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Design and Fabrication of a Piston with Aluminium Alloys and Copper Composite

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ABSTRACT
Pistons are designed and fabricated with such features to satisfy the requirements light weight, good wear resistance, high strength to weight ratio, etc. Pistons are made from different materials for different requirements and applications. Most popular materials are Aluminium alloys, Titanium and Cast Iron. A single material does not satisfy all the requirements. For example, for piston made from Aluminium alloys, lightness and ability to absorb high impact comes at the expense of durability. For piston made of Titanium, the combination of strength and lightness is achieved at the expense of affordability. A prototype of Piston is made using direct machining of Al Alloy and copper material in hand lay-up method forming a Al-Cu composite. This Composite Metallic Material (CMM) is then evaluated for mechanical properties. The results indicate that Al alloy pistons can be replaced with Al-Cu composite pistons for better durability.
Keywords: Keywords: Piston, Al alloy, Al-Cu composite, Composite Metallic Material (CMM)

I. INTRODUCTION

When presented with a motorcycle which had a problem with the piston and the production of the said motorcycle has stopped, a piston was designed and fabricated from a novel CMM using Al alloy – Cu composite. Further, mechanical properties of the said piston were analyzed and evaluated.

Piston is a vital component of a cylindrical engine. It reciprocates inside the cylinder bore. While operating under engine load, piston head is exposed to high pressure. This is due to the expansion of combustion gases. As the piston reciprocates from TDC to BDC, it is subject to thermal cyclic loading. The temperature of initial flame front during combustion exceeds 2200^0C. When the piston is subjected to this temperature for a short span of time, the thermal stress and expansion of the piston head can pose serious concerns. For functionality and durability of the piston, under the above mentioned conditions, the material and design of the piston play a vital role. Several alternatives to cast iron and carbon steel are reported in the literature. Particularly Aluminium alloys [1,2]. A reduction in weight by 43% and 75% reduction in displacement have been reported. Doshi, et. al. found there is a possibility of further reduction in mass of the piston in mass of the piston in commercially available vehicles. [3] Significant improvement was observed in strength, fatigue, modulus, wear resistance and creep. [4, 5] MMCs could have had farther outreach; several factors including fabrication, processing, compatibility between matrix and reinforcement pose challenges to their applications. A good solution to these problems is to choose proven alloy system with solvent as matrix and the solute as reinforcement. In the present study an attempt has been made to investigate the mechanical properties of Al–Cu composite metallic materials (CMMs). The results are compared with that of the alloy.

II. EXPERIMENTAL

2.1 Fabrication of alloy and composite

Pure Aluminium Cut ingots were melted in a pot - type furnace in clay graphite crucible at 700^0 C. For the alloy, copper pieces wrapped in aluminum foil are added to the aluminum melt at 850^0 C until copper has molten completely. Composite metallic materials (CMMs) are prepared by dispersing copper particulates in aluminum matrix. Final alloy is Al – 5%Cu and composites are made up of 10 %, 20% and 30% of weight of Cu.

2.2 **Fabrication of Piston**

Piston is made using direct machining for aluminum alloy and copper material in hand layup method for aluminum and varying copper composite of piston.

Fig 1: Formation of alloy and fabrication of Piston

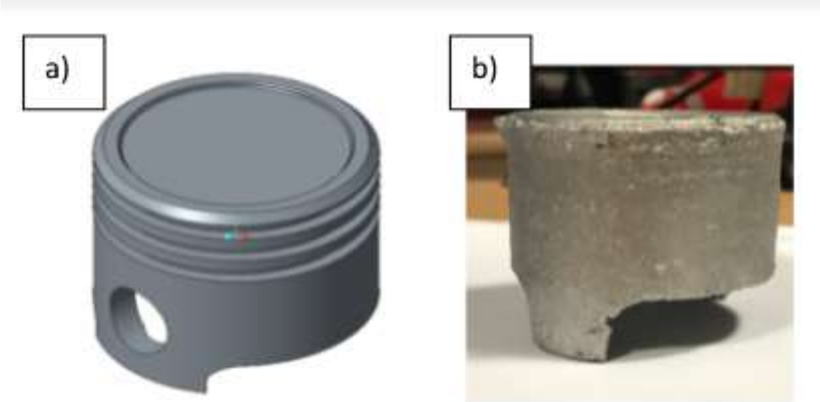

Fig 2: Design of the piston head a) 3d Design b) Fabricated Piston head

2.2. **Tensile test**

40 KN tensile testing machine was used to test the samples. Testing was done at a constant cross head speed of 1 mm/min. Specimens were prepared as per the ASTM-E8M standards. Three samples are tested in total and in each case average values are reported.

2.3. **Impact Strength**

Impact strength was measured using a charpy impact tester. The dimensions of the samples are 10 X 18 X 80 (mm). Six samples are tested in total and in each case average values are reported.

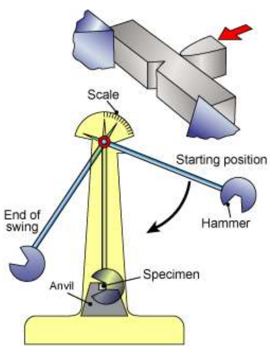

Fig. 3: Schematic of Charpy Impact Tester

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2.4 **Flexural Rigidity**

The three point bend test was carried out in UTM machine in accordance with ASTM D2344-84 to measure the flexural strength of the composites. The loading arrangement for the specimen and the photograph of the machine used are shown in Figure-3.(a) and (b) respectively. The entire specimens were of rectangular cross section of (150x20x5) mm. A span of 100 mm was used for the test specimen. The specimens were tested at a crosshead speed of 0.5mm/min.

The flexural stress in a three point bending test is found out by using equation (1)

$$= \frac{3FL}{2bt^2} \quad (1)$$

Where F is the load, b is the width and t is the thickness of the specimen under test.

The short beam shear tests (SBS) are performed on the composite samples at room temperature to evaluate the value of inter-laminar shear strength (ILSS). It is three point bending test which generally promotes failure by inter-laminar shear. The SBS test is conducted as per ASTM standard using the same UTM, span length 100mm and cross head speed 0.5mm/min.

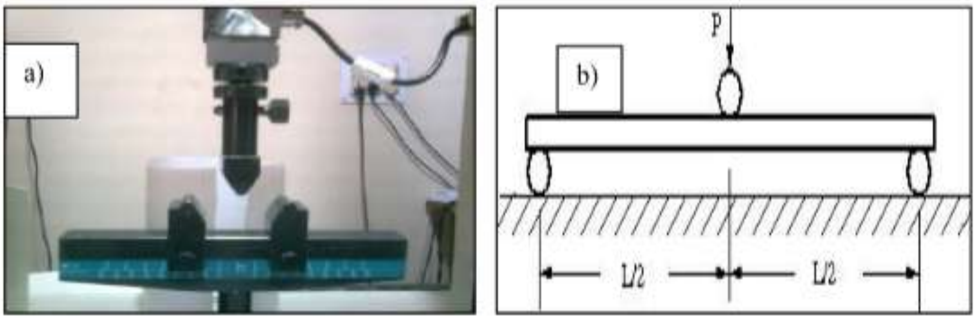

Fig 4: a) Point Bend Test on UTM b) Schematic of Point bend test

III. RESULTS AND DISCUSSIONS

Table 1. Summary of tensile strength, impact strength and flexural rigidity

Composite	Tensile Strength (MPa)	Impact Strength (Joules)	Flexural Rigidity (MPa)
Al – 10 Cu Composite	138	90	232
Al – 20 Cu Composite	132	70	224
Al – 30 Cu Composite	129	67	216

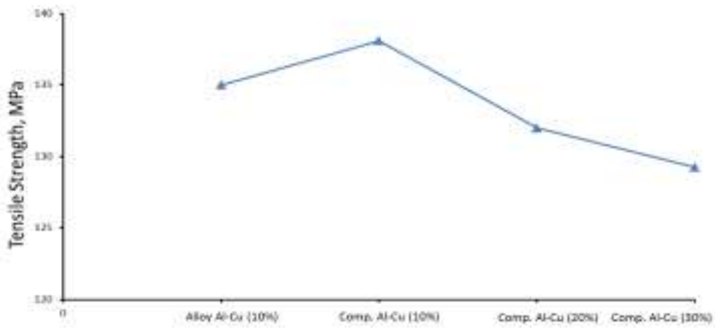

Fig. 5: Effect of copper content on tensile strength, composites

Table 1 summarizes the results of mechanical properties of alloy/composites. Fig. 1 depicts shows the comparison of tensile strength of composites and also alloy of the same percentage composition. A 6% reduction is observed in the tensile strength. The increased strength is attributed to of Base metal (Al), the alloy as well as the reinforcements. However, as the percentage of copper increased, the tensile strength decreased. This may be due to increased difficulty in deformation due to agglomeration of increased reinforcements. [6] It could also be due to void formation within the composite.[7] Void formation can be further investigated using microscopic studies.

Impact strength and flexural rigidity values are depicted in Fig. 6 and Fig. 7 respectively. As explained above, this can be mainly attributed to agglomeration of increased reinforcements. Also with the increased percentage of Cu, the reinforcement becomes stronger than the matrix giving way to formation of voids. It could also be a result of differences in the loading, resulting in uniform plastic deformation of the material, while plastic deformation becomes localized. [6,8]

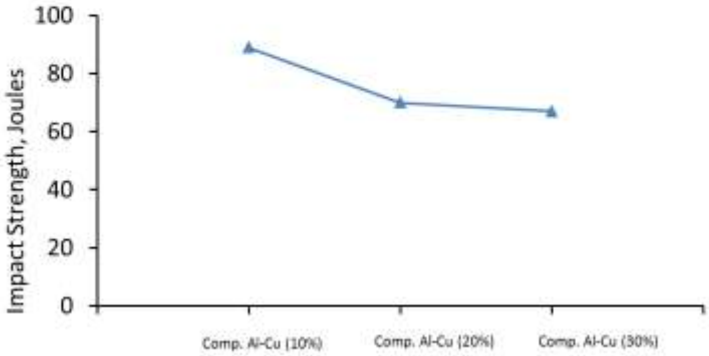

Fig. 6: Effect of copper content on impact strength, composites.

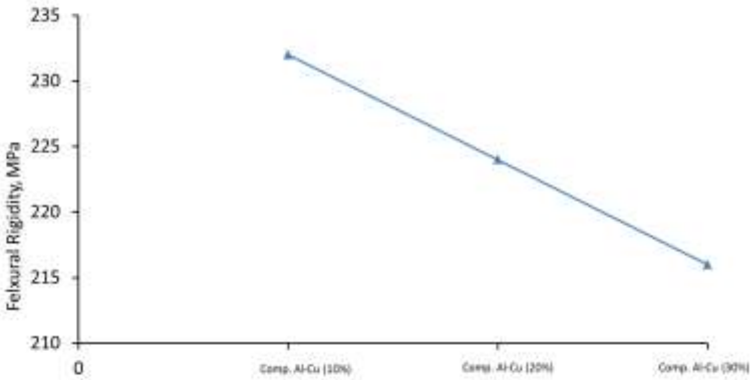

Fig. 7: Effect of copper content on flexural rigidity, composites

IV. CONCLUSIONS

Although increasing initially, as the percentage of reinforcements in the composite, results show a declining trend in the mechanical properties of the resultant composite. High Flexural rigidity values are observed at all concentration. Microscopic studies can further reveal the nature of void formation.

Conflict of interest

The authors have no conflict of interest to declare.

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REFERENCES

[1]. Kuldeep B, Arun L.R, Mohammed Faheem, International Journal of Innovative Research in Science, 2, 6 June (2013).
[2]. Mohamed Abdusalam Hussin, Er. Prabhat Kumar Sinha, Dr. Arvind Saran Darbari,

International Journal of Mechanical Engineering and Technology (IJMET), 0976 – 6340,0976 – 6359, 5, 10 October (2014), 57-69.
[3]. Prof. N.P.Doshi, Prof .N.K.Ingole, International Journal of Modern Engineering Research (IJMER), 3, 1 Jan (2013), 65-68.
[4]. T.G.Nieh, D.J.Chellman, Scripta Metallurgica ,Volume 18, 9, September (1984), 925-928.
[5]. C. M. Friend, Materials Science and Technology, 18 Jul (2013),1-7.
[6]. Siddabathula Madhusudan, Mohammed Moulana Mohiuddin Sarcar, Narsipalli Bhargava Rama Mohan Rao, Journal of applied research and technology,14, 5, October (2016), 293-299.
[7]. C. Hofmeister, B. Yao, Y. H. Sohn, T. Delahanty, M. van den Bergh, K. Cho, Journal of Materials Science, 14 May (2010).
[8]. Dikshit, S.Gurjar, V.Dasgupta, R. Chaturvedi, S.Pathak, K. K.& Jha, Journal of materials science, 45(15), 4174–4179.