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Modeling And Analysis Of Hard Chromium Coating Over Piston Surface In IC Engines.

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ABSTRACT

Measures to boost engine performance and improve efficiency are a continuous quest of the automobile industry. Wear in engine is an inevitable phenomenon. It is a challenging task for the automobile industry to minimize the wear rate to get higher mean time operation. This paper deals with preventive steps for increasing wear resistance in IC engines. Innumerable industries depend on hard chromium lining which is the base hardened anti wear protection for ferrous and non- ferrous substances to protect them from erosion or corrosion. This paper presents the modelling and analysis of the piston surface, both with and without hard chromium coating, by using ANSYS software. An analysis of heat flux rate and hot spot temperature over piston surface was also done, for both with and without hard chromium coating and the results are discussed.

Keywords: Hard chromium, ANSYS.

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INTRODUCTION

In engine, the Grey cast iron provides a good tribological behavior for the cylinder blocks, piston and piston rings. Ongoing researches trying out the aluminum alloys for the engine blocks to provide more wear resistance, though cast iron serves good in engine block. Casting alloy requires the development of a new tribological system. Aluminum casting alloy is not sufficiently wear resistant for this application. Different solutions have been developed over the years for cylinder liners which consisting of suitable materials as pressed-in or cast-in parts. The reduction of thermal expansion in automotive engines creates big potential when looking for possibilities to cut down frictional losses. Thermal differential expansion in the engine accounts for about 10-15 % of the energy that is available in fuel, leading to fuel energy losses. In inefficient older engine designs, the mechanical friction losses can be as much as 20%. Even in most modern low friction engines, the mechanical friction losses still account for about 7% to 9%. The reduction of friction losses in automotive engines is important when looking for possibilities to cut down fuel consumption. In engine block, the cylinder inner wall bore serves as a sliding surface for the piston and piston rings assembly. And this friction loss converted to heat energy in the moving piston engine accounts for equivalent to 10-15% of Fuel, such as gasoline (Petrol, Benzene). The following points keeps the friction losses for each sections by considering 10-15% of energy loss in fuel as 100%.Friction loss between the piston rings and cylinder bore is 26%, Friction loss between connecting rod, crankshaft pin and piston pin accounts for 14%, friction loss between main bearings and crankshaft is 17% . The casting made in existing engines has no coating materials over the surface of piston or in the bore surface of the cylinder to help avoid wear. In this paper an attempt has been made to coat the external surface of the piston and inside cylinder with hard chrome plating and the effect is analyzed. The modelling is carried out by ANSYS software. The objective of this research study is to coat the cylinder wall and piston rings with hard chromium to reduce the extent of frictional losses in IC engines thereby increasing its wear resistance and its mechanical efficiency.

LITERATURE SURVEY

Saghi Beyragh.M.R et al. [2] in this paper, hard chromium coating were done in single and duplex layers over mild steel substrates by direct current (DC) and pulse current (PC) electroplating processes. The direct current poses high degree of rust stains on the surfaces and edges than pulse current in both single and duplex layers electroplating process. The result shown as the highest point of corrosion protection in duplex coatings is achieved with the level of hardness on the surface is higher than the standard hard chromium coating hardness. Hadavi.S.M.M et al. [1]

In this paper, the hard chromium coatings were applied on a 32NiCrMo145 steel. Three different degrees of contraction and crack density, namely low contraction, cracked and high contraction were analyzed for 50 cycles. The pulse electrodeposition techniques were used for all the three different degrees to form crack- free chromium coatings. It results there is no chromium back-diffusion to the substrate was detected even after 200 thermal cycles. Srinivasa Rao.K et al. [4] in this paper, the nitriding has been coated over cylinder liners and the hardness is measured and analyzed in existing and proposed process. Gas nitriding has been selected as a coating. The process had made in to two distinct events in which first carried out at 500°C temperature and the second carried at 560°C. Increase in nitriding layers results much hardness to reduce wear rate for liners. Saurabh.

N. Tiwari et al. [3] in this paper, engine with petrol consumption mechanism has been modified to double the mileage. In four stroke engine the existing inlet path has been changed and shown the result with increased mileage. The above literature reviews clearly gives an idea that the hard chromium coating serves a major role in reducing the wear rates in IC engines.

METHODOLOGY

The hard chromium coating modelling methodology has been explained in below fig 3.1.

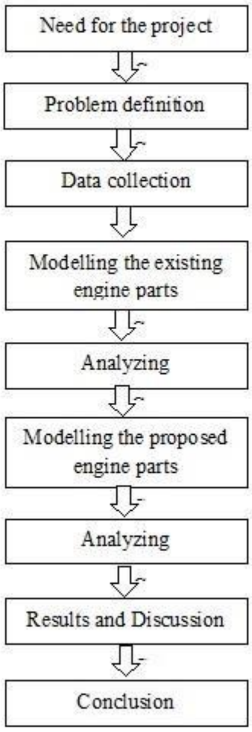

Fig: 3.1 Methodology for the hard chrome coating

Need for the project and the problem identified were explained in introduction.

ANALYSIS OF EXISTING MODEL

The data collected for existing design and tabulated in the table 4.1

Table: 4.1 Existing design data for cylinder and piston

S. N	Parameter	Dimensions (mm)	Material
1	Cylinder Bore	ID: 53+0.02	Aluminium (Al)
2	Cylinder Liner	OD : 53+0/-0.01	Cast Iron
		ID : 50.01+0/-0.05	
3	Piston	OD: 50 +0/ -0.01	Aluminium alloy
4	Piston Ring	OD :50.10 +0/ -0.05	Cast iron

Based on the above data a model has been created by CREO 2.0 ANSYS. The piston 3- Dimensional model is shown in Fig 4.1.The feature transparency has been enabled in the model which is shown here to have a clear view of the entire piston.

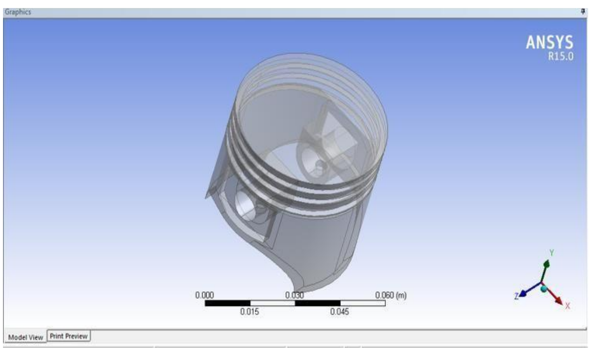

Fig: 4.1 3D Model of Piston's Surface

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Fig 4.2 depicts the triangular mesh placed on the piston in order to study the effects of temperature variations.

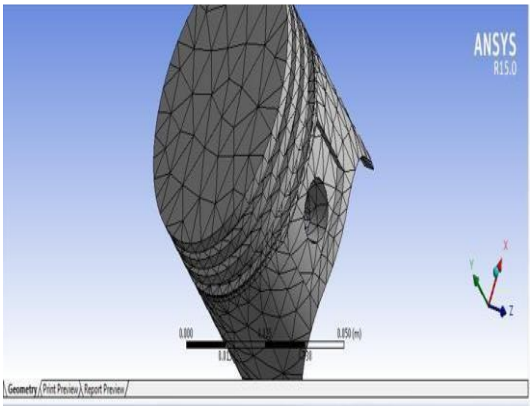


Fig: 4.2 Piston's Mesh View

Meshing is the process of discrete fragmentation of the body into small parts for precise profile study of the test model. The triangular mesh is further intensified as fine at certain required critical points, details of which are mentioned in the boundary conditions. Steady state performance of thermal analysis is done on the body of the piston and the places where fixed isothermal temperature profile is to be acted upon. There are totally seven critical points fixed on the body, as shown in Fig 4.3 with the following temperatures; they are A-Temperature 743°C, B-Temperature 323°C, C-Temperature 180°C, D-Convection 22°C, 440 w/m2°C, E-Convection 2.22°C, 318 w/m2°C, F-Convection 3.22 °C, 221 w/m2°C and G-Heat flux 25.45W. The steady state thermal condition with its relative fixed critical points is analyzed based on the interpolated total heat flux in the existing design and is shown in Fig 4.4. The

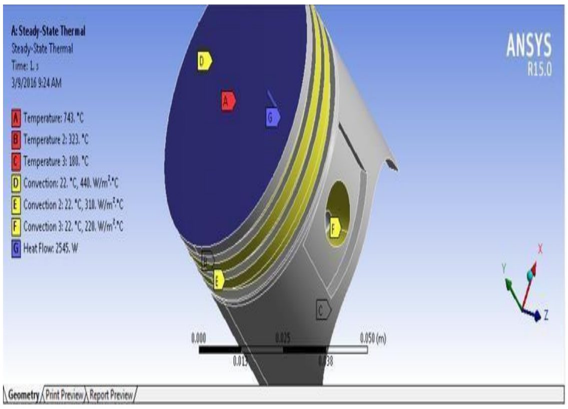
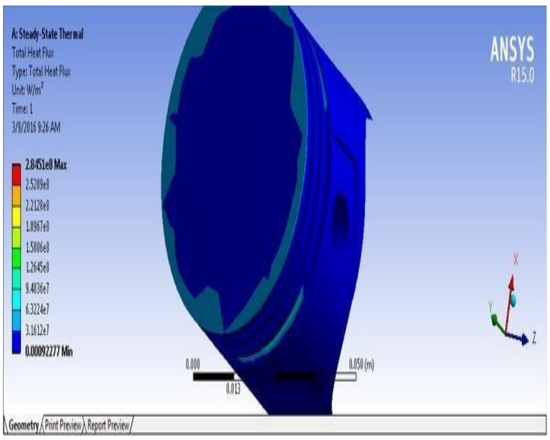


Fig: 4.3 Boundary conditions for mesh analysis

Fig: 4.4 Heat flux analysis on existing Piston Face



minimum heat flux is achieved on the sides of the piston top and its value is 0.00092277 w/m^2; the maximum heat flux is achieved at the center of the piston top and its value is 2.8451 w/m^2. The steady state thermal condition with fixed critical points is analyzed along with the temperature profile produced in the existing design and is shown in Fig 4.5. The minimum heat flux is achieved on the sides of the piston top when its temperature value is 316.09°C. The maximum heat flux is achieved at the center of the piston top when the corresponding temperature value is 765°C.

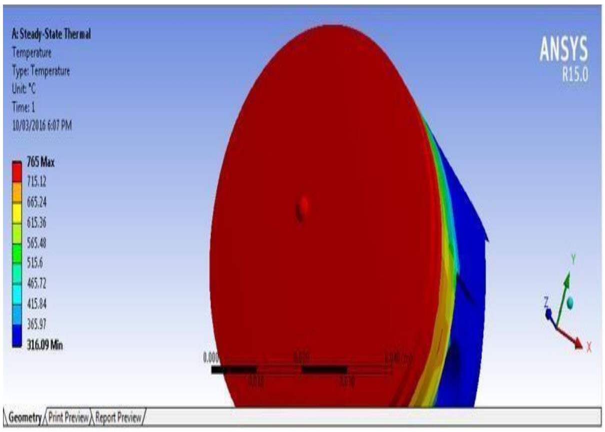


Fig: 4.5 Temperature analysis on existing Piston Face

ANALYSIS OF PROPOSED MODEL

The data for proposed design is tabulated in the table 5.1

Table: 5.1 Proposed design Data for cylinder and piston

S. No	Parameter	Dimensions (mm)	Material	Surface Treatment
1	Cylinder Bore	ID: 53+0.02	Aluminium (Al)	Normal process
2	Cylinder Liner	OD : 53+0/-0.01 ID : 50.01+0/-0.05	Cast Iron	Normal process
3	Piston	OD: 50 +0/ -0.01	Aluminium alloy	Grinding and Hard chromium coating(15 microns thickness)
4	Piston Ring	OD :50.10 +0/-0.05	Cast iron	Hard Chromium

Fig 5.1 below shows the cross-sectional view of the piston assembly. The area in grey colour shows the piston and cylinder material made as per the existing design. The hard chromium coating over the piston is shown in greenish grey colour. The 3- Dimensional assembly for the proposed design is shown in Fig 5.2. The steady state thermal condition with fixed critical points is analyzed along with the total heat flux produced in the proposed design, as shown in Fig 5.3. The minimum heat flux is achievedon the sides of the piston top and its value is 0.0004734 w/m^2; the maximum heat flux is achieved at the center of the piston top and its value is 1.4946 w/m^2. The steady state thermal condition with fixed critical points is analyzed along with the temperature produced in the proposed design, as shown in Fig 5.4. The

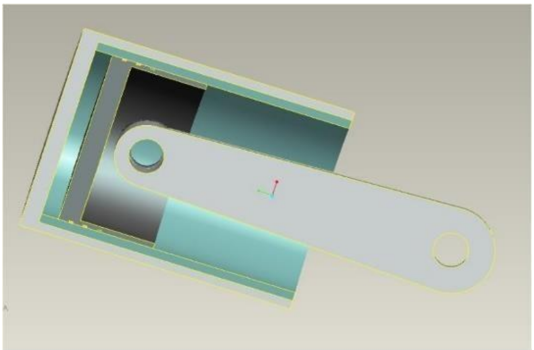


Fig: 5.1 Cross sectional view for proposed design

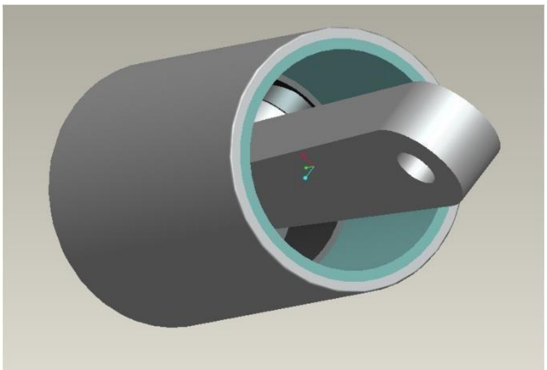


Fig: 5.2 Dimensional view for proposed design

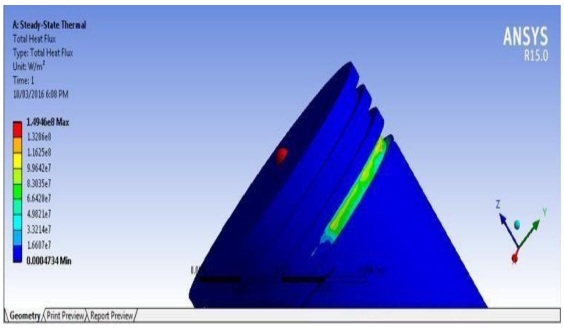


Fig: 5.3 Heat flux analysis on proposed Piston Face

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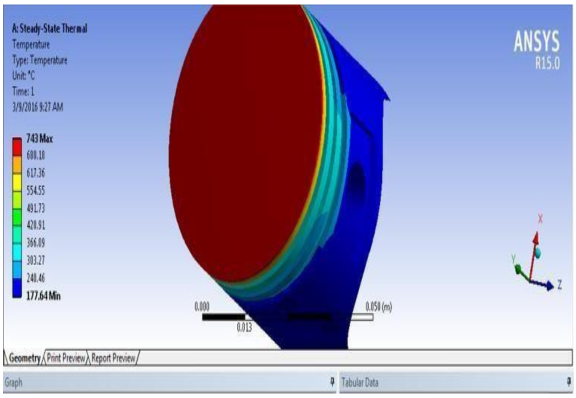

Fig: 5.4 Temperature analysis on proposed Piston Face

minimum heat flux is achieved on the sides of the piston top when its temperature value is 177.64 °C; the maximum heat flux is achieved at the center of the piston top when its corresponding temperature value is 743 °C.

RESULT AND DISCUSSION

The comparison made between the existing design and proposed design is shown below in Table 6.1

Table: 6.1 Comparison for existing and proposed design

S.No	Parameter	Existing	Proposed
1	Heat Flux	0.00092277 w/m2 (Min) 2.8451 w/m2(Max)	0.0004734 w/m2 (Min) 1.4946 w/m2(Max)
2	Temperature	316.09 °C (Min) 765 °C (Max)	177.64 °C (Min) 743 °C (Max)

The above table shows that the minimum and maximum values of the heat flux in the existing design improved a lot by using the proposed design hard chromium coating over piston surface. Similarly, the temperature values also significantly reduced in the proposed design. Both heat flux and temperature variations trend are maximum at the top of the piston and minimum on the side wall surfaces

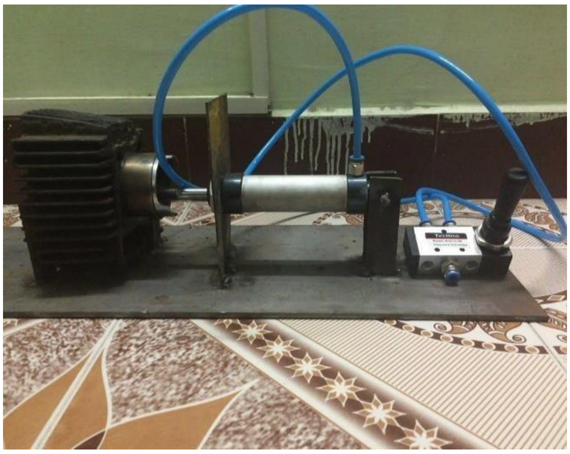

Fig: 6.1 Prototype of Hard chromium coated cylinder and piston assembly

of the piston. To ensure the wear rate in practical, a prototype shown in fig 6.1 has been made and the experimental results has to analyze to compare with design software result.

CONCLUSION

The hard chromium plating in the proposed design gives reduced heat flux and lower surface temperature over the piston surface. Higher temperature plays a major role in increased wear of the components. Reduction of wear can be achieved by reducing the temperature with hard chromium coating. This research study shows that the temperature and heat flux values are drastically reduced when the piston surface is coated with hard chromium. The analysis was done using ANSYS software to correlate temperature reduction and the actual wear rate in a prototype.

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