Effect of Extrusion Ratio & Extrusion Temperature on Mechanical Properties of Hot Extruded Hybrid Composites of Al6061/Sic/Graphite

M.Balaji, Hiregoudar yerrennagoudar, G.B.Veeresh Kumar

Abstract :In this work hot extrusion of hybrid composites of Al6061/SiC/Gr was carried out at ratios of 2:1,3:1&4:1 & temperatures of 450^0,500^0,&550^{0}c at various compositions of 0,2,4,6 &8 % of SiC and fixed amount of graphite i.e 2% using 200 tonn capacity press at a speed of 1mm/sec to investigate mechanical properties like tensile, compression & BHN and after solutionising and aging .It was found that at ratio 3:1 and temperature 500^{0}c all the above three properties were found to be improved compared to extrusion .

Keywords: Extrusion ratio, Extrusion temperature, Hybrid composites

I. INTRODUCTION

In modern days use of MMCs in the form of hybrid composites fabricated by secondary processes like Extrusion, drawing ,rolling forging etc. is widely used. In this work fabrication of specimens has been carried out by stirr casting process using Al6061/SiC/Graphite. Hot extrusion was performed by considering these parameters like extrusion ratio & extrusion temperature .Extrusion ratio is defined as the ratio of initial dimensions to final dimension, extrusion temperature is 0.6 to 0.7 times that of the base metal. Scope of this work is to fabricate I.C Engine piston using extruded composite material with improved properties compared to conventional piston.Al6061 is used because of its light weight and low density & addition of SiC as primary reinforcement to improve the basic properties like Mechanical, Thermal &WEAR by addition of graphite as secondary reinforcement to reduce WEAR properties. Further fabrication is carried out by varying composition of SiC by 0, 2, 4, 6, 8% by weight and fixed amount of graphite i.e 2%

II. LITERATURE REVIEW

S.Ghanaraja et al [1] has worked on Al1100-Mg with wt % of MnO was added into molten metal by stir casting method and hot extruded ,SEM images were studied for Mechanical &hardness for extruded alloys.

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H.R Sabouni et al [2] worked on mechanical alloying and extrusion Al 4% wt –Cu powder was mixture was first milled for 20 hours to form a nano structured solid solution & MWCNT was mixed & milled for 5 hours ,
After extrusion the mixture was studied under XRD, Thermal analysis & SEM & the mixture showed optimum thermal stability at 300^{o}c & compression at 550^{o}c.

I.Estrada.guel et al [3] has worked on Al7075- graphite composites prepared by mechanical milling and hot extrusion & found enhanced mechanical properties as a content of graphite content & strengthening of Al_4C_3 due to grain refinement .

M.S Ashok Kumar et al [4] has proved that composites of Aluminium & Al_2o_3 exhibited improved feasibility ,elasticity & strength of reinforced particles after extrusion compared to as –cast.

Bin Jiang et al [5] has worked on extruded AZ31 sheets considering parameters like extrusion ratio, temperature and structure of conventional die to study mechanical properties and anisotropic properties of as extruded which shows improvement in properties by increase in temperature and ratio of a conventional die and further increase in ratio shows reduction in strength.

Shibayan Roy et al [6] has worked on as- cast Mg/SiC_P & AZ91/SiC_P & extruded at a ratio of 15:1 low & high 54:1 and temperature of 350^{o}c shows significant growth in grain size for AZ_{91} &AZ_{91}/SiC_P due to strong pinning effect from alloying element micro hardness did not increase significantly after as-cast and extrusion before and after alloying but improvement in damping characteristics were confirmed .

Keshav murthy.R et al [7] has worked on heat treatment of Al based alloys which shows increase in hardness ,tribological behaviour of as-cast and forged specimens .

Syaiful Nizambin AB Rahim et al[8] has worked on recycling of AA 6061 aluminium chips using hot extrusion process further mechanical properties were investigated and proved that at extrusion ratio of 6:1 and temperature of 550^{o}c resulted with highest ultimate tensile strength.

V.Jayaseelan et al [9] has worked on extrusion of Al/SiC Composites by stir casting & powder metallurgy technique & found that from primary process the castings were defective & by secondary process i.e extrusion mechanical properties were improved.

S.A Sajjadi et al [10] has worked on novel two step method of injection of Al_2o_3 particles by injection method & stir casting with further extrusion & found that improvement in Mechanical properties when compared to as-cast specimens. **M.S.J Hashmi** et al [11] has found that effect of hot extrusion on microstructure,

Mechanical properties & Fracture behaviour on AA MMCs fabricated by stir casting process & extruded at 450^0c with a ratio of 6:1,12:1,&18:1 & found improvement in Mechanical properties when compared to as cast specimens . **E .Taheri-Nassaj** et al [12] has influenced their work on Nano particles of B_4C by stir casting method & extruded at 500^0c with extrusion ratio of 10:1 & found improvement in mechanical properties compared to as-cast.

III. EXPERIMENTAL SET UP

In this work fabrication is carried out by stirr casting method Fig 1 shown is of stir casting set up.

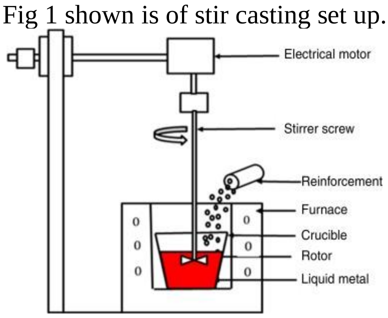


FIG-1 STIRR CASTING SET UP

A known quantity of Al6061 with a composition of

Element	Si	Fe	Cu	Mg	Mn	Cr	Zn	Ti	Al
Composition	0.64	o.63	0.21	0.9	0.09	0.27	0.03	0.03	rema inder

is placed in a graphite crucible of an Induction furnace and heated to a temperature of 720^0c .Mean while a mixture of SiC of varying combinations & fixed amount of graphite is placed in a muffle furnace for a period of 2-3 hrs at a temperature of 150-200^0c to remove the moisture present in it and to improve its wettability after the matrix metal has attained the molten condition it has to be degassed and removal of slag by addition of hexachloroethane tablets. After degassing introducing the stirrer to 1/3 rd of it into the molten metal and stirred at a speed of 400-450 rpm a vortex is created with in it .Further addition of primary and secondary reinforcements mixed & preheated is to be poured into the vortex so that it get mixed uniformly through out [9] . During this process is taking place the mould into which the molten metal is to be poured will be preheated so that it does not produce a defective casting because of sudden drop in temperature. After solidification of the casting billets are to be removed from the mould

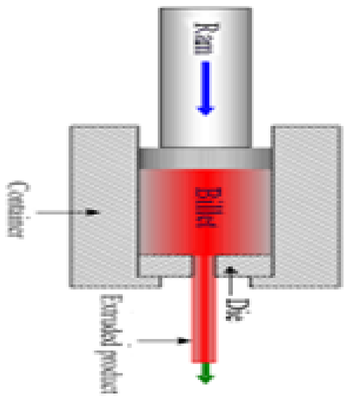


FIG-2 HYDRAULIC PRESS

Second most important process is hot extrusion using a hydraulic press . In this process the billets which were casted by adding different percentages of reinforcement were placed in a muffle furnace & heated to a plastic state in the range of 0.6-0.7 times the melting point of matrix metal and extruded in the direction of ram at a speed of 1mm/s three different temperatures of 450,500 & 550^0c using inserts of 2:1,3:1 & 4:1 ratios. During which alignment of reinforcement takes place so with uniform distribution of reinforcement improvement in properties can be expected later it was machined according to ASTME8M-15a standards to conduct tensile ,ASTM D 3410 for compression & IS 1500-2010 for BHN

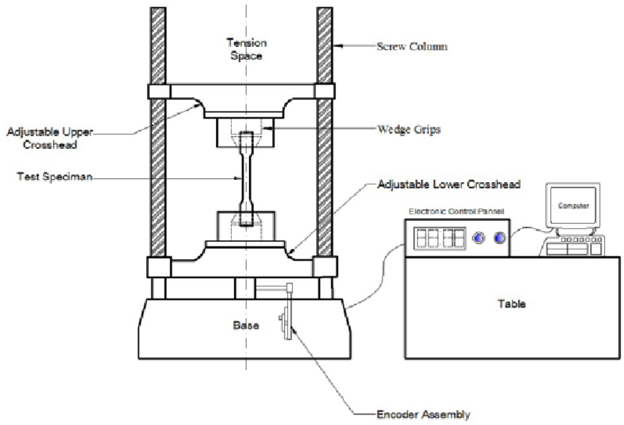
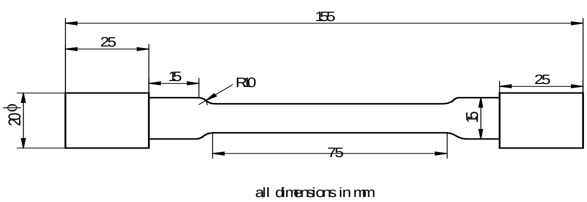
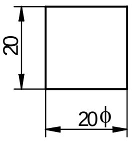


FIG-3 UNIVERSAL TESTING MACHINE



To conduct tensile test extruded material was machined according to the standard. Specimen was fixed in the grips which in turn connected to upper and lower cross head which are adjustable by applying the load which in turn moves the cross heads in opposite directions mean while the UTM [7] is connected to the control panel and the monitor. During the application of load the behaviour of material in the form of stress strain curve finally the breaking load at which it fractures can be obtained .



All Dimensions in mm

During compression tests the specimen is placed on the lower cross head and the adjustable cross head from the top is moved down wards which compresses the specimen placed which is controlled by the control panel and the behaviour observed on the monitor in which the load at which maximum displacement is observed.

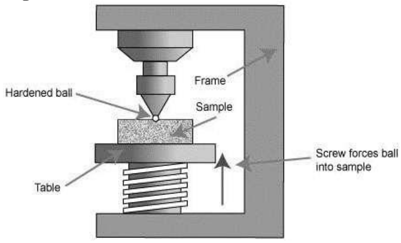


FIG-4 HARDNESS TESTER

Hardness test is conducted by placing the specimen on the table a plunger is fixed with a spherical hardened ball of 5 mm diameter by operating the screw the plunger moves down fixed with the ball which comes in contact with the specimen which is applied with a load of 150 N with a dwell time of 15 seconds after this duration the plunger is moved back and the impression obtained its diameter is obtained from the optical micrometer after substitution in the formula mentioned below its hardness is obtained.

$BHN=F/\pi D\,(D^2-d^2)^{1/2}$

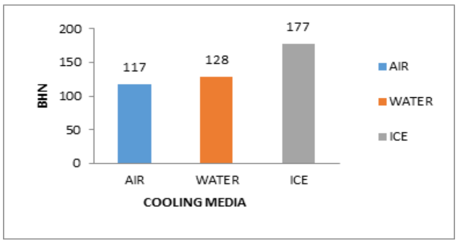
F= Load in Newtons

D= Diamter of the ball in mm

d = Diameter of indentation in mm

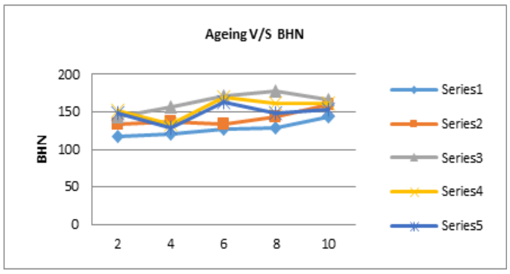
A. SOLUTINISING & AGING

During solutinising specimens will be soaked to a temperature of 530^0c for a period of 2 hours,and immersed in a selected media like air, water & ice.After a duration of 1 hour it is removed from the three different media and subjected to BHN in which specimen immersed in ice had maximum hardness due to sub zero cooling .



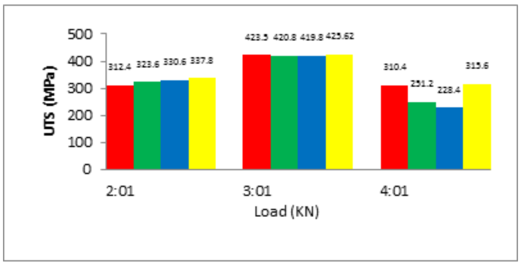
Graph-1 shows the variations of BHN v/s cooling media

Later the specimens with highest hardness i.e ice cooled will be aged at a temperature 175^0c with a duration of 2 hrs gap starting from 2,4,6,8 &10 hours for all the sets of specimens. In which each set consists of specimens in varying proportions of reinforcement in the range of 0,2,4,6,8 % by weight of SiC and 2% graphite which is fixed. After ageing process all the specimens were subjected to BHN and the graph plotted with BHN v/s aged duration.

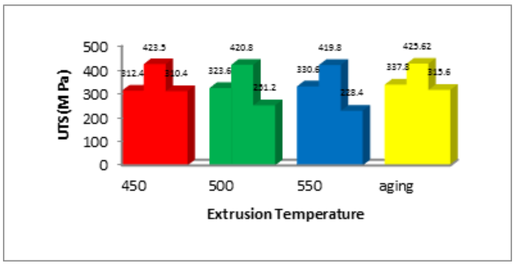


Graph-2 shows variations of Aging duration v/s BHN

IV. RESULTS & DISCUSSION



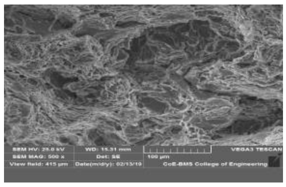
Graph-3 Shows the variations of tensile strength with extrusion ratios of 2:1 3:1 &4:1 forAl6061/8%SiC/2%Gr



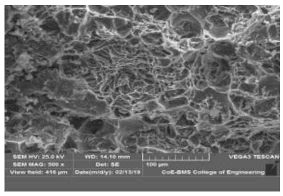
Graph-4 Shows the variations of tensile strength at different temperatures of 450^0c , 500^0c,550^0c for Al6061/8%SiC/2%Gr

From the graph it is observed that at 3:1 & temperature 500^0c tensile strength is maximum due to improvement in ductility which is obtained by solutinising and aging .

B.SEM BEFORE AGING

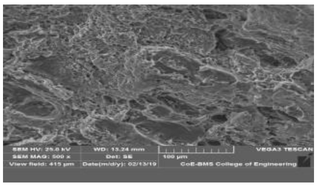


Al6061/8%SiC/2%Gr at 2:1 extrusion ratio & 500^0 c



Al6061/8%SiC/2%Gr at 3:1 extrusion ratio & 500^0 c

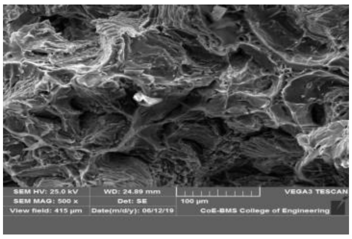
hybrid composite combination the reinforcement SiC has higher density and hardness hence increase in hardness at the cost of ductility.How ever there



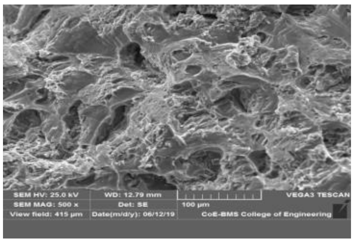
Al6061/8%SiC/2%Gr at 4:1 extrusion ratio & 500^0 c

The fractured SEM images before aging shown above clearly indicates a large portion of brittle fracture & very little ductile fracture. In the present are signs of ductile fracture because of the presence of secondary reinforcement in the form of Graphite because it is very soft and ductile materials .

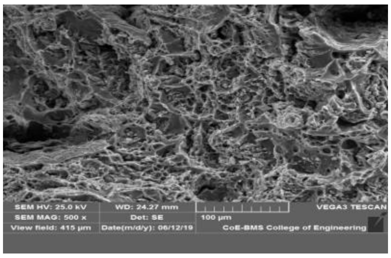
C.SEM AFTER AGING



Al6061/8%SiC/2%Gr at 2:1 extrusion ratio & 500^0 c



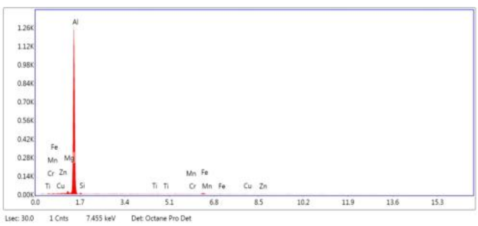
Al6061/8%SiC/2%Gr at 3:1 extrusion ratio & 500^0 c



Al6061/8%SiC/2%Gr at 4:1 extrusion ratio & 500^0 c

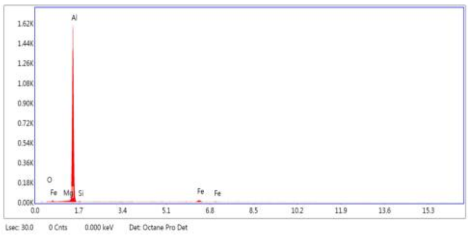
Further after aging of the composite material system under consideration from SEM images it can be noticed that formation of more number of dimples compared fractured surface before aging. The increase in ductility is mainly attributed to grain refinement as a result of this there is more column like structure formation which is responsible for increase inductility due to aging and to some extent it is due to softer secondary reinforcement in the form of graphite.

D.EDAX BEFORE AGING

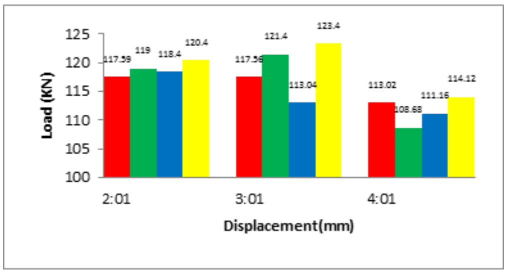


Al6061/8%SiC/2%Gr at 3:1 extrusion ratio & 500^0 c

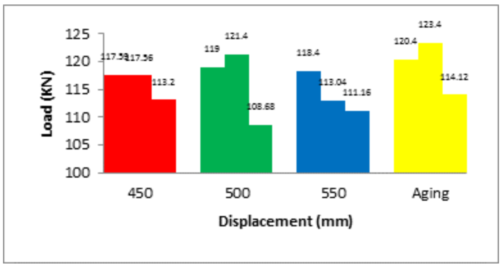
E.EDAX AFTER AGING



Al6061/8%SiC/2%Gr at 3:1 extrusion ratio & 500^0 c

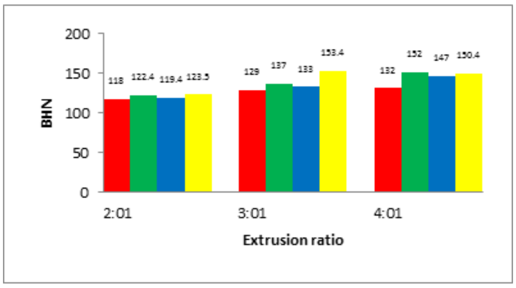


Graph-5 shows Variations of compressive strength at different ratios of 2:1,3:1 &4:1 for Al6061/8%SiC/2%G



Graph-6 Shows the variations of compressive strength at different temperatures at 450^{0}C, 500^{0}C and 550^{0}C for Al6061/8%sic/2%Gr

From the graph it is observed that at 3:1 ratio and500^{0}c the displacement is minimum compared to the same before solutionising and aging because after aging and when the specimen is back to room temperature it contacts along with the specimen due to which even after applying load its displacement is less compared to before heat treatment.



Graph-7 Shows the variations of BHN at different ratios of 2:1,3:1 &4:1 forAl6061/8%SiC/2%Gr

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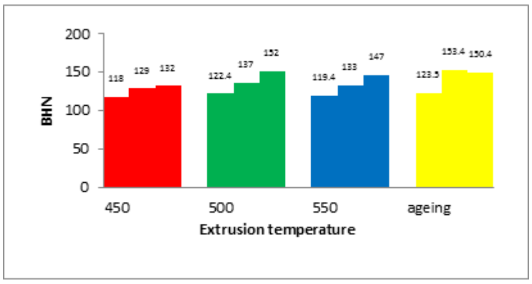

Graph-8 Shows the variations of BHN at different temperatures of 450^0c,500^0c &550^0c forAl6061/8%SiC/2%Gr

Due to heat treatment and attaining the specimen at room temperature the specimen contracts along with the reinforcement added to it when subjected to BHN with 5mm indentation ball the combination of matrix along with the reinforcement which has more hardness its hardness is maximum at 3:1 ratio and temperature 500^0c at which improvement in BHN is attained.

V. CONCLUSIONS:

1.After extrusion alignment of reinforcements can be seen from the SEM images .
2.Fractured surfaces shows very little ductility and formation of dimples due to the presence of Graphite.
3. Further improvement in all the above properties like tensile & compression strength also BHN was observed due to aging at an **extrusion ratio of 3:1 & extrusion temperature of 500^0c** with a combination of **Al6061/8%SiC/2%Gr.** Also from EDAX it is observed that particularly for tensile test energy required for fracture before & after aging increases which shows improvement in tensile strength.

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