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STUDY ON MATERIAL PROPERTIES OF ALUMINUM WITH SILICON CARBIDE AND BLAST FURNACE SLAG

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ABSTRACT:

In this thesis, to develop lightweight AluminumSilicon Carbide & Blast Furnace Slag composites and evaluate the mechanical properties .Objective of this research is to fabricate and testing the mechanical properties of Aluminum metal matrix composites with Silicon Carbide & BFG Slag at different volume proportions. Mechanical properties like tensile strength, impact strength and hardness of newly developed metal matrix composites is improved significantly by incorporating Silicon carbide particlesThe Oberst Beam Method is a classical approach for vibrational analysis of a composite cantilever beam. In this work, the composite beam is made of Aluminum 7075 (as matrix) and Silicon Carbide (as reinforcement).The dimensional parameters of the cantilever beam which is to be analyzed and the requirements of experimental set up are as per ASTM E-756. The OBM has a wide application in characterization of metals by their properties. But here the object of OBM is limited to find Frequency Response Function (FRF) and Damping Ratio of Al 7075 with different compositions of SiC (10%, 15%, 20%, 25%) & BFG Slag (5%, 10%, 15%, 20%). In this, after setting up the Oberst test rig the effects of various parameters on experimental results are cross checked in an attempt to improve the accuracy of the estimated material properties. The main parameters affecting the quality of the measured data are identified by repeatable measurements. Then tests are carried out on the Oberst test rig to determine the effect of the amplitude of the excitation force given to the specimen to be tested.

Keywords: *Silicon Carbide, Blast Furnace Slag, Frequency Response Function.*

INTRODUCTION:

Materials technology and Engineering design field requires advanced engineering materials with high end mechanical, electrical and magnetic properties. To suit the requirements of engineering industries, the ceramic particles like,SiC, BFG Slag are mostly reinforced with Aluminum metal matrix for their improved mechanical properties like hardness, toughness, and low wear rate.. In this work, Silicon Carbide and Blast Furnace Granulated Slag particles are reinforced with Al7075 alloy with different volume proportions. Main objective of this research is developing lightweight Aluminum metal matrix composites and analyzes the influence of Silicon Carbide and reinforcements. The testing specimen is prepared by Stir casting method. The mechanical properties like hardness, toughness and stress-strain behavior are calculated by changing the reinforcement material composition (based on different volume percentage of SiC & BFG Slag).

Vibrations:

The fundamentals of Sound and Vibrations are part of the broader field of mechanics, with strong connections to classical mechanics, solid mechanics and fluid dynamics. Dynamics is the branch of physics concerned with the motion of bodies under the action of forcesVibrations or oscillations can be regarded as a subset of dynamics in which a system subjected to restoring forces swings back and forth about an equilibrium position, where a system is defined as an assemblage of parts acting together as a whole.

Blast Furnace Granulated Slag (BFG) Composition:

- CaO: 32 to 41 %
- SiO2: 31 to 39 %
- Al 2O3: 13 to 21%
- Mg O: 6 to 11%
- MnO: 2% Max
- Moisture: 6 to 9%
- Glass Content: 93% Max

The glass content of slags suitable for blending with Portland cement typically varies between 90-100% and depends on the cooling method and the temperature at which cooling is initiated. The glass structure of the quenched glass largely depends on the proportions of network-forming elements such as Si and Al over network-modifiers such as Ca, Mg and to a lesser extent Al.

Applications:

Blast Furnace Granulated Slag (BFG) is used to make durable concrete structures in combination with ordinary Portland cement and or other pozzolanic materials. BFG has been widely used in Europe, and increasingly in the United States and in Asia (particularly in Japan and Singapore) for its superiority in concrete durability, extending the lifespan of buildings from fifty years to a hundred years Two major uses of GGBS are in the production of quality-improved slag cement, namely Portland Blast furnace cement (PBFC) and High-slag blast-furnace cement (HSBFC), with BFG content ranging typically from 30 to 70%; and in the production of ready-mixed or site-batched durable concrete.

2.0 Literature review:

Fanet al[1] done a survey on damage tolerant design, the failure behavior and analysis methodologies of laminated composites. Though there was much advancement in damage tolerant design and analysis, their method was accepted based on both the experimental data and practical applications. They concluded that as these composite structures develop many failures, it is very important to know the mechanisms involved in failure and develop failure theories and damage models.

Allixet al[2] conducted experimentation on a wide class of specimens-D.C.B,E.N.F and Their main focus was to identify the inter-laminar interface using Fracture Mechanics tests. With very little experimentation, they have succeeded in developing a computational tool and compared both the analytical as well as the numerical stability analyses thus supporting the results of experiments in the literature **AifWakeel, mustafaSaleem[3]** and others have conducted experiments on Nome honeycomb core using double cantilever beam geometry based on three temperatures hot, room and cold temperature. Fatigue crack growths were also tested at the face sheet core joints. They observed that toughness increased with increase in cold temperature while fatigue crack growth rate were relative to room temperature. Compared to bonding of the face sheets, the core was weaker. This core strength would be the most important factor in fracture mechanics properties to minimize scatter and to identify parameters required for carbon fiber-reinforced polymer matrix composites, the author and others analyzed various approaches. Cyclic fatigue tests were performed. Comparison was done on load and displacement control

3.0 Methodology:

Test specimens were fixed like cantilever and impact test was carried out to determine the Frequency Response Function and damping ratio. One end of the sample was fixed in bench vice with the help of C-clamp and another end was free. Accelerometer was put on fixed-end side of the sample. It was excited by Impact hammer having inbuilt force sensor and response was collected by accelerometer. Then LANXI Data Acquisitions System receives signal from accelerometer to determine Frequency Response Function and damping ratio. (Position of sensor and impact hammer are shown in Fig. The frequency range of measurement is DC – 1.6 kHz)

Oberst Beam Test:

Instrumentation used for this test is

Accelerometer: Type 4519-003 (Make: B&K)

Impact hammer: Type 086D05 (Make: PCB)

Data acquisition: LANXI Data acquisition system (Make: B&K)

Analysis software: Pulse Analysis software, Version 16.1(Make: B&K)

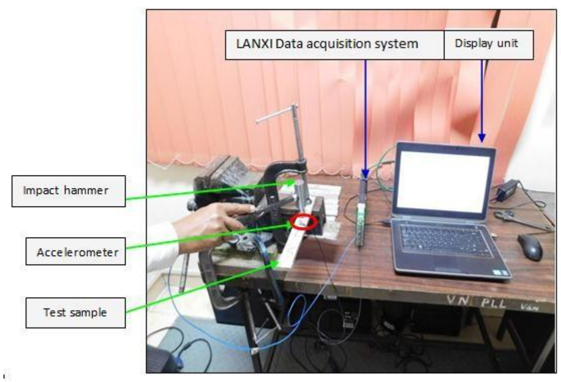


Figure: Experimental test setup for FRF and Damping Evaluation.

Material properties:

Aluminum alloy 7075 + SiC 10% + BF SLAG 5%

Aluminum alloy 7075 + SiC 15% + BF SLAG 10%

Aluminum alloy 7075 + SiC 20% + BF SLAG 15%

Aluminum alloy 7075 + SiC 25% + BF SLAG 20%

Tensile test:

Tensile testing, also known as tension testing is a fundamental materials science test in which a sample is subjected to a controlled tension until failure. The results from the test are commonly used to select a material for an application, for quality control, and to predict how a material will react under normal forces. Properties that are directly measured via a tensile test are ultimate tensile strength, maximum elongation and reduction in area.

Tensile test machine

Hardness test:

Figure: Hardness Test machine

Hardness is a characteristic of a material, not a fundamental physical property. It is defined as the resistance to indentation, and it is determined by measuring the permanent depth of the indentation.used to test materials that have a structure that is too coarse or that have a surface that is too rough to be tested using another test method, e.g., castings and forgings. Brinell testing often use a very high testing load (3000 kgf) and a 10mm diameter indenter so that the resulting indentation averages out most surface and sub-surface inconsistencies The Rockwell hardness test method, as defined in ASTM E-18, is the most commonly used hardness test method.

Machining process for doumble shape:

The shape of the machined surface is determined by the contour of the cutting edges on the broach, particularly the shape of final cutting teeth. Broaching is a highly productive method of machining. Advantages include good surface finish, close tolerances, and the variety of possible machined surface shapes, some of them can be produced only by broaching. Owing to the complicated geometry of the broach, tooling is expensive. Broaching is a typical mass production operation. Broaching can be used for machining of various integrate shapes which cannot be otherwise machined with other operations. Some of the typical examples of shapes produced by internal broaching are: Productivity improvement to ten times or even more is not uncommon, as the metal removal rate by broaching is vastly greater. Roughing, semi finishing and finishing of the component is done just in one pass by broaching, and this pass is generally accomplished in seconds.

Figure: doumble shape machining process

Impact Test:

The impact test, also known as the Charpy V-notch test, is a standardized high strain-rate test which determines the amount of energy absorbed by a material during fracture. This absorbed energy is a measure of a given material's notch toughness and acts as a tool to study temperature-dependent ductile-brittle transition. It is widely applied in industry, since it is easy to prepare and conduct and results can be obtained quickly and cheaply. A disadvantage is that some results are only comparative.the technical contributions and standardization efforts by Charpy. The test was pivotal in understanding the fracture problems of ships utilized in many industries for testing materials, for example the construction of pressure vessels and bridges to determine how storms will affect the materials used.

Figure: Impact Test

4.0 Results and discussions:

A static analysis calculates the effects of steady loading conditions on a structure, while ignoring inertia and damping effects, such as those caused by time-varying loads. A static analysis can, however, include steadyinertia loads (such as gravity and rotational velocity), and time-varying loads that can be approximated as static equivalent loads (such as the static equivalent wind and seismic loads commonly defined in many building codes).

static Analysis:

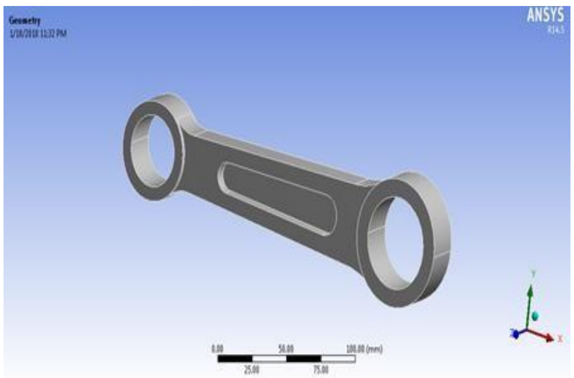


Figure: geometric models

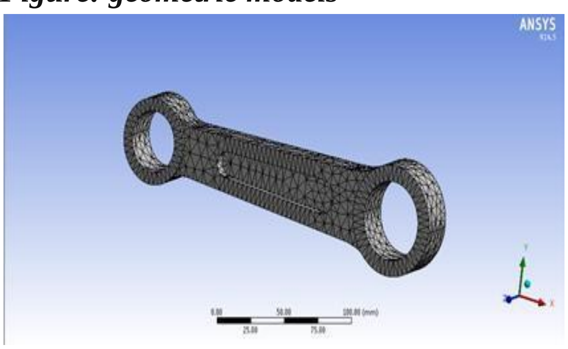


Figure: Meshed model

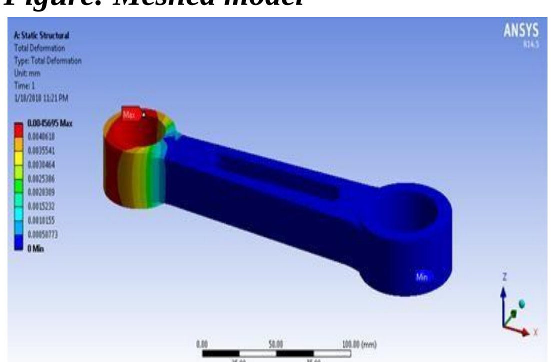


Figure: Total deformations

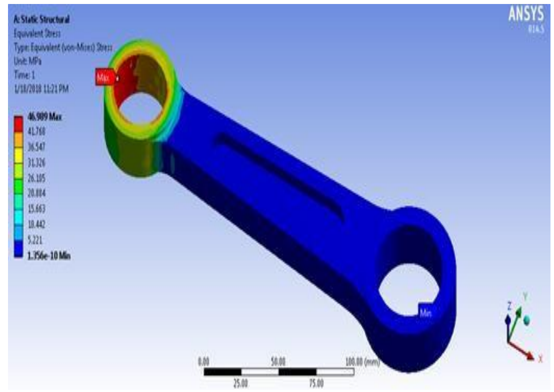


Figure:equivalent von mises stress

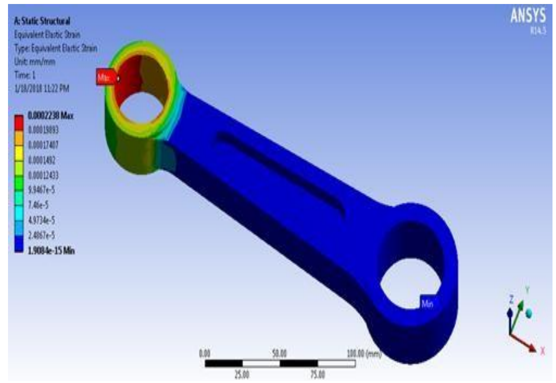


Figure:equivalent elastic strain

Thermal analysis of connecting rod

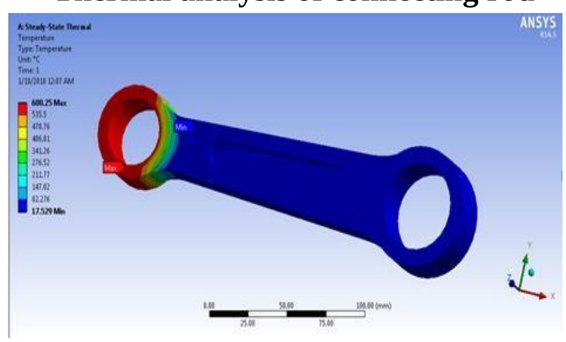


Figure: Temperature distributions

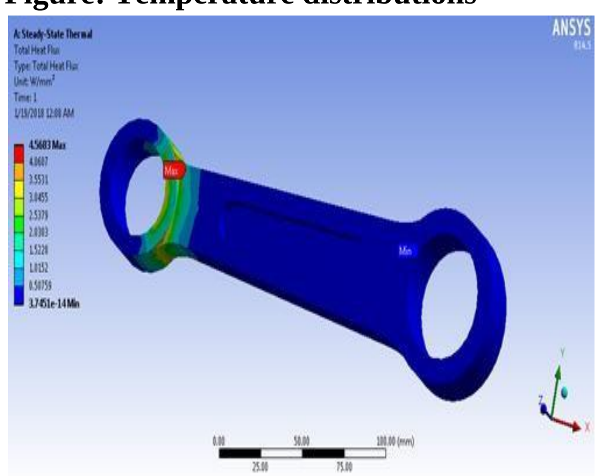
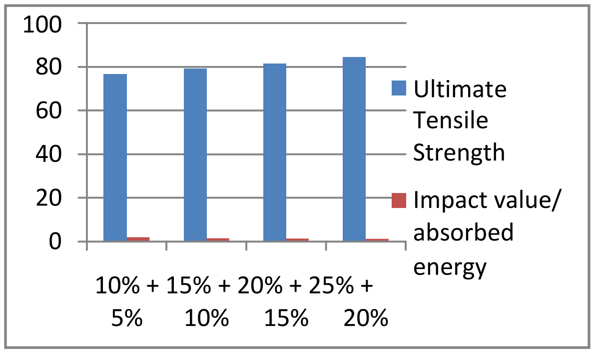


Figure:heat flux

Tensile and Impact Test Results

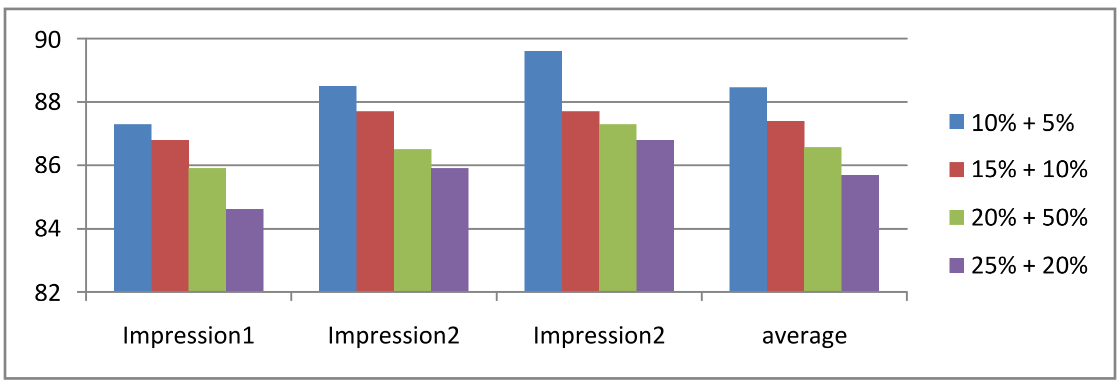
wt% of SiC + BFG	Ultimate Tensile Strength	Impact value/ absorbed energy
10% + 5%	76.761	2
15% + 10%	79.301	1.63
20% + 15%	81.412	1.5
25% + 20%	84.521	1.33



Graph: Effect of Wt% of SiC & BFG on Tensile Strength

Table 4.2 Hardness test results

wt% of SiC + BFG	Impression1	Impression2	Impression2	average
10% + 5%	87.3	88.5	89.6	88.46
15% + 10%	86.8	87.7	87.7	87.40
20% + 50%	85.9	86.5	87.3	86.56
25% + 20%	84.6	85.9	86.8	85.7



Graph: Effect of Wt% of SiC &BFG on BHN value.

CONCLUSIONS:

This experimental evolution of Aluminum and Silicon Carbide & BFG Slag composites leads to the following conclusions:

- Production of Al-Silicon Carbide & BFG Slag composite was completed successfully.
- In the Oberst beam test, from Frequency Response Function we conclude, Modal frequency and Damping ratio at 3rd mode increases with increase the wt% of SiC (10%,15%,20%,25%) &wt% of BF Slag (5%,10%,15%,20%).
- The finite element analysis (FEA) is a powerful computational tool for analyzing complicated structures. It can reduce prototype parts producing and the number of physical tests to shorten the development cycle and reduce the development investment; i.e., it saves much time, effort and cost.

Based on these outcomes, it is recommended that DRSS powder reinforced with polyester composite materials are suitable for internal structural automotive panel applications

FUTURE SCOPE OF RESEARCH:

There is a wide scope for future scholars to explore this area of research. This work can be further extended to calculate complex modulus and loss factor of composite beams and also in the area of multi layered beams. The present work, it is limited to the find Frequency Response Function and Damping ratio of the Oberst beam as per ASTM E-756.

Analysis by FEA can be extended other mechanical parts like

- Propeller blades.
- Cutting tools.
- Cylinder liners.
- Aerospace applications.

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