations in the values of the characteristic solidification temperatures, according to the calculation and diagram of the cooling turns at 730 ° C with the onset phases of solidification at 621 ° C and the reactions shown in the figure according to the temperatures. The solidification interval was completed at 578 °C.

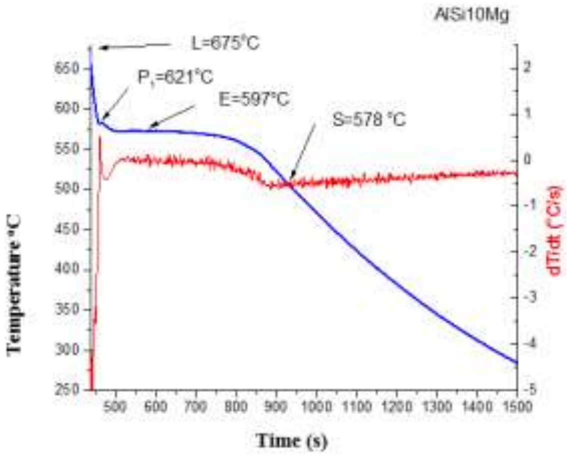


***Figure 1.*** *The cooling curve of AlSi10Mg alloy.*

### 3.2 Metallography

After solidification analysis with thermal analysis technique, samples were prepared for metallographic investigation. According to the micrographs the microstructure consists of the α-Al phase, β-Si phase, the π-AlMgFeSi phase, as seen in figure 2.

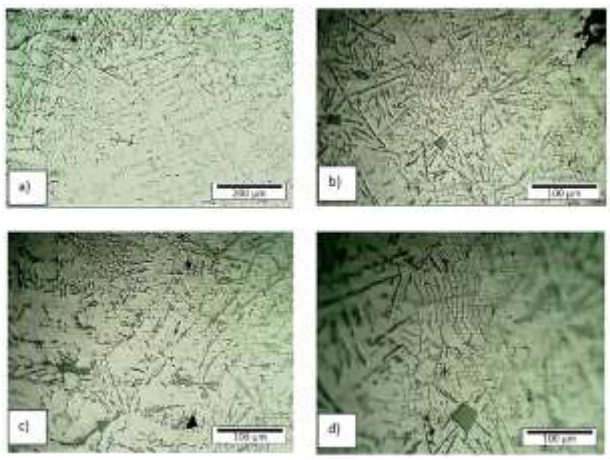


***Figure 2.*** *Microstructure of AlSi10Mg alloy.*

### 3.3 Measurement of hardness

From the samples taken we made a total of three different measurements after solidification of the phases after thermal processing carried out at a temperature of 175ºC and holding 120 minutes. Results are given in table 2.

***Table 2.*** *Hardness of AlSi10Mg alloy.*

| Measurements | After solidification | After artificial ageing |
|---|---|---|
| Sample | Sample croning | Sample croning |
| Load | HV1 | HV1 |
| **Hardness** | **105HV** | **151HV** |

## 4. Conclusions

In conclusion, our investigation has yielded significant insights. We focused on the analysis of the AlSi10Mg alloy, employing thermal analysis to manipulate its properties. Through this process, we observed the formation of various phases and reactions, including α-Al, Si phase, and the π-phase AlMgFeSi during casting. Furthermore, our study explored the development of a microstructure that plays a crucial role in enhancing hardness post-solidification. Notably, we observed a substantial increase in hardness from 105 to 151HV after artificial aging, attributed to the precipitation of elements into the AlSi10Mg alloy.

## Author Statements:

- **Ethical approval:** The conducted research is not related to either human or animal use.
- **Conflict of interest:** The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper

- **Acknowledgement:** The authors declare that they have nobody or no-company to acknowledge.

- **Author contributions:** The authors declare that they have equal right on this paper.

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- **Data availability statement:** The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

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