STATIC STRESS ANALYSIS OF IC ENGINE PISTON FOR DIFFERENT MATERIAL

Mohd Nawajish[1], Mohd Raza[2], I. A. Rizvi[3]
[1,2]Student of M. Tech, [3]Associate Professor,Mechanical Engineering Department,
IEC College of Engineering & Technology, Greater Noida, U.P., (India)

ABSTRACT

Piston is one of the most important part in a IC engine, It acts as a disc which reciprocates within a cylinder. The main function of the piston of an IC engine is to receive the impulse from the expanding gas and to transmit the energy to the crankshaft through the connecting rod. As a result of combustion of fuel takes place inside engine cylinder; high temperature and pressure are developed in the cylinder. Consequently high thermal and structural stresses are developed in the piston. If these stresses exceed the designed values, the piston may fail.

AIM OF STUDY*- Keeping these considerations in mind, 3D model of piston is designed in the designing Software called "SOLIDWORKS". Solidworks also gives us the freedom to do analysis on the piston, so static analysis is done in same software. In this study analysis is done considering different Aluminium alloys. A Comparison is made of results to find out the best material with the reference of useful factors like von mises stress, von mises strain and displacement were obtained.*

Keywords- *Displacement, Engine piston, Factor of safety, FE Analysis, Solidworks, von mises stress, von mises strain.*

I.INTRODUCTION

A **piston** is a component of reciprocating 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 or connecting rod. Pistons are cast from aluminium alloys. For better strength and fatigue life, some racing pistons may be forged instead. Early pistons were of cast iron, but there were obvious benefits for engine balancing if a lighter alloy could be used. To produce pistons that could survive engine combustion temperatures, it was necessary to develop new alloys such as Y alloy and Hiduminium, specifically for use as pistons. There are many aluminium alloys have been developed for manufacturing piston. In this study Finite element analysis of piston is carried out for 2 aluminium alloys named as Al 6061 & Al 7050. And a meaningful comparison is made to find the suitable material for piston.

Soniya kaushik et al [6], (2013) carried out an analysis and found that Aluminium alloy 7475-T761 is best material for the piston among Al 7475-T761, Al 6061, Al LM25.

Mr. Jadhav Vishal et al [7], (2016) performed a static analysis and concluded that AL-GHY1250 aluminum alloy material for piston is better than standard alloy material. So, further development of high power engine is possible by using this material.

Isam Jasim Jaber et al [4], (2014) A FE analysis was done considering three material Al alloy 4032, AISI 4340 Alloy steel and Titanium Ti-6Al-4V (Grade 5) and clarified that maximum stress intensity is on the bottom surface of the piston crown in all the materials, Maximum temperature is found at the centre of the top surface of the piston crown. And concluded that material Al alloy 4032 is the best suitable material for the piston.

Lokesh Singh et al [8], (2015) found that the design parameter of the piston with modification gives the sufficient improvement in the existing results. And The minimum factor of safety is greater than unity so our design of piston is safe under the applied loading conditions.

II. MATERIALS AND THEIR PROPERTIES

Materials and their properties for piston are mentioned below.

Table No.-1

Material	Elastic modulus (N/mm^2)	Density (Kg/m^3)	Yield strength (Mpa)	Tensile strength (Mpa)	Poison Ratio	Thermal conductivity (w/(m-k))
Al 7050 T7451	72000	2830	470	525	0.33	157
Al 6061	69000	2700	227.53	240	0.33	154

III. DESIGN OF PISTON

During designing a piston, the following points should be taken into consideration:

- It should have enormous strength to withstand the high gas pressure and inertia forces.
- It should have minimum mass to minimize the inertia forces.
- It should form an effective gas and oil sealing of the cylinder.
- It should provide sufficient bearing area to prevent undue wear.
- It should disperse the heat of combustion quickly to the cylinder walls.
- It should have high speed reciprocation without noise.
- It should be of sufficient rigid construction to withstand thermal and mechanical distortion.
- It should have sufficient support for the piston pin.

The piston is designed according to procedures and specifications given in machine design and design data book. Dimensions are calculated and these are used for modeling the piston in SOLIDWORKS as shown in Fig.1.

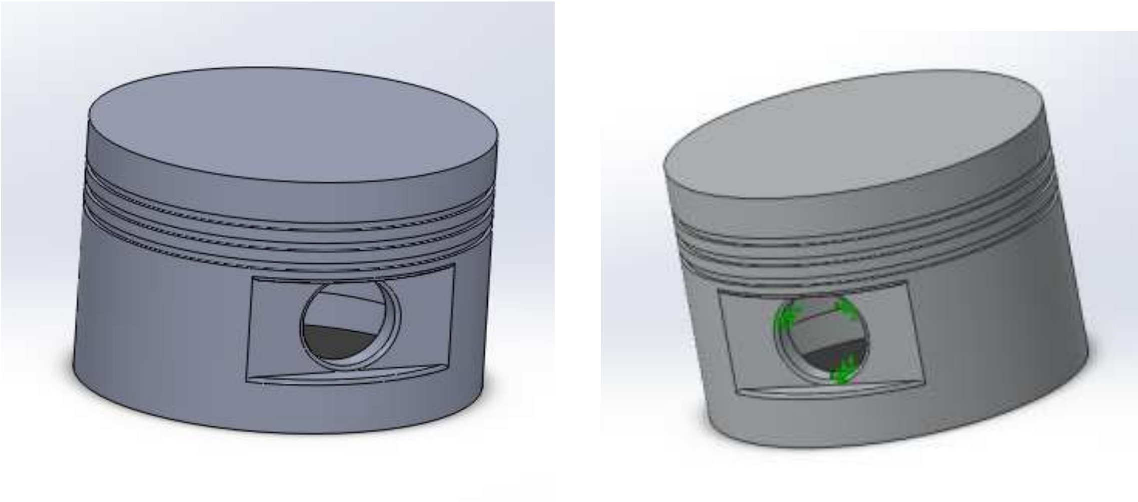

fig.1: 3d model of piston

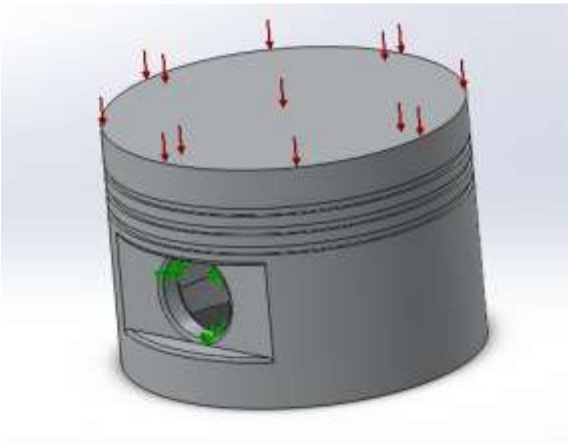

fig.2: piston in loading condition

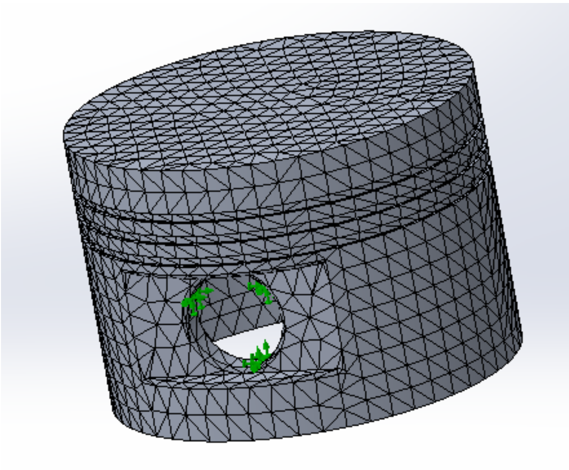

fig.3: mesh model of piston

IV. STATIC STRESS ANALYSIS OF PISTON

A 3D model is developed in designing Software SOLIDWORKS. And a finite element analysis is being done on this piston. For this purpose the boundary conditions are necessary to define.

V. BOUNDARY CONDITION

The maximum explosive pressure is taken as 8 Mpa, and it acts uniformly on the piston head. Because the piston will move from TDC to BDC with the help of fixed support at pin hole. Coupling restraints are imposed on two points on the bottom of piston in order to eliminate the revolving of the piston around the piston pin. The three freedom degrees of the piston pin are restrained to let the piston in a static condition for analysis purpose.

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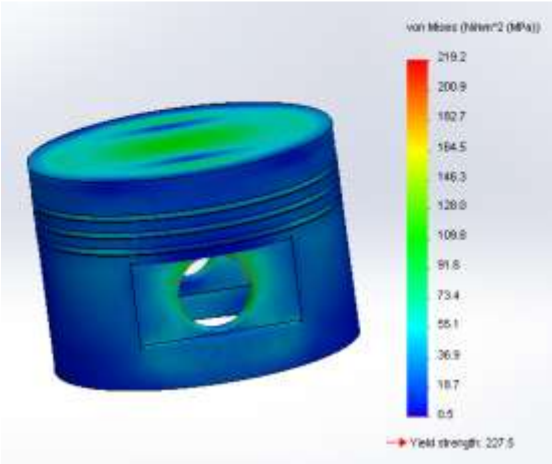

fig.4: von mises stress for Al 6061

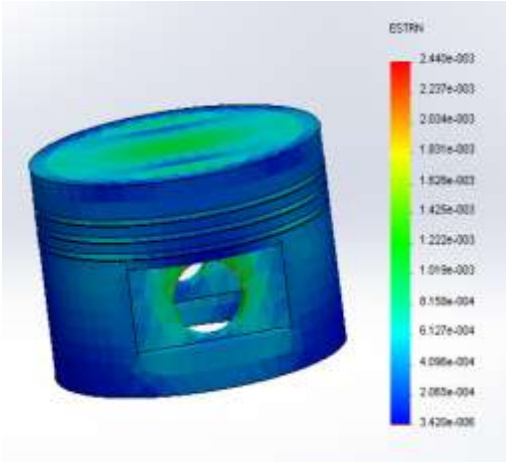

fig.5: von mises strain for Al 6061

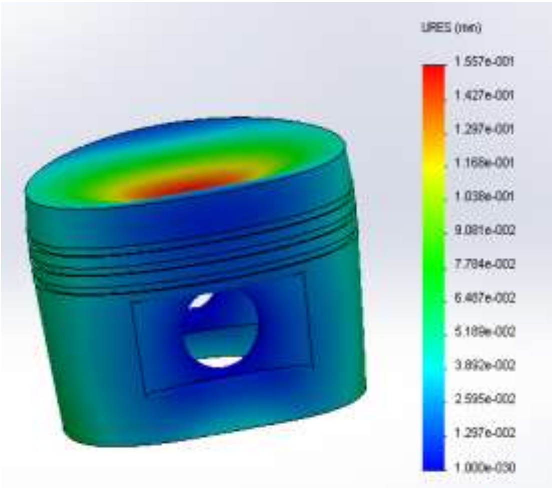

fig.6: deformation for Al 6061

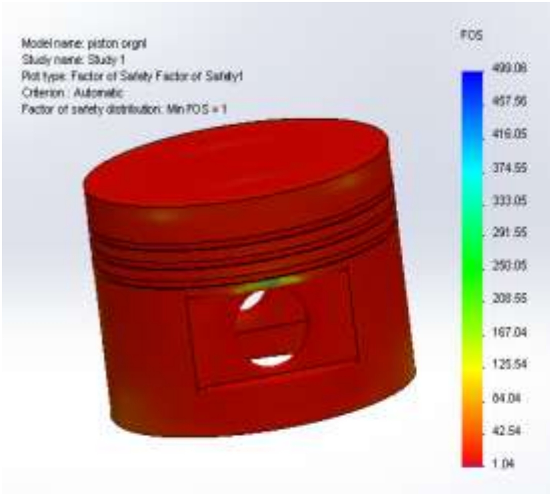

fig.7: factor of safety for Al 6061

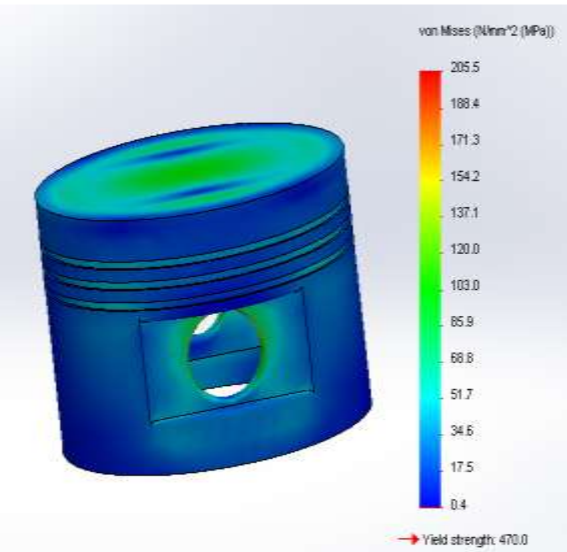

fig.8: von mises stress for Al 7050 T7451

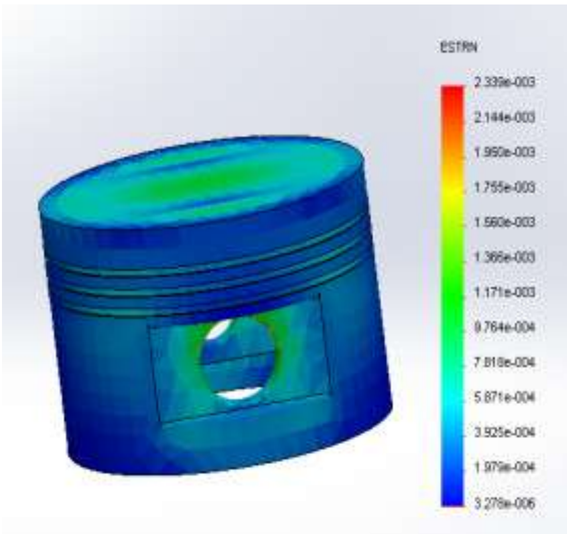

fig.9: von mises strain for Al 7050 T7451

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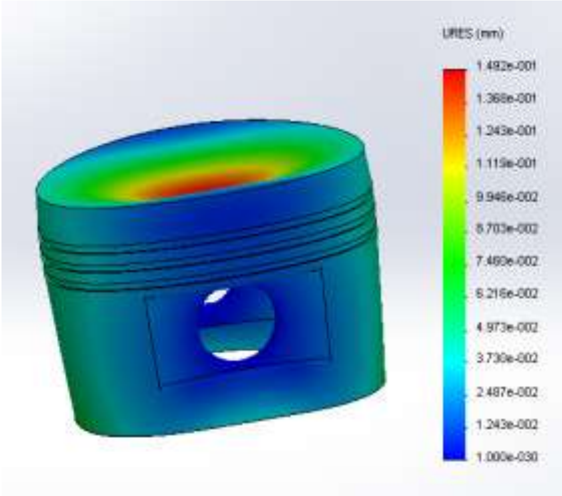

fig.10: deformation for Al 7050 T7451

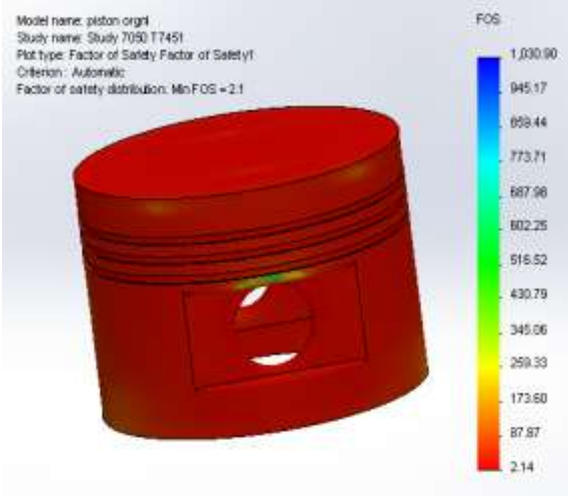

fig.11: factor of safety for Al 7050 T7451

VI. RESULTS AND DISCUSSION

The values of total deformation, von-mises stress, von mises strain and factor of safety of two aluminum alloys Al 6061 & Al 7050 T7451 are listed below in table.

Table No.-2

S. No.	Parameter	Al 6061	Al 7050 T7451
1	Max. Von mises Stress (Mpa)	219.2	205.5
2	Max. Von mises Strain	0.0024	0.0022
3	Max. Deformation (mm)	0.1557	0.1492
4	Minimum Factor of safety	1.04	2.14

It is cleared from the above figures that maximum von mises stress occurs at piston's crown surface, which is 219.2 Mpa for Al 6061 and 205.5 Mpa for Al 7070 T7451. And minimum von mises stress occurs at the piston skirt's lower region, which is 0.5 Mpa for Al 6061 and 0.4 Mpa for Al 7070 T7451.

It is also cleared from the above figures that maximum von mises strain occurs at piston's crown surface, which is 0.0024 mm for Al 6061 and 0.0022 for Al 7070 T7451. And minimum von mises strain occurs at the piston skirt's lower region, which is 0.00000342 for Al 6061 and 0.00000327 for Al 7070 T7451.

It is noticed from the analysis's results that maximum deformation occurs at piston's crown surface, which is 0.1557 mm for Al 6061 and 0.1492 mm for Al 7050 T7451. And minimum deformation occurs at piston skirt's lower region, which is 1.0e-30 mm for Al 6061 and 1.0e-30 mm for Al 7050 T7451.

VII. CONCLUSIONS

In the view of above discussion, following conclusion can be made.

(A) Maximum von mises stress, Maximum von mises strain and Maximum deformation are minimum in Piston of Al 7050 T7451 alloy in comparison of Al 6061.

(B) Maximum stress, maximum strain and maximum displacement occur at the crown of the Piston.

(D) Piston design is safe for Al 7050 T7451 alloy based on the yield strength & ultimate strength.

(E) The minimum factor of safety of Al 7050 T7451alloy is more than Al 6061 so our design of piston is safe under the applied loading condition.

By observing the above views it can be concluded that Al 7050 T7451 is the suitable material for using in production of Piston.

VIII. FUTURE PLAN

In this work static structural analysis is done. For getting more clear and better results we can do Thermal Analysis also in next study.

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