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FABRICATION AND EVALUATION OF MECHANICAL PROPERTIES OF FERROUS REINFORCED ALUMINIUM ALLOY

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ABSTRACT
Composite materials are now-a-days preferred over conventional materials because of their superior nature. They can be conventionally fabricated to alter their properties. Often they are better than metals and alloys. In the proposed project work, a composite material consisting of Aluminium Alloy AA6061 and Steel balls is fabricated. Die casting approach is preferred with four different sizes of steel balls (2 mm, 3mm, 4 mm and 5 mm) respectively. A specimen without any reinforcement was also fabricated for comparison. It was found out that preheating of the reinforcement was an important criterion during casting. Fairly better composite was created by preheating the reinforcement.

Keywords- *Composite materials, Fabrication, Alloys, Reinforcement.*

INTRODUCTION

Basic Concept
Ever since the birth of human civilisation, we humans were unknowingly using composite materials for practical applications. Composite materials are otherwise called as composites. They are typically a combination of two or more materials having different composition and different properties. Technically a composite material can be prepared by incorporating, mixing or fusing a material on another material which is entirely different from each other. This means integrating a metal into a non-metal or two or more metals / non-metals having different properties can create composite material. The combination of the materials having different abilities alters the nature of the composite material. Hence a new material with the abilities of all those materials used to create the composite material will be created.

Fabrication Methods
Fabrication usually involves mixing or saturating the reinforcement with the matrix and then allowing the matrix to bind together into a rigid structure. The operation is usually done in an open or closed forming mould, but the order and ways of introducing the ingredients varies considerably. Within a mould, the reinforcing and matrix materials are combined, compacted, and cured to undergo a melding event. After the occurrence melding event, the part shape is set, although it can deform under some definite process conditions. For a thermo-set polymeric matrix material, the melding event is a solidification reaction that is started by the application of heat addition such as organic peroxide. For a thermoplastic polymeric matrix material, the melding event is curing from the melted state. For a metal matrix material like titanium foil, the melding event is a fusing at high pressure and a temperature around the melting point. For many moulding methods, it is convenient to refer to one mould piece as a "lower" mould and another mould piece as an "upper" mould. Lower and upper specify to the different faces of the moulded panel, not the mould's configuration in space. In this convention, there is always a lower mould but sometimes an upper mould also. Part construction begins by applying materials to the lower mould. Lower mould and upper mould are more generalized descriptors than more common and specific terms like male side, female side, a-side, b-side, tool side, bowl, hat, mandrel, etc. Continuous manufacturing processes use a different nomenclature. The moulded product is often referred to as a panel. For certain geometries and material combinations, it can be brought up to as a casting. For certain continuous processes, it can be referred to as a profile.

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MATERIAL SELECTION

The research work was involved to prepare composite material. Aluminium and Ferrous have been selected as the main compositions for the composite material.

Aluminium

Aluminium is the third richest element and the most abundant metal, in the Earth's crust. It makes up about 8% by weight of the Earth's solid surface. Aluminium is so highly reactive metal that native specimens are rare and limited to extreme reducing environments. Bauxite is the main ore element of the Aluminium. Aluminium is important for the metal's low density and as well as its ability to resist corrosion due to the phenomenon of passivation. Structural components made from aluminium and its alloys are most used in the aerospace industry and are more important in other areas of transportation and structural materials. The most useful compounds of aluminium, at least on a weight basis, are the oxides and sulphates. Aluminium is the widely usable non-ferrous metal. [3] Global production of aluminium in 2005 was 31.9 million tonnes. It exceeded that of any other metal except iron (837.5 million tonnes).[4]Forecast for 2012 is 42–45 million tonnes, driven by rising Chinese output.[5] Aluminium is usually alloyed – it is used as pure metal only when corrosion resistance and/or workability is more important than strength or hardness. A thin layer of aluminium can be deposited onto a flat surface by physical vapour deposition or (very infrequently) chemical vapour deposition or other chemical means to form optical coatings and mirrors.

Iron

Iron is a chemical element with the symbol Fe and atomic number 26. It is the first transition series metal and is the most common element forming much of Earth's outer and inner core. Iron is the fourth most common element in the Earth's crust. It is the common metal in rocky planets like Earth is due to its high production as a result of fusion of high-mass stars, where the production of nickel-56 is the last nuclear fusion reaction that is exothermic. Iron has been used since ancient times as copper. Pure iron is the softer than aluminium but is unobtainable by smelting. Iron is significantly hardened and strengthened by impurities from the smelting process using carbon. The proportion of carbon (between 0.002% and 2.1%) produces steel, which may be 1000 times harder than pure iron. Crude iron metal is formed in blast furnaces, where ore is transferred by coke to pig iron, which has high carbon content. Further on refinement with oxygen it reduces the carbon content to make steel. Steels and low carbon iron alloys with other metals are the most common metals in industrial use, due to their large range of desirable properties. Iron oxide is when mixed with aluminium powder, it can be ignited to create a termite reaction, used in welding and purifying ores. It forms binary compounds with the halogens and the halogens. Among its organ metallic compounds is ferrocene, the first sandwich compound discovered. Iron plays an important role in biology, forming complexes with molecular oxygen in hemoglobin and myoglobin; these two compounds are common oxygen transport proteins in vertebrates. Iron is also the metal used at the active site of many important redox enzymes dealing with cellular respiration and oxidation and reduction in plants and animals.

Table 1. Characteristic values of tensile strength (TS) and Brinell hardness (BH) of different forms of iron.

Material	TS (MPa)	BH (Brinell)
Iron whiskers	11000	
Ausformed (hardened) steel	2930	850–1200
Martensitic steel	2070	600
Bainitic steel	1380	400
Pearlitic steel	1200	350
Cold-worked iron	690	200
Small-grain iron	340	100
Carbon-containing iron	140	40
Pure, single-crystal iron	10	3

The mechanical properties of iron and its alloys can be enhance using a variety of tests, including the Brinell test, Rockwell test and the Vickers hardness test. The data on iron is so consistent that it was often used to calibrate measurements or to compare tests.[10][11] However, the mechanical properties of iron are significantly affected by the sample's purity: pure research-purpose single crystals of iron are actually softer than aluminium,[9] and the purest industrially produced iron (99.99%) has a hardness of 20–30 Brinell.[10] An increase in the amount of carbon, the iron will initially cause a significant corresponding increase in the iron's hardness and tensile strength. Maximum hardness of 65 Rc is achieved with a 0.6% carbon content, although this produces a metal with a low tensile strength.

DESIGN AND CALCULATION OF THE SPECIMEN

The specimen is created out of a composite consisting of Aluminium alloy 6061 as the matrix element and Ferrous balls as the reinforcement. In this composite a combination of metals having distinctive properties from each other is selected. The primary objective of this selection is to analyse the effect on the overall properties of the composite material by the individual composition. In this case, the individual compositions are: AA6061 and Steel balls. The composite material was fabricated using die casting method.

Design and Fabrication of Die

The intention of fabricating the specimen was to be implied for Friction Stir Welding. For this reason a specimen of thickness 10 mm was required and the length of the specimen was required to be 150 mm. The die was fabricated using cast iron. The inner cavity of the die was void for pouring the molten metal during the casting. Runner, raiser and gate of standard dimensions as shown in Fig 6., were made on the cast iron die for pouring the molten metal and maintaining the atmospheric pressure during the fabrication of the specimen.

Design of the Specimen

Five specimens were created for testing the properties of the composite material. Out of the five one of the specimen was not having any steel balls. Four different sizes of steel balls were selected as reinforcement for the specimen. Based on literature survey, it was decided to calculate the number of balls. It was determined that 1% of the volume of the specimen should be occupied by the reinforcement and remaining 99% by the matrix element.

Volume of the specimen

V=l x b x h
Given
Length of the specimen = 150 mm
Width of the specimen b = 150 mm
Thickness of the specimen = 10 mm
V = 225000 mm3
I% volume of the specimen = 0.001 x 225000 = 2250 mm^3

RESULT AND DISCUSSION

The macroscopic examination revealed that the specimen had so many defects. that the matrix element did not flow properly around the reinforcement. The reason is that the 5 mm balls were not pre heated before pouring the matrix element. This created shrinkage of the material. However it is revealed from further macroscopic examination of other specimen that on pre heating the reinforcement before pouring the matrix, the two materials existed in equilibrium condition. Hence this allowed the molten AA 6061 to flow freely around the reinforcement. The presence of tin mesh is not a problem since it is evident that the molten matrix element was able to flow into the mesh. Thus it is relevant that the pre heating of the reinforcement is all necessary to create a defect free composite specimen.

CONCLUSION

It is concluded that

- Composite material as defined by all is a material prepared by integrating two or more material having entirely different properties comparing each others.
- There are different approaches to fabricate composite materials and one among them is casting method
- Initial conditions such as preheating of the reinforcement affect the quality of the fabricated specimen

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