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CHARACTERIZATION OF TENSILE STRENGTH OF ALUMINIUM BASED BASALT MATRIX COMPOSITE

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***Abstract*—The objective of this research work is to investigate on the influence of basalt particles on the microstructure and thermo-physical properties of Aluminium Based Basalt matrix composites. The composite have been fabricated by liquid metallurgical technique and the basalt particles varies from 0 to 30 wt. %. The developed composite had been characterized for Tensile, Hardness, Impact and its Microstructure using Universal testing machine, Brinell hardness machine, Izod impact test and Scanning Electron Microscope. The results shows that the Tensile strength and Impact strength increase with increasing basalt particles addition, but the hardness and density of the material decreases with increase in basalt particles.**

***Index Terms*—About four key words or phrases in alphabetical order, separated by commas.**

I. Introduction

Over the last thirty years, composite materials, plastics and ceramics have been the dominant emerging materials with good strength and available at low cost compared to metals with less weight. Among these materials, plastics are not recyclable and lead to pollution. Ceramics are having lower strength and can be used for domestic applications. The volume and number of applications of composite materials have grown steadily, penetrating and conquering new markets relentlessly. Modern composite materials constitute a significant proportion of the engineered materials market ranging from every product to sophisticated applications. While composite have already proven their worth as weight-saving materials, the current challenge is to make them cost effective. It is obvious, especially for composites, that the improvement in manufacturing technology alone is not enough to overcome the cost hurdle. It is essential that there be an integrated effort in design, material process, tooling, quality assurance, manufacturing, and even programme management for composites to become competitive with metals. Increasingly enabled by the introduction of never polymer resin matrix materials and high performance reinforcement fibers of glass, carbon, aramid, etc, the penetration of these advances materials has witnessed a steady expansion in uses and volume. The increase volume has resulted in an expected reduction in costs.

High performance fiber reinforced composites can now be found in such diverse application as composite armouring designed to resist explosive impacts, fuel cylinder for natural gas vehicle, windmill blades, industrial drive shafts, support beams of highways bridges, paper making rollers, etc. Unlike conventional materials (e.g., steel), the properties of the composite material can be designed considering the structural aspects. The design of a structural component using composites involves both material and structural design. Composite properties (e.g., stiffness, thermal expansion etc.) can be varied continuously over a broad range of values under the control of the designer. Careful selection of reinforcement type enables finished products characteristics to be tailored to almost any specific engineering requirements. So the aim of this research is to improve the behaviour of aluminium and basalt metal matrix composite as applicable to mechanical engineering applications. Within this aim the following specific objectives have been adopted.

1. Review the current status of particulate composite research and the constituent material options for aluminium and basalt metal matrix composite system as mechanical engineering applications.
2. Identify key parameters to aid in the evaluation of constituent materials for aluminium and basalt metal matrix composite for mechanical engineering applications.
3. Develop a fundamental understanding of the relationship between constituent materials and the behaviour of aluminium as matrix system and basalt as reinforcement of the composites.
4. Improving the characteristics of the materials and to evaluate performance of the end product aluminium and basalt meal matrix composites.

II. Literature Survey

Ward et al conducted experimentation with hypereutectic aluminium-basalt short fibre alloy and found that the properties of the composites are producing satisfactory results. Tjong et al analysed the fatigue behaviour of Al-based composites and compared the results by using the additives such as TiB_2, Al_2O_3 and Al_3Ti as reinforcements. Cao et al conducted research on the wear properties on aluminium composite with SiC–whisker as the reinforcement material. Manish et al conducted test on wear during dry sliding for the aluminium alloy 2024–Al_2O_3. Kost explored the properties of the basalt fibres in detail. Czigany manufactured and characterised basalt fiber composite with

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polypropylene composites. The author studied the mechanical properties and acoustic emission

III. BASALT AND ALUMINIUM

Basalt, extrusive igneous (volcanic) rock that is low in silica content, dark in colour, and comparatively rich in iron and magnesium. Some basalts are quite glassy and many are very fine-grained and compact. Olivine and azurite are the most common porphyritic minerals in basalts along with secondary minerals such as calcite, chlorite, and zeolites. Basalts may be broadly classified on a chemical and petrographic basis into two main groups: the tholeiitic and the alkali basalts. Tholeiitic basalt contains 45 to 63 per cent silica, are rich in iron with calcium-poor pyroxene. Comparative technical characteristics of basalt, glass fiber and silica are given in the Table 1.

Properties	SI Units	Basalt	Glass	Silica
Operating temperature	(°C)	600°	480°	1000°
Melting temperature	(°C)	1450°	1120°	1550°
Thermal Conductivity	(W/m K)	0.031-0.038	0.034-0.04	0.035-0.04
Thermal expansion coefficient	(ppm / °C)	8.0°	5.4°	0.05°
Density	(g/cm3)	2.75	2.6	2.15
Filament diameter	(microns)	9-23	9-13	9-15
Elongation at break	(%)	3.15	4.7	1.2
Absorption of humidity (65%RAH)	(%)	<0.1	<0.1	<0.1

Table 1: Properties of Basalt, Glass and Silica

Aluminium alloy (1050) is formed by extrusion or rolling and having high electrical conductivity, corrosion resistance, and workability. It has low mechanical strength compared to more significantly alloyed metals. It can be strengthened by cold working, but not by heat treatment. Chemical composition are Aluminium 99.5%, Copper 0.05%, Iron 0.04%, Magnesium 0.05%, Manganese 0.05%, Silicon 0.25%, Titanium 0.03%, Vanadium 0.05%, and Zinc 0.05%. The density is 2.71 g/cm^3, melting point is 650ºC, modulus of elasticity is 71 GPa, thermal conductivity is 222 W/m.K, tensile strength is 105 – 145 MPa and hardness is 34 B.

IV. MATHEMATICAL ANALYSIS

Composite could increase the strength, decreased weight, higher service temperature, improved wear resistance, higher elastic modulus, controlled coefficient of thermal expansion, improved fatigue properties, etc. It is of utmost importance to have rules or models in order to predict or to calculate the expected properties of the composite. The rule mixture formula for composites is given in the Equation 1.

$$pc = pmVm + prVr \qquad (1)$$

whereas p = property and V = volume fraction.

subscript c, m and r represents composite material, matrix and reinforcement respectively.

The linear upper bound is defined by the simple rule of mixtures as given in the Equation 2.

$$Ec = Em\ Vm + ErVr \qquad (2)$$

Whereas E = Young's Modulus of the material

Calculation of tensile strength

Applied load = 1.445 kN, Area = 24.44 mm², (3.14 x 2.79 ^{2})
Tensile stress = Load / Area = 0.0592 kN/mm²
Elongation = Sl/O.L*100 = 1/30*100 = 3.33%

By comparing the results from the formula based (experimental) and testing result, the tensile strength of the material is appropriately same values.

V. MANUFACTURING PROCESS

Stir casting technique has been used to fabricate the composite specimen, as it ensures a more uniform distribution of the reinforcing particles. In this process, matrix alloy (Al 1050A) was first superheated above its melting temperature and then temperature is lowered gradually below the liquids temperature to keep the matrix alloy in the semisolid state. At this temperature, the preheated Basalt particles of 10 % (by weight) of average size of 150 µm and 300 µm respectively were introduced into the slurry and mixed using a graphite stirrer. The composite slurry temperature was increased to fully liquid state and automatic stirring was continued to about five minutes at an average stirring speed of 300-350 rpm under protected organ gas. The Basalt particles help in distributing the graphite particles uniformly throughout the matrix alloy. The specifications of the fabricated billet composite are following the ASTM standards. The molten matrix is shown in the Figure 1a.

The sand casting operation involves the pouring of the molten composite metal into the sand mould and a sample mould is shown in the Figure 1b. Sand usually has the ability to withstand extremely high temperature levels, and generally

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allows the escape of gases quite well. After the sand casting is removed from the sand mould, it is shaken out, all the sand is otherwise removed from the casting, and the gating system is cut off the part. Then the specimen was used for conducting the experiments to identify the properties of the composite materials.

Fig1.: a. molten composite b. mould

VI. RESULT AND DISCUSSION

Various laboratory experiments were carried out and the average of three experimental results were taken as the final result of the experiment. The first experiment is on universal testing machine for tensile properties. For tensile test, the composite material follows the ASTM D3039 standard to investigate the behaviour and to determine young's modulus, yield stress, ultimate tensile stress, percentage elongation at fracture, percentage reduction in cross-sectional area at fracture and fracture stress. Figure 2 shows the tensile test carried out and the results obtained from the UTM and from the FEA analysis.

Figure 2:Experimental and FEA test Results

Again the ALUMINIUM 1050A WITH 25% BASALT specimen has been prepared in the above method and the similar experimentation had been carried out. The results obtained from the experimentation and the FEA analysis results are given in the Figure 3.

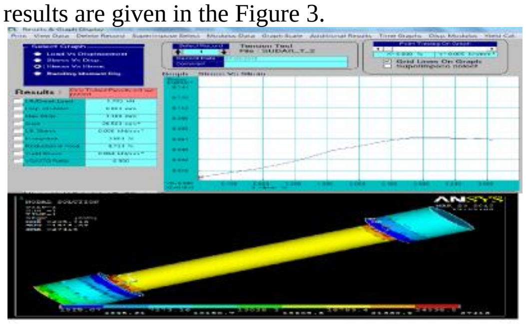


Figure 3: Tensile test Result of ALUMINIUM 1050A WITH 25% BASALT

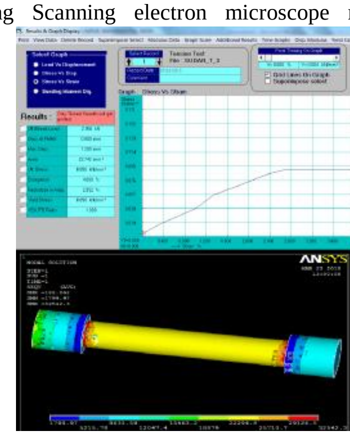
Again ALUMINIUM 1050A WITH 35% BASALT composite matrix have been obtained from the above method and the same experimentation had been carried out and the results obtained are given in Figure 4.

Figure 4: Tensile test result for ALUMINIUM 1050A WITH 35% BASALT

The result obtained for the above three combination is given in the Table 2.

VII. SEM TEST AND ITS RESULT

Using Scanning electron microscope microstructure



features were also studied. The electrons interact with the atoms that makeup the sample producing signals that contain information about the sample's surface morphology, composition, and electrical conductivity. The surface morphologies of surfaces are observed under scanning electron microscope for Aluminium 1050A with Basalt 25% 200 µm, 25% 500 µm, 35% 200 µm, 35% 500 µm are shown in the Figures 5 to 8 respectively.

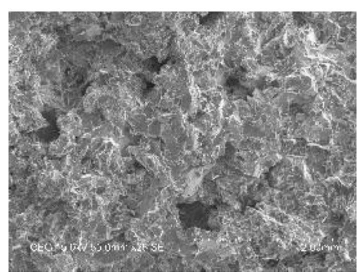


Figure 5: Al & BASALT 25% - 2 µm

VIII. CONCLUSION

From the study it is concluded that we can use Basalt powder for the production of composites and can commercial aluminium into mechanical components. The Tensile Strength of pure Al increased from 1.4 KN to 1.7KN with addition of 25% Basalt. The Hardness of the composite material created reduced from 63.3 BHN to 49.8 BHN. On addition of Basalt in Al moult, there was appreciable reduction of density from 3.398 g/cm3 to 2.807 g/cm3. So it is concluded that the aluminium with 25 % basalt having good tensile properties and can be used for the applications.

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