Proc. of Int. Conf. on Current Trends in Eng., Science and Technology, ICCTEST

Investigation of Mechanical behaviour of Al7075 Reinforced with Mica and Kaolinite based Hybrid Composites

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***Abstract*—The present work is aimed at evaluating the effect of Mica and Kaolinite on hardness and impact strength of AA 7075 Composites. These Hybrid AMCs are finding applications in automobile, aircraft, space, marine and transportation applications. An effort is made to enhance the hardness and impact strength of AMCs by reinforcing AA 7075 matrix with varying different weight percentage of Mica and Kaolinite by stir casting method. Aluminum alloy matrix varying proportions of Mica and Kaolinite were fabricated. The microstructure, impact strength and hardness properties of the fabricated AMCs were analyzed. The optical microstructure images revealed the homogeneous dispersion of Mica and Kaolinite particles and in the matrix. Based on the results obtained from hardness test and impact test of the metal matrix composites it is observed that, the hardness and impact strength shows marked improvement as the increase in the amount of Mica and Kaolinite.**

***Index Terms*— AA7075, Mica, Kaolinite, Hardness, Impact strength, micro structure.**

I. INTRODUCTION

Aluminium is the most abundant metal and the third most abundant element in the earth's crust, after oxygen and silicon. It makes up about 8%by weight of the earth's solid surface and it never occurs as a free element in nature [1]. It is a light weight, good conductor, very high corrosion resistant metal with a strongly react with oxygen. These properties have made it a widely used material, with applications in the aerospace, architectural equipments and stuructural components in marine industries, as well as many domestic applications. Today the production of aluminium is by two different ways: first primary aluminium production from bauxite ore and then is to recycling aluminium from process scrap and used aluminium products.

The aluminum matrix is getting strengthened when it is reinforced with the hard ceramic particles like SiC, Al_2O_3, and Mica etc. Aluminum alloys are still the subjects of intense studies, as their low density gives additional advantages in several applications. These hybrid Aluminium alloys have started to replace mild steel and copper to manufacture friction resistance components. MMCs reinforced with particles tend to improve the properties processed by conventional ways. The 7075 Al-Mica-Kaolinite composites of combinations 0%, 2%, 4%, 6% & 8% were produced through stir casting method and finally conclude that The hardness and impact Strength of 7075 Al with increasing Mica and Kaolinite its increases the hardness

Grenze ID: 02.ICCTEST.2017.1.35

and Impact strength.[2]

A limited research work has been reported on AMCs reinforced with Mica and Kaolinite because both are highly tough, having high elastic in nature. Mica is available in the form of powder. It is having high electrical and thermal insulating stability, high hardness, and low density (2.88g/cm3) and it is used in paints as a pigment extender. Mica will workability and prevents cracking. And kaolinite is a type china clay, it is used to production of paper, its use ensures the gloss on some grades of coated paper. And it has a density of 2.6g/cm3. Hence, Mica and Kaolinite reinforced aluminum matrix composite has gained more attraction with low cost casting Technic [3, 4].

The stir casting method is generally accepted for discontinuous metal matrix composites manufactured, currently worked commercially. Its advantages lie in its simplicity, low cost, and very high flexibility to large quantity production of parts and components of respective application. This liquid metallurgy technique is the most economical and user friendly of all the available sources for metal matrix composite productions methods [5], and allows very large sized parts can be easily fabricated. The cost of preparing composites material using a stir casting method is half that of other competitive methods, it is projected that the cost will fall to 1-10th as compare to other technique [6].

Mica and Kaolinite are lower in density and high hardness than Silicon carbide and Al2O3, thus a good reinforcement type for high performance MMCs (Zhang, 2004).[7] The volume fraction of reinforcement in the microstructure as low as 5% and as high as 20% plays a Major role in the powder consolidated Al-mica-kaolinite MMCs. The density of the entire sample reduces in a small variation with respect to the increment of reinforcement due to the low density value of reinforcement. The hardness values were gradually increasing according to the percentage of increment in the reinforcement.[8][9] The hardness value is very high for the 6% reinforced B_4C sample [8][9].

III. Fabrication of Composites

The simplest and the most low cost method of liquid state fabrication is stir casting technique [9]. In this work stir casting technique is employed to fabricate, which is a liquid state method of composite materials fabrication, in which a dispersed phase (reinforcement particulates) are mixed with a molten metal by means of stirring with help of mechanical operated stirrer. The fabrication of Al-7075, Mica and Kaolinite composites were carried out by stir casting method. The experimental set up used for to fabricate of these composites was shown in figure-1. Mica particles and Kaolinite were initially heated at around 800^{0}C for 1 hrs to make their surfaces oxidized (pre heated). Al-7075 alloy billets were taken into a graphite crucible and melted in an electrical furnace of respective temperature. The preheated mica and kaolinite particulates varying proportion (0%, 2%, 4%, 6%, 8%) were added and mixed with mechanical stirring at 300rpm for 5 min. The final temperature was controlled to be around 750 ^{0}C. After stirring the melted composites was poured into moulds of 15and 25 mm diameter dies are made from cast steel and then allowed to cool with water to obtain cast rods. The ASTM Standard Specimen were prepared from these cast rods. With help of machine tools [9].

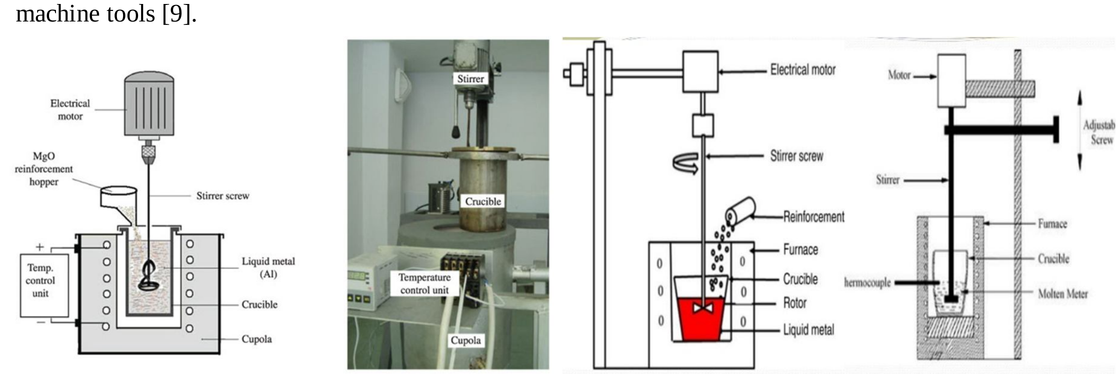

Figure 1. Melt stirring test apparatus (For the production of composite specimens).

Figure1: Stir casting process

III. EXPERIMENTAL PROCEDURE

A. Microstructure

The fabricated specimens were proposed used for various applications in the field of aircraft, automobile and marine to satisfy some mechanical properties like Impact strength and Hardness. The SEM / XRD analysis were analyzed to be done to know the homogeneous dispersion of the reinforcement in the metal matrix.

Aluminium reinforced mica and Kaolinite particulate composites are successfully fabricated by stir casting process. The images of the microstructure of the composites are shown in figure 2(a, b, c, d). It is seen that mica and Kaolinite particles are uniformly dispersed in the aluminum matrix for all weight percentages (2%, 4%, 6%, and 8%). This can be attributed to the effective stirring action and the use of appropriate process parameters. The results indicate that a homogeneous reinforcement distribution into matrix was obtained and no evidence of agglomerate was detected. The bands lacking of reinforcements are not found in this investigation. And the defects such as voids and porosities are absent in these composite materials.

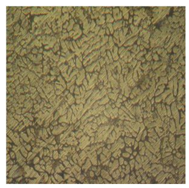
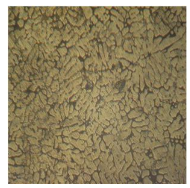

Fig 2 (a) Al+2 %(mica and Kaolinite)   Fig2 (b) AL+4%(mica and Kaolinite)

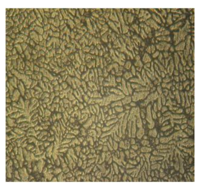
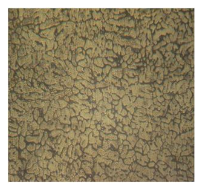

Fig 2 (c) Al+6 %(mica and Kaolinite) Fig2 (d) AL2014+8 %(mica and Kaolinite)

Figure 2: Microstructure analysis of Al7075 with varying percentage of reinforcement

B. Hardness Test

Hardness may be defined as the resistance to permanent indentation. Hardness test measure the resistance to plastic deformation of layers of metal near the surface of the specimen. In the process of hardness determination when the metal is indented by a ball tip, the ball tip first overcomes the resistance of the metal to elastic deformation and then a small amount of plastic deformation. Upon indentation it overcomes large plastic deformation. Brinnell's testing machine is hydraulically operated. Specimen must be choosen with care in order to obtain good results. Brinell's test is not suitable for thin pieces because the indentation may be greater than thickness of the piece. The surface of specimen should be flat & reasonably polished.[7]

Figure 3: Brinell's hardness tester and micrometer

By using the formula find the BHN value.

$$BHN= \frac{2F}{\pi D(D-\sqrt{(D^2-d^2)}}$$

Where,
F= Applied load in N
D= diameter of steel ball indenter.
d= diameter of impression left by the steel ball
Indenter

C. Impact Test

A static load is gradually applied, increasing from zero to its maximum value. The impact load is suddenly applied load & therefore it causes vibration of the structure. Two important properties of material that indicate its resistance to impact loading are Impact test is used to measure the materials ability to withstand shock loads.

Figure 4: Impact tester

The impact test is carried out on a pendulum type Testing machine which consisted of a moving mass is carried out on a pendulum type testing machine which consists of a moving mass whose kinetic energy is great enough to cause rupture of the test specimen. it also has an anvil & a support on which the specimen is placed to receive the blow. It also
Has a meant for measuring the impact energy of the materials after it has been broken in terms of joules. [8]
Angle of rise K can be calculating using formula
U = W Lp (cosK-cosL).
Where,
U = fracture energy (N-m)
W = weight of pendulum *9.81(N)
Lp= length of pendulum (m).
The impact strength ‘K” can be calculated
K=U/A Ls N-m/mm3
Where,
A= cross sectional area of the Specimen at the notch
(mm2)
K= impact strength N-m/mm3
Ls= length of specimen (m)

IV. RESULTS & DISCUSSIONS

A. Hardness results

The measured hardness test results of the mica and kaolinite reinforcement with AL-7075 composites are shown in the Fig.5. The surface hardness of the Aluminum 7075 is maximum at 6% of mica and kaolinite composite. With increase in proportion of mica and kaolinite reinforcement the BHN has comparatively increased. The specimen having maximum BHN exhibits better hardness. This test method was based on indentation of specified indenter are made from very high hardened materials. Forced into the material under specified loading conditions of different weight proportions.

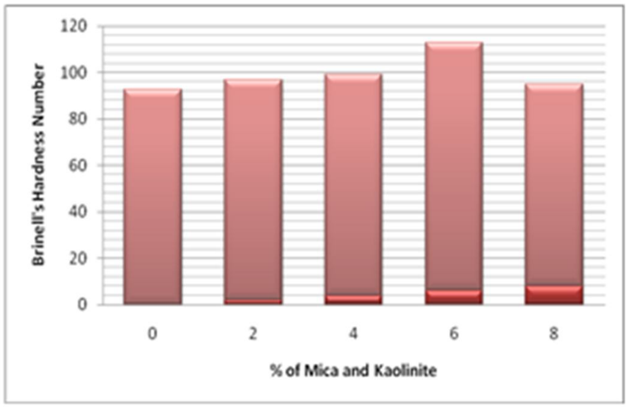

Figure. 5 Brinell's Hardness v/s % of mica and kaolinite reinforcement

B. Impact test Results

The results of impact energy, strength and rising angle of pendulum as a function of Aluminium content of various proportions with mica and kaolinite, and their composites are shown in figure.

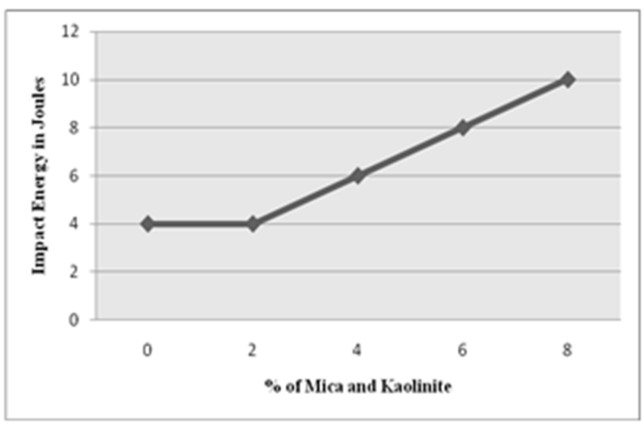

Figure 6: Impact energy v/s % of mica & kaolinite reinforcement

The measured Impact test results of the mica and kaolinite reinforcement with AL-7075 based hybrid composites are shown in the Fig.6. The impact energy of the Aluminium 7075 is increases with increasing the proportion of mica and kaolinite. At 8% of mica and kaolinite reinforcement, the impact energy is maximum of 10Joules.

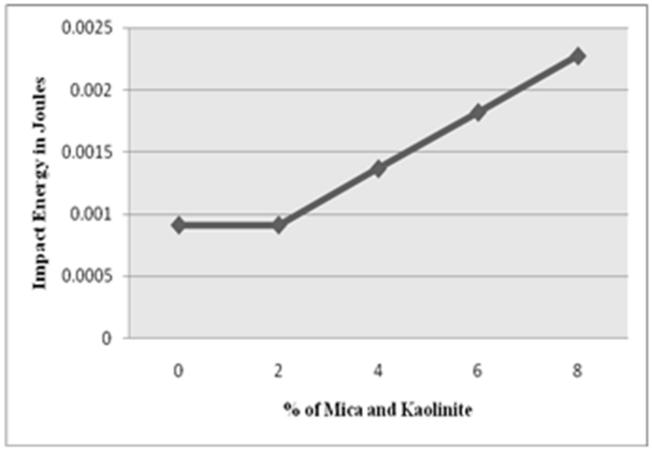

Figure.7 Impact strength v/s % of mica & kaolinite reinforcement

The measured Impact test results of the mica and kaolinite reinforcement with AL-7075 based hybrid composites are shown in the Fig.7. With increasing in the proportion of mica and kaolinite. It observed marked improvement in the impact strength at 8% of mica and kaolinite reinforcement, the impact energy is maximum of 22.8 J/mm^3.

V. CONCLUSIONS

Based on the analysis of experimental results and findings, the following conclusions can be drawn. This work shows that successful fabrication of a multi component hybrid Metal matrix composite (using AL-7075 as matrix, Mica and Kaolinite as reinforcement) was possible by Stir Casting Method. The optical microstructure images revealed the homogeneous dispersion of Mica and Kaolinite particles and in the matrix. Incorporation of this Reinforcement modifies the Impact strength and Hardness properties of the composites. A steady decline in the Effect of Reinforcement of Mica and Kaolinite in the Al-7075 composites causes, whereas the presence of these reinforcement of Mica and kaolinite have caused marked improvement in the Hardness with increasing the Mica and Kaolinite contents up to 6%.after that fall its Hardness at 8% .And also the reinforcements Mica and Kaolinite increases its increases the impact strength.

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