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Experimental Investigations on Stir Cast Aluminium with addition of vanadium pentoxide powders

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ABSTRACT

Metal matrix composites (MMC) have become attractive for structural engineering applications due to their excellent unique strength properties and are increasingly seen as alternatives to traditional materials, especially in the automotive, aerospace and defence industries. Al-V_2O_5 MMC's has aluminium as matrix and particles of vandium pentoxide as reinforcements and exhibits many mechanical properties that are attractive. In the present work, an attempt was made by stir casting technique to produce Al-V_2O_5 composite as it homogeneously distributes the reinforcement in the matrix with no interfacial chemical reaction. V_2O_5 particles containing different weight fractions (5% and 10%) is used as reinforcement. The paper presents the processing of Al-V_2O_5 by the Stir cast method to achieve the desired properties, as well as the findings of the experimental analysis of the mechanical properties of Al-V_2O_5.

Key words: MMC, V_2O_5, Stir casting, Hardness test, Impact test, Bending test.

1. INTRODUCTION

Metal matrix composites (MMC's) are propelled design materials created by a mixture of atleast two materials in which desired properties are achieved. Designing MMC's consisting of irregular fibres or particles in metal for amalgamation having a mixture of properties which are not feasible in solid materials. These properties may combine high explicit consistency, machinability, reduction of wear and low coefficient of thermal expansion. Metal Matrix Composites are metals reinforced with other metals, ceramic or organic compounds. They are rendered by dispersing the reinforcements of the metal matrix. Strengthening is typically performed to strengthen the properties of base metal, such as weight, stiffness, etc. Aluminium and its alloys attracted the most interest as the base metal in metal matrix composites. Aluminium MMCs are commonly used in aircraft, automobiles and other areas[1]. The reinforcements should be stable and non-reactive at the required working temperature. The reinforcements most widely used are Silicon Carbide (SiC) and Aluminium Oxide (Al_2O_3). SiC reinforcement improves the tensile strength , hardness, density and wear resistance of Aluminium and its alloys. Particle distribution plays a very important role in the properties of the Al-MMC which is strengthened by strong shearing [2].

2. EXPERIMENTATION

2.1 Materials Used

For the preparation of metal matrix composite, Aluminium is the base material and Vanadium Pentoxide(V_2O_5) is selected as reinforcement[3]. The detailed composition of the composite is, as mentioned in Table 1.

Table 1: Chemical Constitution of Al-V_2O_5 Composites

S.No.	Composition	Weight (%)
1	PureAluminium(Al)	100%
2	PureAluminum+ V_2O_5	95% + 5%
3	PureAluminum+ V_2O_5	90% +10%

2.2 Preparation of Composites (MMC's)

The composite metal matrix was produced using the most economical process known as Stir Casting or Vortex technique. Pure Aluminium ingot is taken as the matrix material in the present work and vanadium pentoxide as a reinforcement. To start with, the casting of pure aluminium is manufactured. For that reason, the appropriate 2 kg pure aluminium ingot is measured and placed in a muffle furnace inside the graphite crucible present. The furnace temperature is set at 675 ^oC, regulated by the digital temperature control system[4]. After reaching that temperature, the molten Al formed is poured into a cylindrical cast iron mould with a diameter of 200 mm x 20 mm and then, after a few minutes, the mould is unfastened and the solidified Al castings are removed. The Al ingot is now placed in a graphite crucible at a temperature of 700 ^0C for composite preparation (95 percent Al+5 percent V_2O_5) and the V_2O_5 reinforcement added is 5wt percent in the vortex produced by a mechanical stirring assisted by a variable speed motor. The stirring shall be carried out in order to achieve a standardized mixture of two contents in the slurry[5]. The speed of the stirrer is controlled using the speed controller and its rpm maintained is 250. The rotation is sustained for around 5 minutes. Argon is used at a pressure of 10 bar to preserve inertness. Then the molten composite is transferred to the appropriate cylindrical mould. In 10 minutes, the casting solidifies[6]. After that, the 90 percent Al and 10 percent V_2O_5 castings are prepared using the same technique and the temperature of the furnace is set at 750^{0}C. Figure. 1 represents equipment used for Stir Casting and castings obtained in the mould.

Figure 1: Equipment Used for Stir Casting and Castings Obtained in the Mould

2.3 Testing of Specimens

Once the composites were prepared, impact test, bending test and hardness test were performed. For all these tests, the specimens had different dimensions.

2.3.1 Rockwell Hardness Test

The Rockwell test evaluating the significance of passage of an indenter underneath an enormous weight appeared differently in relation to the penetration made by a preload (minor weight). The output is always a dimensionless amount expressed as HRA, HRB, HRC. The spot the rest of the letter is the character Rockwell scale[7]. For hardness test, the composites had the dimension of 25 mm on each side i.e. length, breadth and height. The hardness estimation is finished utilizing the Rockwell hardness analyzer. The sample models are determined to a metal iron square and displayed into closeness with a minimum weight (Ten kilograms), that as analyzing plastic materials is a solid steel ball. This shape the ground indented to "B." The dial is varied as per minimum value under the application of minimum weight applied and the total weight is left (sixty or one hundred kilograms), that makes the ball indent into the model of plastic test giving away the indented surface "D." After that, following an extra fifteen seconds (may be an aggregate of thirty seconds), the examination of hardness is done on the dial with minimum weight although all the things applied and surface yields "R". Figure.2 represents Rockwell hardness test equipment.

Figure 2: Rockwell hardness tester

2.3.2 Impact Test

Charpy Impact test is for toughness and sensitivity of the notch and is measured by finding the amount of energy absorbed by the material during fracturing, typically for metals, ceramics, composites, polymers. Brittle materials absorb little energy, while ductile materials absorb more energy for fractures as well. Test values are determined by dividing the fracture energy with the cross-section area of the specimen. Before the impact test, the specimens are prepared from the form of the cylinder to the square rods (10 mm X 10 mm X 55 mm) by milling. The 'U' notch is made of a saw up to 2 mm deep in the middle of the rod. Initially the specimen shall be made with a size of 10 mm X 10 mm X 55 mm; the notch shall be made at the exact middle of the specimen[8]. The pendulum is held at its highest location and the impact without the specimen is measured to detect the initial impact from the scale given, which could be caused by friction in the machine. After that, this specimen is positioned in the striking edge support so that the 'U' notch is in the direction of the test unit. Figure.3 shows impact testing machine.

Figure 3: Charpy Impact testing machine

Figure 4: Specimens Prepared for Charpy test

Charpy impact test values have been calculated by using the following equaion (1). Then same procedure is followed with keeping the specimen in striking edge support and readings are taken[9]. Figure.4 represents specimens prepared for charpy test.

Charpy Impact : K/A . . . . Eqn. (1)

Where A is Area of cross-section (A)=1cm*0.8cm=0.8cm^2 ,

Fracture energy (K) = K_1 - K_2,

Where K_1 = Initial energy and

K_2 = Final energy

2.3.3 Bending Test

The bend test is similar to the flexural test except the type of hardware and test techniques involved. Bend tests are used for ductile materials, while flexural tests are used for brittle materials [10]. Bending tests are led with the aid of putting a size of specimen over a vary and pushing down alongside the range to twist the material until failure. The dimension of the specimen to be bended was 100mm*30mm*3mm. The bend test may be performed by a test specimen named ASTM D790. The specimen must be cut into shape in accordance with the normal size of the ASTM D790 [11]. Figure.5 represents automated three point bending test machine.

Figure 5: Automated Three point bending test machine

3. Results and Discussions

3.1 Rockwell Hardness Test

The test completed on the cast specimens yield following results:

Table 2: Hardness values

S. No	Composition	Hardness (HR_B)
1	Pure Aluminium	55
2	95% Al and 5% V_2O_5	62
3	90% Al and 10% V_2O_5	67

The values in the above table.2 were noted down after the completion of the test in lab experimentally. There has been slight increase in the hardness of the component after addition of the V_2O_5 in increasing percentile.

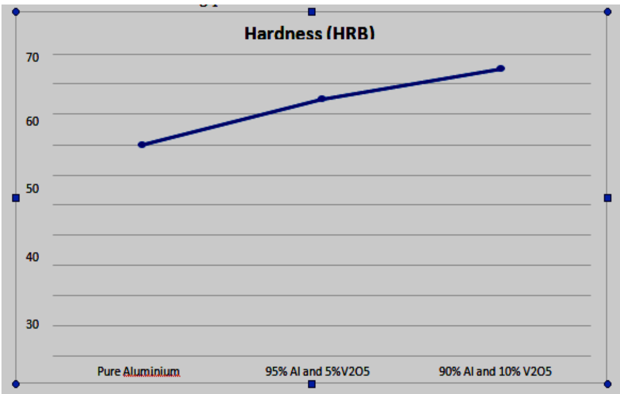

Figure 6: Variation of Hardness in Al with addition of V_2O_5 particulates

Inference: From the above graph(figure.6), it is obvious that the hardness of the composite increased on addition of 5wt.% and 10wt.% of V_2O_5 particulates. In the need of hard materials, this can be utilized as one of the means to get the same[12,13].

3.2 Charpy Impact Test

The specimens after Charpy Impact test gave the following details as shown in table.3:

Table 3: Charpy Impact Test Values

S. No.	Composition	Impact (J/m^2)
1	Pure Aluminium	0.45
2	95% Al and 5% V_2O_5	1.8
3	90% Al and 10% V_2O_5	2.3

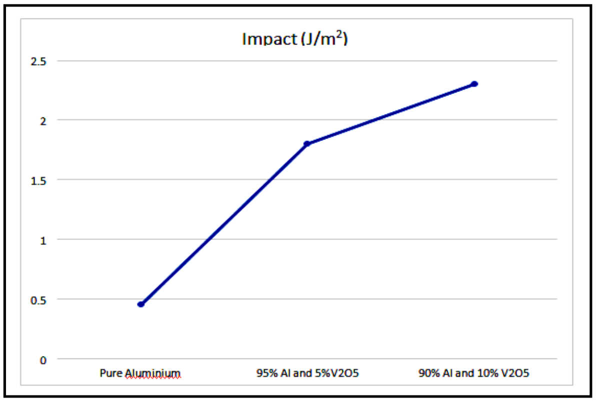

Figure 7: Charpy Impact Test values of Al with V_2O_5 prior and after addition

Inference: From above graph(figure.7), it is evident that impact value for pure Aluminium is negligible. On the other hand, with addition of 5wt% and 10wt% V2O5 particulates, the impact strength increased drastically[14,16].

3.3 Bending Test

Bending test performed on the specimens yield following results as shown in Table.4:

Table 4: Bending stress values of the specimens

S. No.	Composition	Bending stress(N/m^2)
1	Pure Aluminium	127
2	95% Al and 5%V2O5	245
3	90% Al and 10% V2O5	380

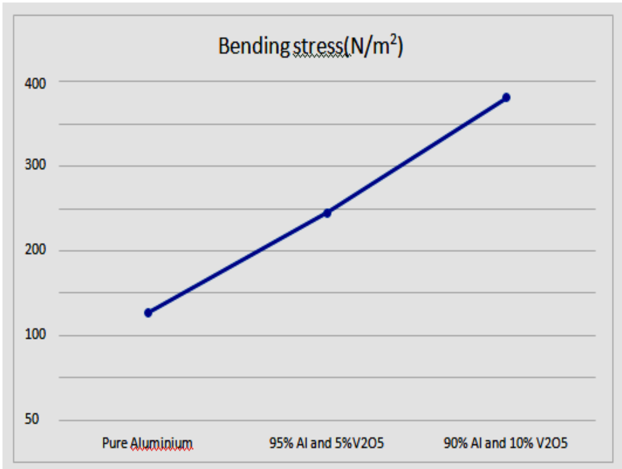

Figure 8: Variation in Bending stress value of Al with

V_2O_5 prior and after addition

Inference: From above graph(figure.8), it is clear that bending stress value for aluminium on addition of 5wt% and 10wt% increased drastically[15,17].

4. CONCLUSIONS

The metal matrix composites can be effectively produced using Stir casting technique. With Rockwell hardness tester, hardness of three specimens was found out and it is clear that composites having 5wt% and 10wt% of V_2O_5 has higher hardness when compared to pure Aluminum. A development in the proportion of help in the main network can be viewed as enhancing the entire properties of the material in line of mechanical aspect. The impact strength of pure Aluminum was found out to be almost negligible but on inclusion of V_2O_5 by 5wt% and 10wt% increased to certain level. Further, the bending stress value of pure Al was comparatively lesser than the values obtained on adding 5wt% and 10wt% of V_2O_5. Hence, using V_2O_5 as reinforcement was found to enhance the mechanical properties of pure Aluminium.

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