Design and Simulation of Double Piston Four Stroke Spark Ignition Engine

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***Abstract*:- In present day global environment four stroke spark ignition engines are widely used in automotive and marine applications etc, over the last one-century, engines continued to develop as our knowledge of engine processes has increased. In the existing competitive automotive scenario, the demand for high performance engine has grown. So the recent research of development in automotive field gives emphasis to improve the efficiency and engine performance. In order to meet the existing demand to increase the efficiency of the existing engine, a modification of the piston in the existing engine is done. This paper reviews the performance of the modified piston engine with existing engine. The numerical computer simulation done with modified piston engine shown considerable increase in efficiency and performance of engine compared with the existing engine.**

Keywords: 4 Stroke Engine, TDC, BDC, Double Piston

1. INTRODUCTION:

First define a cycle. A cycle is a complete sequence of events starting from one state and returning to the same state in the same way. Similarly, an IC engine cycle is a series of events that an internal combustion engine undergoes while it is operating and delivering power. The spark ignition engine was originally developed by August Otto in Germany in 1876. Most of the reciprocating engines operate on a four-stroke five-event cycle. There are four strokes of the piston, two up and two down, for each engine operating cycle.

The basic power-developing components of typical SI engine are

i. The cylinder,
ii. The piston,
iii. The connecting rod,
iv. The crankshaft.

The cylinder has a smooth surface so that the piston, with the aid of piston rings and a lubricant, can create a seal by which no gas can escape between the piston and the cylinder walls [1]. The piston is connected to the crankshaft by means of a connecting rod so that reciprocating motion is converted to rotary motion by means of the connecting rod and crank assembly. The position of the working piston and the moving parts, which are mechanically connected to the piston, at the moment when the direction of its centre. There are two dead centers, viz., top dead centre (TDC) and bottom dead centre (BDC). The limit of travel to which the piston can move into is called TDC and the limit to which it moves in the opposite direction is called BDC. For each revolution of the crankshaft there are two strokes of the piston, one up and one down, assuming that the cylinder is in a vertical position.

2. OBJECTIVES OF MODIFICATION OF THE ENGINE

- To improve the performance of the engine.
- To increase the power output.
- To increase the thermal efficiency.
- To reduce the specific fuel consumption.

3. WORKING PRINCIPLE

The cycle of operation is completed in four strokes of the piston, such as suction, compression, expansion and exhaust.

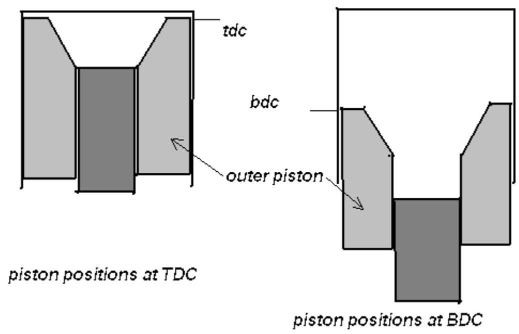


Fig.1 Piston position at TDC and BDC during suction stroke

3.1 SUCTION STROKE

It starts when the piston is at TDC, and about to move downwards. The inlet valve is in open position and the exhaust valve is in closed position. During this stroke, a charge of fresh fuel-air mixture is drawn into the cylinder. Fig.1 shows the pistons relative positions at the TDC and BDC difference in stroke length between the inner and outer piston will increase the amount of fresh charge intake by the system.

3.2 COMPRESSION STROKE

The fresh charge taken into the cylinder during the suction stroke is compressed by the return stroke of the piston. During the compression stroke, both inlet and exhaust valves remain closed.

During the 180°of crank rotation stroke length of the inner piston is Li and outer piston is Lo, Li > Lo. So, during the 180°of crank rotation inner piston travels more length than the outer piston. It might be possible when the speed of the inner piston is high [2]. This relative speed between the pistons will produce the air-swirl during the compression stroke. This air swirl will give the proper mixing of fuel-air mixture. This mixture is compressed into the clearance volume at the end of the stroke is ignited with the help of a spark. Fig1.5a shows the air-swirl produced inside the combustion chamber during the compression stroke.

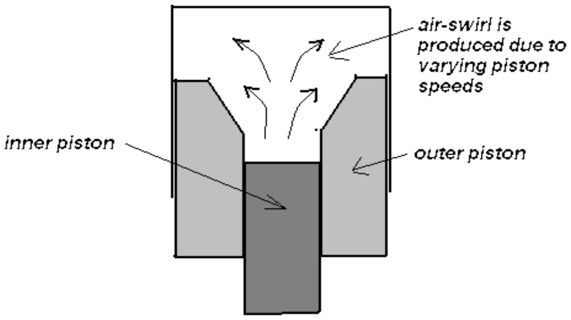


Fig.2 Air-swirl produced during the

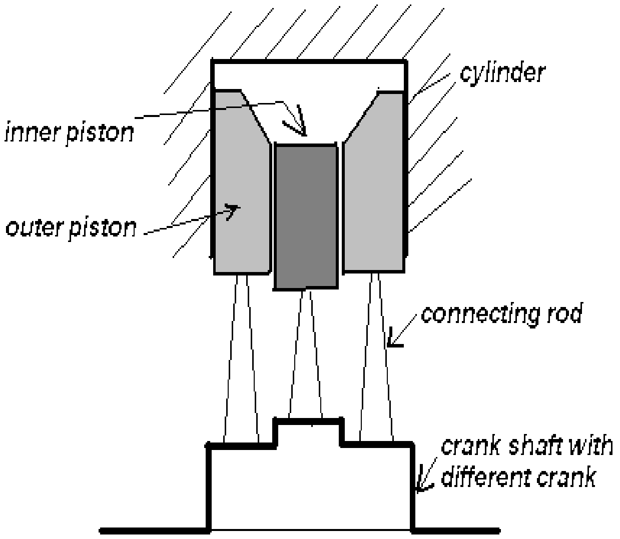


Fig.3 2-D Diagram of modified piston engine

3.3 EXPANSION STROKE

Due to the high pressure, the burnt gases force the piston towards bottom dead centre. During this stroke, both inlet and exhaust valves remain closed [5]. Conical area is the combustion space when the piston is at the TDC peak pressure developed after the combustion process was effectively used by the inner piston by redirecting the gas pressure to act at the smaller area. The inner piston is connected to the larger crank .it will produce the greater torque as compared with the existing engines. Fig.4 shows the flow of gas during the power stroke.

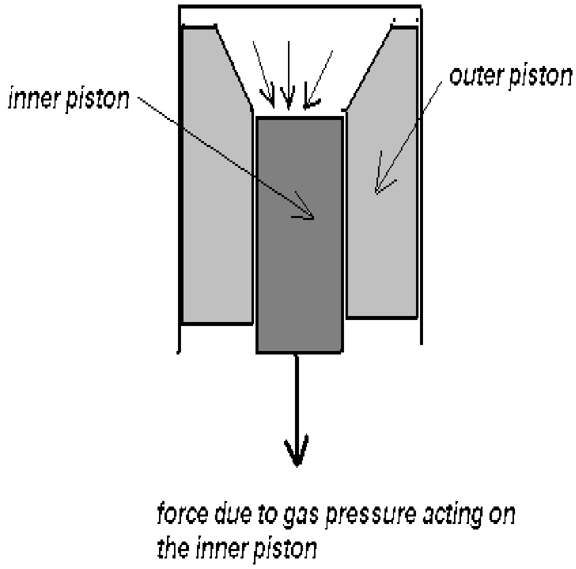


Fig.4 Flow of combustion products at the power stroke.

3.4 EXHAUST STROKE

At the end of expansion stroke, the exhaust valve opened. The piston moves from BDC to TDC and expels the burnt gases from the cylinder through the exhaust valve. The exhaust valve closes at the end of the exhaust stroke and some residual gases remain in the cylinder [3].

To validate this concept computer simulation has become a powerful tool in that it saves time and is also economical when compared to experimental study. A proposed theory can be analyzed quickly using a computer and the cost of setting up an experiment apparatus can be postponed until optimization is achieved.

4. CONCEPT OF NEW ENGINE

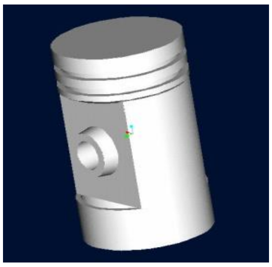
In this paper existing SI engine components are modified to improve the engine performance. Here the two pistons, namely inner solid piston and outer hollow piston, occupy the piston area of the existing engine.

Inner pistons having a flat crown surface; outer piston having the conical crown surface; these pistons are connecting to the crankshaft by the three connecting rods, one is connected to the solid piston and other two is connected to the outer pistons [4]. Crankshaft for this engine was designed such that it will produce the relative motion between the two pistons, this crankshaft consist of two different cranks with different radius.

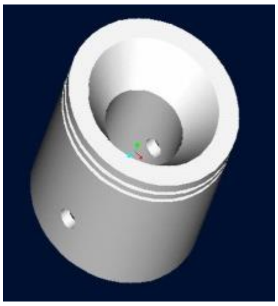
The middle crank having the greater crank radius than the outer cranks; Inner piston was connected to the middle crank and outer piston was connected to the outer crank.

4.1 COMPONENTS OF THE ENGINE

INNER PISTON

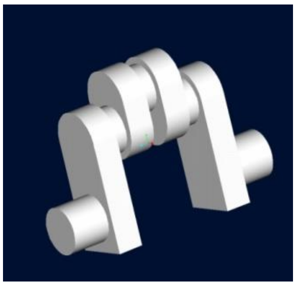


OUTER PISTON



CONNECTINGROD

CRANK SHAFT



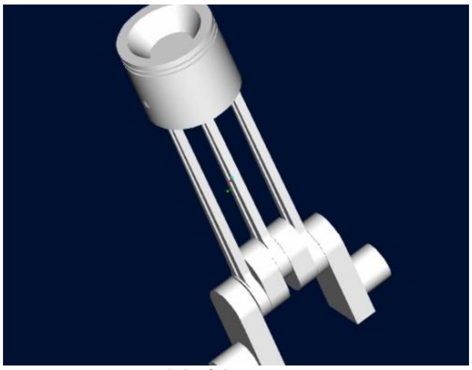


Fig. 5 3D Model of the Engine Components

5. IDEAL CYCLE SIMULATION

Simulation with air as the working medium is called ideal cycle simulation.

5.1 BASIC ASSUMPTIONS

- Air as the working medium.
- There is no intake and exhaust process.
- Heat addition takes place at constant volume and instantaneous.
- There is no heat transfer to the surroundings.
- There is no friction involved

5.2 IDEAL CYCLE SIMULATION RESULTS

Table: 1 Result Analysis of Ideal Cycle

	EXISTING ENGINE	MODIFIED DOUBLE PISTON ENGINE
VOLUME AT BDC	743.756CC	796.137CC
VOLUME AT TDC	82.713CC	84.78CC
PEAK PRESSURE DEVELOPED	86.589BAR	91.88BAR

5.3 ACTUAL CYCLE SIMULATION

Advanced simulation method include the following processes

- Gas exchange process.
- Heat transfer process.
- Friction calculations are included.

6. FUEL-AIR CYCLE SIMULATION

6.1 BASIC ASSUMPTION:

- Fuel-air mixture as the working medium.
- Intake process is taken into account.
- Combustion calculations are constant volume adiabatic combustion calculations.

6.2 TYPES:

1. Full throttle operation.
2. Part throttle operation.
3. Super charged operation.

6.3 FULL THROTTLE OPERATION RESULTS:

Table: 2 Result Analysis of Full Throttle

Output parameter	Standard engine	Modified piston engine	Increase in percentage
Thermal efficiency	44.52%	45.1247%	1.358%
Indicated mean effective pressure (bar)	14.92	15.127	1.387%
Power(kw)	32.885	35.89	9.137%

7. ENGINE SPECIFICATION

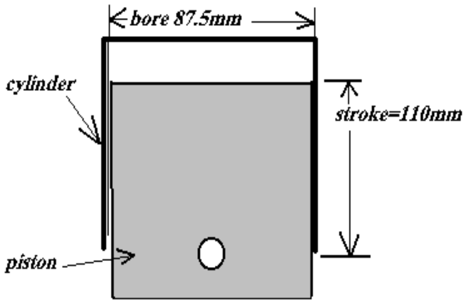


Fig.6 Representation of the Existing Engine

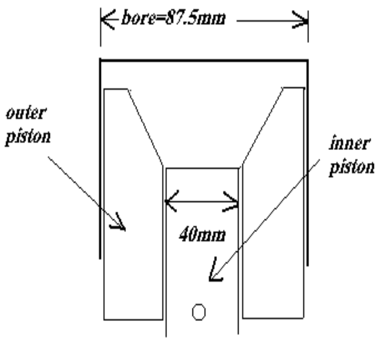


Fig.7 Representation of the modified Double Piston Engine.

Table: 3 shows the details of the Existing Kirloskar Engine for simulation

B	Bore	87.5mm
S	Stroke	110mm
L	Connecting rod length	230mm
R	Compression ratio	8.99
V_{dis}	Displacement volume	661.043cc
V_{TDC}	Volume at TDC	82.713cc
V_{BDC}	Volume at BDC	743.756cc

To check the new concept, engine components of the existing engine is modified to adopt the new concept.

Table: 4 Details of the modified engine for simulation

D_i	Diameter of inner piston	40mm
Max D_0	Max diameter of outer piston	87.5mm
Min D_i	Min diameter of outer piston	40mm
L_i	Connecting rod length of inner piston	210mm
L_0	Connecting rod length of outer piston	230mm
R	Compression ratio	9.39
V_{dis}	Displacement volume	711.857cc
V_{TDC}	Volume at TDC	84.78cc
V_{BDC}	Volume at BDC	796.637cc

8. FINAL RESULTS COMPANRISON:

Table: 5 Comparison Results

	Friction Power(kw)	Bmep(bar)	Brake Power(kw)	Mechanical efficiency
Standard engine	4.15	4.68	10.31	71.278%
Modified engine	4.8	5.62	13.33	73.53%

9. COMPARISION GRAPH:

Fig.8 VOLUME Vs CRANK ANGLE

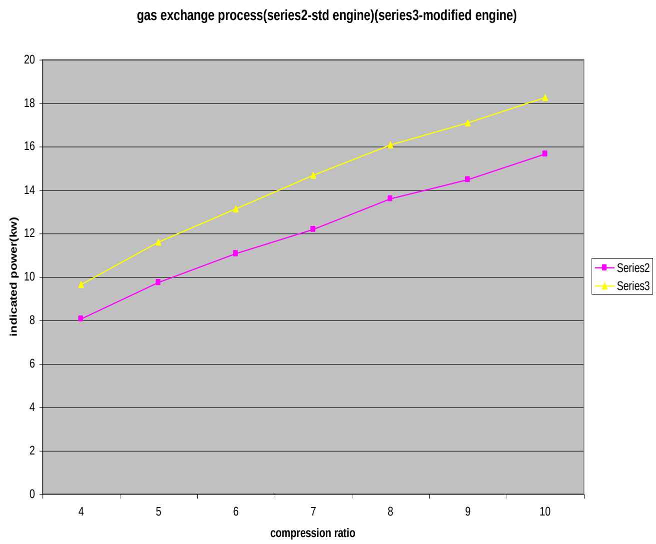


Fig.9 POWER Vs COMPRESION RATIO

10. CONCLUSION

A detailed step by step simulation process conclude that the overall performance characteristics of the modified double piston engine is better than the existing engine at different operating conditions. This shows that the modified double piston engine is practically feasible and definitely it gives the better performance over the existing engines.

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