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Study the Thermal Characteristics of LM13/ MgO Composites

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A B S T R A C T

The demand of today's and future aluminium alloys are best suitable materials in engineering applications. These needs for new materials able to match increasingly stringent engineering requirements have led to the development of Metal Matrix Composites for automotive applications. Al based MMC's are having some excellent properties such as high hardness, high strength & high thermal conductivity at elevated temperatures. Other characteristics are low coefficient of thermal expansion & wear resistances. In the present investigation, the effects of thermal conductivity of LM13/MgO_p MMC's. The as-cast LM13 alloy and its composites were fabricated using stir-casting method by varying the reinforcement content from 2 wt.% to 10 wt.% in steps of 2.The specimens were prepared as per ASTME standards & compare the results Thermal conductivity and electrical conductivity. These composites may be the alternate materials for aero-plane components, automobile parts like piston rod, connecting rod & cylinder head.

Introduction

Metal Matrix Composites are engineered combinations of two or more materials where tailored properties are achieved by systematic combinations of different constituents. The nature and morphology of the composites are mainly depends on the shape & size of individual constituents, their structural arrangement & distribution, the relative amount of each contribute to the overall performance of the composites. The properties such as friction & wear resistance in lubrication condition are importance for the development of engine parts. Al alloy found widespread in transportation engineering applications because of its high strength to weight ratio. However relatively low wear resistance of Al alloys can be overcome by employing Al based MMC's developed especially for thermal & mechanical properties. Demands are increased on Al alloys in automobiles engine components (piston, cylinder head & connecting rod) to operating temperatures exceeding 170^0c. A reinforced Al alloy matrix composite is one of the potential materials for these applications. One of the biggest questions arising for automobiles industry facing today. "What materials are going to add to reduced drastically weight of the engine to save the fuel"? There is variety of alternatives being explored by the automobiles industry, hence the automobiles of the future will continue to be mix of materials of which the candidate materials will be Al based MMC's. Al based MMC's refer to the class of light weight Metals with high performance Al centric material systems. The reinforcement on Al MMC's could be in the form particulate, whiskers, continuous and discontinuous fibers in weight fraction ranging from 15% up to 70%. Properties of Al based MMC's can be tailored to the demands of different industrial applications of matrix, reinforcement and processing route.

Literature review

Now days, the world-wide upsurge in MMCs research and development activities is focusing mainly on Al alloys. Because of its unique combination of properties like, good corrosion resistance, low density and excellent mechanical properties. The unique thermal properties of Al composites such as metallic conductivity with coefficient of expansion, that can be tailored down to zero and are used in aerospace and avionics. LM13/quartz was studied by Joel Hemanth & Norman Tommiswere also studied & received patent award in US. They explained details of light metals properties of LM13/zirconium and thermal properties were studied. Successful developments of MMCs are critical in reaching the goals of many advanced aerospace propulsion and power development programs. The specific space propulsion and power applications require high temperature, higher thermal conductivity and high strength materials. MMCs either fulfill or have the potential of full filling

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these requirements and also offer considerable promise to help automotive engineers to meet the challenges of future & current demands. LM13 based MMCs refer to the class of light weight materials suitable in applications where weight reduction has first priority.

Experimental setup

The matrix material selected was LM13 and reinforcement material was MgO_p and particles were dispersed in the matrix material and chemical composition as shown in Table 1. The size of the MgO Particulates dispersed varies from 5 to 8 μm.

Table 1 Chemical composition of LM13 Alloy

Mg	Cu	Fe	Ti	Ni	Mn	Si	Al
1.2	0.8	0.8	0.02	0.9	0.2	12	84

The as-cast LM13 alloy and its composites were fabricated using stir-casting method by varying the reinforcement content from 0 wt.% to 10 wt.% in steps of 2. The matrix material was first superheated to above its melting temperature and preheated reinforcement particulates were added into molten metal. The molten metal was stirred for duration of 8 min using a mechanical stirrer and speed of the stirrer was maintained at 450 rpm. The melt at 750°C was poured into the pre-heated cast iron dies. The castings were tested to know the common casting defects using ultrasonic flaw detector. The specimens were prepared as per ASTME (1225-99) standards and then the specimen's dimensions are dia 25mm & 80mm length. The samples were subjected to solutionizing at a temperature 510^0c for duration of 2 hrs followed by Ice quenching media & then the samples were heat treated at temperature 190^0c for 6hrs.The thermal conductivity test was conducted on the as-cast and heat treated composites. The surface of the specimens were cleaned by alcohol and then by acetone to remove the dust particle. Then the specimen in mounted in the testing column and the temperature is increased to 50^0c by heat input and once the temperature attains equilibrium condition, the thermocouple readings are recorded .The procedure was repeated up to 200^0c thermal conductivity of the specimen was calculated by using the principle of Fourier's law of conduction at steady state operating condition with unidirectional heat conduction.

$$K= \frac{Q/A}{\Delta T/\Delta L}$$

Where Q is the amount of heat passing through a cross section (A) and causing a temperature difference (ΔT) over a distance of ΔL , (Q/A) is the heat flux which causing the thermal gradient. $\Delta T/\Delta L$

Result & discussion

Syntheses of PMMC's

Synthesis of Al–alloy based PMMC's was successfully accomplished by LMD process followed by Stirrer die-casting. The condition prevails during melts, processing, dispersion, deposition and solidification was instrumental in the prevention of micro porosity, segregation of reinforcement due to effect of its gravity has indicated its suitability of stirring and realization of good solidification conditions during the deposition to produce sound castings. The results, in essential to indicate the feasibility of the LMD process as a potential fabrication techniques for MgO_p composites.

Fig .1 Scanning of electron micrograph of LM13/8%MgO

Thermal & electrical properties of PMMCs

In general, the heat transfer in which energy exchanged between the high temperature region to lower temperature region due to kinetic motion or direct impact of molecules. Due to Fourier law of conduction. P.L.Balley, Studies on conduction & showed that thermal conductivity of the MMCs depends on the size & shape of the reinforcement. This benefits the present's investigation in that lower thermal conductivity due to addition of MgO_P as reinforcement results in lower heat loss from engine resulting in an increase in the thermal efficiency. Thermal conductivity results obtained at different temperature for cast MMCs of LM13 with different volume % of dispersion contents.

Table2 Thermal & electrical properties of PMMCs & Matrix alloy

%MgO	Thermal conductivity (w/m^{0}c)	Electrical conductivity (μΩm)
2	145	3.3
4	142	3.0
6	139	2.7
8	134	2.2
10	130	1.7
Matrix alloy(LM13)	156	3.6

In addition, Mg_{0p} itself has low electrical resistivity with 0.05-0.33μΩm and hence its addition further reduces the electrical resistivity of the composite. It observed form the results that, thermal conductivity and electrical resistivity both reduced gradually with increasing the concentration of $MgO_{p.}$ Results of the tests revealed that thermal conductivity with increasing MgO_p content has a maximum value 145w/mk. It is obtained for 2wt% addition, however electrical resistivity at that instant was 3.3 μΩ m.

Conclusion

LMD techniques coupled with stirrer die casting used to synthesis MgO_p reveal the following.

Thermal conductivity decreases as dispersion content and temperature increases and this result in lower heat loss from the engine resulting in the increasing thermal efficiency at elevated temperatures. The thermal conductivity of Al based MMCs with MgO_p was found to decreases linearly with increasing the MgO_p content, to as much as 17.45% less than that of Matrix Al alloy. It also observed that thermal conductivity & electrical resistivity both reduced gradually with increasing the concentration of reinforcement.

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