Experiments on the thermo-mechanical behavior of Al 319 strengthened with recycled glass.

Mr V. Jaipal Reddy[1], Ms V.Sandhya [1]*, Dr L Suresh Kumar [1], Mr G. Sreenivasulu Reddy[2]
1-Assistant professor, Department of Mechanical engineering, Chaitanya Bharathi Institute of Technology, Gandipet, Hyderabad, Telangana, India
2-Assistant professor, Department of Mechanical engineering, Mahatma Gandhi Institute of Technology, Gandipet, Hyderabad, Telangana, India
* Corresponding Author- V.Sandhya, vsandhya_mech@cbit.ac.in

Abstract—The current study investigates the mechanical behavior of glass/Al composite using powder metallurgy. The main feature of glass content is low weight to high strength reveals enhanced strength.The results of the glass content sintering the temperature and sintering time on the composite properties have been investigated. The common glass content is 5vol%, 10vol% &15vol% and thus the sintering temperature and time are 600-660°C and 6 hours severally.The Al 319 base alloy was compared to their glass-aluminum composite variations in tensile, density, hardness, wear resistance, and the fabrication of recycled glass/aluminum composites using powder metallurgy.Tensile strength and density of fabricated composites decrease as the weight percentage of recycled glass increases while hardness, thermal conductivity, and wear rate remain constant.

Key Words—Al composites, vol.% of recycled glass, powder metallurgy.

1. Introduction

Scrap Al319 reinforced with metallurgically created nano iron compound was investigated with low value producing of sunlight and efficient multi-functional materials for engineering applications [1]. Al composites reinforced with particles tend to improve properties processed by completely different methods [2]. Over the last few decades, high-performance Al composites with high strength, stiffness, density, and wear resistance capability have been widely developed [3].Among these, Al319 aluminum is widely used as an engineering applications [4]. Al319 is an intriguing choice for military and automotive applications because the alloy has important properties such as high quality, lightweight, and a high limit in terms of foundry [5]. This combination can likewise be effectively utilized as a network from the reused crisp piece (chips) to create fantastic metal grid composites in a monetary way [6]. Reused glass can now replace up to 95 % of raw materials; glass is 100 % recyclable and can be reused indefinitely without deterioration in quality or immaculateness. Assembling profits by reusing in a variety of ways: reused glass decreases discharges and utilization of crude materials, extends the life of plant, for example, heaters, and saves vitality, and aluminum mixture reusing is likewise playing an important role in the automobile industry.

Powder metallurgy method for glass/aluminum network composites planning. The prepared composites have a high glass content, are transportable, and have a high scraped area opposition [7].Powder metallurgy(PM) course is one of the alluring techniques for metallic froths generation since it takes into account preparing of wide range segments and close net molded geometries froths and in addition the froths with necessary sandwich structure. Broad scientists have been completed to create Al combination froths by the solid route [8]. Lightweight has turned into a critical perspective with a specific end goal to decrease Co2 outflows in the car and enhancing range in electric vehicles thus lightweight materials, for example, aluminum, magnesium or composite materials are in effect broadly examined for car applications [9]. The sinter capacity of Al combination powder metallurgy PM amalgam was explored. Financially accessible Aluminum alloy319 has been uniaxially squeezed compacts in the scope of 100– 500 MPa were sintered at temperatures in the scope of 610–660°C. The explored composite demonstrates a decent sintering reaction and 98% hypothetical thickness (TD) was accomplished. An ideal sintering profile has been chosen and the mechanical properties were estimated, for example, hardness, elasticity esteems acquired were near the modernly distributed qualities. Notwithstanding the sintering and warmth treatment, the microstructure of sintered material has been inspected and portrayed utilizing optical and filtering electron microscopy [10]. In general, the advanced basic composites use fiberglass, carbon/graphite, boron, Kevlar (aramid), and other natural materials, emphasizing the primary properties of lightweight, higher solidity, and solidity. These fortifying effects of fiber fortifications in composites are influenced by the number of strands (fiber-sap proportion), type of filaments, and fiber introduction in the direction of burdens. [11]. Crack initiation in particulate composites is related to molecule break, interfacial-network disappointment, and incorporation break, depending on the specific composite and lattice condition. [12] Formal paraphrase in the current study, Al319 alloys with varying mesh sizes were used as reinforcement materials [13].

2. Experimental details

Ball with substantial size is chosen which is advantageous to the processing of aluminum combination 319. The dry ball processing is completed in the level jug containing balls, powder and a procedure controlling operator. Aluminum compound 319 of 15g, 900g of tempered steel balls with a breadth of

16mm, and 3wt% of stearic corrosive are utilized as a part of this procedure. Aluminum compounds 319 were cut into strips each with a length of 6mm. These strips are utilized as the underlying processing materials for additionally preparing. The constant processing procedure ought to be proceeded for 45 h at a rotational speed of 100 rpm by cooling with the assistance of the cooling operator. A lot of stearic corrosive is utilized which decreases grinding between aluminum amalgam 319 and the processing device that dispenses with warm. The Chemical composition of scrap A319 is Cu(0.19), Fe(0.20), Mg(0.25), Si(6.5-7.5), Ti(0.20), Zn(0.10) remaining Al content. Die is prepared from the P20 carbon steel which is machined in the CNC lathe machine with required dimensions. Details of prepared composites presented Table.1.

Table.2: produced composites details

Composite mixture
100% Al + 0% Glass
90% Al + 10% Glass
80% Al + 20% Glass
70% Al + 30% Glass

2.1 Metal matrix mixing and compacting process

There are two sorts of powder blending techniques that are dry blending and wet blending. In the examination, dry blending is difficult to be equivalent and takes a moderately prolonged stretch of time. Then again, wet blending needs a lot of solvents, and the blend needs drying before being smothered, and if the drying procedure is timely, it could without much of a stretch prompt surface oxidation or sintered permeable surface. The preparatory property test demonstrates that the readied material isn't essentially extraordinary inconsistency and quality properties by methods for dry blending and wet blending. Along these lines, in future testing and generation, we, as a rule, receive dry blending. We have explored the impact of different sorts of ointments on the concealment procedure. The outcomes demonstrate that under high weight, the impacts of the ointment on the concealment procedure are very unique. In which, MoS_2 is costly; a few fold the amount of as calcium stearate. In the meantime, calcium stearate grease and framing are great under various weights, totally meeting creation necessities. Along these lines, in this investigation, shaping operator and ointment are calcium stearate, which is shoddy and stable.Because the length-diameter ratio of the sample is small in this study, we use the one-way compacting method. Previous research has shown that when the pressure is not too high (no cracks in compaction), the relative density of the product increases as the compacting pressure increases. With respect to the constant and equipment, use a 300tone machine to compact products, with a pressure of about 300MPa and a holding time of 2 minutes.

This study conducts numerous tests to determine the effect of temperature on the sintering process. The test temperature range is 590^0 C – 700^0 C, and the results show that at the same temperature, the densification coefficient changes little for compacts with different glass content, whereas the temperature influence is significant for compacts with the same glass content. It can be seen that the densification coefficient of products increases with increasing temperature.The reason for this is that as the temperature rises, the mutual diffusion coefficient of the sintering system rises, as does atomic activity and sintering. Meanwhile, the glass particles segregate and obstruct the Al, making grain growth difficult. However, the higher the sintering temperature, the better; if the temperature is too high, liquid aluminum will flow out of the block, causing the product to change significantly in shape and size. Given the foregoing considerations, the sintering temperature of the product is set at around 700^0 C in the study.

2.2Thermal Conductivity Testing and Procedure:

Thermal conductivity in "thin" materials, also known as "thermal interface materials." Materials that are "thin" are those that are less than 1-2 cm thick. Thermal conductivity is defined in this method as the ratio of heat flux to the associated thermal gradient under one-dimensional heat conduction conditions. Thermal conduction between two parallel, isothermal surfaces of area A at temperatures TH and TC separated by a layer of the material-under-test with a thickness X and a steady state power of Q can be envisioned in this measurement. As a result, thermal conductivity, k, is defined as ask = Q * X / ((TH - TC) * A).

2.3 Wear test:

This test method describes a laboratory procedure for determining material wear during sliding using the pin-on-disk apparatus depicted in Figure.1. Under nominally non-abrasive conditions, materials are tested in pairs. The main experimental focus areas in measuring wear with this type of apparatus are described. It is also possible to calculate the coefficient of friction.

Figure.1: Pin on disc

2.4Tensile test

The Universal testing machine was utilized to the ductile testing and test samples as appeared in the Figure.2; this test is utilized to locate the pliable conduct of the composites.

Figure.2: Work Specimen obtained from powder metallurgy

2.5. Hardness test

In those strategies, Brinell hardness test is utilized for the hardness testing shown in Figure.3 and applying load is 600kgf, 10mm steel ball utilizing to the infiltration after 15 sec evacuate the heap and measure the entrance gap distance across by utilizing the magnifying lens.

Figure.3: Brinell hardness testing machine

2.6. Density test

Thickness is a material's mass per unit volume. The proportion of the mass of a given volume of material at 23°C to a similar volume of deionized water is measured as particular gravity.

Figure.4: Mettler balance Electronic weighing machine

Particular gravity and thickness are especially relevant because plastic is sold on a per-pound basis, and a lower thickness or particular gravity implies more material per pound or fluctuating part weight. Mettler equilibrium Figure 4 depicts an electronic weighing machine.

3. Results and discussion

3.1Tensile test

The tensile strength variations shown in Figure 5. The below graph shows that the increase in the amount of glass content while decreases the tensile strength of the composite because of the density of material decreases, brittleness increases & porosity increases.

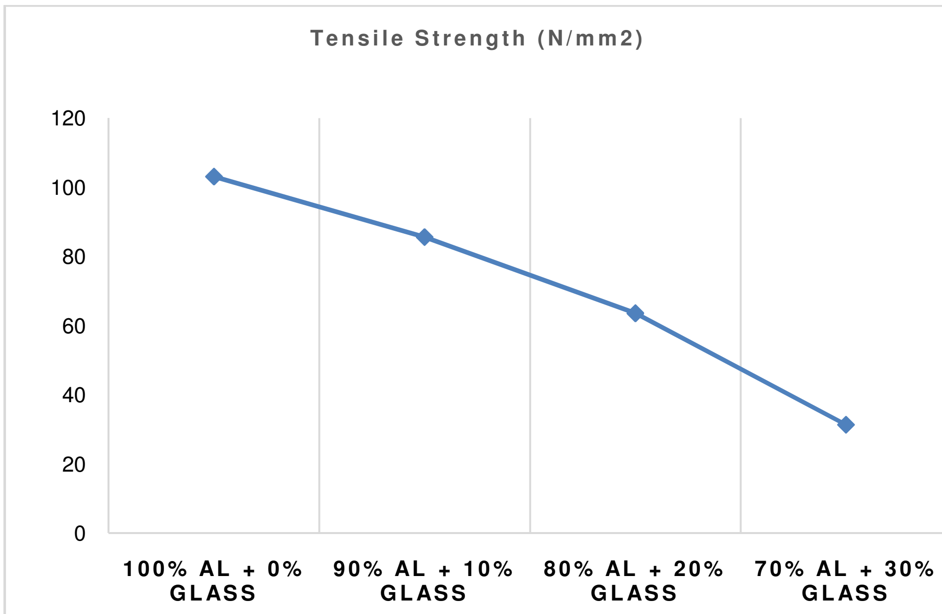

Figure.5: Tensile strength varies with weight % of glass

3.2 Hardness test

Measurement of hardness shown in Figure 6. From the below results, the hardness increases correspondingly with the glass content because of internal energy increases due to porosity.

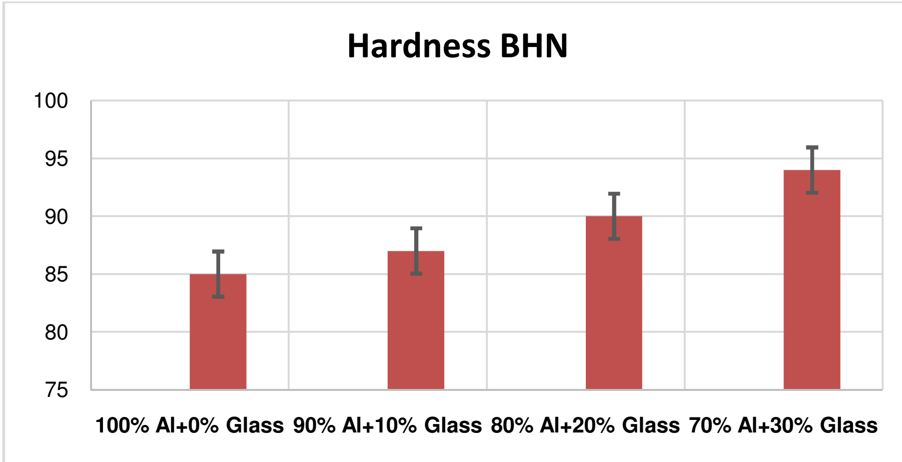

Figure.6: Hardness varies with weight % of glass

3.3 Thermal conductivity test

From the results shown in Figure 7, increase in the glass content, increases the thermal conductivity because the thermal conductivity is higher than to the Al-319, the thermal conductivity of the composites increases with the corresponding increase in the porosity.

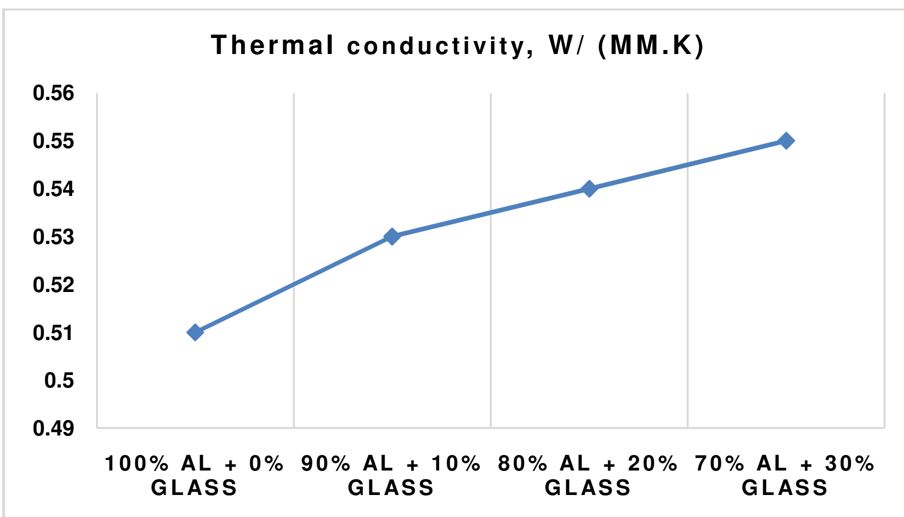

Figure.7: Thermal conductivity varies with weight % of glass

3.4 Density test

The graph (Figure 8) shown that increasing the glass content in samples, decreases the density of the samples respectively because the glass density is less compared to the density of the aluminum alloy 319.

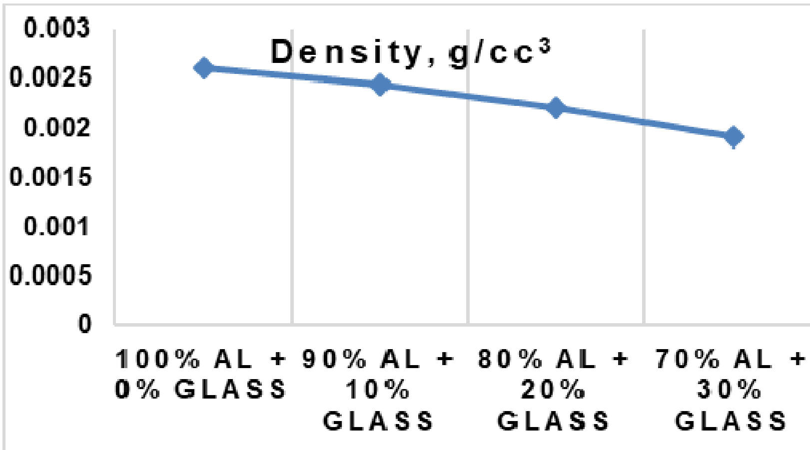

Figure.8: Density varies with weight % of glass

3.5 Wear behavior

The wear rate of the produced composite with recycled glass is shown in below Figure. The wear rate decreases with increases recycled glass. It was found that minimum wear rate at 90% Al + 10% glass.

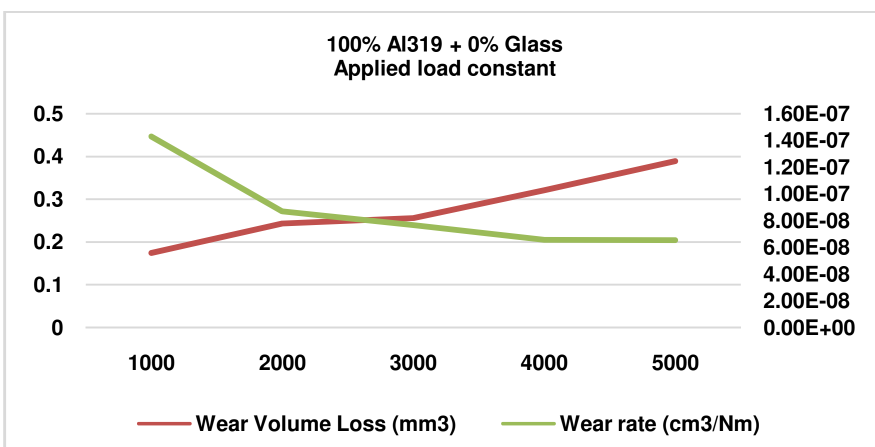

Figure.9: wear rate of pure aluminum with load constant

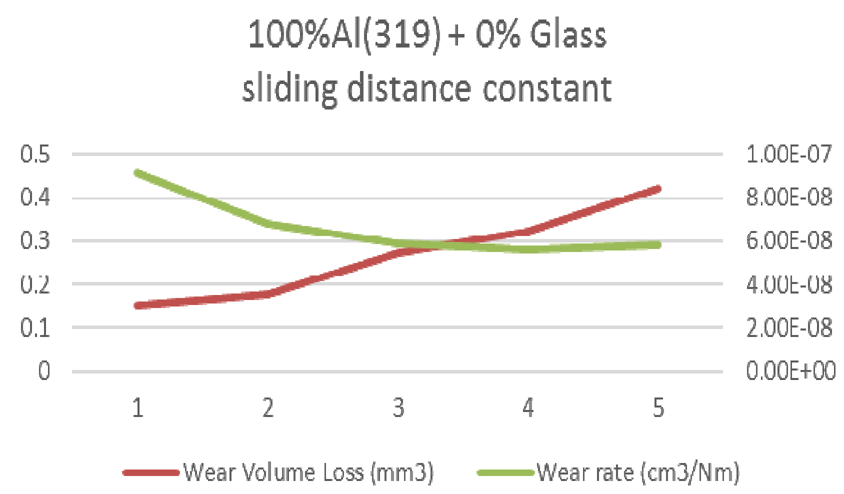

Figure.10: wear rate of pure aluminum sliding distance constant

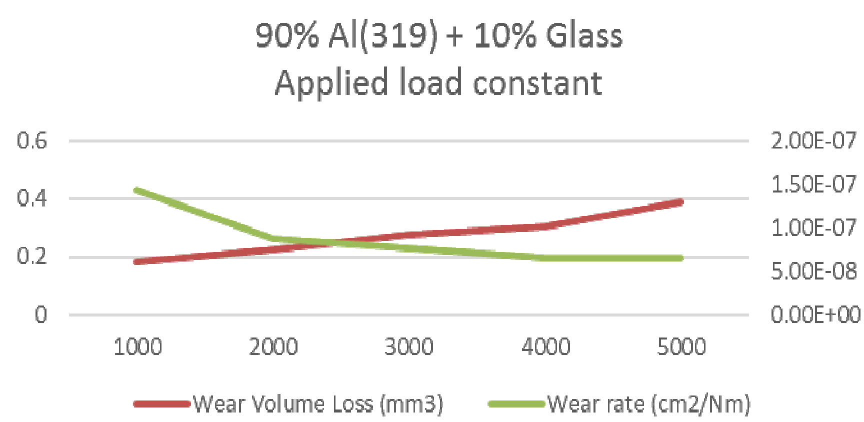

Figure.11: wear rate of sample (90% Al + 10% Glass) applied load constant

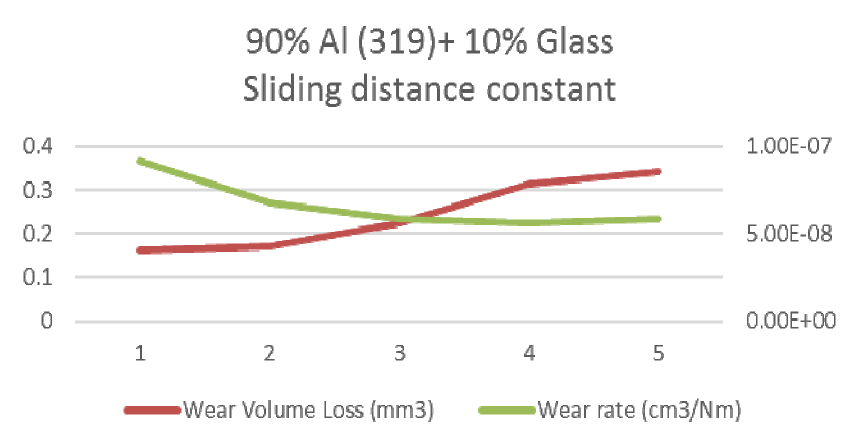

Figure.12:wear rate of sample (90% Al + 10% Glass) sliding distance constant

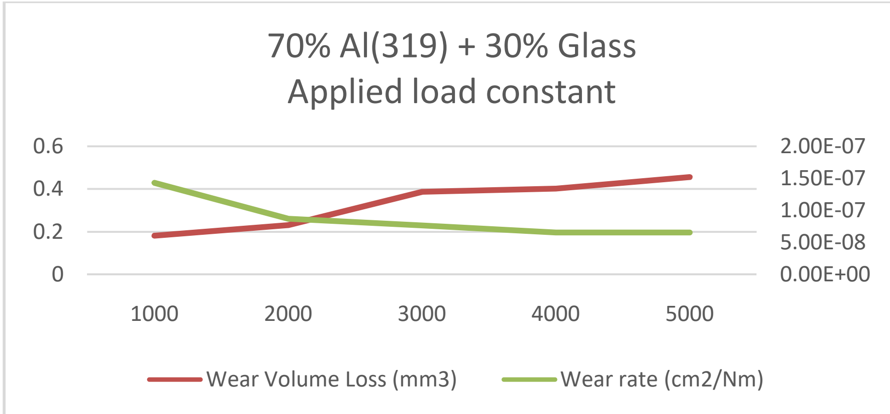

Figure.13:wear rate of sample (70% Al + 30% Glass) sliding distance constant

4.Conclusion

It has been determined that the addition of glass reinforcement increases hardness because load penetration is reduced and internal energy is increased.

- Thermal conductivity increases compared to the pure aluminium because glass is used as reinforcement.

- Wear properties are good because of the hardness increases and for the glass; there is the low coefficientof friction.

- The density decreases since the glass density is less than the aluminium density

- The tensile strength compared to the pure aluminium 319 alloy decreases due to porosity and the brittleness due to the glass.

- The above results and graphs the best properties are obtained at the 20% glass content.

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