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PERFORMANCE EVALUATION OF A SINGLE CYLINDER FOUR STROKE PETROL ENGINE

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ABSTRACT

A research study on evaluation of performance of a single cylinder four stroke otto engine was conducted in the Lab. of Farm Power and Machinery, Sindh Agriculture University, Tandojam. The actual size of engine parameters like bore, stroke, swept volume, clearance volume, compression ratio and r.p.m. were recorded and computed.

Based on the actual size of the engine parameters the indicated horse power (ihp), brake horse power (bhp) and friction horse power (fhp) was determined and were found to be 1.54, 1.29 and 0.25, respectively. The mechanical efficiency and thermal efficiency was also calculated and were found to be 83% and 20.5%, respectively. The fuel consumption per hour was found to be 0.8 liter/hour while the fuel consumption per distance traveled was found to be 60 km/liter.

Keywords: engine, petrol, single cylinder, performance, efficiency.

INTRODUCTION

Performance evaluation of automotive engines is of great importance for their economic operation. The method or criteria for assessing the engine performance include the determination of engine power, engine efficiency, fuel consumption, considering the engine stroke, engine speed, mean effective pressure and bore- all of these affect the horse power, engine efficiency and its performance.

Jones (1980) explained the efficiency of engine which means obtaining the greatest possible power with lowest possible fuel cost or lowest fuel consumption. The actual fuel consumption of engine is usually expressed in pounds per hour power horse or in horse power hours per gallon. The total fuel consumption varies according to size. The power generated and the length of time of operation. When reduced to bases of pound per horse power-hour. The fuel consumption of two entirely different size and type may be very nearly same.

He further reported that fuel consumption of all petrol engine like automobiles, trucks and tractor engine is about same when reduced to the basis of pounds per horse power-hour, provided they all operated under one half to full load, such engines seldom burn less then 0.55 lb/hp. hr. The average is around 0.60 lb and the rate may run as high as 0.70 lb. Diesel type and similar high compression engine show fuel consumption of 0.4 to 0.5 lb. hp-hr and seldom use more than 0.55 lb. Further he pointed that for a certain type of engine, burning a given fuel the most important factor affecting its economical and efficient operation are:

1. Normal operating compression pressure.
2. Operating load-light, medium, heavy.
3. Mechanical conditions.
   a) Ignition correctly timed.
   b) Valves correctly timed and set.
   c) Fuel mixture properly adjusted.
   d) Pistons' rings and cylinders not badly worn.
   e) Bearings properly adjusted.
   f) Proper lubrications.

Webster (1981) explained that the measurements of engine size were concerned with an engine bore, stroke displacement and the compression ratio. These measurements determined how much power an engine could develop. The amount of power an engine actually developed is specified in terms of performance measurement called the horse power. Further he added that the concept of horse power was based upon a number of scientific principal evaluation and measurement.

Boldwin (1983) performed test on compression ignition tractor engine using fuel mixture No.2 diesel fuel oil and fully refined soybean oil. The object of study was to determine the effect of altered ignition timing on the performance of compression ignition (CI) engine. He reported that the possible modification that may improve engine performance was altered injection timing. Questing the results of previous tests that the addition of soy oil increased the ignition delay of injects fuel charge, although fuel burns more rapidly, he hypnotized that earlier injection would further increase the engines thermal efficiency by providing additional time for complete combustion of fuel. He reported that injection timing both advanced and retarded 3 deg from the manufacture settings increased thermal efficiency at part load with advanced injection timings.

Banga (1987) suggested that for evaluating and testing the performance of engine the following parameters must be considered and measured:

- Engine power-indicated horse power (ihp), brake horsepower (bhp) and friction horse power (fhp);

- Mechanical and thermal efficiency; and
- Fuel consumption.

The main objectives of this study were:

1. To study engine size including measurements of bore, stroke, displacement and compression ratio;
2. Measurement of power i.e. indicated horse power, brake horse power and frictional horse power;
3. Evaluating the efficiency of engine based on mechanical efficiency and thermal efficiency, considering the input energy supplied to the engine and the output energy delivered by the engine; and
4. Measurement of fuel consumption (liter per hour).

MATERIALS AND METHODS

Keeping in view the objectives of this study, a single cylinder four stroke cycle engine of motor cycle CD-70 (Model 1992) having following specifications was used:

- Bore = 4.7cm
- Stroke = 4.15cm
- Displacement = 72 cm^3

In order to measure various test parameters and specifications of different parts of the engine, following instruments were used:

- Vernier calliper
- Tachometer
- Cylinder dial gauge
- Compression tester
- Exhaust tester
- Tools (Spanners, screw drivers etc.)

Measurement of bore and stroke

Stroke is the distance traveled by piston from top dead centre to bottom dead centre. It was measured with vernier caliper. The bore was also measured with vernier caliper (inner diameter of cylinder). Readings were taken in triplicate.

Measurement of compression

Compression was measured by the compression gauge. The compression gauge was hold with a force in a hole in which spark plug was fixed. The engine was cranked mechanically and the pressure was noted from the pressure gauge.

Measurement of rpm (revolutions per minute)

A Tachometer was used for measuring r. p. m. The Tachometer wheel was pressed with the fly wheel of the engine and the readings were noted.

Test for fuel ratio

The exhaust tester was used to measure the air fuel ratio used to the engine. The exhaust pipe was fixed into the silencer of the engine and the wires were connected with the battery. The engine was started and the readings were taken on the gauge.

Measurement of fuel consumption

Oil tank of engine was filled with fuel. The engine was operated with average load for about one hour. The tank was again filled with the fuel. The fuel consumed in one hour was recorded.

RESULTS AND DISCUSSIONS

Engine tests

1. Bore = 4.6cm (actually measured)

Table-1. Stroke measurements.

Measurement of stroke		
S. No.	**Position**	**Remarks**
1.	4.1	Centre position
2.	4.175	Edge position
3.	4.150	Sides position
Total	12.425	
Mean	**4.14**	

2. Stroke = 4.14cm

3. Displacement or Swept volume = length of stroke x Area of cylinder

   When stroke = 4.14cm, bore = 4.6cm

   Displacement or Swept volume

   $= \frac{4.14 \times 3.14 \times (4.6)^2}{4}$

   $= 69\ cm^3$

4. Clearance volume: the clearance space was measured and noted as 4.5cm in diameter and 1.6cm high in centre and was segment in its structure.

   The volume of segment = $\frac{3.14}{6} \times h^2\ (3d-2h)$ where

d = distance of dia of circle and h = height of the segment.

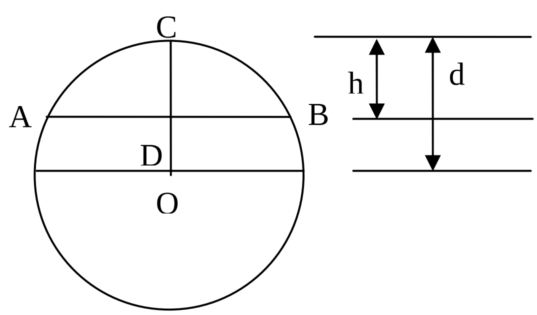

Figure-1. Dimension of cylinder head segment ABC for clearance volume.

ABC is a segment of circle.
The clearance volume is segment of circle. So, the volume of segment = $\frac{3.14 \times h^2 \times (3d - 2h)}{6}$

h = 1.8cm
d = 2.9cm
Segment = $\frac{3.14 \times (1.8)^2 \times 3(2.9) - 2(1.8)}{6}$

= 8.64 cm^3 or 8 cm^3

5. R. P. M: The rpm was measured by mechanical tachometer on various fuel supply positions to the engine, the results are shown in Table-2.

Table-2. R.P.M. on various positions of fuel supply.

S. No	Idling position A	Intermediate position B	Fuel throttle position C
1.	990	1120	1200
2.	1000	1130	1150
3.	1010	1140	1160
Total	3000	3390	3510
Mean	**1000**	**1130**	**1170**

A + B + C
1000 + 1130 + 1170 = $\frac{3300}{3}$ = 1100 r. p. m.

Compression test

The compression of the cylinder was measured by using compression tester model 2502. Readings at various positions of fuel supply throttle was recorded (Table-3).

Table-3. Compression of different positions of throttle opening fuel in cylinder.

#	Idling position A	Intermediate position B	Maximum position C
1.	67	68	70
2.	71	71	71
3.	72	71	69
Total	210	210	210
Mean	**70**	**70**	**70**

A + B + C
70 + 70 + 70 = $\frac{210}{3}$ = 70 lb/ in^2
Compression = 70 lb/ $inch^2$

Exhaust gas test

The exhaust test was measured by portable exhaust analyzer model 4089. The tester was showing fuel mixture rich to lean grades 8-16, air fuel ratio 11-16. The results are given in the Table-4.

Table-4. Exhaust gas test.

S. No.	Air fuel ratio	Condition of mixture
1.	13.9 :1	Slightly rich
2.	14: 1	Approaching ideal
3.	14: 1	Approaching ideal
Total	41: 90	
Mean	**14: 1**	

Fuel consumption test

0.8 liters filled after one hour running of engine.

Indicated horse power

Indicated horse power = $\frac{P \times L \times A \times N}{33000 \times 2}$

Where
P = Indicated mean effective pressure ibs/$inch^2$
L = Length of stroke in feet/meter
A = Area of cross section of cylinder cm^2/$inch^2$
N = No. of revolution per minute
P = 70 ib/$inch^2$
L = 4.14cm = 0.13 feet
A = $Bore^2$ x 3.14
Bore = 4.6 cm = 1.8 inch
A = $(1.8)^2$ x 3.14
A = 10.17 $inch^2$
N = 1100 r. p. m

Indicated horsepower = $\frac{P \times L \times A \times N}{33000 \times 2}$

$= \frac{70 \times 0.13 \times 10.17 \times 1100}{33000 \times 2}$

ihp = 1.54

Brake horsepower

According to Royal Automobile Club formula, the formula takes no account of engine stroke, engine speed, nor the mean effective pressure, all of which affect the horsepower. But at that time for common speed, pressure and stroke, Bore ratios the formula was responsibly accurate.

$$\text{bhp} = \frac{D^2 \times n}{2.5}$$

D = Dia. of cylinder in inches = 1.8 inches
n = no. of cylinder = 1 one

$$\text{bhp} = \frac{(1.8)^2 \times 1}{2.5} = 1.29$$

bhp = 1.29

Mechanical efficiency

$$\text{Mechanical efficiency} = \frac{\text{bhp}}{\text{ihp}} \times 100$$

$$= \frac{1.29}{1.54} \times 100 = 83\%$$

Thermal efficiency

$$\text{Thermal efficiency} = \frac{\text{bhp}}{\text{Power value of fuel}} \times 100$$

$$= \frac{\text{out put}}{\text{input}} \times 100$$

A gallon of gasoline = 6.2 lbs
1 gallon = 4 liters
1 liter = 1.55 lbs
1lb of gasoline = 20,000 Btu
1 horsepower hour = 2545 Btu
1 horsepower = 33000 ft-lb/minute
1 Btu = 778 ft lb

$$1 \text{ hp} = \frac{33000}{778} = 42.\ 42 \text{ Btu/minute}$$

1hp hour = 42.42 x 60 = 2542 Btu

$$\text{Thermal efficiency} = \frac{\text{out put}}{\text{input}} \times 100$$

Engine consumed 0.8 liter of gasoline in one hour (input)
0.8 x 20,000 = 16000Btu

$$\text{Thermal Efficiency} = \frac{\text{bhp} \times 2545}{16000} \times 100$$

$$= \frac{1.29 \times 2545}{16000} \times 100$$

= 20.5%

Compression ratio

The compression ratio of the engine is the ratio of the cylinder volume existing when the piston is on bottom or crank dead centre and volumes remaining above the piston when it reaches top are head dead centre.

Total volume = Swept volume + clearance volume
= 69 cm^3 + 8 cm^2
= 77 cm^3

$$\text{Compression ratio} = \frac{\text{Total volume}}{\text{Clearance volume}}$$

$$= \frac{77}{8} = 9.6$$

= 9.6: 1
Or 10: 1

DISCUSSIONS

Bore, stroke and displacement

According to the workshop manual of Honda CD-70 the rated bore was 4.7cm, stroke 4.15cm and displacement was 72cm^3 where as the measured parameters were bore 4.6cm, stroke 4.14cm and displacement was 69cm^3. The measured parameters are normally equal to given parameters. This little difference was due to the re-boring of cylinder and replacing of sleeves.

Compression ratio

The compression ratio for gasoline engine is suggested at the range of 8.5: 1 to 10.5: 1. The compression ratio of tested engine was calculated 10: 1, the calculated compression ratio falls in the recommend range. So, the compression ratio of the tested engine is satisfactory.

Engine efficiencies

a. Mechanical efficiency

It is recommended that the mechanical efficiency of an internal combustion engine may vary from 75 to 90 percent; the efficiency of tested engine was 83%. The result comes in recommended range and the mechanical efficiency of the engine is satisfactory.

b. Thermal efficiency

The recommended thermal efficiency of an internal combustion engine varies from 15 to 35 percent. The thermal efficiency of the tested engine was 20.5% which is in the normal range and is satisfactory.

Fuel consumption

The fuel consumption was measured and noted. One liter fuel consumed covered around 60 kilometer distance. The service manual of Honda Motor bike recommended 70 km/liter. The fuel consumed was also very near to the recommended consumption but the difference was due to the adjustments of parts like carburetor and point.

Fuel mixture ratio

In case of gasoline engines the proper fuel mixture ratio is about 15: 1. The result of fuel mixture was noted 14: 1 which is very near to the recommended ratio. This shows that fuel mixture of the engine is up to the mark.

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CONCLUSIONS

From the results and discussions, it was concluded that the tested four stroke cycle otto engine compared with its original specifications show generally same results but following dimensions are varying at certain level:

1. The calculated bore was 4.6cm and the original bore was 4.7cm. The calculated displacement was 69 cm^3. Its original displacement was 72 cm^3. The calculated dimensions are smaller than its original dimensions because engine was used for the last six years and sleeves were fixed into its cylinder whose bore was 4.6cm.
2. The result of fuel consumption quoted by manufacturer and given in its original booklet was 70 km/liter where as the calculated fuel consumption was found to be 60 km/liter.
3. The calculated fuel mixture was about 14: 1 and recommended was 15: 1 in the calculated mixture ratio. The amount of air was supplied less in quantity.
4. The other remaining dimensions like stroke, compression, compression ratio, thermal efficiency and mechanical efficiency are equal to the recommended parameters.

SUGGESTIONS

Only few dimensions are varying from its original parameters like bore, displacement, r. p. m, fuel consumption and fuel mixture ratio. It may be due to that some parts are not adjusted properly and some of them are not working properly.

The following suggestions are given to improve the proper functioning of the engine and improving the performance of the engine.

1. The engine may be tuned up and the parts may be adjusted like valves, contact point and spark plug.
2. For the supply of correct fuel mixture, the carburetor and its parts may be cleaned. The jets, nozzles and needles valve may be checked and adjusted. If any part is older than new part may be fitted.
3. The proper discharge of exhaust gases also affects the performance of the engine. The silencer may be dismantled, cleaned adjusted and fixed properly.
4. The occurrence of spark at proper time also affects the performance of the engine. So, the timing of the spark may be checked and adjusted properly.
5. The air cleaner may be checked and cleaned for proper supply of clean air.

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