Design And Material Optimization of the Piston By using PROE And ANSYS

M. SreeDivya[1] , Dr K.RajaGopal[2]
[1]M.Tech(CAD/CAM) P.G Scholar, Dept. of M..E, KSRM College of Engineering, Kadapa.
[2] Phd ,Professor & HOD, Dept of M..E, KSRM College of Engineering, Kadapa.

Abstract- ***The main objective of this study is to explore the analysis of a piston with design change to attain less volume and better efficiency. This has entailed carried out a precise thermal analysis. The Project deals with structural and transient thermal analysis. A suitable Finite detail model is developed using Cad program pro/E Wildfire 5.0. On this mission the design and material of the piston has modified for optimization of the piston. On this the task 3D model of the piston is designed by using pro-e program and the analysis taken by distinctive substances and the analysis taken by using the ansys program. At the moment the pistons are made via the fabric of AL-Mg-Si, on this undertaking we proven the same load below with SILUMIN material. Then the thermal analysis is completed to examine the total Heat flux in the traditional and Optimized Piston for the given temperature conditions. The temperature acting on the surface of the piston is applied. The outcome had been also used to check the total Heat flux for a exact material..***

Keywords: Piston, IC engine, Aluminium & Silumin Alloys

1. INTRODUCTION

The Piston is a 'heart' of an automobile engine. The perform of the piston is bearing the gas pressure and making the crankshaft rotation by means of the piston pin. Piston works in high temperature, high pressure, high pace and terrible lubrication stipulations. Piston contact with excessive temperature gas directly, the instantaneous temperature can also be excessive. Considering of the excessive temperature and the bad cooling situation, the temperature of the top of the piston can also be reach designated level when the piston working in the engine. And the temperature distribution is uneven. The highest of the piston bears the gas stress, in precise the work pressure. The investigations indicate that greatest stress appears on the upper finish of the piston and stress awareness is likely one of the generally motive for failure. In this be taught, the piston is used in low idle and rated velocity engine. In order to enhance the engine dynamic and financial, it is quintessential for the piston to put into effect optimization. Situated on the analysis of optimum effect, the stress concentration on the upper end of piston has end up evaluate, which provides a better reference for redesign of a piston. As one of the most important moving constituents in the vigour-transmitting assembly, the piston must be so designed that it may possibly stand up to the severe warmness and stress of combustion. It additionally transmits warmth to the cooling oil and one of the most warmth through the piston rings to the cylinder wall.

The top of the piston is called head or crown. In general low rate low performance engines have flat head as proven. In some such pistons which come quite nearly the valves, the head is furnished valve remedy. Pistons utilized in some high powered engines have a raised dome which is used to expand the compression ratio as good as to manage combustion.
In another engines the piston may be dished to type a desired shape of combustion chamber, collectively with cylinder head. In case of piston containing a part of the combustion in its crown, compression ratio may also be controlled very properly however the disadvantage is that in this case much better amount of warmth needs to be dissipated through the pistons and rings. Towards the top of the piston of a few grooves are cut to house the piston rings. The bands left between the grooves are often called lands. These lands support the rings against the gas pressure and advisor them so that they may flux freely in the radial path. The helping webs transmit the force of explosion instantly from the crown to the piston pin bosses thereby relieving the groove element of the tremendous load and therefore by using preventing the deformation of the ring grooves.

The part of the piston beneath the rings is referred to as skirt. Its perform is to form a consultant suitable for absorbing aspect thrust due to gas strain. The facet thrust is produced due to the inclination of the connecting rod with the cylinder axes. The skirt is supplied with the bosses on the within of the piston pin. It have to be of enough size to resist tilting of the piston below load. It is stored particularly shut becoming in the cylinder but even then it's separated from the cylinder walls by means of lubricating oil film for gentle jogging. The combustion pressure from the piston crown is transmitted to the connecting rod through webs inside the piston. The bosses form a bearing floor for the rocking movement of the connecting rod. The thick-sectioned webs additionally form warmth paths from the piston crown to the pin bosses and the skirt and as a result ought to be designed as a way to prevent growth problems.

The gap between the axis of the piston pin and the top of the piston crown is known as compression height and determines the compression ratio for a given engine. Hence the equal engine a piston with lesser compression top would give lesser compression ratio and vice versa.

The material used for pistons at one time was forged iron which has good carrying characteristics. As the technology developed Aluminium alloy containing silicon replaced cast iron as piston fabric, considering of two distinct advantages. First of all it is as a lot as three times lighter than the solid iron

which makes it's desirable from inertia factor of view. Preserving the heat far from the cut back a part of the piston so far as possible. This is finished by chopping horizontal slot in the piston on the thrust and non thrust aspects just now the oil control ring. Accordingly the skirt does no longer emerge as very scorching and therefore it does not increase stop so much. In some designs the circumferential slots are made within the oil manipulate ring groove and these slots end in inclined slots extending downwards. These elongated slots provide further warmness barriers and so decrease even more the quantity of warmness achieving the working faces of the skirt. Moreover the drooping end makes the skirt flexible in the higher neighborhood. Making a heat dam. It consists of a groove cut close the top of the piston. This reduces the trail of heat journey from the piston crown to the skirt. The skirt therefore runs cooler and does now not expand a lot.

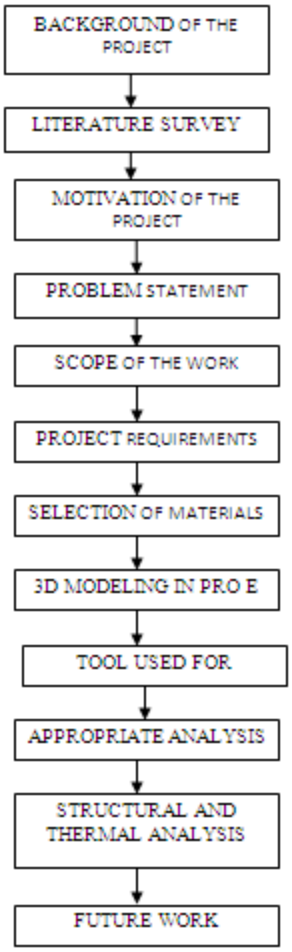

Fig 1: Methodology Flow Diagram

II .LITERATURE SURVEY

A couple of early fuel engines had double-appearing cylinders, but in any other case conveniently all inner combustion engine pistons are single-acting. During World warfare II, the U.S. Submarine Pompano used to be outfitted with a prototype of the infamously unreliable H.O.R. Double-appearing diesel engine. Although compact, to be used in a cramped submarine, this design of engine used to be now not repeated.

In global of science engineering and technology Mr. Vijaya kumar paluri in short described concerning the material optimization of piston i.E. The aluminium alloy piston is optimized with the silumin piston. On this assignment deformation, stress and stress values of the aluminium alloy piston are when put next with the silumin piston through utilizing static evaluation.

In global journal of progressive research in science, engineering and technological know-how S. Srikanth Reddy described about thermal analysis and design optimization of current piston with the decreased dimensions of the piston. This project most likely applied for lowering rate of the materials and the burden discount of the engine.

The inducement for doing this undertaking was principally an interest in assignment a difficult challenge in an exciting subject of research. Piston is likely one of the key components of the engine and it's working the rough condition. Right here the material and design of the present piston is changed to present better outcomes for optimized model to toughen our innovation and this mission carried out by using us will make an impressing mark within the area of vehicle.
In engine the piston is the major part. The weight reduction of the piston can have a certain role in the weight reduction of the engine and is a highly desirable goal if it can be achieved without increased in cost and decrease in quality and reliability. It is possible to achieve a design of piston with less weight to increase the strength and decrease in stresses which can be done by design and material optimization of the piston.

III. FUNCTIONS

The functions which a piston is called to perform in an IC engine are;

• To form a seal so that the high strain gases within the combustion chamber do not get away into the crankcase.
• To serve as a consultant and a bearing for small end of the connecting rod. Aside from its ability to perform the above functions efficaciously the pistons need to have some other fascinating characteristics.
• The design will have to be such that the seizure does now not occur.
• It must offer adequate resistance to corrosion because of some other products of combustion.
• It must have the shortest viable length as a way to cut down overall engine measurement.
• It must be lighter in weight in order that inertia forces created via its reciprocating motion are minimal.
• Its fabric will have to have a high thermal conductivity for effective warmth switch in order that bigger compression ratios may be used with out prevalence of detonation.
• It must have a long life.

IV. MOTIVATION OF PROJECT

In engine the piston is the major part. The weight reduction of the piston can have a certain role in the weight reduction of the engine and is a highly desirable goal if it can be achieved without increased in cost and decrease in quality and reliability. It is possible to achieve a design of piston with less weight to increase the strength and decrease in stresses which can be done by design and material optimization of the piston. The inducement for doing this

undertaking was principally an interest in assignment a difficult challenge in an exciting subject of research. Piston is likely one of the key components of the engine and it's working the rough condition. Right here the material and design of the present piston is changed to present better outcomes for optimized model to toughen our innovation and this mission carried out by using us will make an impressing mark within the area of vehicle. This work deals with the replacement of conventional aluminium alloy IC engine piston with silumin piston for automobile applications.

V. SELECTION OF MATERIALS

Aluminium alloys customarily have an elastic modulus of about 70 GPa, which is set one-1/three of the elastic modulus of most types of steel and metallic alloys. For this reason, for a given load, a element or unit comprised of an aluminium alloy will capabilities a better elastic deformation than a metal part of the same measurement and type. Although there are aluminium alloys with reasonably-higher tensile strengths than the more usually than no longer used varieties of metal, effortlessly changing a metallic part with an aluminium alloy would effect in problems.With completely new steel products, the design alternatives are more commonly ruled via making use of the replacement of producing science. Extrusions are principally important on this regard, because of the benefit with which aluminium alloys, especially the Al–Mg–Si series, can also be extruded to style intricate profiles of engine components like piston.

Generally, stiffer and lighter designs may even be implemented with aluminium alloys than is viable with steels. For instance, don't forget the bending of a skinny-walled tube: the 2nd 2d of discipline is inversely involving the stress in the tube wall, i.E. Stresses are decrease for bigger values. The 2d 2nd of area is proportional to the cube of the radius occasions the wall thickness, therefore developing the radius (and weight) through 26% will result in a halving of the wall stress. Hence, bicycle frames manufactured from aluminium alloys make use of higher tube diameters than metal or titanium with a rationale to yield the favored stiffness and strength. In vehicle engineering, cars made out of aluminium alloys rent space frames fabricated from extruded profiles to be precise strain. This represents a radical exchange from the long-centered procedure for current metallic auto design, which depend upon the physique shells for stiffness, that may be a unibody design.

Aluminium alloys are commonly used in car engines, mostly in cylinder blocks and crankcases as a result of the burden fiscal financial savings which perhaps feasible. Due to the fact that aluminium alloys are prone to warping at expanded temperatures, the cooling approach of such engines is imperative. Manufacturing procedures and metallurgical tendencies have also been instrumental for the strong utility in automobile engines. Inside the Sixties, the aluminium cylinder heads of the Corvair earned a repute for failure and stripping of threads, which isn't seen in reward aluminium cylinder heads. An fundamental structural drawback of aluminium alloys is their scale down fatigue force in evaluation with metal. In managed laboratory stipulations, steels exhibit a fatigue restrict, which is the stress amplitude below which no disasters come up – the steel does now not continue to weaken with accelerated stress cycles. Aluminum alloys do not have this lower fatigue limit and will continue to weaken with continued stress cycles. Aluminium alloys are therefore sparsely used in parts that require high fatigue strength in the high cycle regime (more than 107 stress cycles).

Silumin is the title that is used in some international locations for alloys situated on Al–Si process. Silumin is a sequence of light-weight, excessive-force aluminium alloys with silicon content inside range of three–50%. A lot of these alloys are casting ones, but also it would be produce with the aid of speedy solidification approaches and powder metallurgy. Inside the Aluminum association designation method silumin are comparable to alloys of two techniques: 3xx.X – Aluminum–silicon alloys, and 4xx.X – Binary aluminum–silicon alloys. Among the many advantages of silumin is its high resistance to corrosion, making it valuable in humid environments. The addition of silicon to aluminium also makes it less viscous when liquid, which along with its low cost (both component elements are relatively inexpensive to extract), makes it a very good casting alloy and a brisker metallic. It is also used on 3 section motors to allow speed law. Another use is rifle scope mounts and digicam mounts.

Mechanical And Thermal Properties

S No	Properties	Value
1	Young's modulus	3.17×10^5Mpa
2	Poisons ratio	0.27
3	Density	2659 kg/m^3
4	Thermal conductivity	134 W/m^{0}C
5	Specific heat	867 J/kg^{0}C

Table: 1 Mechanical and Thermal Properties of Silumin

IV. RESULTS

To create a Sweep cut feature, the approach to be followed is the equal as that in Sweep Protrusion. The only difference is that in case of cut features, the fabric is eliminated from an present function. The cut choice may also be invoked through settling on Insert > Sweep > reduce from the menu bar. A cut can be a strong swept cut or a thin swept cut.

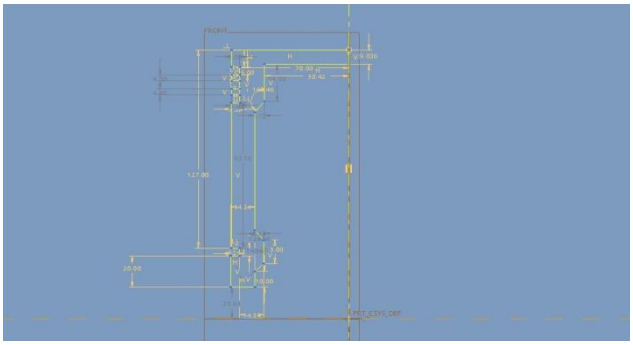

Fig: 2 2-Dimensional Diagram of Existing Piston

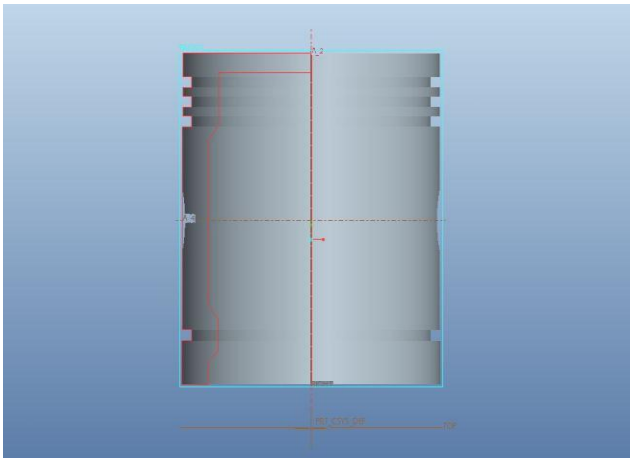

Fig: 2 3-Dimensional Model of Existing Piston

Fig:.3 2-Dimensional Digram of Optimized Piston

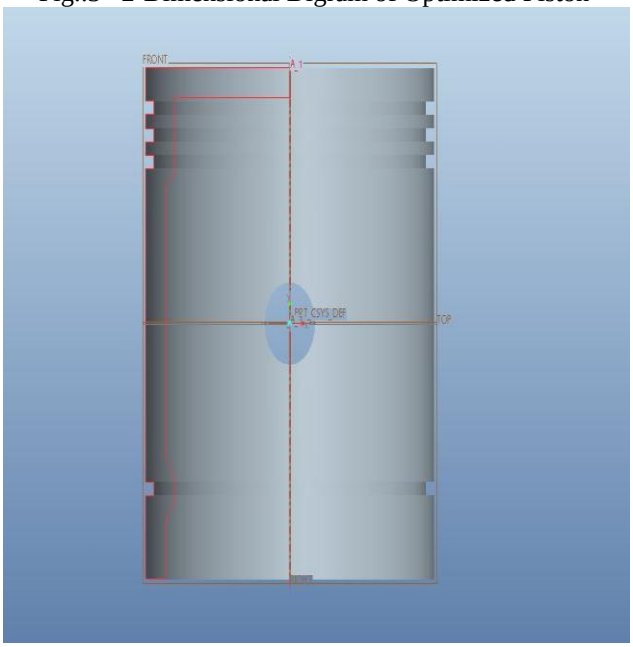

Fig: 4 3-Dimensional Model of Optimized Piston

Geometry Imported View In Ansys Workbench

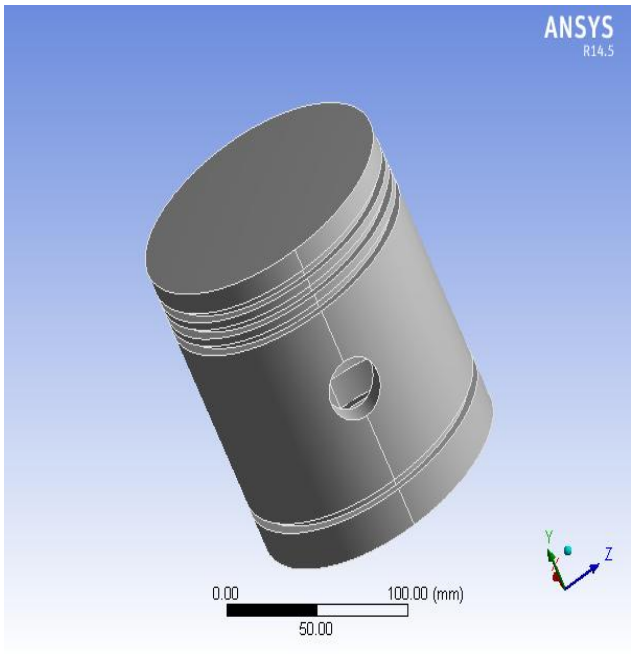

Fig: 5 Geometry View of the Piston

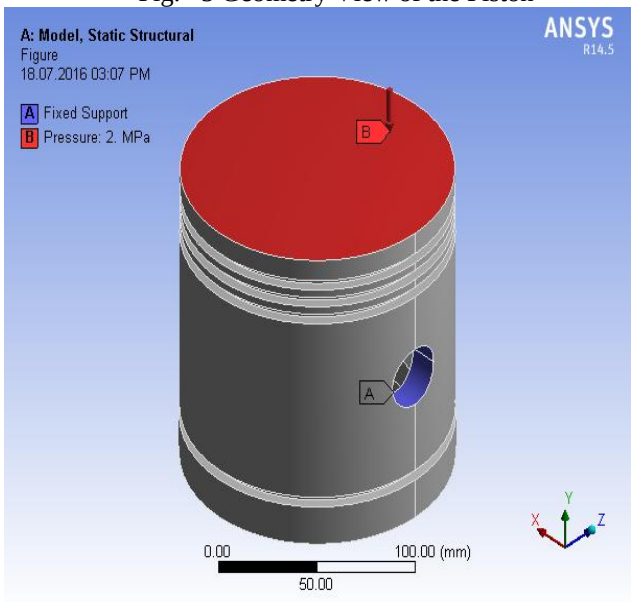

Fig: 6 Boundary conditions of the Piston

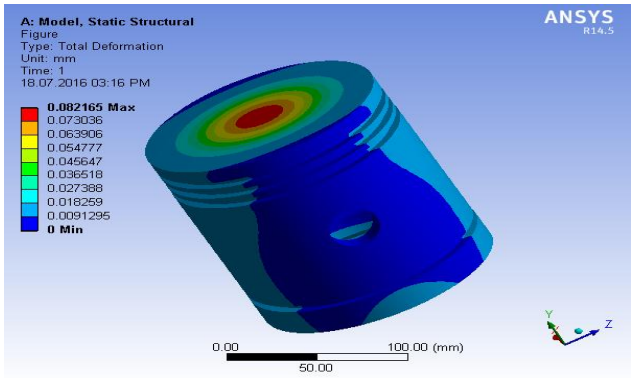

Fig: 7.4 Deformation Plot for Existing Design (Material: Aluminium)

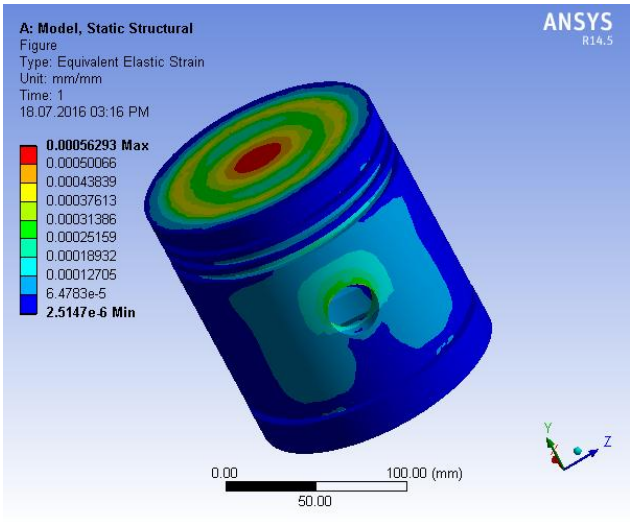

Fig: 7 Plastic Strain Plot for Existing Design (Material: Aluminium)

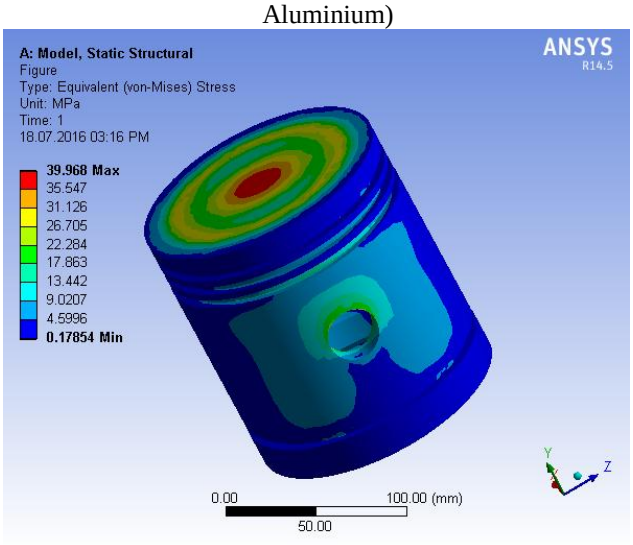

Fig: 8 von-mises stress Plot for Existing Design (Material: Aluminium)

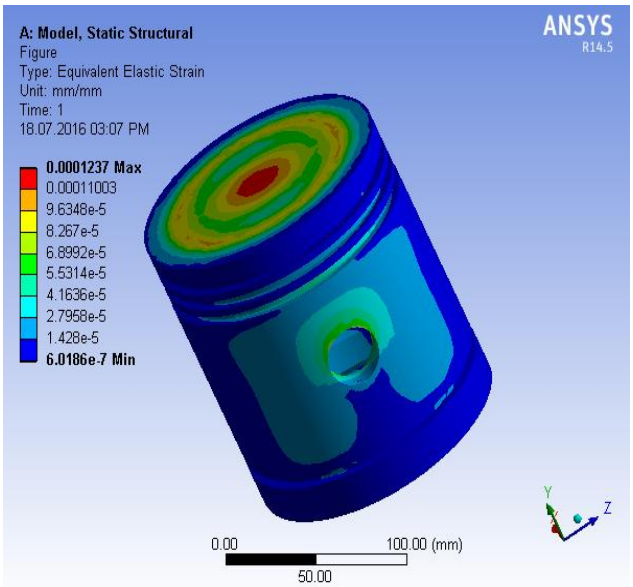

Fig: 9 Plastic Strain Plot for Existing Design (Material: Silumin)

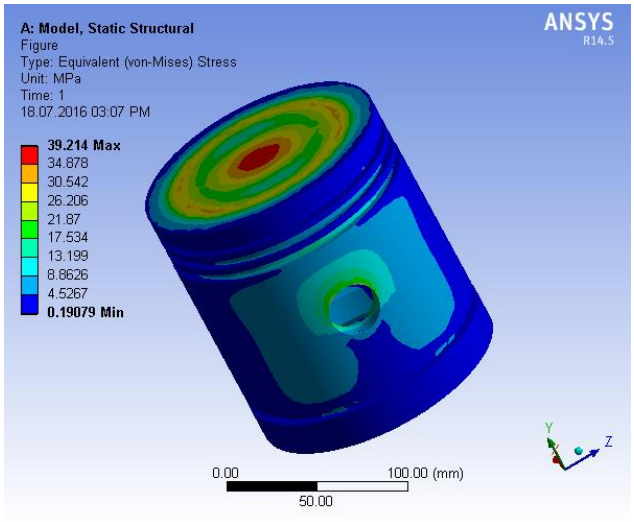

Fig: 10 Von-mises Stress Plot for Existing Design (Material: Silumin)

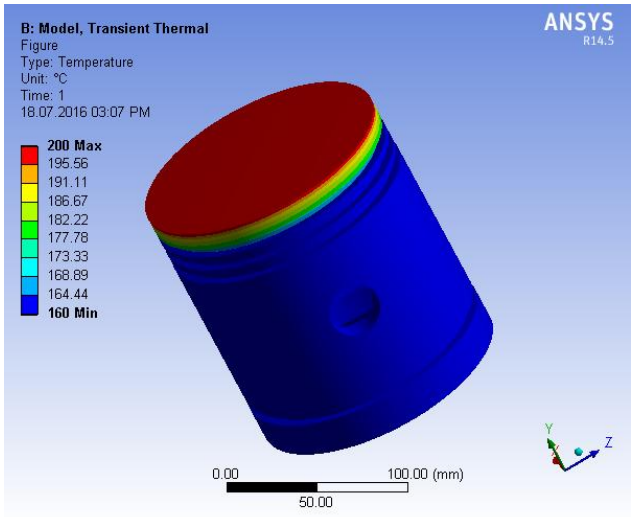

Fig: 11 Temperature Distribution Plot for Existing Design (Material: Silumin)

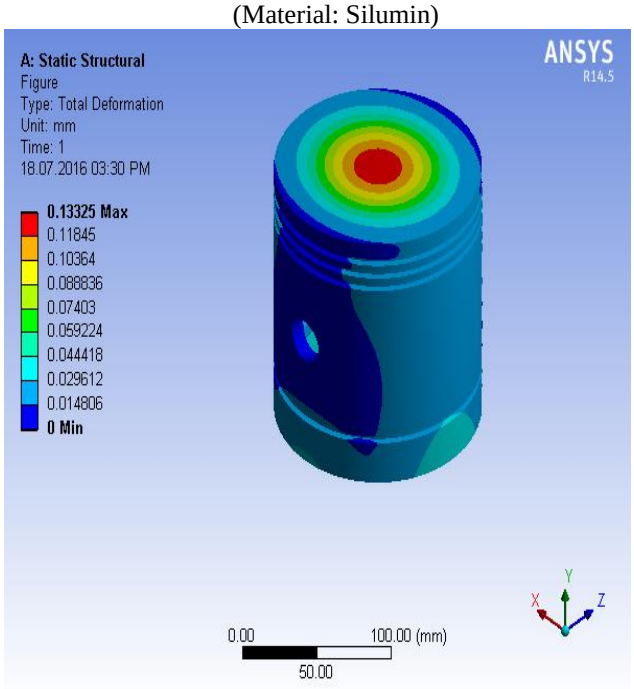

Fig: 12 Deformation Plot for Optimized Design (Material: Aluminium)

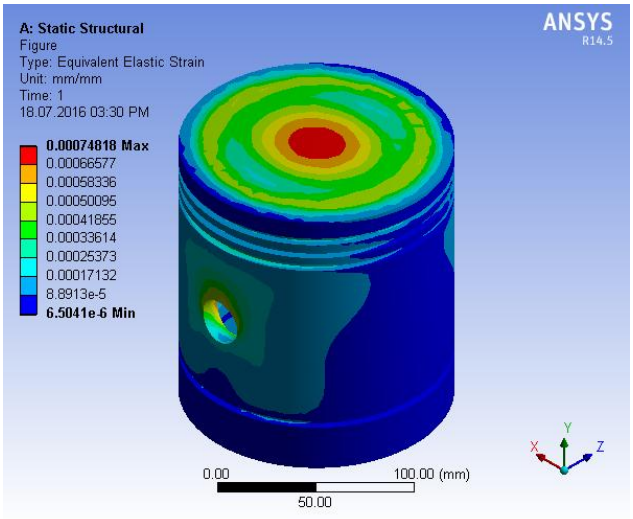

Fig: 13 Plastic Strain Plot for Optimized Design (Material: Aluminium)

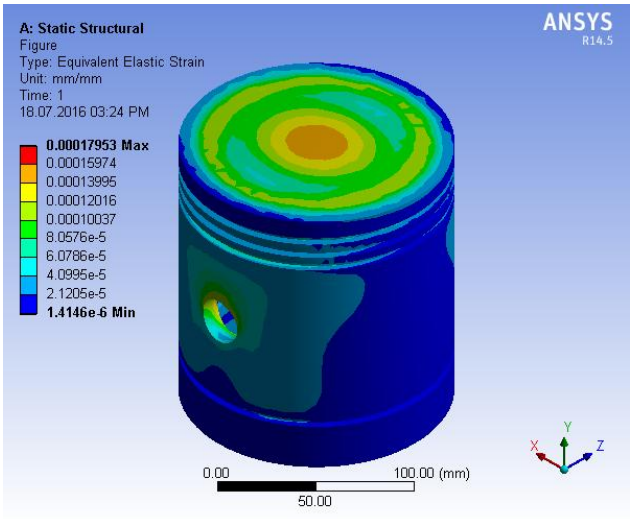

Fig: 17 Plastic Strain Plot for Optimized Design (Material: Silumin)

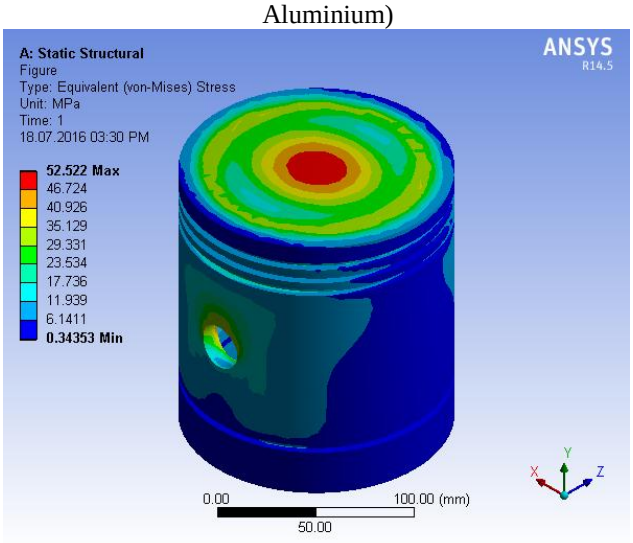

Fig: 14 Von-mises Stress Plot for Optimized Design (Material: Aluminium)

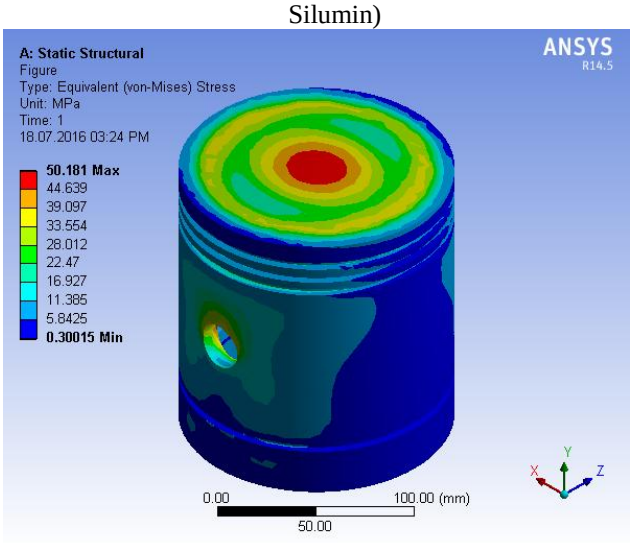

Fig: 15 Von-mises Stress for Optimized Design (Material: Silumin)

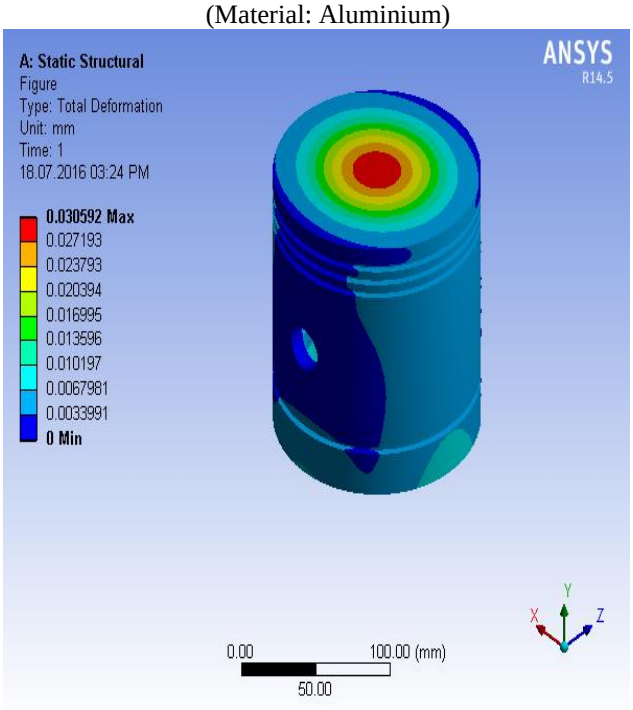

Fig: 16 Deformation Plot for Optimized Design (Material: Silumin)

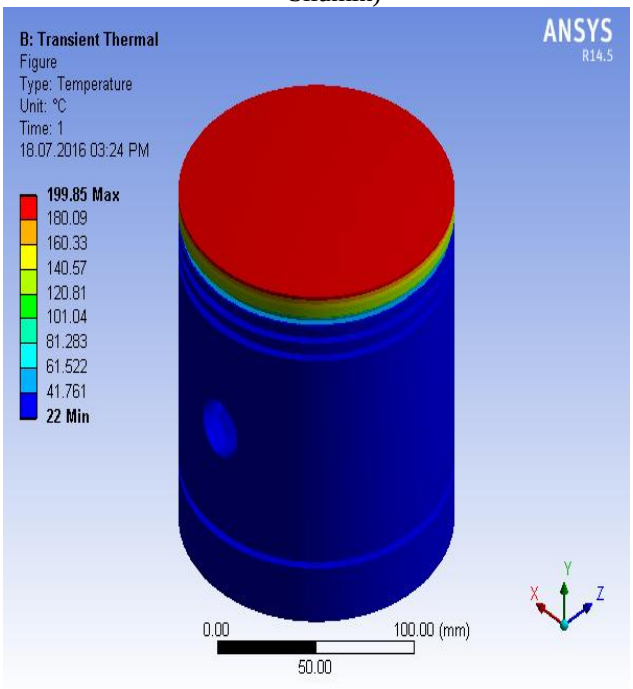

Fig: 18 Temperature Distribution for Optimized Design (Material: Silumin)

COMPARISION TABLES

	EXISTING PISTON	OPTIMIZED PISTON
MATERIAL	Stress in MPa	Stress in MPa
ALUMINIUM	39.968	52.522
SILUMIN	39.214	50.181

Table: 2 Comparison Table for Stress (Existing Design Vs Optimized Design)

	EXISTING PISTON	OPTIMIZED PISTON
MATERIAL	Strain in mm/mm	Strain in mm/mm
ALUMINIUM	5.63e-4	7.48e-4
SILUMIN	1.20e-4	1.79e-4

Table: 3 Comparison Table for Strain (Existing Design Vs Optimized Design)

	EXISTING PISTON	OPTIMIZED PISTON
IATERIAL	Deformation in mm	Deformation in mm
LUMINIUM	0.08217	0.13325
LUMIN	0.01887	0.03059

Table: 4 Comparison Table for Deformation (Existing Design Vs Optimized Design)

	EXISTING PISTON	OPTIMIZED PISTON
MATERIAL	Heat Flux in MW/mm^2	Heat Flux in MW/mm^2
ALUMINIUM	0.57152	2.3265
SILUMIN	0.44602	1.8696

Table:5 Comparison Table for Total Heat Flux (Existing Design Vs Optimized Design)

IV. CONCLUSION

From the above analysis, the weight reduction has been achieved by both design and material optimization. The weight reduction that is been achieved by 23.09 %. From this analysis, the optimized design silumin piston has low deformation and equivalent strain values compared to Existing design aluminium alloy piston deformation and equivalent strain values. So the optimized design silumin piston can be used to reduce the cost of the material and the weight of the engine can be minimized to improve the efficiency. So we conclude that the best material for piston is silumin as it has low values of deformation. By this project we studied about the 3Dmodelling software (PRO-E) and Study about the analyzing software (ansys) to develop our basic knowledge to know about the industrial design.

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