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Thermal Conductivity & Thermal Expansion Behaviour of Hot Extruded Hybrid Composites of Al6061/Sic/GR

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

Abstract: In This Proposed Work Specimens Prepared By Stir Casting Method For Different Combinations Of Reinforcement's Sic , Gr And Al6061 As Matrix, Further Subjected To Hot Extrusion At Ratios Of 2:1,3:1 & 4:I Temperatures Of 450,500 &5500c & Machined To ASTME831 And These Specimens Were Tested For Thermal Conductivity And Co-Efficient Of Thermal Expansion, Least Of All The Above Ratios And Temperatures Were Solutionised And Aged And The Process Repeated It Was Found That At Extrusion Ratio Of 3:1 With A Combination Of Al6061/4%Sic/2%Gr Both Thermal Conductivity & Thermal Expansion Was Found To Be Improved Compared To Conventional Aluminium.

Keywords: Thermal Conductivity, Hybrid Mmcs, Coefficient Of Thermal Expansion, Hot Extrusion.

I. INTRODUCTION

I.C Engine pistons require least thermal conductivity and expansion to improve its working life. In this work specimens prepared by liquid metallurgical route and hot extruded at 2:1,3:1 & 4:1 as extrusion ratio and temperatures of 450,500,550^{0}c by adding Silicon carbide (SiC) as primary reinforcement from 0 to 8% by weight in multiples of 2 & fixed amount of Graphite(Gr) 2% as secondary reinforcement for Aluminium6061 (Al) as the matrix metal addition of SiC increases its temperature resistance because it melts at higher temperature than Aluminium and Graphite acts as solid lubricant which resists WEAR while it reciprocates within the cylinder. Conductometer is used to find the conductivity of specimen and its conductivity is measured in reference to standard specimen .Thermal expansion is found out by using an instrument called Dilatometer. Further it will be subjected to solutionising and aging. So that improvement in thermal properties can be obtained. Conductivity is measured in terms of W/m^{0}k and expansion in 1/^{0}c

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II.LITERATURE REVIEW

A.Fathy et al [1] has prepared a composite of Cu-Alumina by powder metallurgy technique synthesized by thermo chemical technique by adding Cu powder to an aqueous solution of Aluminium nitrate and varying Al_2o_3 content and observed reduction of thermal conductivity and CTE were ascribed to the strong interfacing between Cu-Al_2o_3 Nano composite.

Trann-Huu Nam et al [2] has improvised Al based MMCs containing 70%vol SiC , measured based on the length change from room temperature to 500^{0}c using thermo elastic models instantaneous CTE was studied using FEA modelled for heating and cooling cycles from 200c to 500^{0}c by observation of voids CTE decreased above 250^{0}c.

S.A. Mohan Krishna et al [3] has conducted the evaluation of thermal conductivity, thermal diffusivity, thermal expansivity and thermal capacity has been accomplished for Al6061, SiC, Gr (MMCs) from room temperature to 300^{0}c and observed variation in thermal behaviour was observed by varying SiC, Gr with Al6061.

Subodh Kumar Sharma et al [4] has successfully applied to a water cooled four stroke direct injection diesel engine which allows piston cylinder wall temperature based on FEM models and experimental procedure to investigate the measure of distortion temperature and radial thermal stresses after thermal loading.It includes the effect of thermal conductivity of material of piston, piston rings and chamber walls which shows variation of temperature stresses and deformation at various points on the piston.

Khalid Al Madani et al [5] has worked on effective thermal properties of AMMCs reinforced by ceramic particles and Aluminium as continuous matrix are directly affected by type, size geometry and dispersion and dispersion in heat transfer and difference in heat transfer mechanisms of composite play an important role by resistance influence effectively on heat transfer inside the composite and thus the thermal properties.

Koshi Takenaka et al [6] has worked on negative thermal expansion of materials, on which materials expand on heating ,but some materials contract such materials show enormous industrial merit because they can control the thermal expansion of materials ,So NTE is opening new phase of control of thermal expansion in composites.

Keshav Murthy et al [7] has fabricated a composite with a combination of AA7075/ TiO_2/fly ash by stir casting method and hot forging as fixed and varying $TiO_{2,}$ SEM images revealed a homogenous dispersion of both the reinforcements and measured CTE between 50^{0}c-250^{0}c and found decrease in CTE with addition of TiO_2 and fly ash further slight decrease in thermal conductivity.

Ramazan Karsli Glu et al [8] has prepared a composite by stir casting and squeeze casting processes for a combination of Al-Si based hybrid composites / SiC / Gr and by varying the size of graphite content by different particle size .Thermal properties were investigated and found that by increasing the graphite content found improvement in dimensional stability and also reduction in expansion and conductivity. G.Sarvanan et al [9] has worked on mechanical and thermal properties of Al/SiC_P/LM25 using sand casting technique and examined for 350,400,450^{0}c.

The result show concurrent augmentation of thermal as well as mechanical when compared to LM25.

Mahagundappa et al [10] has studied coefficient of thermal expansion (CTE) of as-cast and heat treated composites with a combination of hybrid MMCs (Al6061 / SiC / E glass fibre) and subjected to aging for a duration of 1,3,5,7 hours at a temperature of 175^{0}c and conducted tests for both as cast and heat treated and found increase in CTE with increase in duration of aging .After solutionising at 530^{0}c and aging at 175^{0}c and found decrease in CTE by increase in duration of aging.

III. EXPERIMENTAL PROCEDURE

Fig-1 Conductometer

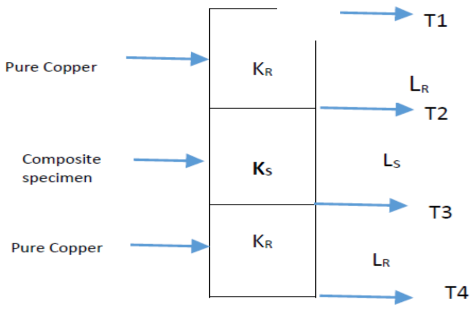

Fig-2 Arrangement of specimens

$K_S = K_R * L_S / L_R [(T_1-T_2)+(T_3-T_4)] / [2(T_2-T_4)]$

K_S = Thermal Conductivity of specimen (W/m^{0}K)

K_R = Thermal Conductivity of Reference (W/m^{0}K)

L_S = Length of specimen (mm)

L_R = Length of specimen (mm)

T1, T2, T3 &T4 Temperatures of specimens as shown in above fig in ^{0}c.

Specimens prepared by stir casting method with a combination of Al6061 /SiC/Gr by varying the percentage of SiC from 0 to 8 % by weight in multiples of 2 and fixed amount of Graphite 2%.Further extruded to different ratio and temperatures of 2:1, 3:1 & 4:1 along with temperatures at 450,500 &550^{0}c and machined to ASTM E-831 and arrangements made as shown in fig-2 in a conductometer to investigate its Thermal condLuctivity [1]. Further two specimens of which thermal conductivity is already known i.e copper (385 W/m^{0}k) in between these two a composite of which thermal conductivity is to be found out is placed. Initially a power supply is made to pass at point T_1 until it reaches a particular temperature of around 70^{0}c at this point a temperature's for T_1, T_2,T_3 and T_4 are noted at the bottom of standard specimen water is made to pass around it at a flow of constant rate so that it gets cooled faster this process is continued until the conductivity reaches a peak value and suddenly drops and allowed to cool to room temperature for further process as already mentioned for each ratio ,temperature and percentage of reinforcements around 15 specimens are to be tested of which three temperatures exists of each composition. Finally out of three temperatures of extrusion at which conductivity is minimum is considered for comparison after solutionising at 530^{0}c and aging at 175^{0}c for 8 hours by repeating the above process [10].

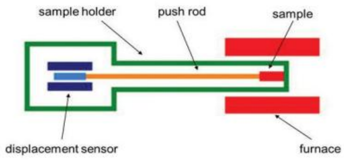

Fig- 3 Dilatometer

$$CTE = (\Delta L/\Delta T)/L$$

CTE= Co efficient of Thermal Expansion

ΔL=change in length (microns)

ΔT=Change in temperature (^{0}c)

L= overall length of specimen (mm)

The above figure shown is of dilatometer, it is used to measure the Expansion [2] of a specimen (Al6061 /SiC /Gr) because of its design and tube type sample carrier it is made easier to move the specimen into the furnace. A thermocouple is connected to the sample to measure temperature and in turn to a measuring device. Expansion of a specimen is confirmed at an interval of every 25^{0}c change in temperature and continued until it expands and stopped at a particular temperature where it is found to drop suddenly .Out of the 15 specimens with a combination of temperatures and reinforcements mentioned for conductivity. A specimen with least expansion of each combination is subjected to comparison after solutionising and aging at the above said conditions for Thermal conductivity.

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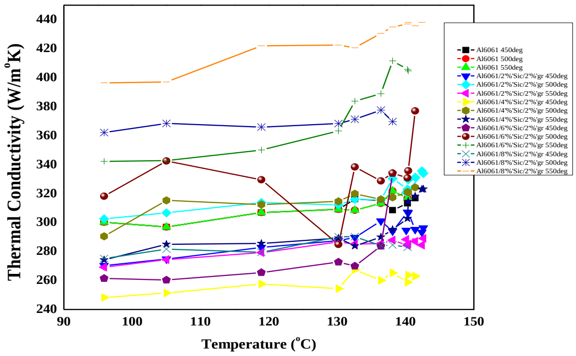
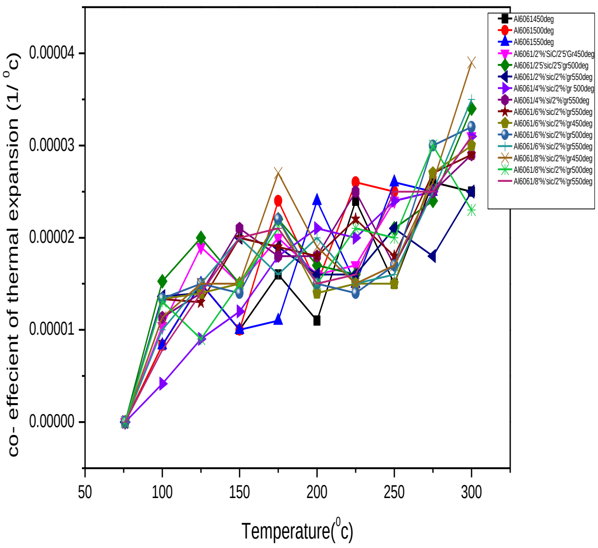
IV. RESULTS & DISCUSSION



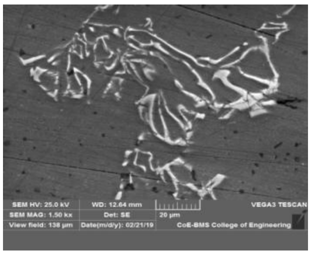
Graph-1 Variations of Thermal Conductivity of specimens of various combinations of Al6061/SiC/Gr at Extrusion ratio of 3:1



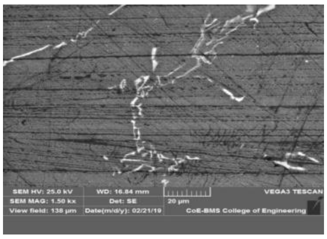
Graph-2 Variations of Thermal Expansion of specimens of various combinations of Al6061/SiC/Gr at Extrusion ratio of 3:1

After conducting tests on both the properties by plotting the above graph it is found that for all the combinations of both the matrix and reinforcement at 500^{0}c these were found to be minimum .

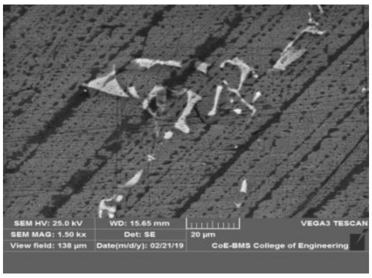
A: Before Aging



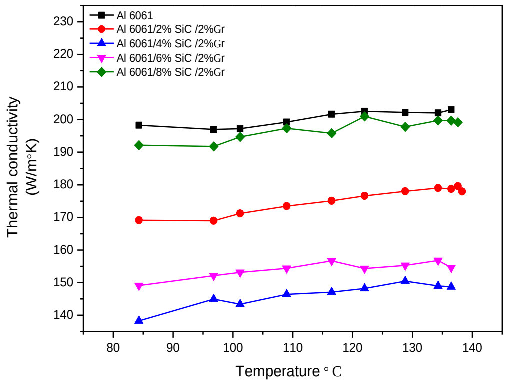
Al6061, extrusion ratio 2:1, extrusion temperature 500^{0}c



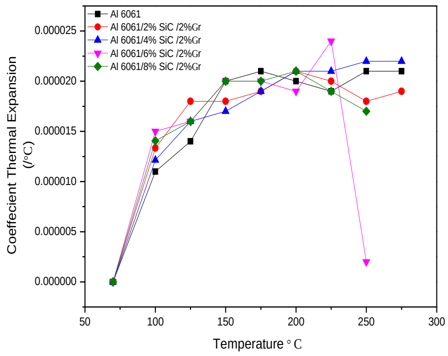
Al6061/ 4%SiC/ 2% Gr, extrusion ratio 3:1, extrusion temperature 500^{0}c



Al6061/ 8%SiC/ 2% Gr, extrusion ratio 4:1, extrusion temperature 500^{0}c



Graph-3 Variations of Thermal Conductivity of Solutionised & Aged specimens of various combinations of Al6061/SiC/Gr at Extrusion ratio



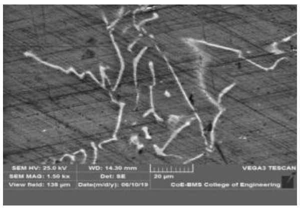
Graph-4 Variations of Thermal Expansion of Solutionised & Aged specimens of various combinations of Al6061/SiC/Gr at Extrusion ratio of 3:1

From the graph-3 & 4 it is observed that after solutionising & Aging at a combination of Al6061/4%SiC/2%Gr both the properties were found to be minimum.

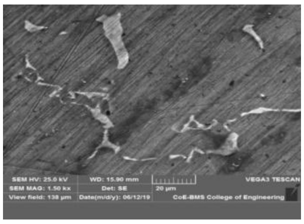
But at 2:1 ratio both the conductivity and expansion was much more compared to 3:1 ratio & less than the conventional Aluminium.

It was found from SEM images that dispersion of reinforcements was found to be uniform along with grain refinement.

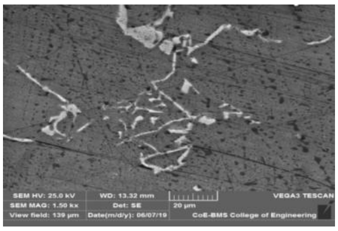
B: After Aging



Al6061, extrusion ratio 2:1



Al6061/ 4%SiC / 2% Gr, extrusion ratio 3:1



Al6061/ 8%SiC/ 2% Gr, extrusion ratio 4:1

The bonding between the matrix and the reinforcement also form the SEM images the amount of porosity noticed is also very less, the same can be witnessed from the SEM image in extruded condition and also in after aging treatment of composites. The better is the bonding the more it resists the temperature so conductivity and CTE will be less Further from the SEM images, the distribution of the reinforcement particulates is very much even in the matrix material.

The images (Before aging) shows change in microstructure of extruded specimens with variation in section size and images (After Aging) shows changes in microstructure of aged extruded specimens. In Extruded condition microstructure is found fine for small section size and coarse for large section size this is due to grain refinement of smaller section size caused by fast cooling rate. Microstructure is found much refined and uniform in all section size for aged treated extruded specimens.

V. CONCLUSIONS

1. Specimens prepared by stir casting method and subjected to hot extrusion, further machined to ASTM E831 were subjected to thermal conductivity and thermal expansion and plotted as shown in graph 1&3.
2. After obtaining the results specimens with least values of both the tests in each ratio, temperature & combinations were subjected to solutionising and aging and the process repeated & values plotted as shown in graph 2 &4.
3. From the SEM images it is observed good bonding between the reinforcements and matrix that resists conductivity and expansion.
4. After solutionising and ageing grain refinement was fine for small sections and coarse for large sections as observed from the images.
5. Finally Improvement in thermal properties of Hybrid composites of Aluminium were observed.

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