Development of aluminum based composite material for cylinder liner application

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***Abstract*— Thermal conductivity is the property of the material which is essential for the heat transfer applications. The thermal conductivity of the composite material will vary with varying composition. Now a days, aluminium based composites are widely used in many application because of light weight and low cost. The main objective of this work is to find suitable alternate material for the cylinder liners. The aluminium composites using alumina and graphite with various proportions (sample1: Gr1%, $Al_2O_3$6%, sample2: Gr1%, $Al_2O_3$12%, sample3:Al_2O_3 12%) were fabricated and tested for their suitability as cylinder liners. An experimental setup was fabricated to measure the thermal conductivity of samples. Thermal conductivity of the samples was determined and the values are compared. The results showed that the thermal conductivity of the material is decreasing with increase in graphite composition. The decrease in thermal conductivity results in less heat loss which is more suitable for cylinder liners.**

Keywords*— *Thermal conductivity, aluminium composite, alumina and graphite, cylinder liner, heat loss.

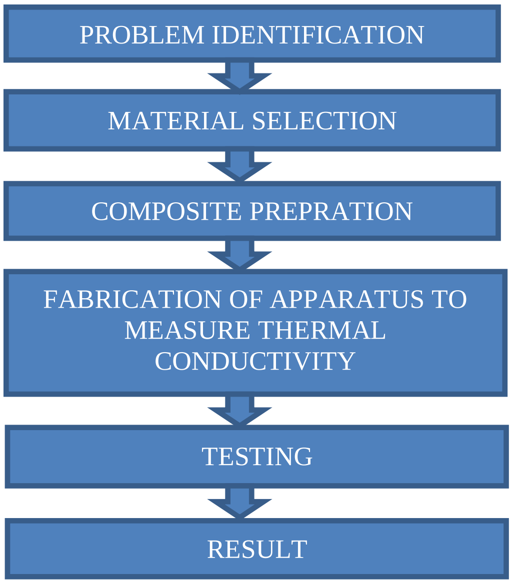
I. Introduction

Now days, the engine design is to be optimized and it has to give the better performance. The heat energy produced in IC engine is not fully converted in to the mechanical energy. There are some losses in the engine. The heat loss is the loss of heat produced inside the engine through the cylinder liner and piston. In combustion process approximately 35% of heat is lost through the cylinder walls.

The cylinder liner is also called as the sleeve which is used in engine to avoid the wear. The functions of cylinder liner are to provide the sliding surface for piston. There are two types of cylinder liner namely wet cylinder liner and dry cylinder liner. The wet liner contact with the cooling medium while dry liners made direct contact with the cylinder block.

Aluminium alloys are also used in the cylinder liners because of its light weight. The aluminium composite has many advantages than the aluminium. Heat loss from the cylinder liner can be eliminated by using the material which has low thermal conductivity and high strength. The aluminium composites exhibit the better strength and thermal property.

II. Methodology



III. Material Selection

The aluminium alloys are already employed in cylinder liner application. The aluminium has light weight and better strength. The aluminium composite are exhibiting different thermal and mechanical property in when compared to aluminium. The aluminium alloy, alumina and graphite were taken to fabricate the metal matrix composite in different composition. The metal matrix composite is composite material which having at least two constituents parts, one should be a metal and other may be material like ceramic or organic compound.

A. Alumina

Al2O3 is widely used as the reinforcing additive in the metal matrix composites. the alumina oxide particles with an average particle size of 20μm were used as a filler material. Figure shows the alumina filler material. Alumina is the most cost effective and widely used material in family of engineering ceramics. The raw materials from which this high performance technical grade ceramic is made are readily available and reasonably priced, resulting in good value for the cost in fabricated alumina shapes, with an excellent combination of properties and an attractive price, it is no surprise that fine grain technical grade alumina has a wide range of application.

Fig. 1. Alumina powder

B. *Graphite*

The graphite has good thermal conductivity. The graphite is selected to increase the strength of the composite to with stand the pressure developed by combustion.

IV. COMPOSITE PREPRATION

The metal matrix composites are prepared using the stir casting. Stir casting involves the process of stirring the molten metal are used for continuous stirring of particles into metal alloy to melt and immediately pour in to the sand mould the cooled and allowed to solidify. In stir casting, the particles are often tends to form agglomerates, which can be only dissolved by vigorous stirring with high temperature.

TABLE I. TABLE STYLES

Sample	Percentage of Material in Composite		
	Aluminium	***Alumina***	***Graphite***
1	100	0	0
2	88	12	0
3	87	12	1
4	93	6	1

V. FABRICATION OF THERMAL CONDUCTIVITY APPARATUS

A. *Voltmeter*

A voltmeter is an instrument used for measuring electrical potential difference between in an electric circuit. A digital voltmeter measure shows the voltage in numbers

Fig. 2. Voltmeter

B. *Ammeter*

An ammeter is an instrument used for measuring electrical current in circuit. A digital ammeter shows the current in numbers.

Fig. 3. Ammeter

C. *Heater*

The heater is the device which is used to heat the material when it is connected to the supply. 560W heater is selected to heat the material.

Fig. 4. Heater

D. *Thermocouple*

Thermocouple is used to measure the temperature. The k type thermo couple is used to measure temperature of the material at particular place. Stem diameter is 4mm and length is 25mm.

Fig. 5. Thermocouple

E. *Temprature indicator*

The temperature indicator is used to display the temperature. Its range is 600ºC.

Fig. 6. Temprature indicator

F. Voltage regulator

The voltage regulator is used to change supply voltage of the heater.

Fig. 7. Voltage regulatore

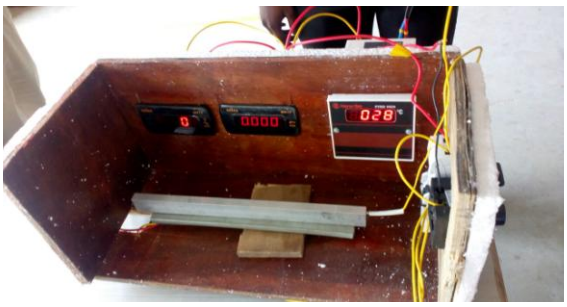
G. Sample

In the sample the two holes are made to insert the thermocouple. The hole is 4mm diameter and 25mm depth.Example of a figure caption. *(figure caption)*

H. Connection

The double pole MCB switch is connected with the incoming lines. The outgoing line from MCB is connected with voltmeter, ammeter and temperature indicator in serious connection. The voltage regulator is connected with line and voltmeters V terminal. Voltmeters V terminal is connected with ammeter S1 terminal. The thermocouple is connected with the temperature indicator. An ammeters S2 terminal is connected with the heater and another terminal of heater is connected with neutral line.

Fig. 8. Fbricated apparatus



VI. Thermal Conductivity Measurement

The samples are placed on the heater. Thermocouple is fitted in to the hole in the sample. When the switch is on voltage is regulated using the voltage regulator. Readings were noted down in the steady state.

TABLE II. SAMPLE1

S.no	Voltage(V)	Current(A)	T1(ºC)	T2(ºC)
1	97	0.846	133	132
2	105	0.913	148	146
3	109	0.94	158	155
4	117	1.014	178	174
5	122	1.042	194	191

TABLE III. SAMPLE2

S.no	Voltage(V)	Current(A)	T1(ºC)	T2(ºC)
1	95	0.82	220	216
2	99	0869	156	153
3	103	0.898	168	166
4	108	0.942	183	172
5	144	0.998	197	194

TABLE IV. SAMPLE3

S.no	Voltage(V)	Current(A)	T1(ºC)	T2(ºC)
1	94	0.638	152	149
2	101	0.885	162	158
3	104	0.908	170	165
4	110	0.958	183	177
5	115	0.998	202	198

TABLE V. SAMPLE4

S.no	Voltage(V)	Current(A)	T1(ºC)	T2(ºC)
1	92	0.797	142	139
2	95	0.83	153	150
3	101	0.876	159	156
4	111	0.961	181	177
5	120	1.029	194	189

TABLE VI. CROSS SECTION AREA OF SAMPLES

Sample	Length(m)	Width(m)	Area(m^2)
1	0.292	0.012	0.00350
2	0.185	0.010	0.00185
3	0.170	0.010	0.00170
4	0.155	0.010	0.00155

VII. Calculation

$$Q = V*I \quad (1)$$

$$K = QL/A\ (T1-T2) \quad (2)$$

For Sample1,

$K = 81*0.015/ (0.0035*1)$
$K = 349\ W/m*K$

TABLE VII. SAMPLE1 CALCULATION

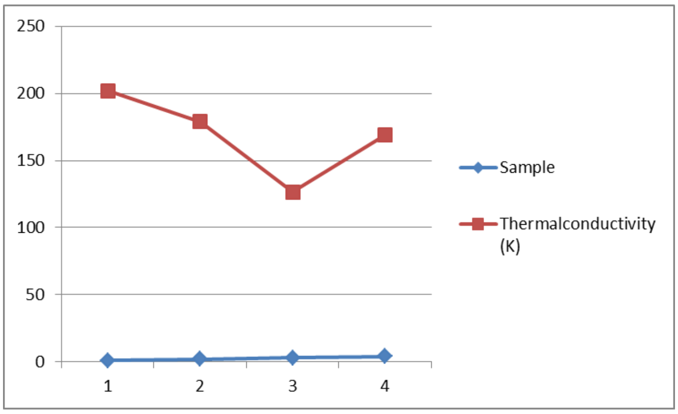
S.no	Q(W)	T1-T2(°C)	K(W/m*K)
1	81	1	349
2	95.865	2	205.425
3	102.46	3	146.37
4	118.17	4	126.6
5	126.88	3	181.25
		Average	201.77

TABLE VIII. THERMAL CONDUCTIVITY OF SAMPLES

Sample	Thermal conductivity (K)
1	201.77
2	178.81
3	126.41
4	169

VIII. RESULT

Chart1 Thermalconductivity vs samples



IX. CONCLUSION

From the above table and the chart the thermal conductivity of sample3 is less than the other samples. Sample3 is a composite of Al87%, Gr1%, $Al_2O_3$12%. The increase in the alumina in the composite decreases the thermal conductivity. This composite may be suitable for the application of the cylinder liners when compared with the aluminium alloys. This composite having good strength compared with others .It will reduce the heat loss happened in the aluminium cylinder liners.

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