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Improving Engine Life by Weight Reduction of Four Wheeler (Diesel Engine)

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Abstract: IC engine is the most important in power generation. IC engine is the assembly of many components like piston, connecting rod, crank shaft, cylinder block, cylinder head, etc., coming to the automobile the power produced by the IC engine is utilized by the automobile and also by the engine its self i.e. automobile consists of engine and other parts, all are fitted to the chassis. All the weight of the automobile i.e. Engine and other parts will be on the engine. So the mileage of the automobile also depends on the weight of the automobile. the major weight is engine. As the engine is the assembly of many components, we will take the particular component and optimization of weight is done i.e. With respective to its function. IC engine components like piston, connecting rod crank shaft are made of steel because of its good strength. Replacing the steel components with aluminum components will reduce the weight but the strength is not enough. so we are taking the aluminum alloy such that the aluminum alloy exhibits the strength like the steel because of its alloying material and own property of less weight. Therefore if as many as components are replaced then automatically overall weight is reduced. therefore the power required to run itself by automobile is reduced resulting in the increase in the mileage. In this project we are taking the 5086 - H32 aluminum alloy Material of using four wheeler diesel engine. The components are designed by using Solid works and analysis is done by Ansys14.0.

Key words: Diesel Engine · 5086 Aluminum Alloy Material · Solidworks · Analysis14.0

INTRODUCTION

Basic of the Engine Study: A reciprocating engine is also known as a piston engine. It is a heat engine that uses one or more reciprocating pistons to convert pressure into a rotating motion. The main types are the internal combustion engine, used extensively in motor vehicles, the steam engine and the niche application Stirling engine. Internal Combustion engines are further classified in two ways as a spark-ignition (SI) engine, where the spark plug initiates the combustion or a compression-ignition (CI) engine, where the air within the cylinder is compressed, thus heating it, so that the heated air ignites fuel that is injected then or earlier. Each piston is inside a cylinder, into which a gas is introduced. The hot gases expand, pushing the piston to the bottom of the cylinder. This position is also known as the Bottom Dead Centre (BDC), or where the piston forms the largest volume in the cylinder. The piston is returned to the cylinder top (Top Dead Centre) (TDC) by a flywheel, the power from other pistons connected to the same shaft or (in a double acting cylinder) by the same process acting on the other side of the piston. This is where the piston forms the smallest volume in the cylinder. In most types the expanded or "exhausted" gases are removed from the cylinder by this stroke.

Diesel Engine: Diesel engines are also known as Compression-ignition (C.I.) engines. Diesel engines take in a air which is Ignited by a Fuel injection when the air is compressed. Four Stroke Compressed-ignition (C.I) engines require four piston strokes to complete one cycle: an air intake stroke moving outward from the cylinder head, an inward movement towards the cylinder head compressing the charge, an outward power stroke and an inward exhaust stroke.

- Induction stroke
- Compression stroke
- Power stroke
- Exhaust stroke

Objective and Scope: The main objective of the paper is to design and optimize the performance of the Piston & Connecting rod in an I.C. engine by replacing the traditional material with a composite material. This paper

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deals with the design of a connecting rod & Piston using various composite materials. The model of the Piston & connecting rod is developed using Solid works software. The static analysis of the designed Piston & Connecting rod is done using FEM software and the results are compared with each material. By using 5086 – H32 aluminum alloy weight optimization of Piston & Connecting rod is achieved. The designed Piston & Connecting rod is having higher stiffness to weight ratio than the existing Piston and connecting rod [3].

1. High Fuel efficiently
2. Increased productivity
3. Cheaper than Old models

Materialselection:

Table 1: Before of engine parts material

Name	Material	Weight
Piston	Cast Alloy Steel	291 gm
Connecting Rod	1060 Aluminium Alloy	40 gm
Crank webs	Alloy steel	1024 gm
Crank pin	Alloy steel	179 gm

Table 2: After modification of engine parts material

Name	Material	Weight
Piston	5086–H32Aluminium Alloy	107 gm
Connecting Rod	5086 – H32 Aluminium Alloy	40 gm
Crank webs	Alloy steel	1024 gm
Crank pin	Alloy steel	179 gm

Cast Alloy Steel: Alloy steel castings are broken down into two categories: low-alloy steels and high-alloy steels. Silicon above 0.60% [2, 3].

Purpose of Alloying:

- Strengthening of the ferrite
- Improved corrosion resistance
- Better hardenability
- Grain size control

Aluminium Alloy 1060: Aluminum alloys are alloys in hich aluminum (Al) is the predominant metal. The typical alloying elements are copper, magnesium, manganese, silicon, tin and zinc. structures and components where light weight or corrosion resistance is required.Alloys composed mostly of aluminium have been very important in aerospace manufacturing since the introduction of metal-skinned aircraft. Aluminium-magnesium alloys are both lighter than other aluminium alloys and much less flammable than alloys that contain a very high percentage of magnesium.

5086 – H32 Aluminium Alloys

5086: Is an aluminium alloy, primarily alloyed with magnesium. It is not strengthened by heat treatment, instead becoming stronger due to strain hardening, [1] or cold mechanical working of the material. Since heat treatment doesn't strongly affect the strength, 5086 can be readily welded and retain most of its mechanical strength.

Benefits: Appearance, strength, durability have been the points of 5086 Aluminum. Combined with excellent welding characteristics and corrosion resistance, 5086 offers an economical high strength for a wide variety of industrial applications.

Material Properties:-

1. Young's modulus (Mpa) = 71000
2. Poisson's ratio = 0.33
3. Bulk modulus (Mpa) = 69608
4. Shear modulus (Mpa) = 26692
5. Density ($Kgmm^{-3}$) = $2.77x10^{-6}$
6. Coefficient of thermal expansion = 2.3×10^{-5}

4. METHODOLOGY

- Review of Papers
- Behaviour of Piston, connecting rod in various loads.
- Modelling of Piston, connecting rod
- Analysis of piston, connecting rod with various materials.
- Result Interpretation.

Design Consideration for a Piston:

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 sufficient rigid construction to withstand thermal and mechanical distortion.
8. It should have sufficient support for the piston pin.

Procedure for Design of Piston: The procedures of the piston design are

1. The thickness of the piston head.(t_H)
2. Heat flow through the piston head.(H)
3. Radial thickness of the right.(t_1)

4. Axial thickness of the ring.(t_2)
5. Width of the top land.(b_1)
6. Width of the other land.(b_2)

Table 3: Designing specification of piston

S. no	Dimensions	Size in mm
1	Length of the Piston(L)	110
2	Cylinder bore/outside diameter of the piston (D)	140
3	Thickness of piston head (t_H)	9.04
4	Radial thickness of the ring (t_1)	5.24
5	Axial thickness of the ring (t_2)	5
6	Width of the top land (b_1)	10.84
7	Width of other ring lands (b_2)	4

Table 4: Designing specification of connecting rod

S. No	Dimensions	Size in mm
1	Length of connecting rod (L)	300
2	Connecting rod thickness (t)	5
3	X section big & small breath (b)	25
4	Cross section of Connecting rod (C)	2
5	Mean Ratio of height (H)	30
6	Connecting rod mean height (H)	30
7	Connecting rod small end height (H)	72
8	Connecting rod big end height (H)	27

Modeling of Engine Component

Modeling of in Solidworks: The piston was modeled using Solid works 2012 software with standard dimensions.

Solid works is a solid modelling computer-aided design (CAD)and computeraidedengineering (CAE) software program that runs on Microsoft Windows. The Solid works is produced by the Dassault Systems. Building a model in Solid works usually starts with a 2D sketch (although 3D sketches are available for power users).

Finally, drawings can be created either from parts or assemblies. Views are automatically generated from the solid model and notes, dimensions and tolerances can then be easily added to the Drawing as needed. The drawing module includes most paper sizes and standards (ANSI, ISO, DIN, GOST, JIS, BSI and SAC).

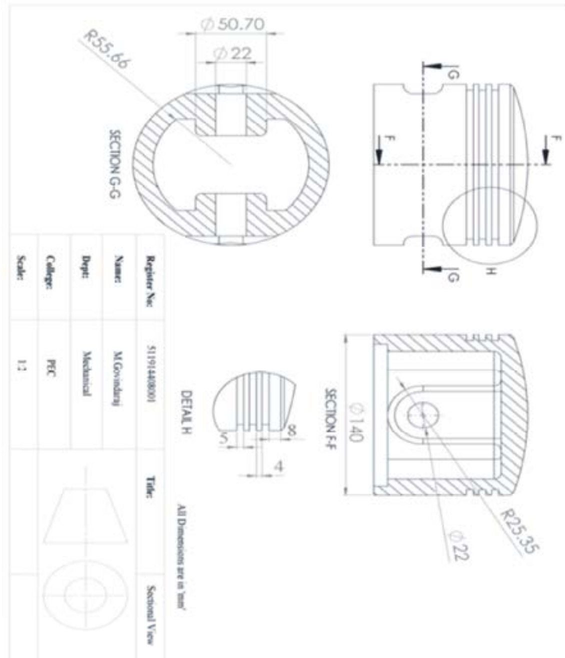
All the required dimensions for the piston were derived from various literature surveys.

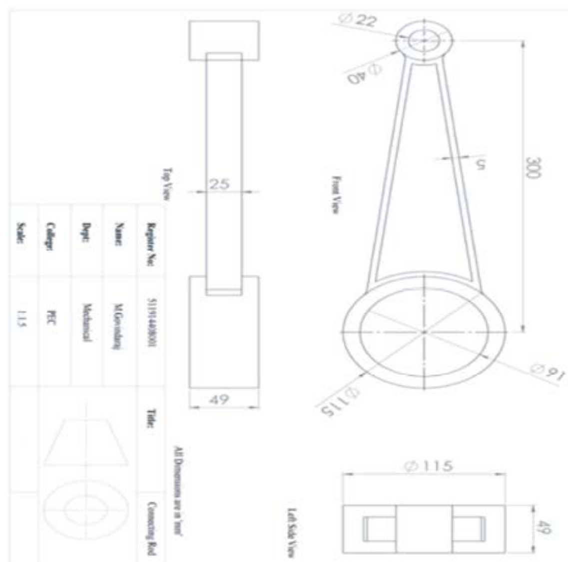
By using that dimensions, piston was modeled in Solid works by following commands.

By using the dimensions the drawing of piston cross section was drawn by taking front plane as sketch plane.

Go to – Sketch – lines

Modeling of Piston and Connecting Rod: *A*fter that, the 2D sketch of Connecting rod should be drawn by using required dimensions. The sketch should be drawn in different part file.





Numerical Analysis

FEA: Finite Element Analysis (FEA) is one of the branches of solid mechanics that uses numerical methods and algorithms to solve and analyze problems that involve analysis of structures or objects. Computers are used to simulate the interaction of forces over the surfaces defined by boundary conditions.

Outline Of Finite Element Analysis Process: *Fi*nite Element Analysis codes are structured around the numerical algorithms that can tackle all kinds of structural problems.

1. Pre-processor
2. Solver
3. Post processor

Meshing And Pre-Processing: The pre-processing of the FEA process consists of the input of a structural problem by means of user-friendly programs or software and the subsequent transformation of this input into a form is made suitable to use by the solver.

Numerical Solver: The finite difference and element method are usually suitable for stress and structure analysis. following sequence:

1. Formal integration of the governing equations of structure over all the control elements or finite elements of the solution domain.
2. The conversion of the integral forms of the equations into a system of algebraic equations.
3. Calculations of the algebraic equations by an iterative method.

Post Processor: This phase uses the versatile data visualization tools of the FEA solver to observe the following results of the simulation:

1. Domain geometry and Grid display
2. Deformation contours
3. Stress contours
4. Strain contours
5. Strain Energy contours

The mesh parameters defined is as given below:

Relevance Center	: Fine
Span Angle Center	: Fine
Minimum Size	: 0.624 mm
Growth Rate	: 1.2
Number of Nodes	: 685055
Number of Elements	: 441305

Boundary Conditions: The problem is a structural analysis problem. the boundary condition for the problem is pressure force of 5 MPa to 7 MPa with the shaft to be fixed. The forces are varied from 5 MPa to 7 MPa by varying the material property of the piston assembly.

Numerical Results:

Case 1: Cast alloy steel with pressure load of 5 MPa

Case 2: Cast alloy steel with pressure load of 6 MPa

Case 3: Cast alloy steel with pressure load of 7 MPa

Case 4: 5086 aluminium alloy with pressure load of 5 MPa

Case 5: 5086 aluminium alloy with pressure load of 6 MPa

Case 6: 5086 aluminium alloy with pressure load of 7 Mpa

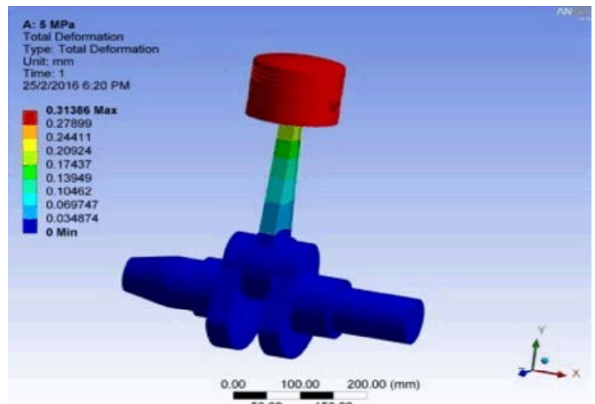


Fig. 1: Deformation for case-1

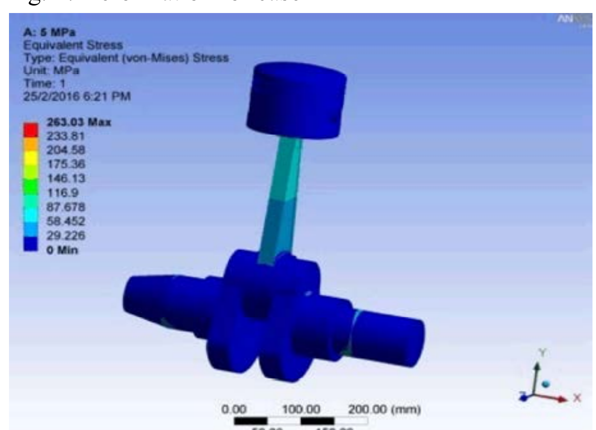


Fig. 2: Stress for case-1

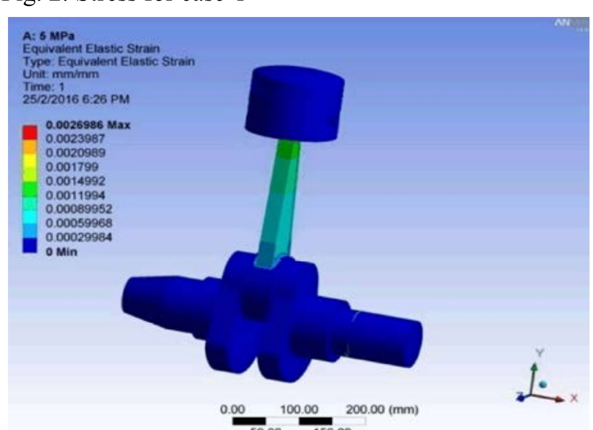


Fig. 3: Strain for case-1

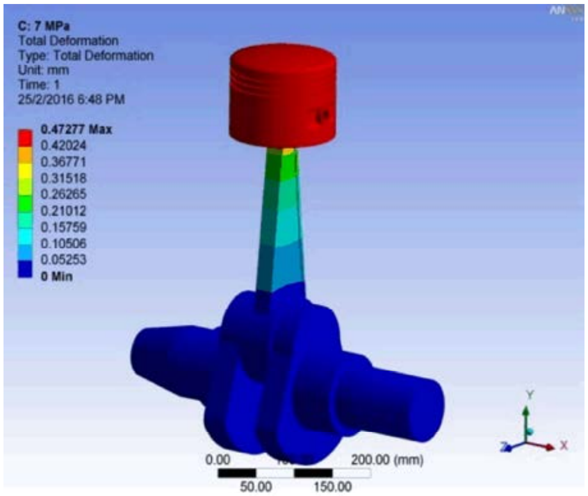


Fig. 4: Deformation for case-6

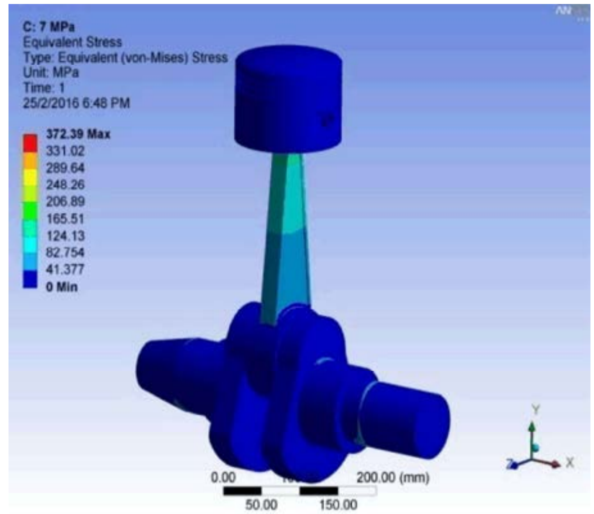


Fig. 5: Stress for case-6

Table 5: Structural behaviuor

Loading Condition	Deformation		Stress		Strain	
	Old	New	Old	New	Old	New
Pressure @ 5 Mpa	0.31386 mm	0.33769 mm	263.03 MPa	266 MPa	0.0026986	0.0026629
Pressure @ 6 Mpa	0.37663 mm	0.405 mm	315.64 MPa	319.2 MPa	0.0032383	0.0031955
Pressure @ 7 Mpa	0.43941 mm	0.47277 mm	368.25 MPa	372.89 MPa	0.003778	0.003728

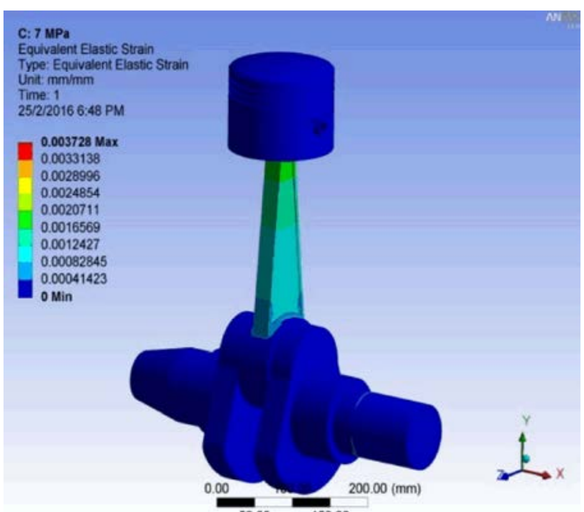


Fig. 6: Strain for case-6

Table 5 Structural Behaviuor: The diagrams shown are the structural behavior of piston assembly while it's subjected to the pressure loads over the piston head. From the contours it's clear that the replacement of material can hold a better performance than the previous material. The material also holds a less weight by replacing the material also by improving the structural performance too.

Table 6: Weight of piston components

Component	Old material	New Material
Piston	6.27 Kg	2.286 Kg
Connecting rod	1.3445Kg	1.3246 Kg
Crank web + Crank shaft	22.57 Kg	22.57 Kg

CONCLUSION

The piston and the other components have been modeled by using some theoretical calculations. A detailed study has been carried out about the piston and other components. Also the material that has been used earlier is considered and its advantages and disadvantages has been studied in detail to modify them. By a detailed study the material for piston has been considered to be as Aluminium alloy 5028 due it considerable performance. This material holds good behavior than the existing material. Later the modeled piston and other components will be analyzed in ANSYS workbench to determine the change in weight and structural performance. From the detailed study it's clear that the aluminium alloy 5086 have less weight than the aluminium alloy 1086. It have to be also tested for its structural performance to compare the result.

REFERENCES

1. Kuldeep, B., L.R. Arun and Mohammed Faheem, 2013. Analysis 14.0 and Optimization Of Piston And Connecting Rod Using 6061 Aluminium, International Journal of Innovative Research in Science, Engineering and Technology 2(6).
2. Arnd Baberg, 2013. Analysis 14.0 of Piston Performance Using Aluminum In Rising Stress Contribution, International Journal of Developed Science in Technology of Manufacturing and Design Development.
3. Marcus Freidhager, S., 2010. Aluminium Performance of Piston and Connecting Rod of Diesel Engine, National conference in Mechanical Engineering Research Postgraduates Studies, pp: 3-4.