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TRANSIENT THERMAL ANALYSIS OF INTERNAL COMBUSTION ENGINE PISTON IN ANSYS WORKBENCH BY FINITE ELEMENT METHOD

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ABSTRACT

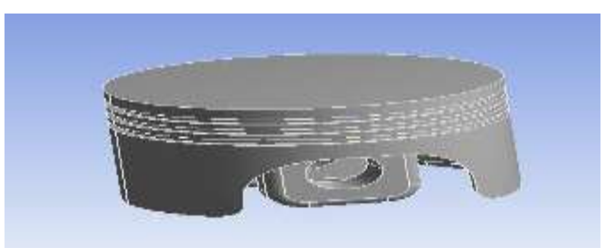
A piston is a component of reciprocating engines. Its purpose is to transfer force form expanding gas in the cylinder to the crank shaft via piston rod and a connecting rod. It is one of the most complex components of an automobile. In present, work a three dimensional solid model of piston including piston pin is designed with the help of SOLIDWORKS software.The temperature, total heat flux are calculated to investigate factor of safety and life of the piston assembly using ANSYS workbench software. Aluminium alloy is used as piston material. The transient stress analysis results also help to improve component design at the early stage and also help in reducing time required to manufacture the piston component and its cost.

KEYWORDS: Piston, ANSYS, FEA, Thermal Analysis.

INTRODUCTION

A piston is a component of reciprocating IC-engines. It is the moving component that is contained by a cylinder and is made gas-tight by piston rings. In an engine, its purpose is to transfer force from expanding gas in the cylinder to the crankshaft via a piston rod and/or connecting rod.

As an important part in an engine, piston endures the cyclic gas pressure and the inertial forces at work, and this working condition may cause the fatigue damage of piston, such as pistonside wear, piston head/crown cracks and so on. The investigations indicate that the greatest stress appears on the upper end of the piston .On the other hand piston overheating-seizure can only occur when something burns or scrapes away the oil film that exists between the piston and the cylinder wall. Understanding this, it's not hard to see why oils with exceptionally high film strengths are very desirable. Good quality oils can provide a film that stands up to the most intense heat and the pressure loads of a modern high output engine. Thermal analysis is a branch of materials science where the properties of materials are studied as they change with temperature. FEM method are commonly used for thermal Analysis. Due to the complicated working environment for the piston; on one hand, the FEA for the piston became more difficult, on the other hand, though there have many methods which are put forward to apply optimal design, the optimal parameters is not easy to determine.In order to enhance the engine dynamic and economic, it is necessary for the piston to implement optimization. The mathematical model of optimization is established firstly, and the FEA is carried out by using the ANSYS software.



Piston Before Meshing

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MATERIALS AND METHODS

In designing a piston,the following points should be taken into consideration:
1.It should have enormous strength to withstand the high gas pressure and inertia forces.
2.It should have minimum mass to minimise the inertia forces.
3.It should form an effective gas and oil sealing of the cylinder.
4.It should provide sufficient bearing area to prevent undue wear.
5.It should disperse the heat of combustion quickly to the cylinder walls.
6.It should have high speed reciprocation without noise.
7.It should be of sufficient rigid construction to withstand thermal and mechanical distortion.
8.It should have sufficient support for the piston pin

Aluminium Alloy > Constants

Density	2.77e-0006kg mm^-3
Coefficient of Thermal Expansion	2.3e-005 C^-1
Specific Heat	8.75e+005 mj kg^-1 C^-1

Alluminium Alloy > Compressive Yield Strength

Compressive Yield Strength MPa
280

Alluminium Alloy > Tensile Yield Strength

Tensile Yield Strength MPa
280

Alluminium Alloy > Tensile Ultimate Strength

Tensile Ultimate Strength MPa
310

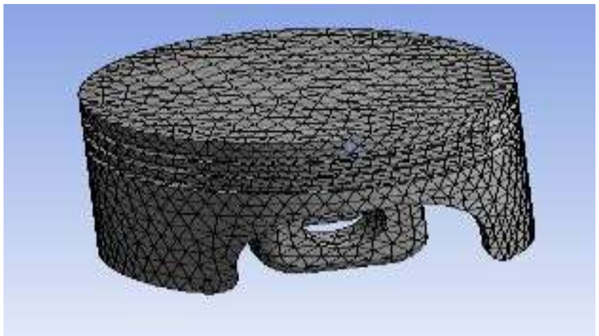
Alluminium Alloy > Isotropic Secant Coefficient of Thermal Expansion

Isotropic Secant Coefficient of Thermal Expansion MPa
22

Standard Units used

Unit System	Metric (mm, kg, N, s, mv mA) Degree rad/s Celsius
Angle	Degrees
Rotational Velocity	Rad/s
Temperature	Celsius

Meshing



Piston after Meshing

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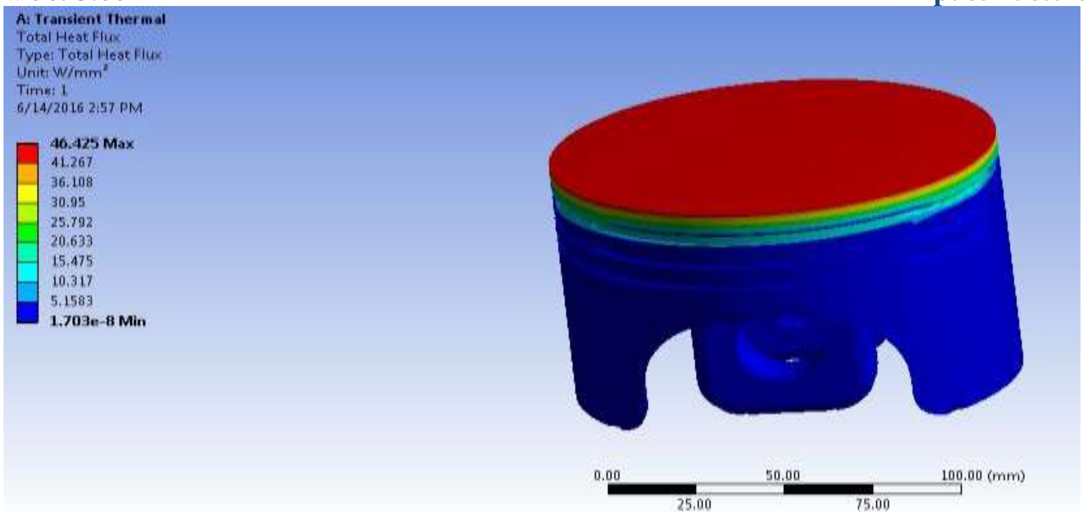
Object Name	Mesh
State	Solved
Defaults	
Physics Preference	Mechanical
Relevance	0
Sizing	
Use Advance Size Function	On.. Proximity
Relevence Center	Coarse
Initial Size Speed	Active Assembly
Smoothing	Medium
Transiction	Fast
Span Angle Center	Coarse
Proximity Accuracy	0.5
Num Cell Across Gap	Default (3)
Proximity Min Size	6.0 mm
Max Face Size	8.00 mm
Max Size	12.0 mm
Growth Rate	Default (1.850)
Minimum Edge Length	1.36780 mm
Inflation	
Use Automatic Inflation	Non
Inflation Option	Smooth Transaction
Transition Ratio	0.272
Maximum Layer	5
Growth Rate	1.2
Inflation Algorthm	Tre
View Advanced OPtion	No

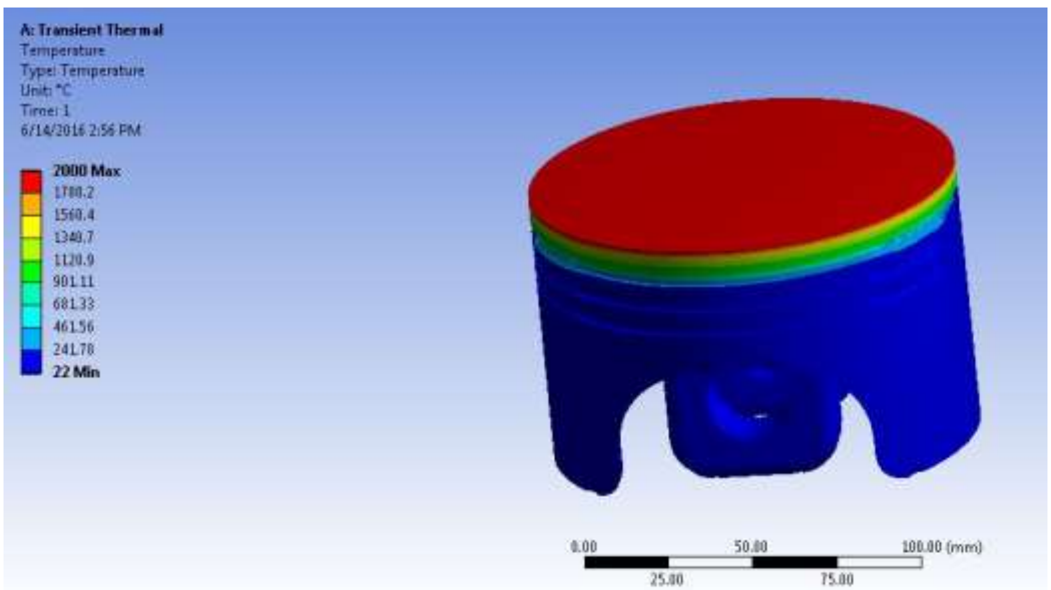
RESULTS AND DISCUSSION

The temperature distribution of piston is very important to check the effect of temperature is maximum on which part of piston. After the analysis of temperature distribution theresultcomesout that the maximum temperature is on the piston head and the minimum temperature is on the piston skirt. The temperature distribution of the piston is from 241.78 to 2000 max and Heat Flux range from5.1583 to 46.425 max.

ANSYS 14.0 Workbench is selected for thermal analysis of engine piston to check the suitability at higher temperature. high temperature of 2000^0c is applied throughout the body for thermal analysis. The heat flux generation inpiston is under safe condition. It is mention by blue colour region .The red colour region is not available which shows that localization of thermal stresses is not available and design and material is safe.The orientation of nodes from its original position is very less which shows that the deformation is less.



Total Heat Flux Range



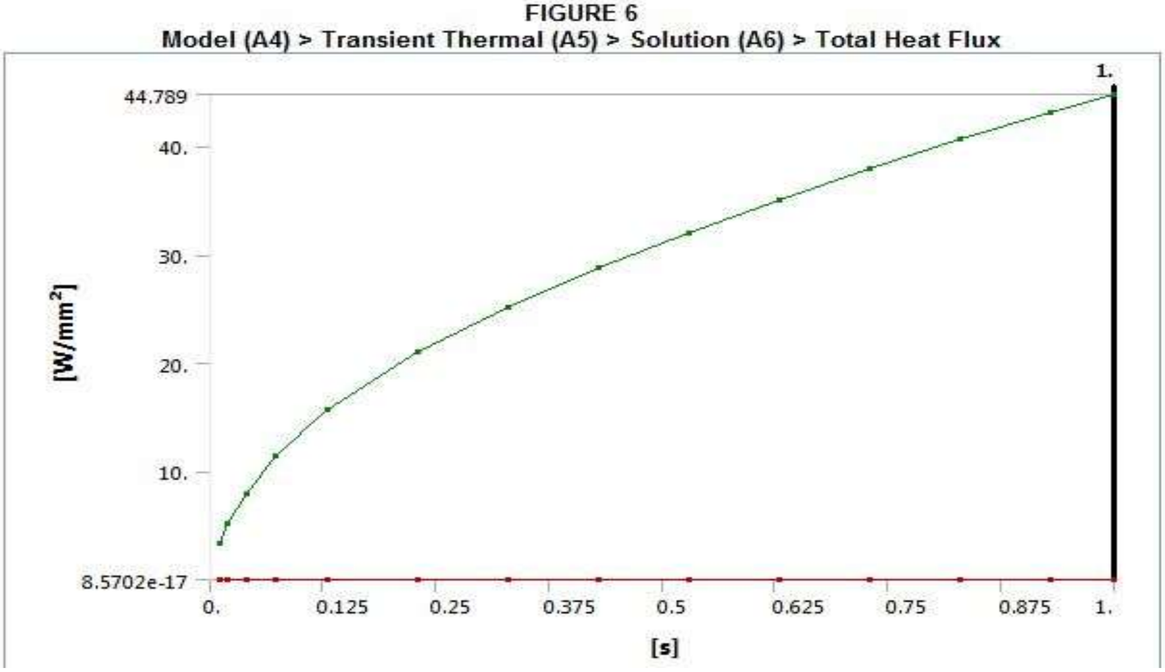
Temperature Range

Model(A4) > Transient Thermal (A5) > Solution (A6) > Total Heat Flux

Time (s)	Minium (W/mm2)	Maxium (W/mm2)
1.e-002	4.965e-016	3.3349
2.e-002	1.5548e-016	5.1972
4.0108e-002	5.5246e-016	7.9335
7.3124e-002	8.5702e-017	11.359
0.12971	3.4429e-016	15.719
0.22971	3.2803e-014	20.97
0.32971	3.888e-013	25.207
0.42971	3.3149e-012	28.784
0.52971	1.897e-011	32.02

0.62971	7.3509e-011	35.105
0.72971	2.4187e-010	37.965
0.82971	6.9956e-010	40.623
0.92971	1.8209e-009	43.113
1.	3.139e-009	44.789

FIGURE 6



By this research we found that the piston of following composition is perfect to withstand the thermal stresses and covective heat.

CONCLUSION

Concluded from above study and analysis by using ANSYS software the thermal stress reduction is very important factor which is responsible for the designing of piston crown or piston head. In this work the main consideration is to optimize the piston with reduction of piston weight. The material of the piston becomes reduced. Then the optimized result of the piston obtained.

Piston skirt may appear deformation at work, which usually causes crack on the upper end of piston head. Due to the deformation, the greatest stress concentration is caused on the upper end of piston, the situation becomes more serious when the stiffness of the piston is not enough, and the crack generally appeared at the point A which may gradually extend and even cause splitting along the piston vertical. The stress distribution on the piston mainly depends on the deformation of piston. Therefore, in order to reduce the stress concentration, the piston crown should have enough stiffness to reduce the deformation.
1. The optimal mathematical model which includes deformation of piston crown and quality of piston and piston skirt.
2. The FEA is carried outfor standard piston model.
This fragment should obviously state the for most conclusions of the exploration and give a coherent explanation of their significance and consequence.

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