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EFFECT OF HEAT TREATMENT ON AA2024 BY CO_2 CASTING PROCESS

Rishitha Gonapa[1], B. Srinivas[2]

[1]Department of Mechanical Engineering, MVGR College of Engineering, Andhra Pradesh 535005, India

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Abstract - *Casting is one of the well known process to the mankind and also the oldest among all. The major problem with the castings is it is impossible to produce 100 % sound casting due to variety of reasons. Sand casting is also one of the widely used casting processes in the manufacturing industries. Here the defects can be reduced by choosing the proper casting process and also by performing the proper heat treatment of the components.*

In the present study, silica sand was taken as moulding material and efforts were made to observe the effect of heat treatment on microstructural, mechanical and wear properties of the material. As the silica sand was one of the widely used moulding sand in the casting industries because of its easy availability and variety of properties. From the results, it was observed that after heat treatment there was an enhancement of properties observed compared with as cast condition. In the micro structural analysis, dendrite structure was observed in the all the components. Rectangular component showing the higher hardness in both the conditions and cylinder component was showing the lower hardness. Wear was higher in the case of rectangular component and lower in the case of cylinder in both the cases of heat treatment as well as as-casted condition.

Key Words: **CO_2 Casting, Aluminium Alloy 2024, Hardness, Micro structural, Heat treatment; silica sand**

1. INTRODUCTION

Aluminium is one of the most important materials in the manufacturing industries due to its light weight, strength to weight ratio, ductility, electrical and thermal conductivity. It is also third most abundant material in the earth quest [1]. It is also used in many domains like automobile sector, aerospace sector and marine sector. AA2024 was using for the present study and it is an alloy of Al-Cu which is second strongest alloy among the family of aluminium alloys. These alloys are having good strength, light in weight and also having the good fatigue resistance [2]. Here, the fabrication technique which was used to cast these alloys was important because, the fabrication technique used decides the quality of the product and properties of the products [3]. Silica sand was taken as a moulding material for the present study due to its ease of availability, cost and moulding properties. Here the many researches were discussed on the Co2 casting of aluminium alloys [4-6]. A356 alloy was produced with the help of co2 casting process and mould properties, material properties were discussed. Also Al-4.5 Cu alloy produced with the help of Co2 casting process [7]. It was also reported that the LM24 Al alloy showed the better properties throught he silica sand method than the any other casting methods. Here, in the present study efforts were made to produce the AA2024 components in different shapes with Co2 casting process.

Also, Heat treatment was performed to the components produced to enhance the properties of the components produced through AA 2024 which is a heat treatable alloy. Now a days, the heat treatment also become the most common process to observe how the mechanical behaviour of the material changes. Therefore, the present study aims to use the silica sand moulds for the AA2024 alloy. Here the Co2 casting process was use d to perform the different shapes of the components. The main objective of the study was to produce the defect free components with best suitable component by silica sand as moulding sand through Co2 casting process out of the all shapes of the components. To study the best various tests were performed on the components like microstructural, Micro hardness, and wear properties of the components in two conditions were studied at as cast and heat treated condition. Co2 casting was performed with 8% of sodium silicate as a binder by passing the co2 gas for 15 sec. Four components of same volume were taken for the comparison study between it with addition of heat treatment.

2. Experimental Procedures:

Aluminium alloy 2024 was taken for the present study in the rod form. It has been cut into small pieces for the ease of melting. The chemical composition of AA2024 is Mg 1.1 %, Cu 4.3% , Cr 0.55 %, Fe 0.4 %, Si 0.5 %, Mn 0.60 %, Ti 0.10%, Zn 0.16 %. Silica sand was used and it was firstly dried and then cleaned thoroughly in the sieve to remove all foreign particles and dust and is used for the casting. The silica sand is weighed in the weighing machine to add the sodium silicate, for every 100% of weight 92% of silica sand and 8% of sodium silicate was added to get the moulded silica sand. The silica sand was weighed 92 % in the weighining machine and it was kept in a tray and 8% of the sodium silicate weighed again in the weighing machine and added to the tray and it was mixed with hands thoroughly until it completely gets mixed. After that the mixture was poured in the flasks than rammed gently to not to disturb the pattern. After that sprue and riser were placed and from the cope part it was filled again to complete the procedure of the moulding.

Fig -1: Mould preparation for the casting

At first the casting were taken at the as cast condition. The casted shapes after trimming and fettling were machined up to the required dimension. After that, the casted and machined components were heated at 480°C and it was solution heat treated. The temperature rising time in the furnace 5 minutes and the soaked at 480°C for 2 hours and then the specimens were quenched in water rapidly.

After solution heatt reatment the specimens subjected to aging at elevated temperature above the room temperature. The heat treated components are aged at 180°C temperature. Temperature raise time for the furnace was 5 minutes, soaking time of the components at 180°C for 8 hours. Then the material is quenched into the water.

Fig -2: Muffle furnace used for heat treatment

After that the specimens were cut at the centre part of all the components for the following studies like micro structural, micro hardness and wear property studies.

For the micro structural study the specimen micro structures were captured under the dewinter microscopy and keller's reagent was used to reveal the micro structures. Vickers hardness tester is used for measuring the hardness of casted components before and after heat treatment at a load of 2 kg.

The equipment used for the wear test is pin on disc tester model which is used for knowing the wear rate of all casting components before and after heat treatment. The wear test was conducted at two rotational speeds which were at 600 rpm and 780 rpm at a load of 19.6 N for 10 minutes was used for the study for all the components.

3. RESULT AND DISCUSSIONS

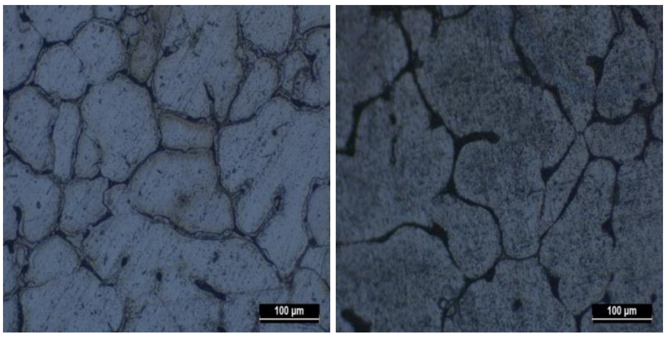
3.1 Micro structural analysis

Optical micrographs of the casting components are shown in Fig.3 and 4. It is observed from the microstructures that at the cube component in both as weld and heat treated conditions the coarser grain size was observed and at the gear the lower micro hardness was observed. Through the microstructures it was observed that there was a development of the epitaxial growth was observed in the grain structure and the same results were supported by the hardness results also. In general the grain size depends upon the cooling rates of the components and here the to get the finer grain structure in the gear as well in the cylinder the cooling rates plays an important role in it.

Table -1: Grain size of the components

S.No	Shape of the component	Grain size (As cast condition) µm	Grain size (Heat treated condition) µm
1	Cube	132.355 µm	139.749
2	Gear	102.182	110.677
3	Cylinder	102.214	111.905
4	Rectangular plate	115.01	127.690

Here the most of the part of the gear as well as cylinder was in contact with the surface of the mould where the heat transfer rate was higher in it resulting the finer structure.



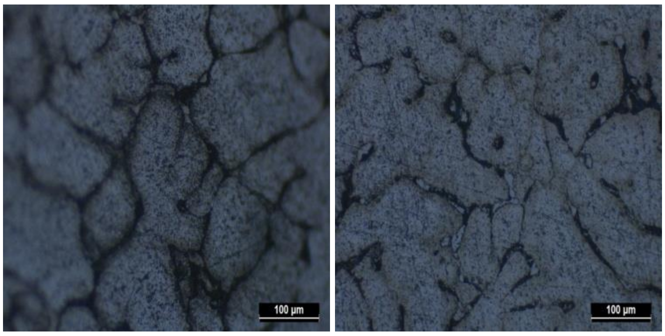


Fig -3: Microstructures of the components in as cast condition a) Cube b) Cylinder c) Gear d) Rectangular plate

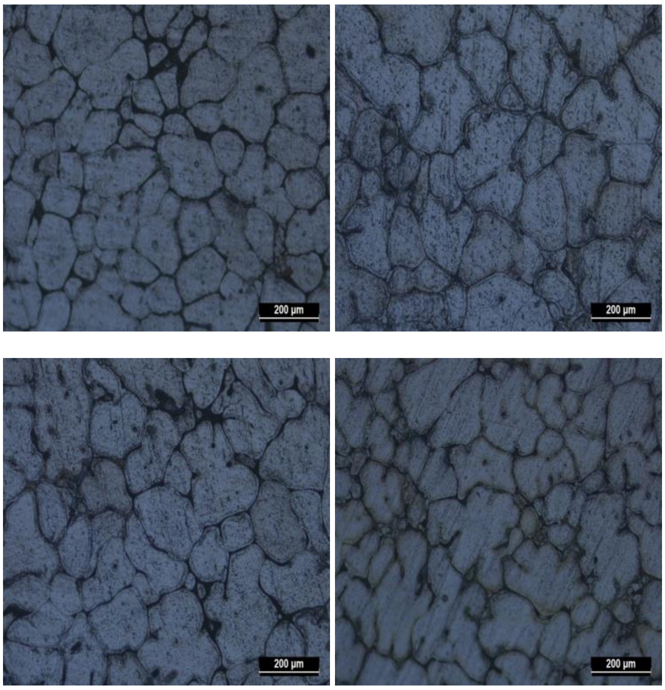


Fig -4: Microstructures of the components in Heat treated condition a) Cube b) Cylinder c) Gear d) Rectangular plate

3.2. Microhardness studies

The hardness profile of the silica sand for different shapes of casting components in as-cast and heat treated condition were shown in Fig 5. The microhardness profile showing that the higher microhardness shown at gear i.e., 138.6 Hv compared with the other three different shapes of the castings and lowest microhardness observed at cylinder component with 124.4 Hv as the rectangular plate showing 136.1 Hv and cube showing 129.6 Hv. Also, after heat treatment similar observations made as the gear component got the higher hardness as during the heat treatment precipitates generates which creates the hardness to the component. It is because of the grain size of the gear was finer than the remaining components compared to the other components as the surface area of the gear plays a major role as the cooling rates which were higher in the case of the gear as compared to the other components. It is evident that also the thermal conductivity plays a major role in the conduction of heat from the component to all the area. The surface contact area at the single piece patterns of the gear and the flat plate was larger from the one side ie., at the bottom side of the component the contact area is more. Silica sand was showing better results with the single piece pattern compares with the split piece pattern as the microhardness profile showing the higher microhardness in both the single piece pattern components. Also, silica sand components showing minor variations in the microhardness values as shown in the figure 5.

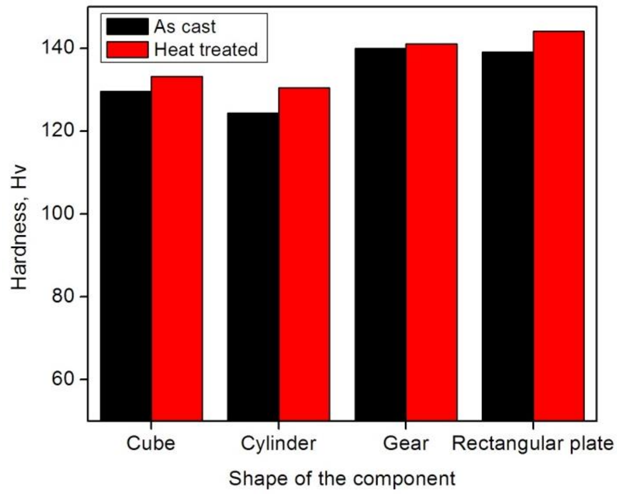


Fig -5: Microhardness analysis of different shapes

4. CONCLUSIONS

This study is focused on the properties of AA2024 casted and heated through silica sand. This study also focused on which shape yields better properties to the casting after heat treatment using silica sand as the moulding material.

The following conclusions are drawn through this study:

1. Casting of the components was successfully prepared without any defect and shape deviation through CO_2 casting process. It can be concluded that the casting products at constant volume produced in silica sand as mould material has better properties after heat treatment then before heat treatment.

2. The rectangular plate shaped casting exhibits better micro hardness with heat treatment and Gear shape casting exhibits better micro hardness without heat treatment.

3. Gear shape product have lesser average grain size compared to all other shapes with heat treatment and Cylinder shape product has lesser grain size compared to all other shapes without heat treatment.

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