Investigation of Al6063/Sic/15P with Mg for Heat Transfer Application in Pin Fin Apparatus – An Experimental Approach

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Abstract

Aluminium reinforced silicon carbide particle composite possess improved operational potential for critical structural components due to its attractive properties when compared to monolithic materials. These properties include improved strength and stiffness, high elastic modulus, hardness; wear resistance and low coefficient of thermal expansion. The combination of Al/Sic/15p with Magnesium plays a vital role in the recent advancement in composite mixtures. 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. The work discussed about the composite of Al/Sic/15p in addition to Magnesium, to evaluate the heat transfer properties through Pin- Fin apparatus.
Keywords: Aluminium, Silicon Carbide, Composite, Heat Transfer coefficient, Pin-Fin apparatus

I. INTRODUCTION

Al-Mg-Si alloys are being increasingly used in automotive and aerospace industries for critical structure applications because of their excellent castability and corrosion resistance and, in particular, good mechanical properties in the heat treated condition [1]. Parametric Study of Extended Fins in the Optimization of Internal Combustion Engine they found that for high speed vehicles Engines thicker fins provide better efficiency [2, 3]. When fin thickness increases, the gap between the fins reduces that resulted in swirls being created which helped in increasing the heat transfer. The rectangular shaped extended surfaces shows the high rate of heat transfer when compared to other extensions at same length and also made many experiments to find the fin efficiency and concluded that the efficiency of fin is useful when the value of NTU is zero otherwise the fin efficiency is high when the NTU is high and is used in air conditioning systems [4, 5]. Some work explained that the notch is provided on the surface of fin with a rectangular shape the fin supports for much heat transfer and compared the heat transfer rate of fins by changing the material from Aluminium to copper and found that copper shows much heat transfer value than aluminium [6, 7]. As earlier resulted that to achieve high thermal performance the cylindrical perforated pin fins are used they leads to high heat transfer than the cylindrical pin fins. The efficiency varies depending upon clearance ratio and inter-spacing ratio and also lower clearance ratio, lower inter-fin spacing ratio and lower Reynolds numbers are suggested [8].

In view of the above-mentioned heat transfer problems, the main objective of the paper is to study of the various combinations of composites for the perfect heat transfer in Pin-Fin apparatus.

II. FABRICATION OF COMPOSITES

The base metal Al6063 is cleaned using acetone. Then it is melted using electric arc furnace (capacity 20kg/melt).Temperature of the melting process is 710- 725 degree centigrade. At this, stage all cover flux is added in the furnace. Once the base alloy is melted completely, degassing process is carried out by adding hexachloroethane tablets. This removes nitrogen, carbon-di-oxide and other gases absorbed by the melt in the furnace. The silicon carbide is now preheated to a temperature of 790 degree centigrade. The melted base alloy is stirred for about 5-6 minutes at 450rpm.Silicon carbide and magnesium are continuously added to the melt. The magnesium is added in order to compensate for its losses during melting and for wetting purposes. After this stirring purpose the molten mixture is poured into the steel moulds of required diameter and length.

III. HEAT TRANSFER THROUGH FINS

Fins are used in a large number of applications to increase the heat transfer from surfaces. Typically, the fin material has a high thermal conductivity. The fin is exposed to a flowing fluid, which cools or heats it, with the high thermal conductivity allowing increased heat being conducted from the wall through the fin. Heat transfer between a solid surface and a moving fluid is governed by the Newton's cooling law: q = hA(Ts-T), where Ts is the surface temperature and T is the fluid temperature. Therefore, to increase the convective heat transfer, one can

- Increase the temperature difference (Ts-T) between the surface and the fluid.
- Increase the convection coefficient h. This can be accomplished by increasing the fluid flow over the surface since h is a function of the flow velocity and the higher the velocity, the higher the h. Example: a cooling fan.
- Increase the contact surface area A.

IV. EXPERIMENTAL PROCEDURE & RESULTS AND DISCUSSION

Commercially Fabricated cylindrical bars having 15% of SiC particles and 5% Magnesium on matrix of Al 6063, using stir casting method of diameter 20 mm along with Pin-Fin apparatus, the fin securely installed and the variac set to the proper voltage, the fin temperature measurements are monitored until a steady state condition has been reached. Steady state temperatures are then recorded along with the measured power.

Fig. 1: Pin-Fin Apparatus

A. *Heat Transfer Test*

The method of calculating heat transfer coefficients as reported by many researches and also based on the knowledge of known temperature histories at the interior points of the casting or mould together with the numerical models of heat flow during solidification. These temperatures are difficult to measure due to the difficulty in locating accurate position of thermocouple at the interface.

Table – 1
Reading for Alunimium 6063 (Base Metal)

VOLTS	*AMPS*	*T1*	*T2*	*T3*	*T4*	*T5*	*T6*	*T7*	*HEAT TRANSFER COEFFICIENT (H)*
40	*0.30*	*38*	*36*	*33*	*28*	*26*	*26*	*22*	*13.712*
50	*0.45*	*39*	*38*	*35*	*30*	*29*	*28*	*24*	*14.385*

Table – 2
Reading for Al/Sic/15_P/Mg/5_p

VOLTS	*AMPS*	*T1*	*T2*	*T3*	*T4*	*T5*	*T6*	*T7*	*HEAT TRANSFER COEFFICIENT (H)*
40	*0.31*	*41*	*37*	*32*	*28*	*25*	*23*	*22*	*14.366*
50	*0.45*	*43*	*39*	*32*	*31*	*26*	*24*	*23*	*16.352*

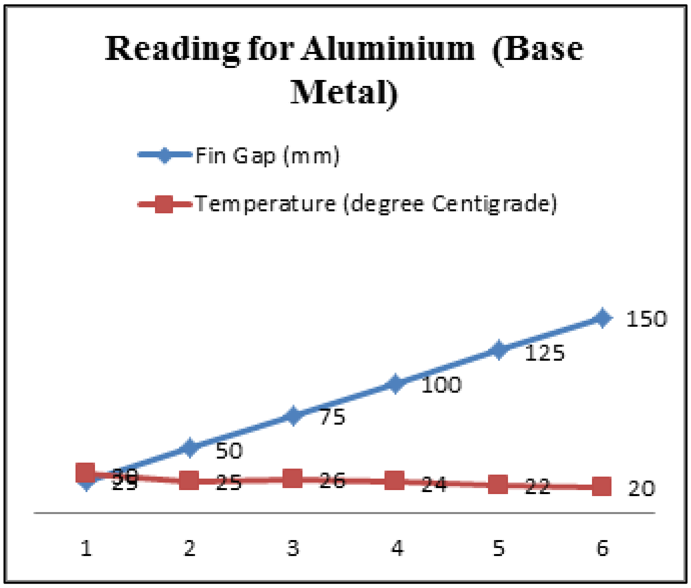

Fig. 2: Aluminium (Base Metal) Fin Gap vs Temperature

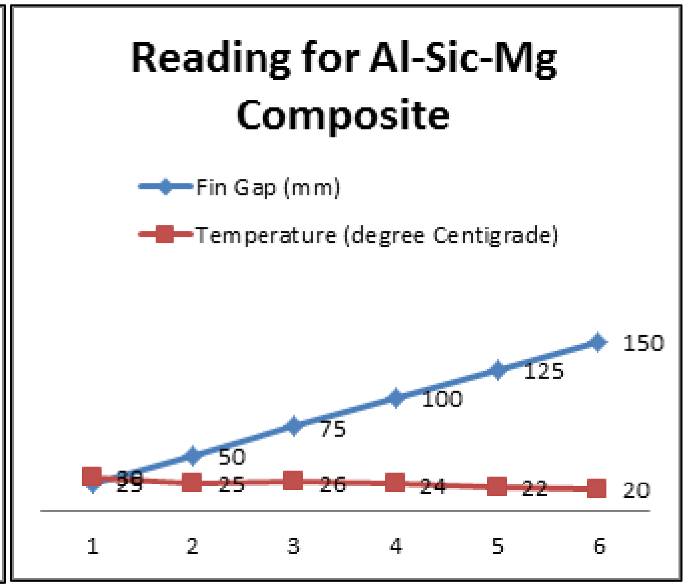

Fig. 3: Composite Fin Gap vs Temperature

V. CONCLUSION

In this research work, a hybrid surface composite based on the Al-Sic-Mg ternary system was produced. The obtained results are as follows

1) Micron-sized SiC particles were incorporated into a melt of aluminium and Silicon Carbide with Magnesium the aid of addition as a wetting agent to fabricate aluminium matrix composite.
2) The casting temperature 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 aluminum and silicon composites having good mechanical properties compared with the conventional materials. The addition of magnesium will give the improved strength.
3) The prepared composite is used for the Pin-Fin apparatus and also in various industrial applications these materials having light weight along with high hardness.
4) The Component made by casting technique will support the application orientation in Pin-Fin apparatus.
5) Finally it was concluded that the percentage of Al-Sic-Mg increases, automatically the hardness, strength and heat transfer rate is increased consecutively.

REFERENCES

[1] U.A.Dabade and M.R.Jadhav "Experimental study of surface integrity of Al/SiC particulate metal–matrix composites in hot machining". 48th CIRP Conference on Manufacturing Systems - CIRP CMS 2015. Procedia CIRP 41 (2016) 914 – 919.
[2] Durbadal Mandal, Srinath Viswanathan "Effect of Heat Treatment on Microstructure and Interface of SiC Particles Reinforced 2124 Al Matrix Composite". Material Characterization doi:10.1016/j.matchar.2013.08.014.
[3] Jufu Jiang, Gang Chen, Ying Wang "Compression Mechanical Behavior of 7075 Aluminum Matrix Composite Reinforced with Nano-Sized SiC Particles in Semisolid State". Journal of Materials Science & Technology http://dx.doi.org/doi: 10.1016/j.jmst.2016.01.015.
[4] K. Soorya Prakash , P. Balasundar , S. Nagaraja , P.M. Gopal and V. Kavimani " Mechanical and wear behaviour of Mg–SiC–Gr hybrid composites". Journal of Magnesium and Alloys 4 (2016) 197–206.
[5] G. Sivakumar , V. Ananthi and S. Ramanathan "Production and mechanical properties of nano SiC particle reinforced Ti−6Al−4V matrix composite". Trans. Nonferrous Met. Soc. China 27(2017) 82−90.
[6] M.J. Shen and X.J. Wang "Effect of bimodal size SiC particulates on microstructure and mechanical properties of AZ31B magnesium matrix composites". Materials and Design 52 (2013) 1011–1017.
[7] Y.Q. Wang and X.J. Wang "Effect of SiC particles on microarc oxidation process of magnesium matrix composites". Applied Surface Science 283 (2013) 906–913.
[8] S.H. Abdollahi, F. Karimzadeh, M.H. Enayati "Development of Surface Composite based on Mg-Al-Ni System on AZ31 Magnesium Alloy and Evaluation of Formation Mechanism". Journal of Alloys and Compounds. doi: http://dx.doi.org/10.1016/j.jallcom.2014.11.029