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HEAT TRANSFER ANALYSIS OF CYLINDER LINER IN WITH DIFFERENT COMPOSITE MATERIALS

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ABSTRACT

Cylinder liner is the cylindrical component which is located at interior portion of the engine. It guides the piston for reciprocation inside the engine smoothly. The Material used for the production of cylinder liner should be able to withstand high temperature and pressure and also acts as solid lubricant. In Today's world, Grey Cast iron along is used as cylinder liner. The Problem faced in the cylinder liner is less lubrication. To overcome this problem, the use of materials like Aluminium Oxide (Al_2O_3), Aluminium-Titanium Di Boride (Al/TiB_2), Graphite are need to be considered which has similar and high properties compared to grey cast iron. These materials like Al_2O_3, $Al/TiB_2$and Graphite will be analysed along with the currently used grey cast iron in ANSYS and perfect cylinder liner material will be identified based on the results.

Keywords: Al/TiB_2, Graphite, Cast iron, Cylinder liner, Ansys.

I. INTRODUCTION

The Main Purpose of Cylinder liner is the formation of sliding surface for the reciprocation of piston smoothly, Heat transfer from the piston to the coolant and the protection of exhaust gas leakage to the atmosphere. The most required property for a cylinder liner is lubrication property, in which graphite acts as the solid lubricant. High temperature and pressure will be developed inside the cylinder, so the material used as cylinder liner should have the ability to withstand high temperature and pressure. The Materials like Grey Cast iron, Al_2O_3, $Al/TiB_2$and Graphite has the capacity to withstand high temperature and pressure.

Heat flux is indirectly proportional to heat dissipation. Therefore, if the heat flux is higher than the heat dissipation is low. The Drawback faced in the currently used cylinder liner is lubrication. The Cylinder liner is differentiated into three types according to their functions and capabilities into Dry, Wet and Finned Cylinder liners as show in Fig.1

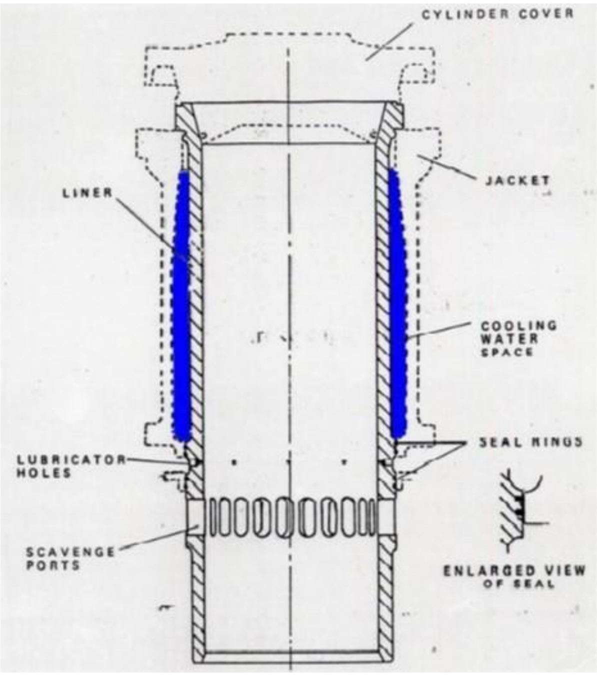

Fig.1 Cylinder Liner

The Cylinder liner which does not have any contact with the coolant is called Dry Cylinder liner. Dry cylinder liner requires proper finishing fitting into the cylinder, because it is not designed along the cylinder like in wet cylinder liner. In Dry Cylinder liner, cooling in upper part of the cylinder is high than the lower part. It provides rigidity and it resist impurities from deposit, but the heat flow is less compared to wet cylinder liner. The Cylinder liner which will be in contact with the coolant is called wet cylinder liner. At top, it is sealed with the by the metallic sealing ring and at bottom, it is sealed by the rubber sealing. Wet cylinder liner will be attached along the cylinder, hence there is no necessity of accurate finishing as like in dry cylinder liner.

Wet cylinder liner is removable. Due to its direct contact with the coolant, the heat dissipation is higher than the dry cylinder liner. It has good anti-corrosion ability and the heat conduction is high. Finned cylinder liner has the fin like structure around the surface for the flow of air which acts as the air passage way. Finned cylinder liner is mostly used in air cooled engines in automobiles. It cannot be used in engine with coolant mechanism. It has high heat withstand ability. Corrosion resistance is high compared to other cylinder liners. It acts as the resistance from impurities. The Material selection of cylinder liner is depending on their mechanical and thermal properties.

II. DESIGN AND CALCULATION OF CYLINDER LINER

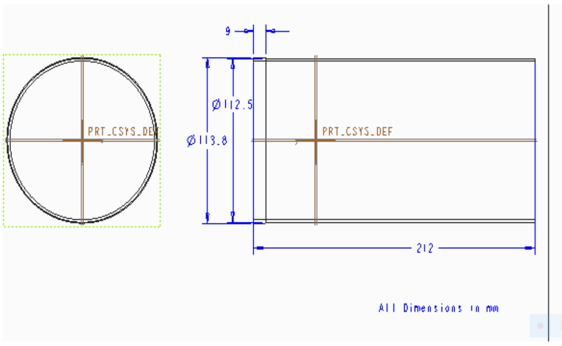

Fig. 2 Cylinder line diagram Calculation of Film coefficient

d_i= 0.1055m, d_o= 0.1138 m

Heat transfer coeffiecient of cylinder wall

h=2k/di ln(do/di)

where, h- heat transfer coefficient of cylinder- W/m2k, k- thermal conductivity-W/mk, d_i - inner diameter of cylinder-m, d_o - outer diameter of cylinder-m

Film Coefficient of Grey Cast Iron,

k= 52 W/m°C

h= (2*52)/(0.1055*ln(0.1138/0.1055)) h= 15361.89 W/m^2k

Film Coefficient of Graphite,

k= 1950 W/m°C

h= (2*1950)/(0.1055*ln(0.1138/0.1055)) h= 576070.90 W/m^2k

Film Coefficient of Al/TiB2, k= 110 W/m°C

h= (2*110)/(0.1055*ln(0.1138/0.1055)) h= 32496.30 W/m^2k

Film Coefficient of Al2O3, k= 35 W/m°C

h= (2*35)/(0.1055*ln(0.1138/0.1055)) h= 10339.73 W/m^2k

Calculation of Heat flux

Maximum Heat Flux of Cylinder liner,

q = -k(dT/dx)

Where,

k- Thermal conductivity of the cylinder liner,dT- Temperature gradient (T_2-T_1), dx- Thickness of cylinder

q= -k(T2-T1)/t

T1= Temperature outside the cylinder liner, T2= Temperature inside the cylinder liner

Heat Flux of Grey Cast Iron Cylinder liner

q= -k(T2-T1)/t

q = -52(2000-22)/7x10^{-3} q = 3.5014x10^{6} W/m^{2}

Heat Flux of Grey Cast Iron/Graphite Cylinder liner

q= -k(T2-T1)/t

q= -46(2000-22)/7x10^{-3}

III. MODELLING AND ANALYSIS OF CYLINDER LINER

Fig. 3 Typical Modal of cylinder liner using Cero Software

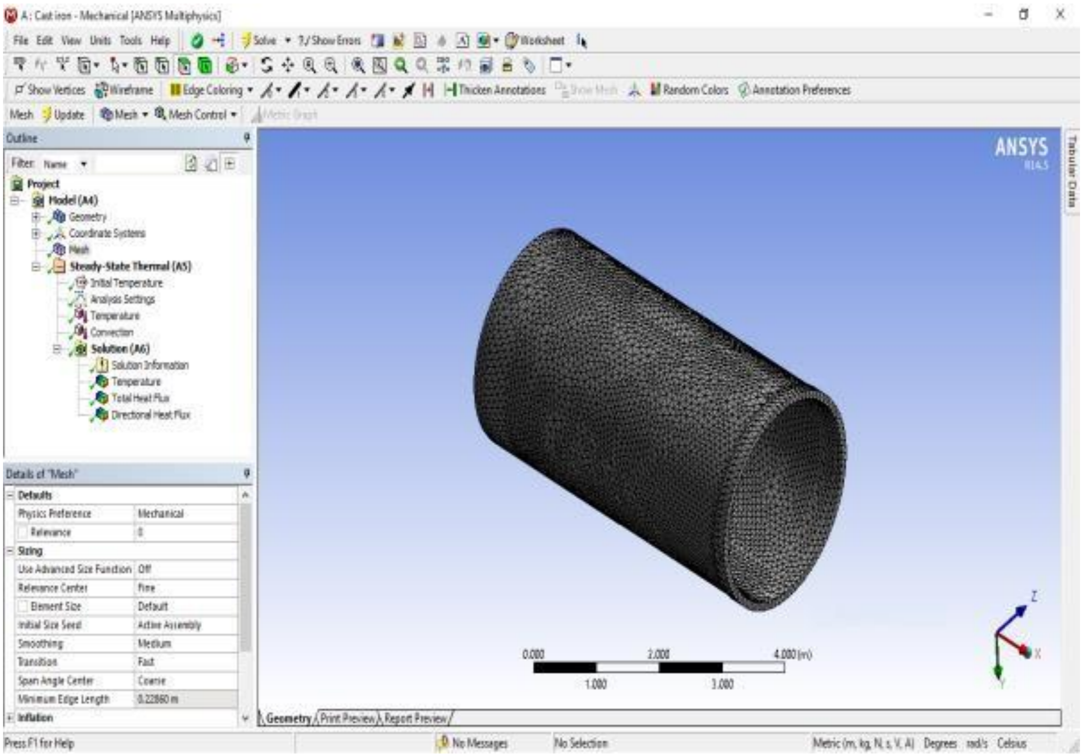

Fig. 4 Typical meshing of cylinder liner

In fig.3 shows typical model of cylinder liner and fig 4 show the typical mesh model of cylinder liner. The properties of cast iron and Al/TiB2, graphite and Al2O3 as shown in table.1

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Table 1 Properties of Different Material

PROPERTIES	GRAPHITE	GREY CAST IRON	Al - TiB_2	Al_2O_3
Density (Kg/m^3)	2266	7200	2770	3970
Poisson 's Ratio	0.17	0.28	0.33	0.27
Young 's Modulus (MPa)	27600	110000	71000	393000
Ultimate Tensile Strength (MPa)	330	240	310	260
Thermal Conductivity (W/mk)	1950	52	110	35
Melting Point °C	3800	1090	582	2072
Specific Heat (J/gm °C)	0.720	0.490	0.896	0.21

$q= 9.166x10^7 W/m^2$

Heat Flux of Al - TiB2/Graphite Cylinder liner

$q= -k(T_2-T_1)/t$

$q= -110(2000-22)/7x10^{-3}$ $q= 1.873x10^8 W/m^2$

Heat Flux of Al2O3/Graphite Cylinder liner

$q= -k(T_2-T_1)/t$

$q= -35(2000-22)/7x10^{-3}$ $q= 6.854x10^7 W/m^2$

IV. RESULTS AND DISCUSSION

Grey Cast iron (GCI) and Grey Cast Iron/Graphite of cylinder liner

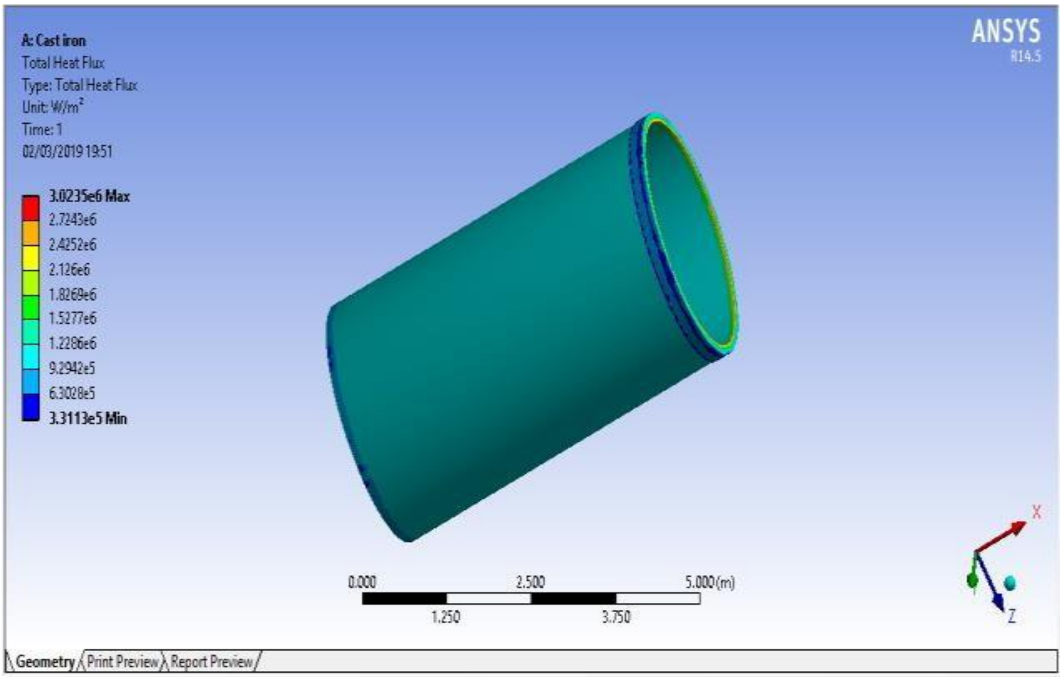

Fig. 5 Total Heat Flux of Grey Cast iron

Grey Cast iron is one of the most commonly used cast iron, because of high wear resistance and ability to put up with high temperature and pressure. The internal stress of grey cast iron is higher. It is available at low cost and the presence of graphite in grey cast iron plays a huge role to use it in the manufacturing process of cylinder liners. The heat flux value of **GCI** attained $8.7455e^7$ as shown in fig.5.

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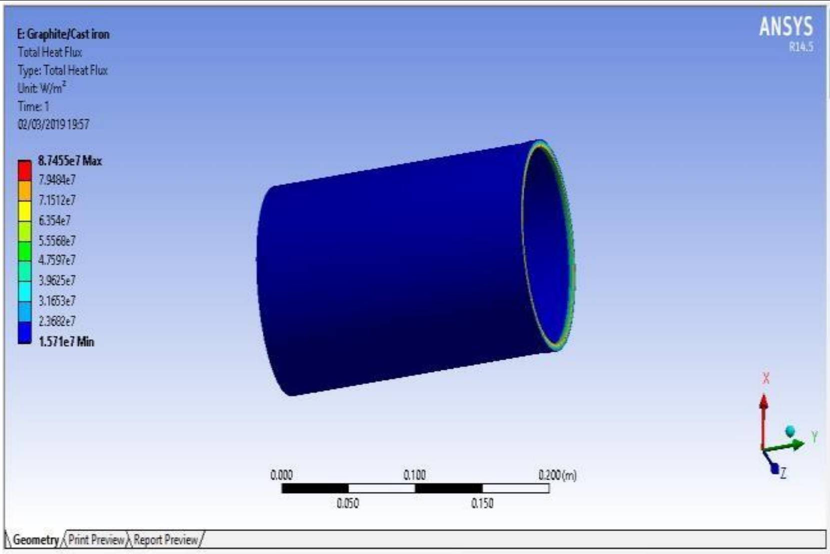

Fig 6 Total Heat Flux of GCI/Graphite

Grey cast iron contains lamellar graphite (ASTM attained 8.7455e^{7} simulation values as shown in fig.6

Al - TiB2/ Graphite of cylinder liner

Al/TiB2 MMCs is formed by the TiB2 particles reinforced over the aluminium. It is formed by the salt metal reaction. It is highly used because of its high mechanical properties, good corrosion resistance and low electrical resistance. Aluminium 7075 is used as base matrix for the formation of this metal matrix composite. In TiB2 material, 68.85% of titanium is mixed with 31.15% of Boron. In fig.7 shows the Heat Flux of Al-TiB2/Graphite of cylinder is obtained 1.7252e^{8}.

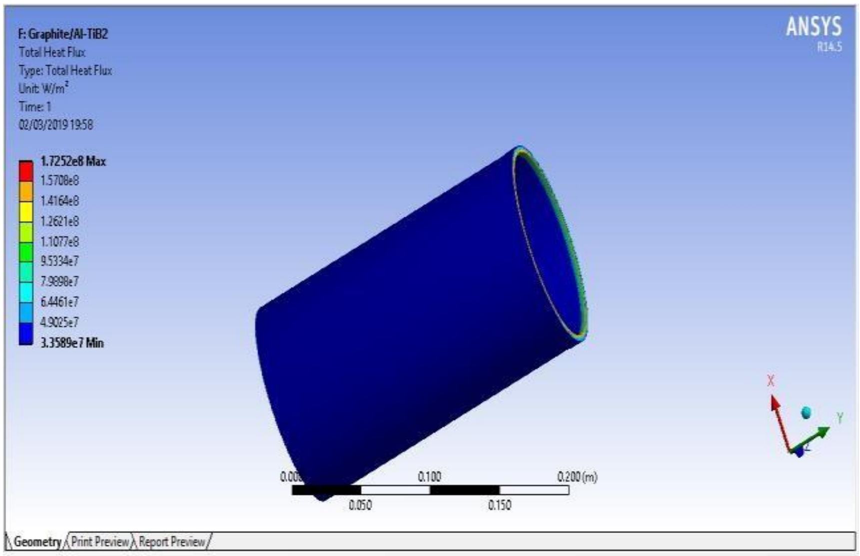

Fig 7 Total Heat Flux of Al – TiB2/Graphite

Al2O3/Graphite of cylinder liner

It is the chemical compound of aluminium and oxygen. It is also called alumina, oxide and alundum. It occurs naturally in its crystalline polymorphic phase α-Al2O3 as the mineral corundum, varieties of which form the precious gemstone and sapphire. In fig.7 shows the Heat Flux of Al-TiB2/Graphite of cylinder is obtained 1.7252e^{8}. Al2O3 is Grade 40). The heat flux value of **GCI/Graphite** significant in its use to produce aluminium metal, as an abrasive owing to its hardness, and as a refractory material owing to its high melting point. It has high corrosion resistance

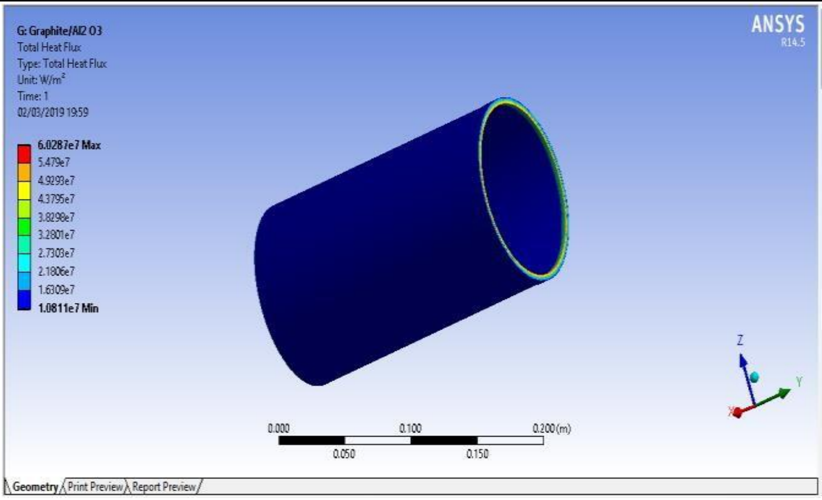

Fig. 8 Total Heat Flux of Al2O3/Graphite

The Al–TiB2/Graphite, Al2O3/Graphite and grey cast Iron/Graphite were analysed along with grey cast iron in ANSYS. From the analysis, different results were observed from the different composite materials. The heat flux comparison of simulation results and theoretical results. It shows theoretical and simulation values are come to close as shown in fig.9

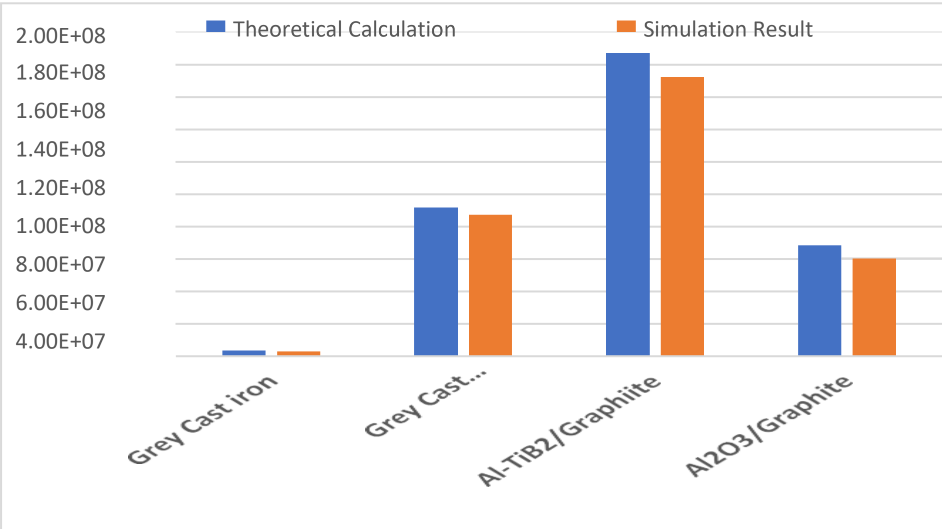

Fig. 9 Total Heat Flux Comparison

Table.2 Shows the Error between theoretical calculation and simulation result is within the range of 14% only. It is found that Al – TiB2/Graphite has the highest heat flux than Al2O3/Graphite and Cast Iron/Graphite and grey cast iron materials. To reduce the heat dissipation of cylinder liner of different materials. And increase the durability of cylinder liner. Heat flux should be higher.

Table 2 Heat Flux of Different Material

Materials	Theoretical Calculation	Simulation Result	Error
GGI	$3.535e^{6}$	$3.0235e^{6}$	14%
GCI/Graphite	$9.166e^{7}$	$8.7455e^{7}$	4.5%
Al/TiB_2/Graphite	$1.873e^{8}$	$1.7252e^{8}$	7.9%
Al_2O_3/Graphite	$6.854e^{7}$	$6.0287e^{7}$	12%

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V. CONCLUSION

The percentage of error maximum 14 % only so theoretical and simulatation values are come to close. By comparing the thermal heat flow of all the materials, Al – TiB2/Graphite material can be used as best cylinder liner in automobiles engines and also increase the lubrication property of the cylinder liner

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