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Experimental Investigation of Aluminium-Zinc with Graphene Composite Materials by using Pin Fin Apparatus

Muthusamy. A[1], Akash. M[2], Akash. T[3], Dharun Kumar. V[4], Gokul. A[5]

[1]*Assistant Professor, Department of Mechanical Engineering, Anjalai Ammal Mahalingam Engineering College. kovilvenni, India.*
[2,3,4,5] *Student, Department of Mechanical Engineering, Anjalai Ammal Mahalingam Engineering College. kovilvenni, India.*

*Corresponding author

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Abstract

The aim of the present study is to improve the heat transfer characteristics and to investigate the performance of fin efficiency by using fins of different materials in pin fin apparatus. Here the system follows forced convection as the mode of heat transfer and it is the principle used in it. Engine cylinder can be cooled by fluids like oil and air as media. To improve the efficiency of air cooling, fins will be provided as they provide the more surface area for heat dissipation. But when we keep increasing the surface area, there are other factors like weight & size will shoot up which will complicate the design of fins and engine cylinder. This paper discussed composite of Al- ZINC-GRAPHENE materials and to evaluate the heat transfer properties through PIN- FIN apparatus and evaluate the hardness of the model composite plate.

Keywords: Engine Cylinder, Heat Dissipation.

1. Introduction

In reaction to increasing worldwide competition and developing concern for environment, the auto manufacturers have already been encouraged to meet up the conflicting demands of increased power and performance, lower fuel consumption, lower pollution emission and reduced vibration and effective heat transfer. Now days, most of the engineering processes require better design of fin configuration for any heat transfer application with progressively less weight, volume, accommodate shape, new manufacturing process and cost as well as the thermal behaviour.

The rate of heat transfer depends on the surface area of the fin and selection of materials. The annular composite fin is one of the most popular choices for exchanging the heat from the primary surface to surrounding. An extended surface is a heat absorbing or heat rejecting surface from base surface to surrounding fluid, when it is connected with the prime surface. In general, the conventional water pump which is coupled with crankshaft is used for the forced circulation of coolant into the system. But this conventional method takes high time for initial warm up (under cold phase) due to this, incomplete burning of the fuel will occur that causes increased pollutant emission & after the engine turned off, the cooling of the system doesn't takes place which may leads to the after boil condition. In winter season cooling of the system is achieved by natural convection, less pumping effort is enough for this condition but in conventional type the pump depends on shaft rotation. Using the electric water pump, the circulation of coolant will be possible under above situations in controlled manner which enhance the behavior of the whole system. If the pumping action is controlled, the huge amount of energy is reserved & may use it for vehicle transmission which also leads mileage and power improvement.

The hydraulic efficiency of the pump is limited about 45% and also durability of the centrifugal pump mainly depends on the shaft seal. To overcome those problems the major factors like cavitation, frictional loss and seal strength are considered for the analysis and new type of polymer composite based systems were developed. The thermostat is mounted on the engine either at the coolant inlet or at the coolant outlet. Currently, the flat seat valve loaded with wax system is used as thermostat to regulate the flow of coolant. But this system is not a position free one and also as low frequency of response. So, there is need of alternate for this type of control system. The electronically controllable valve shows quick response and also these components are position free, might operate at any position at any condition. Improvement in automotive cooling system is achieved by different researchers through different modifications. A group of researchers worked to improve the heat transfer on air side by increasing the air side convective heat transfer coefficient using vortex generators and electrostatic principle. Johannturnow et.al., investigated about the vortex structures and heat transfer enhancement of turbulent flow over a staggered array of dimples in a narrow channel and concluded that the flow pattern of dimples had more concentric values in turbulence creation.

For particular Reynolds number it was found that the dimple package with an h/D ratio =0.26 provided maximum thermo-hydraulic performance and heat transfer rate enhanced up to 201% of the plain tube. The heat transfer can be increased by the following different Augmentation Techniques. They are

Broadly classified into three different categories:

- Passive Techniques
- Active Techniques
- Compound Techniques.

2. Heat Transfer

A compound augmentation technique is the one where more than one of the above mentioned techniques is used in combination with the purpose of further improving the thermo-hydraulic performance of a heat exchanger. When any two or more of these techniques are employed simultaneously to obtain enhancement in heat transfer that is greater than that produced by either of them when used individually, is termed as compound enhancement. This technique involves complex design and hence has limited applications.

3. Literature Review

The development of metal matrix composites (MMCs) reinforced with graphene has received significant attention due to the exceptional properties of graphene, including high mechanical strength, electrical conductivity, and thermal conductivity. Graphene is a two-dimensional material that consists of a single layer of carbon atoms arranged in a honeycomb lattice. Due to its high surface area and unique electronic properties, graphene has emerged as a promising reinforcement material for MMCs.

Aluminum 7175 is a high-strength aluminum alloy that is widely used in various aerospace and defense applications due to its excellent mechanical properties, including high strength and toughness. The addition of graphene to the aluminum matrix is expected to enhance its thermal conductivity, thermal stability, and other thermal properties. Several studies have been conducted on graphene-reinforced aluminum composites. For instance, Arunachalam et al. (2019) reported on the fabrication and characterization of graphene-reinforced aluminum composites using a powder metallurgy technique. The study showed that the addition of graphene to the aluminum matrix resulted in a significant improvement in the mechanical and thermal properties of the composite.

In another study, Zhang et al. (2016) investigated the thermal properties of graphene-reinforced aluminum composites fabricated by a powder metallurgy method. The study showed that the thermal conductivity of the composite increased with the addition of graphene, and the composite exhibited enhanced thermal stability.

Furthermore, Xiong et al. (2018) reported on the thermal conductivity of graphene-reinforced aluminum composites fabricated by a spark plasma sintering technique. The study showed that the thermal conductivity of the composite increased with the volume fraction of graphene, indicating that the thermal properties of the composite can be tuned by varying the amount of graphene in the aluminum matrix.

In summary, the literature suggests that the addition of graphene to the aluminum matrix can significantly improve the thermal properties of the resulting composite, including thermal conductivity and thermal stability. However, the fabrication process, dispersion of graphene in the aluminum matrix, and other processing parameters can affect the final properties of the composite. The present study aims to investigate the thermal properties of graphene-reinforced aluminum 7175 composite, providing insights into the potential of such composites for various engineering applications.

4. Thermal Analysis

In general, there are three mechanisms of heat transfer. These mechanisms are conduction, convection and radiation. Thermal analysis calculates the temperature distribution in a body due to some or all of these mechanisms. In all three mechanisms, heat energy flows from the medium with higher temperature to the medium with lower temperature. Heat transfer by conduction and convection requires the presence of an intervening medium while heat transfer by radiation does not. Mode of Heat Transfer – λ Conduction λ Convection λ Radiation.

4.1. Development Of Aluminium Alloys

The chief alloying constituents added to aluminium are copper, magnesium, silicon, manganese, nickel and zinc. All of these are used to increase the strength of pure aluminium. Two classes of alloys may be considered. The first are the 'cast alloys' which are cast directly into their desired forms by one of three methods (i.e., sand-casting, gravity die casting or pressure die casting), while the second class, the 'wrought alloys', are cast in ingots or billets and hot and cold worked mechanically into extrusions, forgings, sheet, foil, tube and wire. The main classes of alloys are the 2000 series (Al-Cu alloys), which are high-strength materials used mainly in the aircraft industry, the 3000 series (Al-Mn alloys) used mainly in the canning industry, the 5000 series (Al-Mg alloys) which are used unprotected for structural and architectural applications, the 6000 series (Al-Mg-Si alloys) which are the most common extrusion alloys and are used particularly in the building industry, and the 7000 series (Al-Zn-Mg alloys) which are again high strength alloys for aircraft and military vehicle applications. The alloy used in any particular application will depend on factors such as the mechanical and graphene oxide al properties required, the material cost and the service environment involved.

If a finishing treatment is to be applied, then the suitability of the alloy for producing the particular finish desired will be an additional factor to be taken into account. The great benefit of aluminium is that such a wide variety of alloys with differing mechanical and protection properties is available, and these, together with the exceptional rang e of finishes which can be used, make aluminium a very versatile material

4.1.1. Preheating of graphene oxide with zinc Particles

Heat treatment of the particles before dispersion into the melt aids their transfer by causing desorption of adsorbed gases from the particle surface. Heating silicon carbide particles to 1000

C. Preheating of Graphene oxide with zinc particles removing surface Impurities and in the desorption of gases, and alters the surface composition by forming an oxide layer on the surface. The addition of pre-heated Graphene oxide with zinc particles in Al and Graphene oxide with zinc melt has been found to improve the wettability property. A clean surface of Graphene oxide with zinc provides a better opportunity for melt particles interaction, and thus, enhances wetting.

4.1.2. Pouring of Molten Metal

The material is stirred with 300 rpm for thirty minutes. The stirred metal is then slowly poured into the die which is preheated to a temperature of 973 C. The die is allowed to cool in air for two hours and then the specimen is removed.

5. Test Specimen

Figure 1. Test Specimen

5.1. Tensile Specimens and Testing Machines

Consider the typical tensile specimen. It has enlarged ends or shoulders for gripping. The important part of the specimen is the gage section. The cross-sectional area of the gage section is reduced relative to that of the remainder of the specimen so that deformation and failure will be localized in this region. The gage length is the region over which measurements are made and is centred within the reduced section. The distances between the ends of the gage section and the shoulders should be great enough so that the larger ends do not constrain deformation within the gage section, and the gage length should be great relative to its diameter affiliations as succinct as possible.

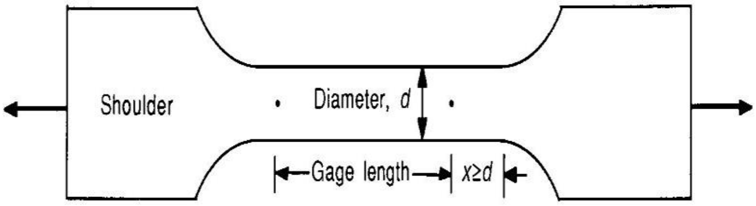

Figure 2. Tensile Specimen

6. Composition and Results

Table 1. Composition

Material	Mixture1	Mixture2	Mixture3
Aluminium	90	80	70
Graphene	9	15	20
Zinc	1	5	10

6.1. Hardness Test

Table 2. Hardness Test

Material	Hardness Number BHN	Hardness Value Mpa
Mixture1	4.83	13.6
Mixture2	14.43	47
Mixture3	8.12	27.2

6.2. Tensile Test

Table 3. Tensile Test

Material	**Tensile Stress(N/mm2)**
Mixture1	137.25
Mixture2	255.65
Mixture3	180.85

6.3. Heat Transfer Test

Table 4. Mixture 1

sno	**V**	**I**	**P**	**H**	**T1**	**T2**	**T3**	**T4**	**T5**	**Ta**
	volts	**amps**	**Watts**	**mm**	**0c**	**0c**	**0c**	**0c**	**0c**	**0c**
1	106.8	0.56	60	50	43	37	35	34	34	34
2	107.6	0.57	65	50	44	38	36	35	35	31
3	108.1	0.58	70	50	45	38	36	35	35	31
4	120.2	0.63	75	50	45	38	38	36	36	31

Table 5. Mixture 2

Sno	**V**	**I**	**P**	**H**	**T1**	**T2**	**T3**	**T4**	**T5**	**Ta**
	volts	**Amps**	**Watts**	**mm**	**0c**	**0c**	**0c**	**0c**	**0c**	**0c**
1	107.6	0.57	61	50	30	43	37	35	34	28
2	110.4	0.58	65	50	45	38	36	35	35	29
3	114.2	0.61	70	50	46	39	36	35	35	29
4	117.7	0.61	70	50	46	39	37	36	35	31

Table 6. Mixture 3

sno	V	I	P	H	T1	T2	T3	T4	T5	Ta
	volts	Amps	Watts	mm	0c	0c	0c	0c	0c	0c
1	97.5	0.52	50.8	50	45	41	39	39	38	31
2	107.2	0.57	61.1	50	48	42	40	40	39	29
3	117.2	0.59	73	50	51	44	41	40	40	33
4	119	0.63	74.97	50	51	44	40	41	40	33

7. Conclusion

Micron-sized Graphene oxide and zinc particles were incorporated into a melt of Aluminium with Graphene oxide and zinc the aid of addition as a wetting agent to fabricate aluminium matrix composite. Two casting temperatures and stirring time were applied to focus on the ceramic particle incorporation, porosity formation, agglomeration of ceramic particles, and interfacial reactions between Composite materials especially Aluminium with Graphene oxide and zinc having good mechanical properties compared with the conventional materials. It is used in various industrial application these materials having light weight along with high hardness. It with stand high load compare with the existing materials are most applicable in the engineering products instead of existing materials. Finally, it was concluded that the percentage of Aluminium with Graphene oxide and zinc increases automatically the hardness strength and heat transfer rate increased.

REFERENCES

[1]. Aripala Sree shyam, R.Sundarajan anandha kumar B Thiruchitrambalam study of mechanical characteristics of al-sic-zn metal matrix composite international journal of pure and applied mathematics volume 119 no.15 2018, 2123-2129.

[2]. Chandong, precipitation phenomena in al-zn-mg alloy matrix composites reinforced with b4c particles scientific reports.

[3]. M.H.Chakrabarti, C.T.J.Lowc, N.P.Pbrandonb, V.Yufit, M.A.Hashmia, M.F.Irfand Progress in the electrochemical modification of graphene based materials and their applications electrocehmica acta 107 (2013) 425-440.

[4]. El kurbatkina, Processing of al-zn-mg-cu/sic composite prepared by mechanical alloying international conference on synthesis and consolidation of powder materials .material science and engineering.

[5]. Punith Kumar, M.K Mhander pratap singh and Chandan srivastava, Electrochemical behavior of zn-graphene composite coatings RSC Advances.

[6]. Ramesh Raliya Caroline Avery Sampa Chakrabarti Pratim Biswas Photocatalytic degradadtion of methyl orange dye by pristine titanium dioxide zinc oxide and graphene oxide nanostructures and their composites under visible nanoscience

[7]. Tharani kumar B mohan G anbuchezhiyan Enhancing the microstructure and mechanical properties of strengthened al-mg-zn alloy hybrid nano composites using vaccuum assisted stir casting method journal of materials research and technology

[8]. Younwen Ynag Yung cheng Shuping Peng Microstructure evolution and texture tailoring of reduced graphene oxide reinforeced zn scaffold bioactive materials 6 (2021) 1230-1241.

[9]. Zhigang Shen 1 Ning Li Ting Wang And Zhisehang Wu Effects Of sic Content on wear resistance of al-mg-zn-cu matrix composite fabricated via laser powder bed fusion crystals 2022 12 1801.