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MODELING AND ANALYSIS OF PISTON USED IN DIESEL ENGINES

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ABSTRACT: A **piston** is a component of reciprocating engines, reciprocating pumps, gas compressor and pneumatic cylinders, among other similar mechanisms. It is the moving component that is contained by a cylinder and is made gas-tight by piston rings. The piston transforms the energy of the expanding gasses into mechanical energy. The piston rides in the cylinder liner or sleeve. Pistons are commonly made of aluminium or cast iron alloys.

The main aim of the project is to design a piston for 1300cc diesel engine for two materials Cast Iron and Aluminium Alloy. The designs of the pistons are modelled using PRO-E software.

The designs are evaluated by structural and thermal analysis by applying pressures and temperatures respectively.

The result is evaluated by checking the stress, displacement, thermal gradient and thermal flux to decide the best design of the piston.

Structural and Thermal analysis are done in ANSYS software.

INTRODUCTION TO PISTON

In every engine, piston plays an important role in working and producing results. Piston forms a guide and bearing for the small end of connecting rod and also transmits the force of explosion in the cylinder, to the crank shaft through connecting rod.

The piston is the single, most active and very critical component of the automotive engine. The Piston is one of the most crucial, but very much behind-the-stage parts of the engine which does the critical work of passing on the energy derived from the combustion within the combustion chamber to the crankshaft. Simply said, it carries the force of explosion of the combustion process to the crankshaft.

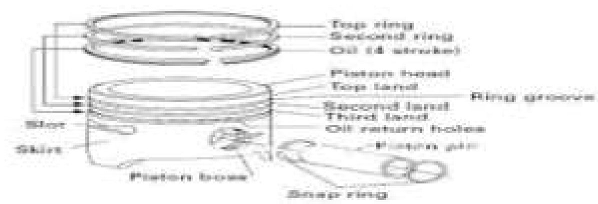

Figure :1A Basic parts of Piston.

__1.1 Construction of Piston:-__ Its top known by many names such as crown, head or ceiling and thicker than bottom portion. Bottom portion is known as skirt. There are grooves made to accommodate the compression rings and oil rings. The groove, made for oil ring, is wider and deeper than the grooves made for compression ring. The oil ring scraps the excess oil which flows into the piston interior through the oil return holes and thus avoiding reaching the combustion chamber but helps to lubricate the gudgeon pin to some extent. In some designs the oil ring is provided below the gudgeon pin boss .The space between the grooves are called as lands.

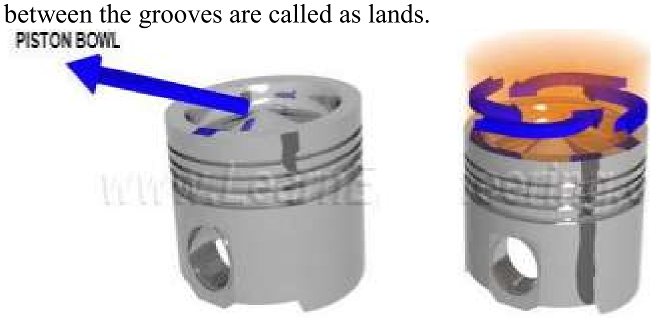

Figure: 1.1A Piston Bowl Indication

__Design of Piston:-__

A piston does the dirty work of actually taking the brunt of the force of explosion arising of the combustion of the fuel and passes it onto the crankshaft (the big, heavy part of an engine that rotates due to the movement of the piston). It takes a tremendous amount of pressure (about

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1000 Psi) notwithstanding the severe heat that it has to take.

1.4 PISTON DESCRIPTION:-

The piston is an important component of a piston engine and of hydraulic pneumatic systems. Piston heads form one wall of an expansion chamber inside the cylinder. The opposite wall, called the cylinder head, contains inlet and exhaust valves for gases. As the piston moves inside the cylinder, it transforms the energy from the expansion of a burning gas usually a mixture of petrol or diesel and air into mechanical power in the form of a reciprocating linear motion. From there the power is conveyed through a connecting rod to a crankshaft, which transforms it into a rotary motion, which usually

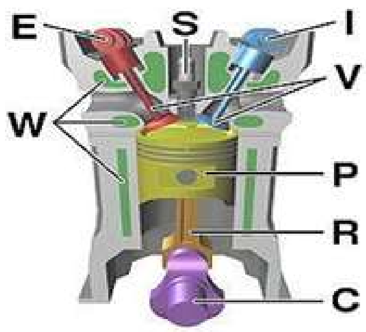

Figure:1.4 A Piston Functional View

Drives a gearbox through a clutch. Components of a typical, four stroke cycle, DOHC piston engine. (E) Exhaust camshaft, (I) Intake camshaft, (S) Spark plug, (V) Valves, **(P) Piston**, (R) Connecting rod, (C) Crankshaft, (W) Water jacket for coolant flow.

II. LITERATURE REVIEW

Design Evaluation of Diesel Engine Piston Using Materials CI and Aluminum Alloy A piston is a component of reciprocating engines, reciprocating pumps, gas compressors and pneumatic cylinders, among other similar mechanisms. It is the moving component that is contained by a cylinder and is made gas-tight by piston rings. The piston transforms the energy of the expanding gasses into mechanical energy. The piston rides in the cylinder liner or sleeve. Pistons are commonly made of aluminium or cast iron alloys. The main aim of the project is to design a piston for 1300cc diesel engine for two materials Cast Iron and Aluminium Alloy. The designs of the piston are modeled using Creo software. The designs are evaluated by structural and thermal analysis by applying pressures and temperatures respectively. The result is evaluated by checking the stress, displacement, thermal gradient and thermal flux to decide the best design of the piston. Structural and Thermal analysis are done in ANSYS software.

III. INTRODUCTION TO CAD

Computer-aided design (**CAD**) is the use of computer systems (or workstations) **to** aid in the creation, modification, analysis, or optimization of a design. CAD software is used to increase the productivity of the designer, improve the quality of design, improve communications through documentation, and to create a database for manufacturing. CAD output is often in the form of electronic files for print, machining, or other manufacturing operations. The term **CADD** (for Computer Aided Design and Drafting) is also used.

INTRODUCTION TO CREO

PTC CREO, formerly known as Pro/ENGINEER, is 3D modeling software used in mechanical engineering, design, manufacturing, and in CAD drafting service firms. It was one of the first 3D CAD modeling applications that used a rule-based parametric system. Using parameters, dimensions and features to capture the behavior of the product, it can optimize the development product as well as the design itself.

3D MODEL

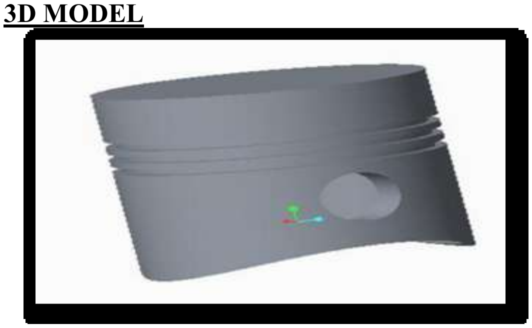

Figure:3.3 A 3D Modelling view

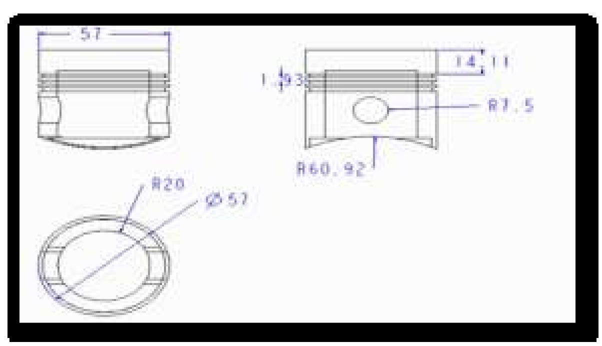

Figure 3.4 A 2D Modelling view

INTRODUCTION TO FEA

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Finite element analysis is a method of solving, usually approximately, certain problems in engineering and science. It is used mainly for problems for which no exact solution, expressible in some mathematical form, is available. As such, it is a numerical rather than an analytical method. Methods of this type are needed because analytical methods cannot cope with the real, complicated problems that are met with in engineering.

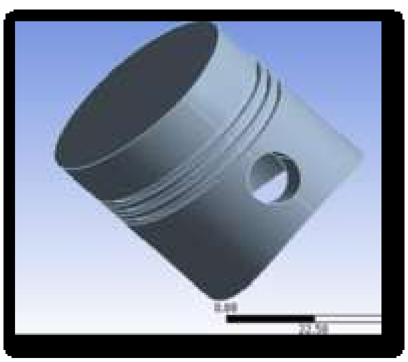
ANSYS Mechanical:-

ANSYS Mechanical is a finite element analysis tool for structural analysis, including linear, nonlinear and dynamic studies. This computer simulation product provides finite elements to model behaviour, and supports material models and equation solvers for a wide range of mechanical design problems. ANSYS Mechanical also includes thermal analysis and coupled-physics capabilities involving acoustics, piezoelectric, thermal–structural and thermo-electric analysis.

STATIC ANALYSIS OF PISTON

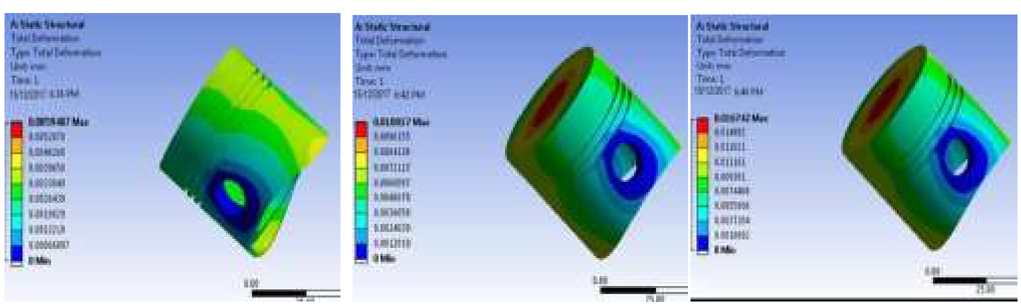
Material	Young's modulus (MPa)	Poisson's ratio	Density(kg/m3)
Steel	205000	0.3	7850
Cast iron	110000	0.28	7200
aluminium alloy	68900	0.32	4150

Imported model



Meshed model

DEFORMATION



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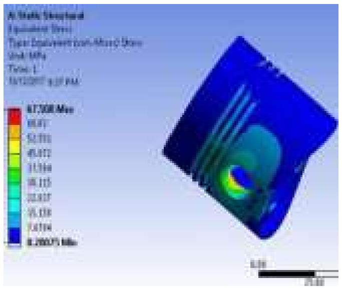
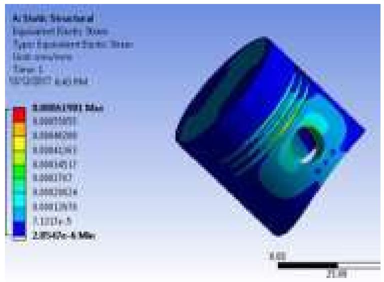
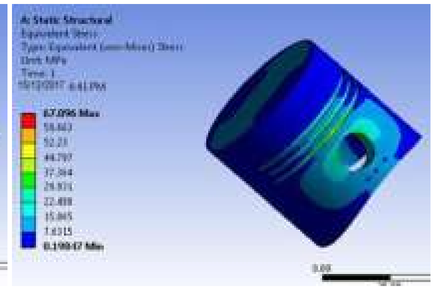
(a)deformation for steel (b) deformation for cast iron (c) deformation for aluminium

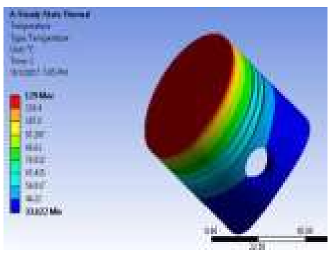
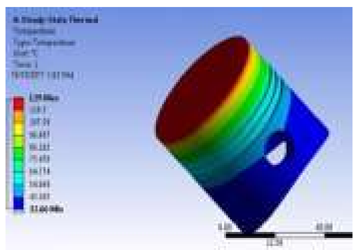
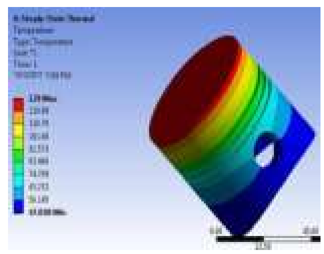
STRESS

(a)stress for steel (b) stress for cast iron (c) stress for aluminium

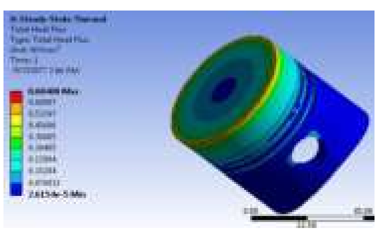
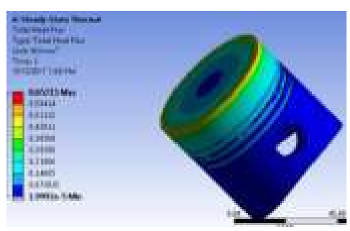
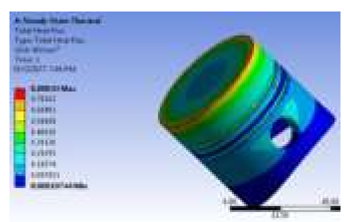
THERMAL ANALYSIS OF PISTON

Temperature distribution

(a)temperature for steel (b) temperature for cast iron (c) temperature for aluminium

heat flux

(a) heat flux for steel (b) heat flux for cast iron (c) heat flux for aluminium

STATIC ANALYSIS RESULT TABLE

MATERIAL	DEFORMATION(mm)	STRESS(N/mm2)	Strain
Steel	0.0059487	67.508	0.00033915
Cast iron	0.01817	67.771	0.00061901
Aluminium alloy	0.016742	67.096	0.00094959

MODAL ANALYSIS RESULTS TABLE

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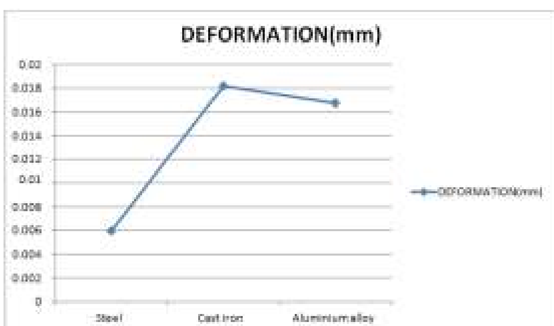
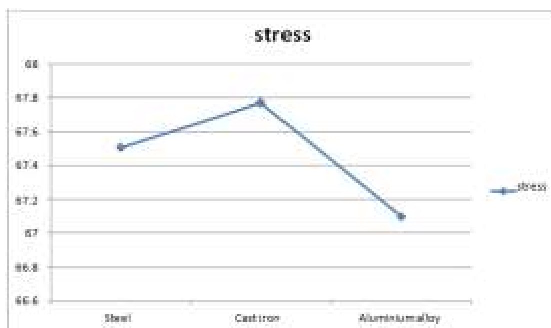
MATERIAL	Frequency (Hz)	deformation1` (mm)	frequency (Hz)	deformation2(mm)	frequency (Hz)	deformation 3(mm)
Steel	6787.1	72.637	10333	63.784	14514	80.754
Cast iron	5290	75.886	8010.2	66.629	11266	84.467
Aluminium alloy	6740.1	122.17	10349	107.28	14511	135.5

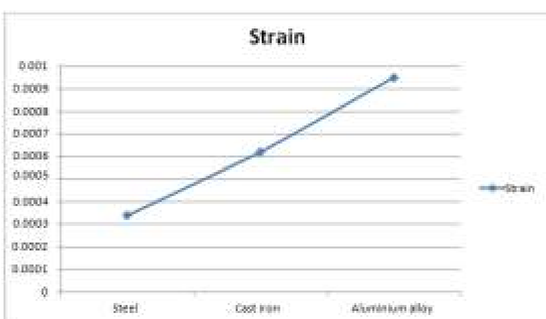
THERMAL ANALYSIS RESULT TABLE

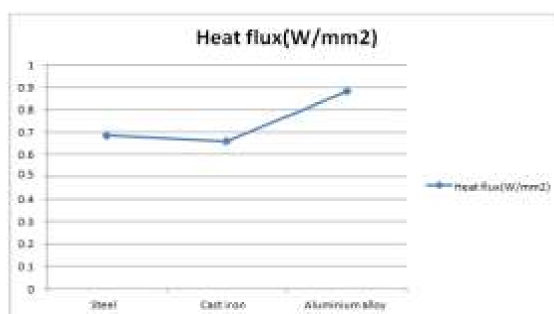
MATERIAL	Temperature (^{0}C)	Heat flux(W/mm^2)
Steel	129	0.68408
Cast iron	129	0.65715
Aluminium alloy	129	0.88043

COMPARISON GRAPHS









CONCLUSION

Physically, chemically and mechanically aluminium is a metal like steel, brass, copper, zinc, lead or titanium. It can be melted, cast, formed and machined much like these metals and it conducts electric current. In fact often the me equipment and fabrication methods are used as for steel. Aluminium is a very light metal with a specific weight of2.7 g/cm3, about a third that of steel. For example, the use of aluminium in vehicles reduces dead-weight and

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energy Consumption while increasing load capacity. Its strength can be adapted to the application required by modifying the composition of its alloys.

By observing the static analysis the stress values are less for aluminium alloy material than steel & cast iron.
By observing the thermal analysis the heat flux values are more for aluminium alloy than steel and cast iron.

So it can be concluded the aluminium alloy is better material for piston.

FUTURE SCOPE

For further betterment of the performance of the piston simulation can be done with different coating material having different dimensions with all the simulation result optimization can be done for best possible combination of materials and dimension values. Furthermore research can be extended also in the regain of material properties to find out different coating materials which can retrain region able amount of temperature in the piston without increasing the cost of the piston much.

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