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IC ENGINE WET LINERS THERMAL ANALYSIS

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ABSTRACT
In practical only 52% of the heat input is converted into work in diesel engine . About an equal amount of heat is carried away by cooling system and the remaining heat is lost in exhaust and friction. The main objective of this project is to study the performance of the diesel engine by changing the cylinder wall material. About 2500°F temperature is produced while combustion process in internal combustion engine with diesel as fuel. In this combustion process approximately 35% of heat is lost through the cylinder walls; heat transfer in excess to the coolant will also reduce the engine performance. The scope of this project is to select proper material for the cylinder liners, so that the heat loss through liner wall in IC engine can be reduced. To achieve this low thermal conductivity materials with required mechanical properties is considered and compared.

KEYWORDS: Wet liners, liner material, Inconel 713 C, Mechanical properties

INTRODUCTION
In Internal Combustion engine, heat transfer from the working gas to the cooling system of a conventional Diesel engine accounts for up to 30% of the fuel energy. About 50% of this energy is lost through the piston and 30% through the head. In general, the combustion chamber of an internal combustion engine is formed by cylinder wall, head and piston, where the temperature distributions are different for each surface. Typically, the temperature of each surface is assumed to be a constant, where this is not consistent with the actual situation occurring on the surface of the combustion chamber. A cylinder liner or also known as sleeve is a cylindrical component that is placed in an engine block to form a cylinder. It is an important part because it gives a wear protective surface for piston and piston rings. There are two types of liner which are wet liner and dry liner. Wet liner will contact with coolant while dry liner will contact directly with cylinder block. Among important functions of cylinder liners are to form a sliding surface, to transfer heat and to compress a gas.

For the scope, three material are considered such as Grey cast iron ASTM grade 60, Inconel 713C and Cast SS17-4PH,H1100. The liner 3D modeling has been done in SolidWorks 2012. The reduction in heat loss and at the same time to maintain the engine performance at high levels. To this scope, computer simulation engine models are extensively used to investigate how each engine parameter affects engine performance and efficiency. As computer power increases, the role of Computational Fluid Dynamic (CFD) models is becoming more and more significant, using detailed sub-models for the various processes and finer grids together with high quality dynamic mesh techniques

METHODOLOGY
Methodologies of this study starts with the product selection (wet liners) and continue with problem identification it refers to the problem in excess amount of heat loss through liners, collection of geometric data from an already existing desiel engine cylinder wet liners and goes to creation of model using solid works software finally it ends with the CFD analysis to optimize

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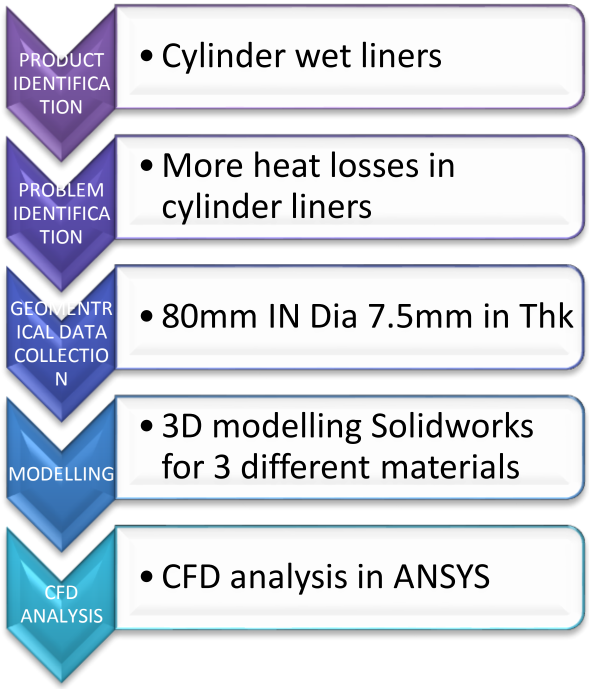

PROBLEM IDENTIFICATION

Internal combustion engines at best can transform about 25 to 35 percent of the chemical energy in the thermal into mechanical energy, about 35 percent of the heat generated is lost to the cooling medium, remainder being dissipated through exhaust and lubricating oil.

GEOMENTRICAL DATA & MODELLING

Geomentrical Data

For the scope a 5bhp four stroke Diesel engine with direct injection system is selected with the compression ratio of 16.5:1 with 1500rpm. The bore and stroke length is 80mm X 110mm and medium of cooling is water.

3D modeling

Modelling of cylinder wet liner are done in solidworks, when compared to other software solidworks modeling are more userfriendly.

The Cylinder liner with 80mm inner dia with 7.5mm thickness are considered. Since it is wet liners the coolent passage width is taken as 19 mm and the length is 75 percentage of stroke length which is 85mm

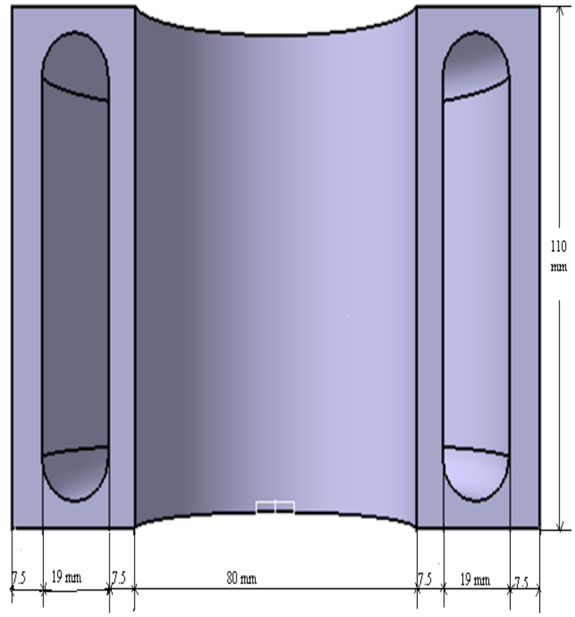

Fig 1 : Section view of Cylinder wet liner with cylinder

Fig 2 : 3D view of cylinder liner in solidworks

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MATERIAL PROPERTIES

GREY CAST IRON GRADE 60

- Density - 7100 Kg/m^3
- Hardness - 250 HV
- Tensile strength - 430 Mpa
- Yield Strength - 276 Mpa
- youngs modulus - 206 Gpa
- Max service temperature - 551 ° C
- Thermal Conductivity - 46 W/mK

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INCONEL 713C

- Density - 8000 Kg/m^3
- Hardness - 420 HV
- Tensile strength - 990 Mpa
- Yield Strength - 900 Mpa
- youngs modulus - 216 Gpa
- Max service temperature - 980 ° C
- Thermal Conductivity - 17 W/mK

CAST SS17 PH

- Density - 7900 Kg/m^3
- Hardness - 420 HV
- Tensile strength - 1000 Mpa
- Yield Strength - 914 Mpa
- youngs modulus - 207 Gpa
- Max service temperature - 320 ° C
- Thermal Conductivity - 19 W/mK

The aim of this project is to find the alternate material for the internal combustion engine cylinder liners, so that the engine heat loss in the cylinder liner will reduce considerably and performance of the engine will increase. For these purpose similar materials (Grey castiron Grade60, Cast SS17, Inconel 713C) with considering the thermal conductivity and working temperature has been.

CFD ANALYSIS

CFD analysis is carried out to optimize which material will transfer less heat energy to the to the sourrounding by means of the following steps.

1) **Model Creation**
The Model is created in Solidworks and it is imported in ANSYS.

2) **Mesh Generation**
After importing the model to the ANSYS, fine meshing is done, the component 2D view and right side of the component is consired for meshing, this is done in order to reduce the processing time and since the liner is a cylinder shaped any one side can be considered for processing.

3) **Applying boundary conditions**
After fine meshing is done the boundary conditions are applyied to this system, as per the working process there are two similar boundary condition i.e the linear inside and outer side where the heat transfer from working area to the coolent through conduction and convection. The rest of the

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boundary conditions are taken from the Materials properties as stated above.

4) Intilization

The solver functioning areas its initialization values in constant working temperature at max 1200 °F and with forced convection to the water.

5) Solution converged plot

In solver stage optimum results computed with the solution converged plot. In the below shows fig's, the solution converged plot, wich is taken from ANSYS/CFD is shown for three different materials.

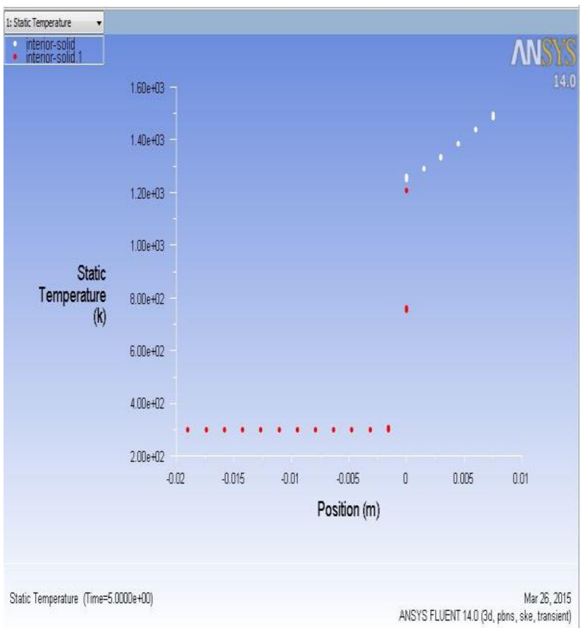

Fig 3 : Grey CI grade 60

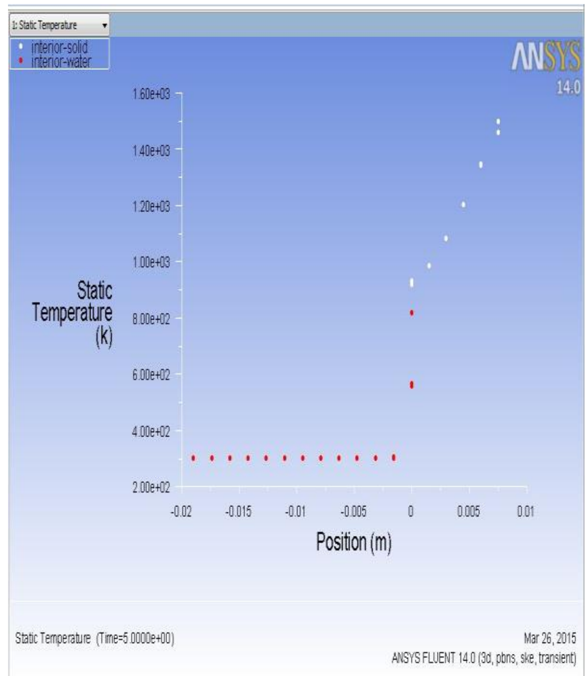

Fig 4 : Cast SS17 PH

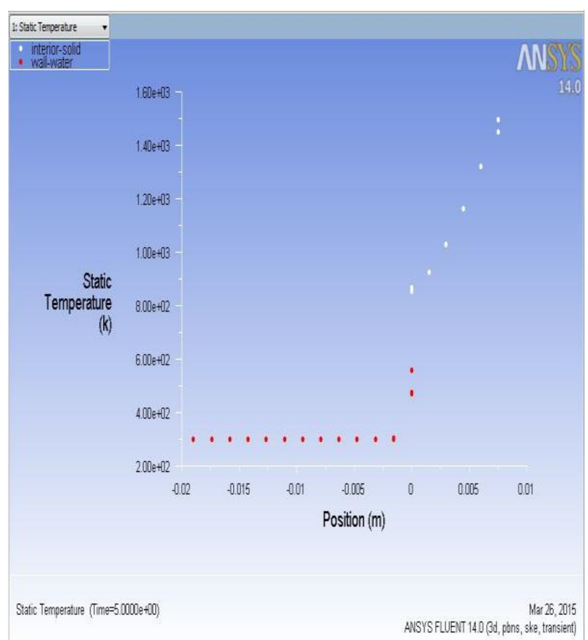

Fig 5 : Inconel 713C

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From the above plotted result the Inconel 713C material transfer heat in lesser amout when compared to Grey CI grade 60 and Cast SS17PH materials.

Table 1. Comparison table for Different materials for temperature

Materials	Processing temperature	Convection Temperature
	°K	°K
Grey Cast Iron ASTM 60	1500	1128
Cast SS17 PH	1500	820
Inconel 713C	1500	610

RESULTS

In table 1 comparision for three materials for temperature is shown. The counter plot images for component for three different materials are shown below

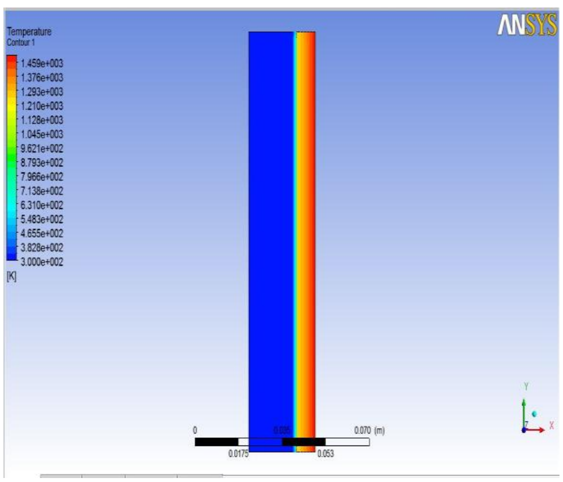

Fig 6 : counterplot for Grey CI grade 60

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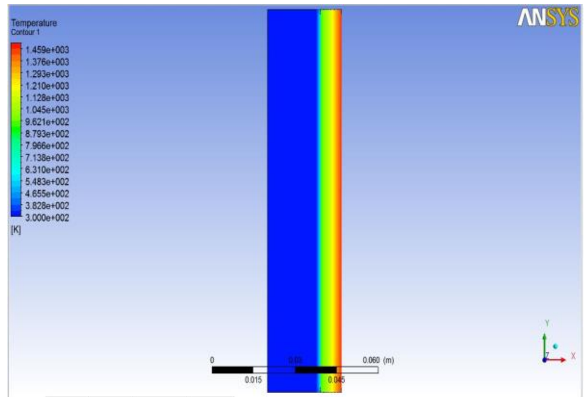

Fig 7 : counterplot for Cast SS17PH

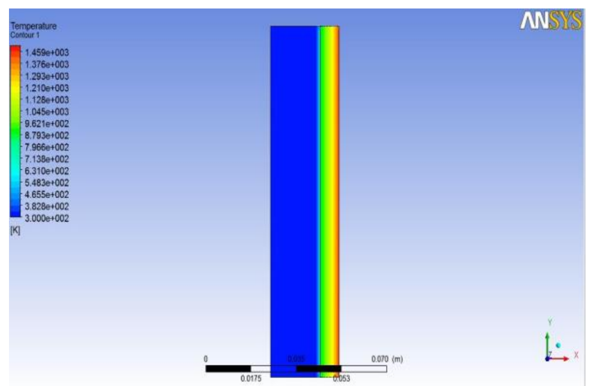

Fig 8 : counterplot for Inconel 713C

From the above fig's its is shown that the temperature distrubtion for Inconel 713C is minimum when compared to other two materials.

Table 2. Table of Mechanical and Thermal factors

Materials		Unit	Grey CastIron ASTM grade 60	Inconel 713C	Cast SS17 PH
Mechanical factors	Tensile Strength	Mpa	430	990	1000
	Yeild Strength	Mpa	276	900	914
	Youngs Modulus	Gpa	206	216	207
Thermal factors	Thermal Conductivity	W/mK	46	17	19
	Maximum	°C	551	982	320

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	service temperature				

Mechanical Factors

The normal operating pressure is around 5 Mpa to 9 Mpa, but this normal operating pressure depends on air fuel mixture also. In some extreme conditions, the pressure may also exceed 12 Mpa. So it is important that the cylinder should withstand the high pressure.

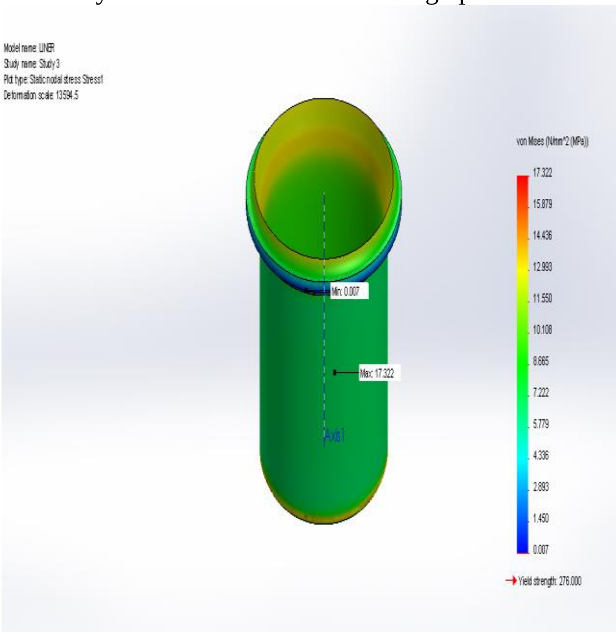

Fig 9 : Mechanical Factors for Grey cast iron ASTM 60

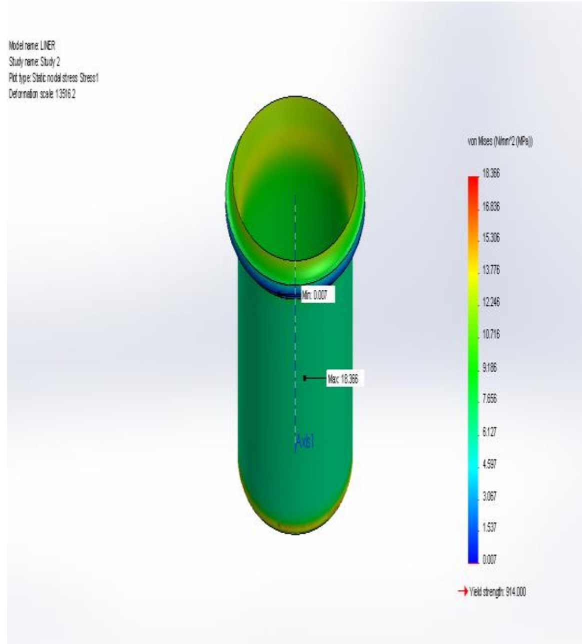

Fig 10 : Mechanical Factors for Cast SS17 PH

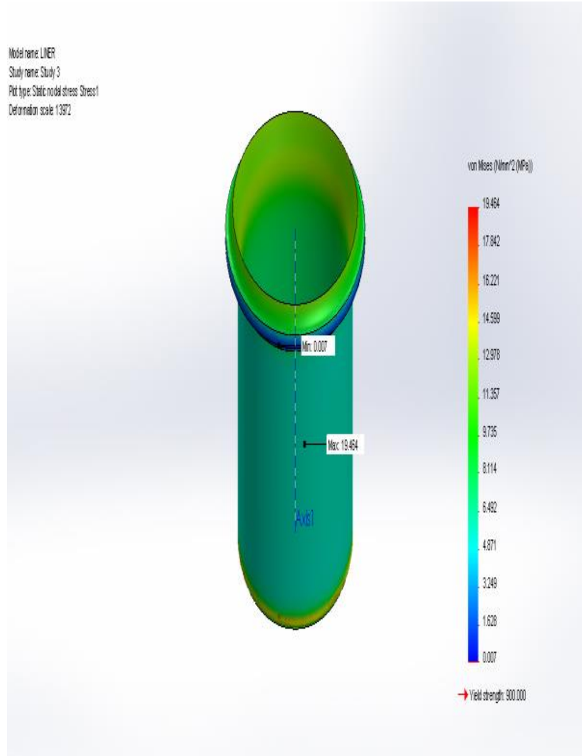

Fig 11 : Mechanical Factors for Inconel 713C

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The pressure analysis is done in solidworks 2012 for the selected materials and the result are tabulated below

Table 3. Result of minimum and maximum pressure

Materials	Minimum	Maximum
	Mpa	Mpa
Grey castiron ASTM 60	0.0073	17.32
Cast SS17 PH H1100	0.0069	18.36
Inconel 713C	0.0065	19.46

CONCLUSION AND DISCUSSION

1) Mechanical factors

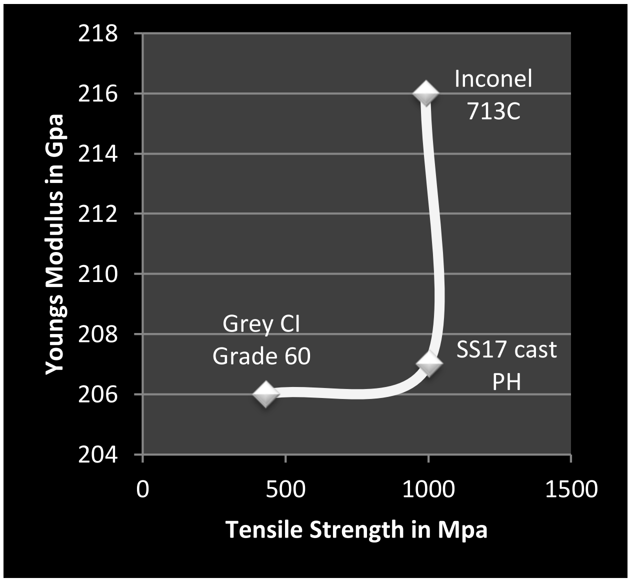

Fig 12 : Youngs modulus Vs Tensile strength

From the above graph and tabulation the tensile strength of materials Cast SS17 and Inconel 713C is higher than the grey cast iron Grade 60 material. So it is well shown that both the cast SS17 and Inconel 713C can withstand the high pressure.

2) Thermal factors

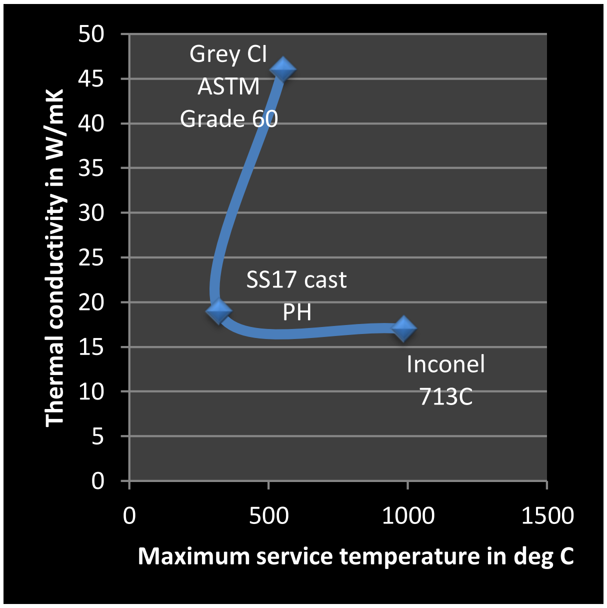

Fig 13 : Thermal conductivity Vs Maximum service temperature

It is observed that the operating temperature may vary from 550 °K to 1700 °K, so the material with higher service temperature can used. From the above graph it is shown that the Inconel 713C material has the operating temperature 850 to 980 °C with thermal conductivity of 17 W/mK, therefore Inconel 713C material will transfer the lesser amount of heat when compared to other two materials.

It is concluded based on the above analysis that the Inconel 713C material can transfer lesser amount of heat energy, that means the excess heat energy may be converted into work done. In the mean while it should be noted that the other important component of the engine like piston, connecting rod ,cylinder head, etc should also be considerably designed.

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