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Design, Analysis and Manufacturing of Newly Invented Pendulum Type Combustion Engine

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Abstract—*There is scope for a lot of research in the field of energy generation, because none of the machines made yet is perfect, both in performance and in design. Also the engines used have very low efficiencies, so efforts can be made to improve the terms. Even modern internal combustion engines convert only one third of the energy of fuel into useful work. All of the steps at which energy is wasted are opportunities for advanced technologies to increase fuel economy. The world is becoming compact and there is problem of space, so everything we need should accommodate in small space and it should be light in weight. The essence of the invention is that the pendulum engine with a combustion chamber in which the energy of combustion is being converted into a swinging motion of a blade fixed to a shaft, which is adequate to a piston role in piston combustion engine, and the engine principle of operation is to use the same combustion chamber space by both the sides of the blade placed inside the combustion chamber on the engine. Due to spherical shape its volume to surface area ratio is very high so it requires minimum space and at the same capacity it gives double power because it is double acting in nature. The engine works in such a way that when one side of engine carries suction stroke the other side of engine carries exhaust from previous cycle. Now the rotor compresses the air-fuel mixture leading to suction stroke on other side and the side which is under compression now is subjected to power stroke as spark plug gives o the spark. This leads to compression on other side and hence the rest of the strokes follow in order. In this paper, it introduces complete design and manufacturing of combustion chamber, rotor blade for pendulum type engine for strength and rigidity. In this paper work, also the forces which act on the parts of engine are calculated and Mechanical Stress simulation and Thermal simulation of spherical chamber, on rotor from both sides is studied using ANSYS software and then results obtained for further implementation.*

Keywords*: Pendulum Engine, Swinging motion, Combustion chamber, Rotor blade.*

1. INTRODUCTION

Pendulum engine is basically a double acting engine, but here the engine has an oscillatory motion, hence the name Pendulum engine. The engine works in such a way that when one side of engine carries suction stroke the other side of engine carries exhaust from previous cycle. Now, the rotor compresses the air-fuel mixture leading to suction stroke on other side and the side which is under compression now is subjected to power stroke as spark plug gives o the spark. This leads to compression on other side and hence the rest of the strokes follow in order. Improvement is the motto of engineering, now-a-days there is tough competition among the automotive industries to make the engine better and better. Locomotive engine needs to be light in weight; compact that leads to less inertia forces which in turn improves life of engine and reduces maintenance cost and being light in weight will improve mileage of the engine. A double acting engine like pendulum engine can meet the above said requirement. Being double acting, in the same volume of combustion chamber, it will produce twice of power. It is designed to be an S.I. engine so it will add to the life of engine and reduced maintenance cost and less inertia of engine makes it a perfect t for automotive engine. However, there is always a scope for improvement. Being a double acting engine, it is prone to problem of detonation, gets overheated easily so there is a need of design or use of present material that can sustain high temperature and improvement in design of combustion chamber is needed that can bring more turbulence and will reduce detonation tendency.

The pendulum engine with a combustion chamber in which the energy of combustion is being converted into a swinging motion of blade fixed to a shaft, playing role which is equivalent to a piston role in piston combustion engine, and the engine principle of operation is to use the same combustion chamber space by both the sides of the blade placed inside the combustion chamber on the engine shaft. So to make it possible, it has designed various required parts taking into account all necessary calculations concerning with kinematics, dynamics and strength calculation of basic details. Also In this paper, it has been analyzed various parts of the design with Pro-E and has also used advanced software's like MATLAB, Pro-E, for designing various parts at different stages of progress in this research work. Various assumption before proceeding were taken as per our requirements and are as under Compression ratio is equal to7.6 Engine shall be designed as single cylinder, double acting and air cooled

Clearance volume is equal to 20.26cc. As basis on this assumption and considering the simple Air Standard Cycle it has drawn P-V diagrams and from there it has been calculated various end state values namely as Power produced ,Work done produced in a cycle. It introduced in depth, the complete design and manufacturing of main parts such as combustion chamber, rotor blades of newly invented pendulum engine and also the thermal and mechanical stress analysis of combustion chamber and rotor blades are carried out using software's.

2. CONCEPTUAL TYPE PENDULUM ENGINE

Pendulum engine is basically a double acting engine, but here the engine has an oscillatory motion, hence the name Pendulum engine. The engine works in such a way that when one side of engine carries suction stroke the other side of engine carries exhaust from previous cycle. Now, the rotor compresses the air-fuel mixture leading to suction stroke on other side and the side which is under compression now is subjected to power stroke as spark plug gives o the spark. This leads to compression on other side and hence the rest of the strokes follow in order. Improvement is the motto of engineering, now-a-days there is tough competition among the automotive industries to make the engine better and better. Locomotive engine needs to be light in weight; compact that leads to less inertia forces which in turn improves life of engine and reduces maintenance cost and being light in weight will improve mileage of the engine.

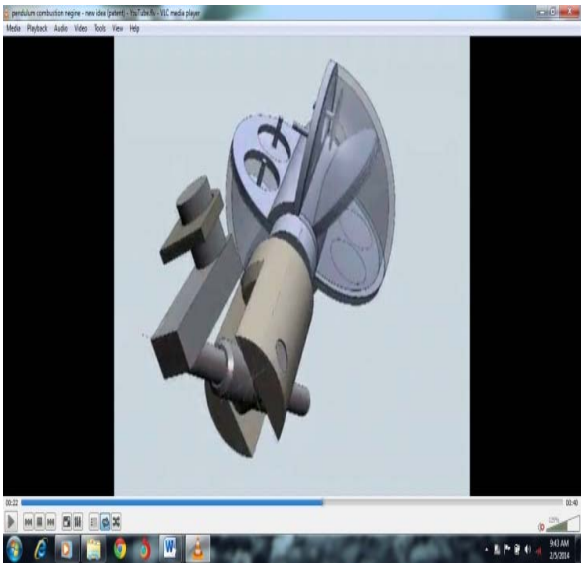


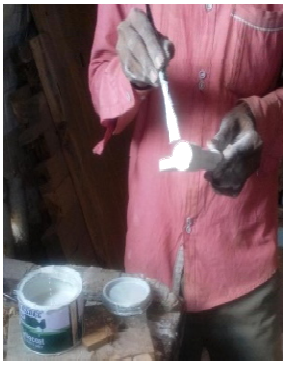
Fig. 1: Conceptual Pendulum type combustion engine

A double acting engine like pendulum engine can meet the above said requirement. Being double acting, in the same volume of combustion chamber, it will produce twice of power. It is designed to be an S.I. engine so it will add to the life of engine and reduced maintenance cost and less inertia of engine makes it a perfect t for automotive engine. However, there is always a scope for improvement. Being a double acting engine, it is prone to problem of detonation, gets overheated easily so there is a need of design or use of present material that can sustain high temperature and improvement in design of combustion chamber is needed that can bring more turbulence and will reduce detonation tendency.

3. DESIGN, ANALYSIS AND MANUFACTURING

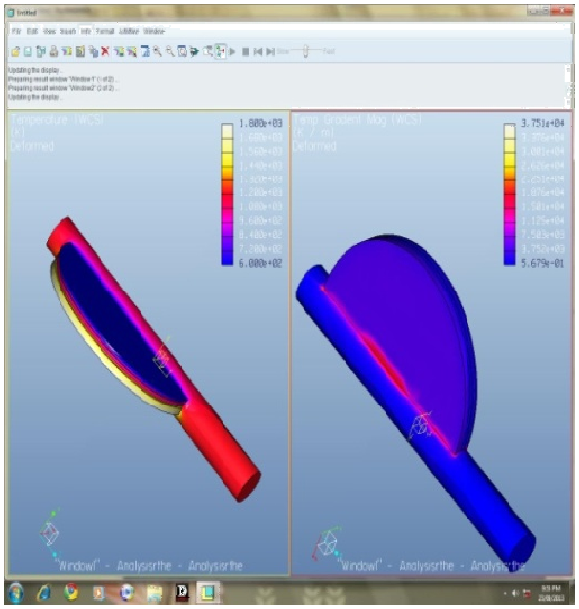
3.1 Design of Engine Components

3.1.1 Combustion Chamber- It is a place where the mixing of air fuel takes place and after appropriate mixing, combustion takes place and these results into increased temperature and stresses at the walls of the combustion chamber. The type of stress that acts on this casing is of radial and longitudinal type as the combustion chamber is spherical in shape. So it is designed to withstand safely the amount of stress produced due to combustion. The cylinder wall is subjected to gas pressure and the piston side thrust. The gas pressure produces the two types of stresses i) longitudinal stress. ii) Circumferential stress. Since these two stresses act at right angles to each other, therefore, the net stress in each direction is reduced. The piston side thrust tends to bend the cylinder wall, but the stress in the wall due to side thrust is very small and hence it may be neglected. It can be considered as thin pressure vessel. The pattern, cast and drafting of combustion chamber is shown in fig 2.



i) Application of primer and final pattern

ii) Cast of Combustion Chamber



iii) Drafting of Combustion Chamber

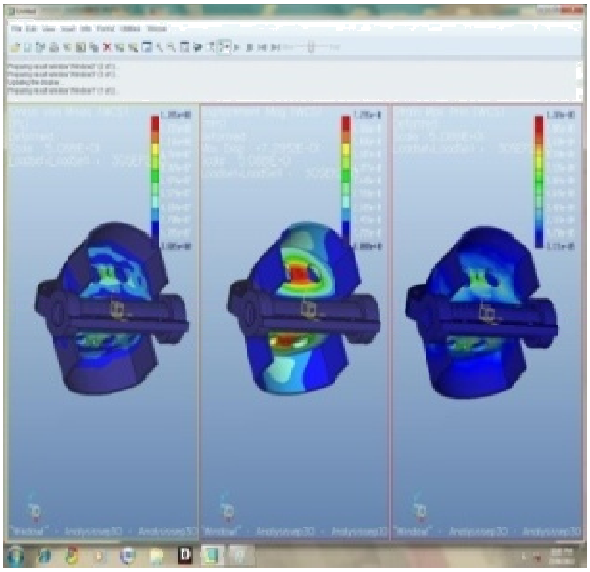
Fig. 2: Pattern, Cast and drafting of combustion chamber

3.1.2 Design of spherical chamber -In designing a cylinder for an I. C. engine, it is required to determine the following values :-

Thickness of the spherical chamber wall -The cylinder wall is subjected to gas pressure and the piston side thrust. The gas pressure produces the following two types of stress i) Longitudinal stress ii) Circumferential stress. Since these two stresses act at right angles to each other, therefore, the net stress in each direction is reduced. The piston side thrust tends to bend the cylinder wall, but the stress in the wall due to side thrust is very small and hence **it** may be neglected. It can be considered as thin pressure vessel. The thickness of a spherical chamber wall thickness (t) is usually obtained by using formula of thin cylinder t = 4:58, d = Inside diameter of the cylinder or cylinder bore in cm

For our design = Inside diameter of the cylinder or cylinder bore = 11 cm

Thickness of cover plate and bolt size selection -Usually, a separate cylinder head or cover is provided with most of the engines. It is usually, made of box type section of considerable depth to accommodate ports for air and gas passages, inlet valve, exhaust valve and spark plug (in case of petrol engines) or atomizer at the centre of the cover (in case of diesel engines).The cylinder head may be approximately taken as a at circular plate whose thickness (t_h) and cover plate bolt(d) may be determined by the relation, for grey cast iron, t_h = 8mm,d=M6 fine series bolt



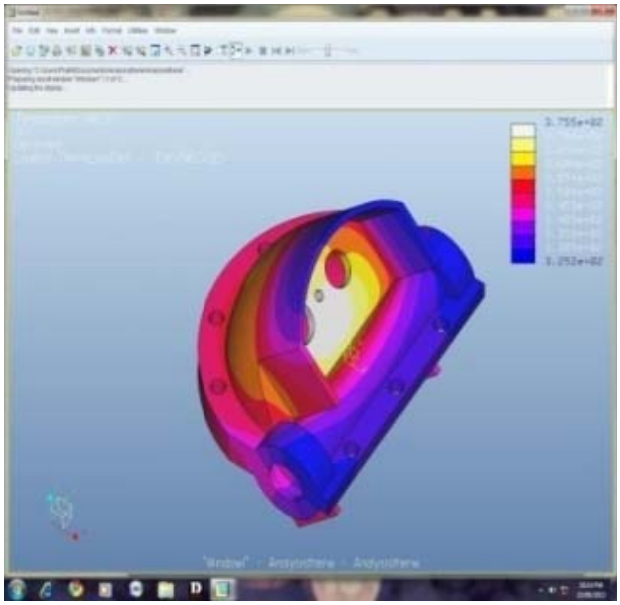


Fig. 3 Mechanical Stress and Thermal simulation of spherical chamber

Fig. 4: Drilling and Taping work for spherical chamber

Fig. 5: Set up for EDM operation for spherical chamber

3.1.3 Rotor Blade-It does the same work as piston does in reciprocating internal combustion engine in this case unlike reciprocating it swings about it mean position. When the gas force acts on the centroid of semi-circular rotor blade, It is subjected to bending moment (M_b), So Design is based on bending stresses induced in it.

Design of shaft of rotor blade -The material selected for material of shaft is FeE steel and the design of shaft is based on ASME code.

Properties of Material- Ultimate Tensile Strength S_{ut} = 770 MPa,

Yield StrengthS_{yt} = 580 MPa, Load factor for bending=K_b =2 ,

Load factor for twisting=K_t =1,For allowable shear stress,S_{ut} = 138:6 MPa

Gas force, F = 14. 445335 x 10^3N,

Diameter of shaft (D), $D^3 = 16 (K_b M_b + K_t M_t)$, D = 23.139 mm

Design of thickness of rotor blade -When the gas force acts on the centroid of semi-circular rotor blade, it is subjected to bending moment (M_b), So Design is based on bending stresses induced in it. Again selecting the FeE steel for rotor blade, with S_{yt} =580 MPa, from flexure formula, t = 8 mm

Fig. 6: Rotor blade pattern and Mould

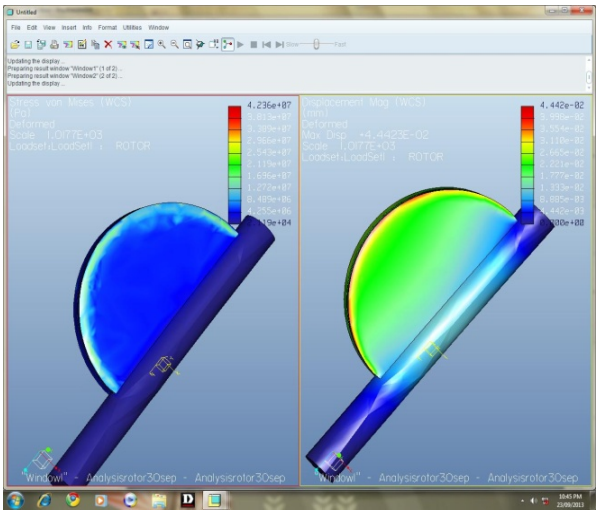


Fig. 7: Mechanical stress simulations on rotor blade

3.1.4 Synthesis of four bar linkage- It is used here to convert the swinging motion of rotor blade into full circular motion and for that we have designed the length of linkages required to convert the small swinging motion into complete rotating motion.

1. Graphical method-By using inversion method for three position synthesis of four bar chain mechanism. The method was used to draw a sketch in 'Pro-Engineer is shown window dialog box in fig.
2. Analytical method-A program was typed in C language which gave the required out-puts on entering the inputs. Hence using all above assumed and calculated data, the linkage mechanism was designed and analyzed on Pro-E. Hence all the parts designed above were assembled and mechanism was given to see chances of failure while rotating.

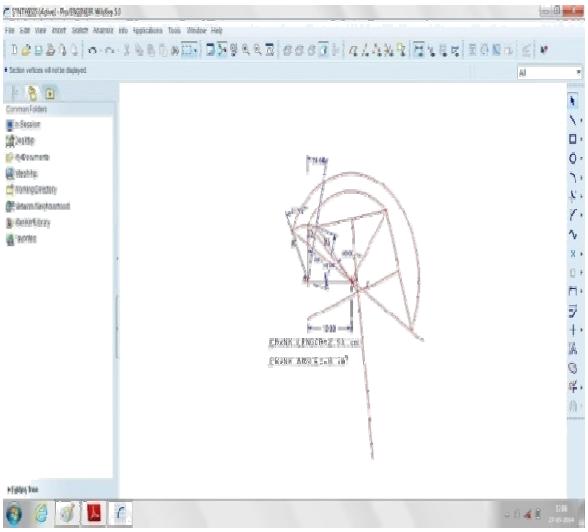


Fig. 8: Inversion method for four bar chain mechanism

4. CONCLUSION

The conventional engine has already gone so much into research that increasing its efficiency is not possible. Hence, it is tried out new designs could give a solution to increase efficiency. In our tremendous effort to achieve the objective of the research, with the expert guidance from various industrial experts, it is designed the double sided Pendulum type engine and manufactured the whole engine. The idea was to completely manufacture and assemble the engine and to check the static stability and the test the innovative use of four bar chain mechanism. It has been pretty achieved objective of the research and hence it concludes that

1) To get highly efficient engines it is required to think beyond the conventional shapes.
2) The engine we designed needs to undergo a lot of design changes after we put our prototype to actual testing.
3) The four bar mechanism used to convert the oscillatory motion to complete rotary motion works well but friction at the riveted joints may pose a problem and hence more rigid links would be required.

5. DISCUSSIONS

i. Rotor -Cooling of the rotor: It can be done e efficiently by providing internal holes for the flow of coolant, but to produce such a rotor the conventional casting process cannot be practiced and hence we have to switch to investment casting process.

ii. Rotor blade rings: In consultation with Dr.S.S.Thipse (General Manager-Power Train Department, ARAI, Pune.), we have found that the sealing between rotor and combustion chamber can be improved by using metal attached to the rotor with the help of advanced adhesives.

iii. Double acting Engine -Making the engine double acting will improve the combustion volume utilization and will also reduce the size of flywheel required.

iv. Better Cooling of Engine -The cooling of engine can be improved by providing ns on the external surface of the engine.

6. ACKNOWLEDGEMENTS

"Completing a task is never a one man‟s effort. Several prominent people in production, academics, and administrative field have helped in Design Analysis and Manufacturing of Newly Invented Pendulum Type Combustion Engine for this present research work. Their collective support has led in successful design and development of this work. To name them all is impossible."

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