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Research paper



Heat Treatment and Analysis of Al- 7005 Alloys Reinforced with Sic Metal Composite

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Abstract

This paper deals with the 7005 aluminium alloy characterization which has similar physical properties to 6061 aluminium alloy, depending on the temper, may be slightly stronger. To increase their mechanical and physical properties silicon carbide had been introduced in it as reinforcement. Based on mass three different compositional were made and mixed thoroughly, and cast. Stir casting method is used for casting proportioned alloys. Heat treatment process is carried out after casting the alloy is mixed in the three proper compositions. Mechanical properties like hardness, Tensile strength and impact strength were conducted and analyzed. Properties can be altered in a better way using silicon carbide as an reinforcement in aluminium-7005.

Keywords: *Aluminium 7005 alloy, Heat Treatment, SiC metal composite, Reinforced SiC*

1. Introduction

Composites materials provides improved mechanical and physical properties such as greater strength to weight ratio, increase in hardness, less wear rate and hence fewer chances of failure. This work is concerned with replacing metallic gear with a gear of composite material of Aluminium Silicon Carbide so as to improve the performance of the machine and to have the longer working life. Silicon carbide is used as reinforcement for strengthening metals due to its extensive mechanical and physical properties They proposed to use this material as a reinforcement enhancing properties. Aluminium is the most abundant metal on the earth's crust. Although its property is useful in resisting corrosion, it is troublesome when soldering, welding and electroplating. It has low specific gravity. The lightness of aluminium is its most important property. Pure Aluminium has a specific gravity of 2.7 as compared to 7.8 for steel. Good corrosion resistance. Aluminium composites are a combination of one or more material with aluminium alloy which enhances its properties. They are made up in such a way that the properties of the resulting materials should be improved. Aluminium Silicon carbide alloy composite materials are widely used for many numbers of applications like engineering structures, industry and electronic applications, sporting goods and so on.
To produce good properties of metal matrix composite, the processing method should be capable of producing good properties to comply with the industry need. Al-SiC composites can be easily produced by the stir casting technique due to its good castability property and machinability behaviour. So here these alloys of aluminium are prepared in three different ratios based on the weight composition of aluminium and silicon carbide.

2.1 Methodology

2.1 Aluminium Alloy 7005

Aluminium 7005 is an alloy of aluminium which is predominantly used in frames of bicycles due to its relative ease of welding nature, high strength to weight ratio, manufacturability and also it does not require expensive heat treating. It has more or less similar physical, mechanical properties to 6061 aluminium alloy, but it has a higher density of 2.78 g/cm^3 and maybe a little stronger depending on the temper.
The chemical composition of Al 7005 alloy is 93.3% of aluminium, 4.5% of zinc and 1.4% of zinc. Also very small compositions of zirconium, chromium, titanium in 0.14%, 0.13%, and 0.04% respectively.

2.2 Preparation of Aluminium-SiC MMC

Heating and melting of Al-6061-T6 Alloy by around 750°C which is high over the melting point temperature of the alloy. The feeding process of preheated silicon micron particles (0, 5 and 10% of micron SiC) for the preparation of the composites.
When the alloy reaches a semi solid stage, the surface is covered with flux agent and about 5 grams of the flux was added to the molten metal for the degassing process. It describes mechanical stirring is done for 20 min to ensure the proper mixing of for the composite alloys in uniform distribution of the particles.

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Before the mechanical stirring manual stirring is required for better distribution of silicon carbide particles in the molten metal. Degassing of the melt with N2 gas for removing the air inclusion in the material. In sand, the mould is ready for the making specimen components for MMCs. The mould is made as per the standards of ASTM which further required during testing of various properties. Then the molten metal of aluminium alloy 7005 mixed with silicon carbide powder is ready to the poured into the pre-prepared sand mould. After allowed it to cool, the mould is opened and the alloy specimens were taken. In order for smooth conduction of the various tests, the alloy specimens were machined again to ensure that they were in respective sizes as per the ASTM standards for the tensile, Charpy impact tests. The prepared test specimen is shown in the below figure.



Fig 1: SiC reinforced Al 7005 composite test specimens

For determination of mechanical properties of the Al7005 reinforced with aluminium 7005, tests like Rockwell hardness test, Charpy impact test and tensile load test are conducted as per the respective ASTM standards and these values are compared with the previous alloys to know the improvement of properties.

3. Experimentation

3.1 Rockwell Hardness Test

Measuring the hardness of a material by pressing a chromium-steel or tungsten-carbide ball (as per the ASTM stansdards) against the material of which the hardness to be measured. (generally between 300 to 3000 kilograms of force for 5 to 30 seconds) The hardness is expressed in Rockwell Hardness Number (RHN) computed by dividing the load in kilograms by the area of indentation made by the ball measured in square millimetres. For comparing the hardness properties of metals it would be idle to apply constant load for all the different composition alloys. Here the constant load applied was 100kg, for all test specimens.

3.2. Tensile Test

Properties that can be measured directly through universal testing machine are tensile strength, strength, deformation, fatigue strength, maximum elongation and reduction in area. ASTM E8 was used as the standard for the tensile test. The specimen of tensile test is a standardized sample cross-section and should have two shoulders and a gauge in between them. The shoulders are large so they can be gripped and larger contact area provides better holdability, whereas the gauge section has a smaller cross-section so that the deformation and failure can occur in this area. The shoulders of the specimen to be tested were manufactured in different ways to mate to different materials various grips in the testing machine. These specimens may not be an exact representation of the whole work piece because the grain structure may be different throughout. The universal testing machine is used to test the tensile strength and compressive tension of materials. It can perform standard elongation and compression test on materials, components and structures . The threaded drip was used to hold the specimen during tensile testing.

3.3. Chirpy Impact Test

The apparatus that has a pendulum whose mass is known and length that is dropped from a known height to impact a notched specimen of material. The energy transferred to the material by breaking the test material can be inferred by comparing the difference in the height of the hammer before and after the fracture which is measured using the scale attached in the equipment.
The notch in the sample affects the results of the impact test, thus it is necessary for the notch to be of regular dimensions and geometry

4. Results

Tests like tensile, Charpy impact and Rockwell hardness are performed and their results were recorded to compare with other alloys of different compositions.

4.1. Hardness test

Hardness test was done in Rockwell testing machine. The following table shows the hardness values for three different compositions.

Table 1: Rockwell hardness test results

S.No	Rockwell Hardness Machine Scale: C Intender: Diamond Cone 1200	
	Material composition	**Hardness Number (HRC) Load 981 N**
1	Aluminium7005 alloy (90%) + silicon carbide (10%)	76
2	Aluminium7005 alloy (80%) + silicon carbide (20%)	67
3	Aluminium7005 alloy (70%) + silicon carbide (30%)	52

Here these results indicate that the addition of silicon carbide increases the properties of aluminium 7005 when it was added in a small amount. Even on increasing the load by a little, still, the alloy with low silicon carbide has higher hardness values than the alloys with a higher percentage of silicon carbide. Rockwell hardness results show that the addition of aluminium 7005 and silicon carbide improve the material properties. From comparing with pure aluminium 7005 it has increased its Rockwell hardness strength by about 10%. But when the addition of silicon carbide increases above 10% level, the strength begins to reduce. For a further increase in 10% of SiC, 12% has been reduced from the Al 7005 10% SiC alloy. On adding further 10% the hardness falls even below 24% has been reduced.

4.2. Tensile Test

The following table shows the tensile values for three different compositions, the universal tensile machine is used for testing.

Table 2: Tensile load test results

S.No	Tensile load test	
	Material composition	Ultimate tensile load (KN)
1	Aluminium7005 alloy (90%) + silicon carbide (10%)	26.8
2	Aluminium7005 alloy (80%) + silicon carbide (20%)	23.2
3	Aluminium7005 alloy (70%) + silicon carbide (30%)	19.8

Thus the results show that addition of SiC up to 10% gives the maximum value of tensile strength and further adding SiC the values of tensile gets decreased. Also like tensile strength, Young's modulus was getting decreased. But comparing the composition of alloys properties with pure aluminium 7005, they have definitely higher properties. The addition of silicon carbide in-

creases its tensile strength and Young's modulus at first. But on further adding the properties values begins to reduce. Especially when it reaches beyond 10% of silicon carbide in the composition. UTM tensile test results show that the addition of aluminium 7005 and silicon carbide improve the tensile strength. By comparing with pure aluminium 7005 tensile strength has increased. Its tensile strength was about increased by 10%. But when the addition of silicon carbide increases above 10% level, the strength begins to reduce by 14%. For the further increase in 10% of SiC, 29% of total tensile strength has been reduced from the Al 7005 10% SiC alloy.

4.3. Test Report Values for Impact Test

The following table shows the impact values for three different compositions, Charpy impact testing machine is used for testing

S.No	Charpy impact test	
	Material composition	Impact values in Joules
1	Aluminium7005 alloy (90%) + silicon carbide (10%)	160
2	Aluminium7005 alloy (80%) + silicon carbide (20%)	148
3	Aluminium7005 alloy (70%) + silicon carbide (30%)	127

Same as like the other two test results, this also shows that addition of SiC up to 10% gives the maximum impact strength in Charpy impact test and on exceeding the 10% SiC the impact strength gets decreased. But comparing with pure aluminium 7005, they have better properties. The addition of silicon carbide increases its impact strength up to a certain composition. But on increasing the composition of silicon carbide the properties values begins to reduce. Especially when it reaches beyond 10% of silicon carbide in the composition. Charpy Impact test results show that the addition of aluminium 7005 and silicon carbide provides better impact strength compared to pure aluminium 7005. The addition of silicon carbide increases above 10% level, the impact strength begins to reduce by 7%. For the further increase in 10% of SiC, 12% has been reduced from the Al 7005 10% SiC alloy. On adding further 10% the impact strength even below 24% has been reduced by 20%

5. Conclusion

From the results of the Rockwell hardness test, Charpy impact strength and the tensile strength tests which are conducted as per the ASTM standards respectively, it is inferred that the addition of silicon carbide increases the mechanical properties of aluminium 7005 to a level, and on increasing the composition of silicon carbide the property values are pulled down. So for applications where strength is considered it is better to use least composition of aluminium 7005 with silicon carbide rather than increased mass ratio composition.

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