Design of Small Capacity Automobile Engine to Run on Compressed Air

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Abstract— The excess use of gasoline and other major fuels in I.C engines releases unburnt gases in the environment and are counted in the major sources of pollution, compressed air engine can be used for cleaner, pollution free travel. The project is been focused on piston of compressed air engine and to compare it with the conventional I.C engine. In present study the Hero Honda kinetic dx(two stroke petrol) engine is been taken. From this engine reverse engineering is been done to make models of piston CREO 2.0. 100cc petrol engine will convert in pneumatic engine with help of pneumatic equipments. New design geometry is been made for piston, cylinder, cylinder head in CREO for pneumatic engine. Dynamic analysis of piston is been done in ANSYS for both IC engine and for pneumatic engine.

Key words: Piston; Two stroke engine; pnuematic engine; piston dynamic analysis; Creo 2.0; ANSYS

I. INTRODUCTION

In internal combustion engine, piston is one of the important components. It reciprocates within the cylinder bore by force produced during the combustion process.

Piston is the heart of the internal combustion engine and is subjected to loads such as thermal and structural stress. Piston reciprocates within the cylinder at that condition two extreme position will take place top dead center (TDC) and bottom dead center (BDC).

In this study which engine is been taken its Specifications are as follow:

1) Type : 2 stroke, petrol
2) Engine capacity : 100cc
3) Bore : 50 mm
4) Stroke : 50 mm
5) Maximum pressure : 50 bar
6) Compression ratio : 6.7:1
7) Maximum power : 5.74 KW at 5500 rpm
8) Maximum torque : 9.8 N.m at 5000 rpm

II. ALTERNATIVE SOURCES

In the past decades energy conservation, carbon reduction, greenhouse effect and pollution have become very crucial issues worldwide. To find a replacement for conventional IC engine, several types of engines that use green energy to determine:

1) Electric engine
2) Hydrogen engine
3) Pneumatic engine (Compressed air engine)
4) Liquid nitrogen engine

A. Compressed Air Engine:

Compressed air vehicle is powered by air engine using compressed air which is stored in a tank. Instead of mixing fuel with air and burning it in the engine to drive piston with hot expanding gases. Compressed air engine is used the expansion of compressed air to drive pistons.

Motor development International (MDI) is a French company which was established by Guy Negre has designed the air car prototype which is shown in figure 2.1. In which they have produced the two pistons in one cylinder chamber and also at some stage in process they have applied hot air in to chamber to make more efficient.

All the research worked mentioned that Compressed air engine has the working pressure range is between the 5 bar to 9 bar. All modification has been done for the converting the 4-stroke internal combustion engine to 2-stroke compressed air engine is focusing on cam profile of the engine. For making of compressed air engine there will be elimination of fuel tank and spark plug from the conventional 4-stroke IC engine. In compressed air engine at 9 bar leakage will be measured 1800 L/min which is try to solved by installing strong spring at the valve.

At 9 bar working pressure inlet pressure will be drops to 0.5 bar at low rpm and will increase when rpm increases. For outlet pressure it will be increases from 1.5 bar to 2.25 bar at 500 rpm to 200 rpm respectively.

In internal combustion engine material which is used for piston are aluminium alloy 6061 and Al 4032. In aluminum alloy the aluminium is the main material component in addition it consists of copper 4-5%, ferrous 1.3%,silicon 16-18%, magnesium 0.45-65%, zinc 1.5% and nickel 0.1%.

III. MODELING & ANALYSIS

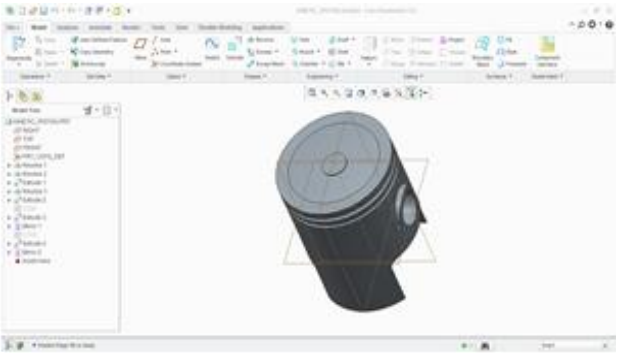

Fig. 3.1: Piston ISO view

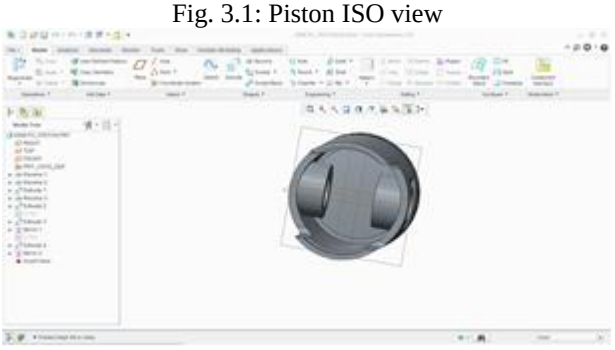

Fig. 3.2 Piston bottom view

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This modeling is done by using reverse engineering. 50 mm bore and 50 mm stroke length.

A. Transient Dynamic Analysis:

Transient dynamic analysis (sometimes called time-history analysis) is a technique used to determine the dynamic response of a structure under the action of any general time-dependent loads. Transient dynamic analysis is used to determine the time-varying displacements, strains, stresses, and forces in a structure as it responds to any combination of static, transient, and harmonic loads.

The basic equation of motion solved by a transient dynamic analysis is

$[M]\{\ddot{u}\} + [C]\{\dot{u}\} + [K]\{u\} = \{F(t)\}$

Where:

[M] = mass matrix , [C] = damping matrix

[K] = stiffness matrix , {F(t)} = load vector

{ü} = nodal acceleration vector ,{u̇}= nodal velocity vector

{u} = nodal displacement vector

B. Total Deformation and Equivalent (Von Mises) Stress:

Deformation in continuum mechanics is the transformation of a body from a reference configuration to a current configuration. A configuration is a set of containing the position of all particles of the body.

$$e = \frac{\Delta L}{L} = \frac{\ell - L}{L}$$

Von mises stress is which when shear stresses or shear strains intersect each other at that place one stress is been developed that developed stress is called Von mises stress.

$$\sigma_v^2 = \frac{1}{2}\left[(\sigma_{11} - \sigma_{22})^2 + (\sigma_{22} - \sigma_{33})^2 + (\sigma_{33} - \sigma_{11})^2 + 6(\sigma_{23}^2 + \sigma_{31}^2 + \sigma_{12}^2)\right]$$

C. Dynamic Analysis of Two Stroke IC Engine:

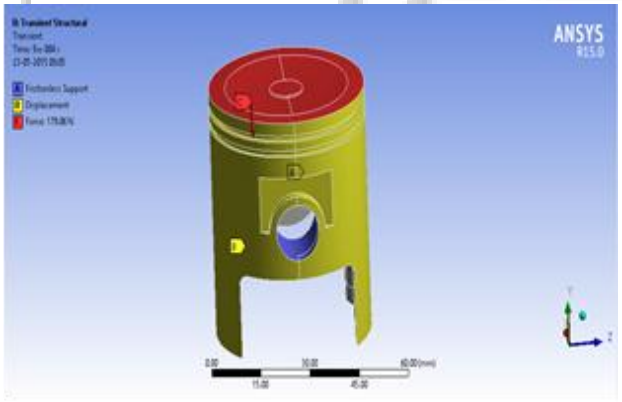

Fig. 3.3: Boundary Conditions of IC piston

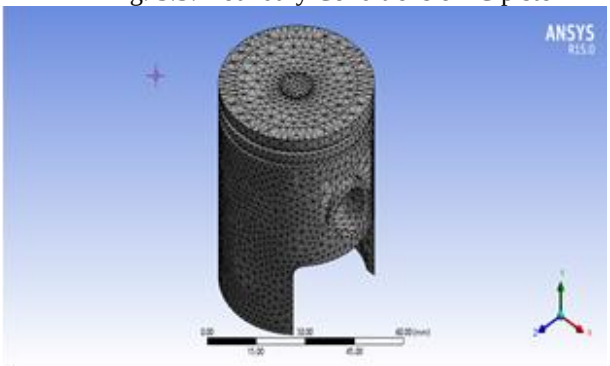

Fig. 3.4: Piston with meshing

Figure in which boundary conditions is shown which is frictionless support at pin bore, Displacement constraint at cylindrical surface and downward force due to gas load acting on piston head. Force will be applied is 9817.5 N on the top surface of piston. Piston meshing is having 20263 elements and 36605 nodes, the type of the element is fine tetrahedron and element size is 2 mm.

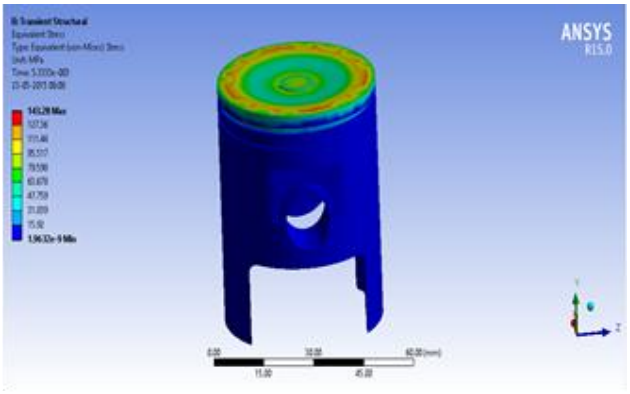

Fig. 3.5: Equivalent stress of IC engine piston

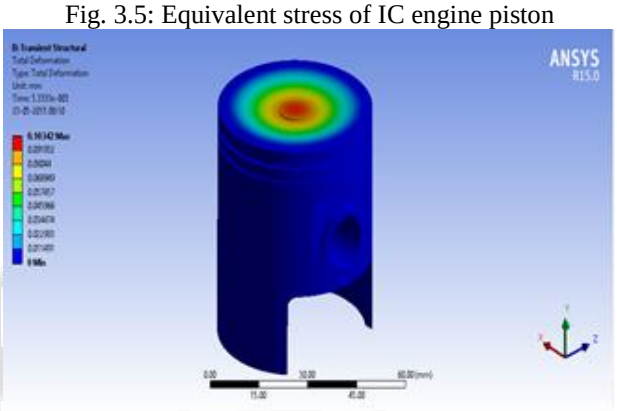

Fig. 3.6: Total deformation of IC engine piston

Maximum equivalent stress is 143.28 MPa and maximum total deformation is 0.10342 mm

D. Dynamic Analysis of Pnuematic Engine Piston:

In pneumatic engine piston geometry will remain same but inputs will be deferent as compared to IC engine.

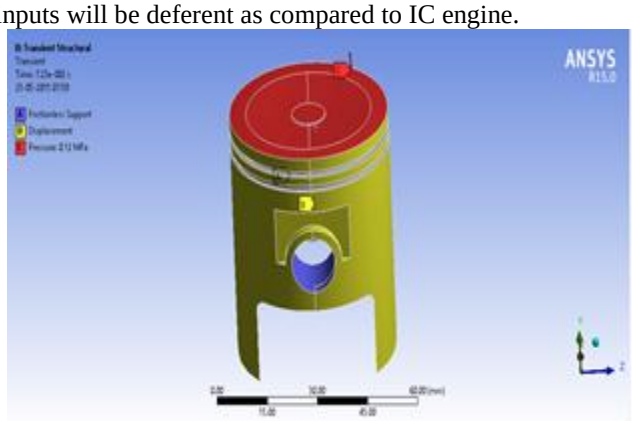

Fig. 3.7: Boundary condition of pneumatic engine piston

Figure in which boundary conditions is shown which is frictionless support at pin bore, Displacement constraint at cylindrical surface and downward pressure due to gas load acting on piston head. Maximum pressure will be applied is 6.45 bar on the top surface of piston. Piston meshing is same as IC engine which is having 20263 elements and 36605 nodes, the type of the element is fine tetrahedron and element size is 2 mm.

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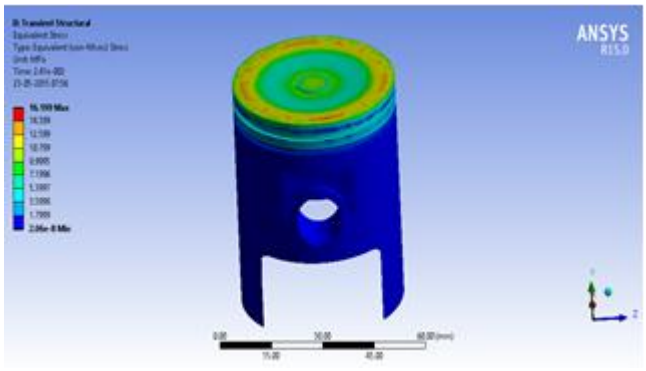

Fig. 3.8: Equivalent stress of Pneumatic engine piston

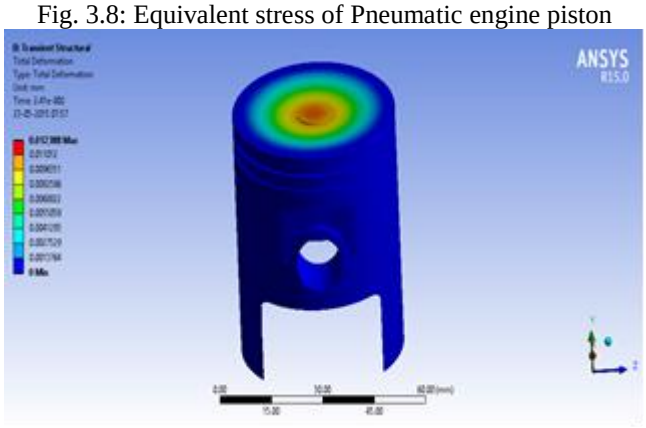

Fig. 3.9: Total deformation of Pneumatic engine piston

Maximum equivalent stress is 16.199 MPa and maximum total deformation is 0.12388 mm.

IV. RESULTS AND DISCUSSION

	Two stroke IC engine	**Pneumatic engine**
Maximum pressure	50 bar	6.45 bar
Equivalent stress	143.28 MPa	16.199 MPa
Total deformation	0.10342 mm	0.12388 mm

Table I: Compression

As we can see that from the table that the IC engine pressure is 50 bar and pneumatic engine pressure is 6.45 bar that means that geometry modification is not required. Thus in new modification inlet and outlet of air will be from top side of the piston that means uniform motion will e there thus piston geometry is safe for 100cc pneumatic engine.

V. CONCLUSION

- Equivalent (von mises) stress of pneumatic engine is less then IC engine.
- Total deformation of pneumatic engine is also less then IC engine.
- That means geometry modification is not required for pneumatic engine.
- Aluminum alloy made piston is safer in pneumatic engine.

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