Experimental Investigation on Variable Compression Ratio S.I. Engine

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***Abstract*— Need of improving the performance characteristics of the gasoline engine has necessitated the present research. Increasing the compression ratio below detonating values to improve on the performance is an option. The compression ratio is a factor that influences the performance characteristics of internal combustion engines. This work is an experimental and theoretical investigation of the influence of the compression ratio on the brake power, brake thermal efficiency, brake mean effective pressure and specific fuel consumption of the variable compression ratio spark ignition engine. Compression ratios of 8.23, 9.3 and 10.7, and engine speeds of 1000 to 3500 rpm, in increments of 500 rpm, were utilized.**

The maximum compression ratio corresponding to maximum brake power, brake thermal efficiency, brake mean effective pressure and lowest specific fuel consumption is 10.7.The theoretical values were compared with experimental values.

***Index Terms*— Compression ratio, brake power, brake thermal efficiency, specific fuel consumption, brake mean effective pressure.**

I. INTRODUCTION

Improving internal combustion (IC) engine efficiency is a prime concern today. A lot of engineering research has gone into the improvement of the thermal efficiency of the (IC) engines, so as to get more work from the same amount of fuel burnt. Of the energy present in the combustion chamber only a portion gets converted to useful output power. Most of the energy produced by these engines is wasted as heat. In addition to friction losses and losses to the exhaust, there are other operating performance parameters that affect the thermal efficiency. Compression ratio is the ratio of the total volume of the combustion chamber when the piston is at the bottom dead centre to the total volume of the combustion chamber when piston is at the top dead centre. Theoretically, increasing the compression ratio of an engine can improve the thermal efficiency of the engine by producing more power output. The ideal theoretical cycle, the Otto cycle, upon which spark ignition (SI) engines are based, has a thermal efficiency, which increases with compression ratio.

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The concept of variable compression ratio (VCR) promises improved engine performance, efficiency and reduced emissions. The higher cylinder pressures and temperatures during the early part of combustion and small residual gas fraction owing to higher compression ratio give faster laminar flame Speed. Therefore, the ignition delay period is shorter. As a result, at low loads, the greater the compression ratio, the shorter is the combustion time. Time loss is subsequently reduced. Therefore, it seems reasonable that fuel consumption rate is lower with high compression ratios at part load.

II. CONCEPT

Historically, every mechanical element in the power conversion system has been considered as a means to achieve variable compression. No attempt is made here to present an exhaustive listing but examples of the main concepts appear below.

Modify the compression ratio by:

- Cutting the cylinder blocks head
- variation of combustion chamber volume
- variation of piston deck height
- modification of connecting rod geometry (usually by means of some intermediate member)
- moving the crankpin within the crankshaft (effectively varying the stroke)
- moving the crankshaft axis
- Varying the length of connecting rod.

In this case, we have cut the cylinder block by 1 mm and got the positive result in output as compared to the actual system.

III. PROBLEM DEFINITION

In present two stroke SI engine of scooter more problems regarding the fuel consumption, emission and less thermal efficiency are there. This is the need of present world to improved engine performance, efficiency, and reduced emissions. To save the environment, to be economical in automobile and to maintain the healthy life of mankind these problems from the exhaust emission and more fuel consumption the alternate method should be taken to save these things. The VCR is the technique to avoid such problems and to save the environment as well as the money of human being.

IV. EXPERIMENTAL SETUP

Fig: 4.1 Experimental setup

The selected engine is a Single Cylinder Two Stroke, 150 cc. A rope brake dynamometer which consists of rope, two spring balances as shown in the fig is used for loading the engine to measure brake power. The air flow is measured with the help of Air box, which pressure is measured with the help of U-Tube manometer, mounted itself on the air box. The fuel measurement is taken with the help of Burette which is calibrated.

Table 4.2: Engine specification

TECHNICAL SPECIFICATIONS OF BAJAJ CHETAK ENGINE-		
PERFORMANCE		
Peak power	7.5 bhp / 5.93 kW @ 5500 rpm	Highest power amongst 2-stroke scooters
Peak torque	10.8 N-m @ 3500 rpm	Instantaneous pick-up
ENGINE		
Type	2-stroke with reed valve induction	Advanced engine for superior performance
Transmission	4-Speed gear box	Smooth easy shifting
Clutch	Wet multi-disc type	
Operating cycle	Two-stroke spark ignition, 145.45 cc engine	
Compression ratio	6-10	
Bore	0.057 m	
Stroke/bore ratio	1	
Max rated BMEP	4-10 Atm.	
Wt/power ratio	5.5-2.5	
Approx. Best bsfc	350 (gm/kW hr)	

V. TEST PROCEDURE

1] Start the engine by cranking the kick provided for cranking.
2] After engine is started adjust burette reading up to 25ml fuel level.
3] Then close the tank fuel valve and open burette valve & adjust the RPM of engine as per required.
4] Note down the load from spring balance & mass of fuel consumed from burette.
5] Note down the manometer reading from u-tube manometer.
6] Note down the different readings on different speeds and loads from the same procedure.

7] Assembled the gasket of decrease in length by 1mm and note down the readings via the same procedure listed above.

8] Assembled the cut cylinder block of decrease in length by 1mm and note down readings via same procedure listed above.

VI. GRAPHS

GRAPHS REPRESENTING RELATIONSHIPS BETWEEN SPEED VS. MASS OF FUEL AT VARYING LOADS.

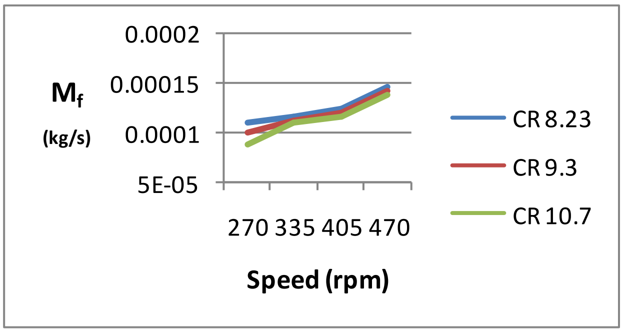

FIGURE 6.1:- SPEED Vs M_f AT NO LOAD

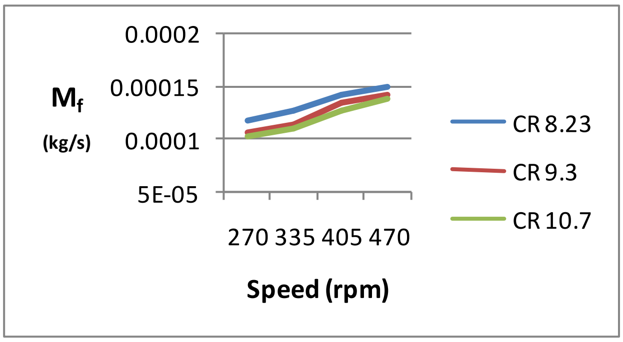

FIGURE 6.2:- SPEED Vs M_f AT LOAD=4 kg

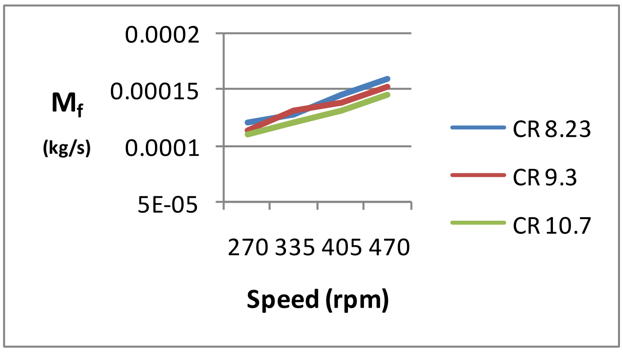

FIGURE 6.3:- SPEED Vs M_f AT LOAD=7 kg

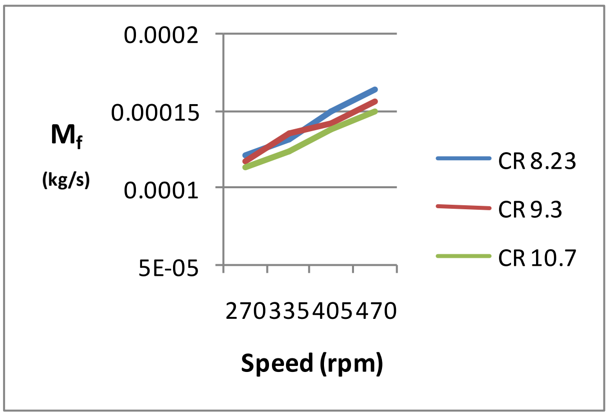

FIGURE 6.4:- SPEED Vs M_f AT LOAD=10 kg

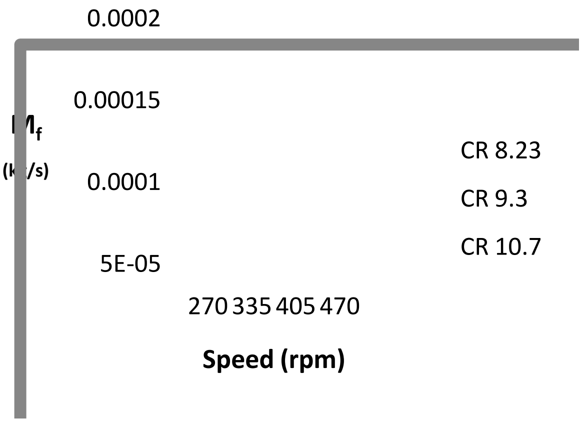

FIGURE 6.5:- SPEED Vs M_f AT LOAD=13 kg

From Fig. 7.6 to 7.10 it is observed that as Speed increases, the mass of fuel consumption also increases (This is due to at low Speed the heat loss to the combustion chamber wall is proportionally greater and combustion efficiency is poorer resulting higher fuel consumption produced).

The reason behind this is as Speed increases, the piston has to travel at faster Speed and suction increases and acceleration increases. So the fuel port opens at faster rate to maintain proper air – fuel ratio.

As Speed increases engine have to maintain the proper air-fuel ratio and for this engine requires rich mixture of air and fuel.

GRAPHS REPRESENTING RELATIONSHIPS BETWEEN SPEED VS. MASS OF AIR AT VARYING LOADS.

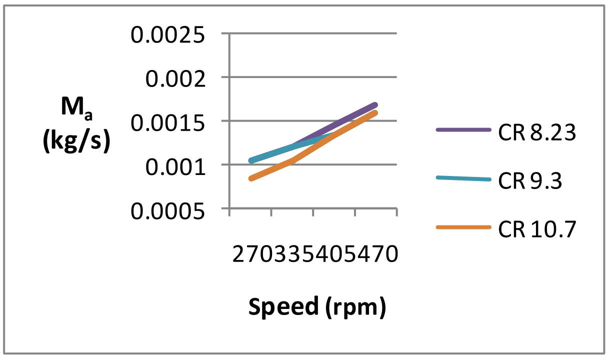

FIGURE 6.6:- SPEED Vs M_a AT NO LOAD

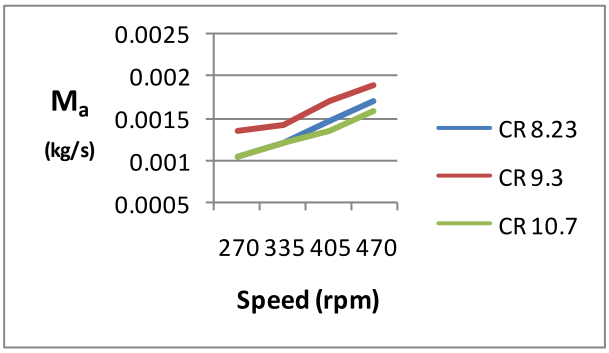

FIGURE 6.7:- SPEED Vs M_a AT LOAD=4 kg

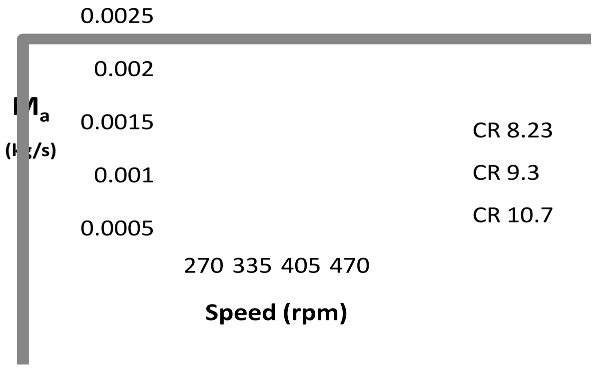

FIGURE 6.8:- SPEED Vs M_a AT LOAD=7 kg

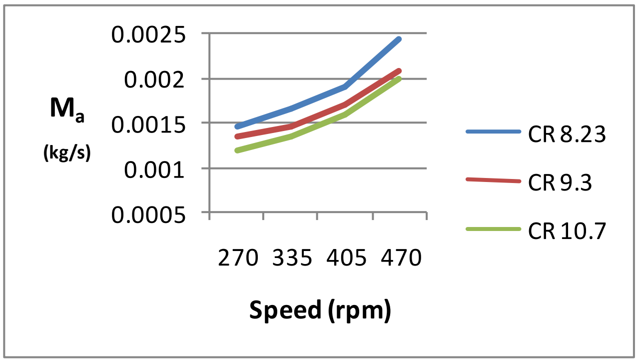

FIGURE 6.9:- SPEED Vs M_a AT LOAD=10 kg

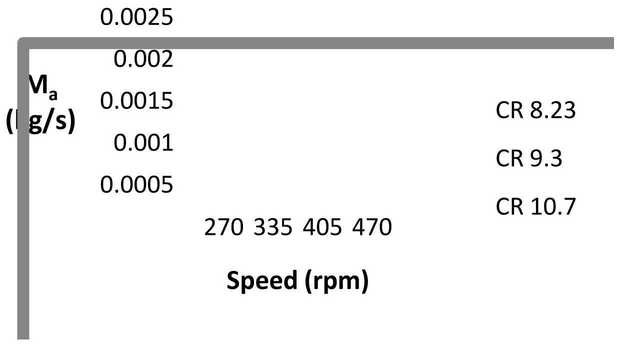

FIGURE 6.10:- SPEED Vs M_a AT LOAD=13 kg.

Increase in air consumption means that increased quantity of fuel can be added per unit time increasing power output. In fact IP is directly proportional to engine air consumption.

From Fig. 7.1 to 7.5 it is seen that as Speed increases it results in increase in mass of air consumption. Reason for this is increase in Speed directly results in more rotation of crank shaft that is piston has to travel at more Speed. Suction increases as the rotation of crankshaft increases and to maintain proper air-fuel ratio mass of air consumption increases.

GRAPHS REPRESENTING RELATIONSHIPS BETWEEN SPEED VS. BRAKE POWER AT VARYING LOADS.

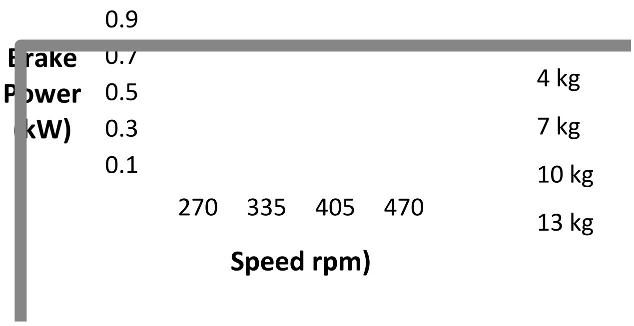

FIGURE 6.11:- SPEED Vs BP

It is seen that engine brake power increases as the compression ratio increases. This due to the increases in brake torque at high compression ratio increases in compression ratio induces greater turning effect on the cylinder crank that mean engine is giving more push on piston and more torque is generated. Fig. 7.26 shows that the engine torque is directly related to the brake power.

GRAPHS REPRESENTING RELATIONSHIPS BETWEEN SPEED VS. MASS OF AIR AT VARYING LOADS.

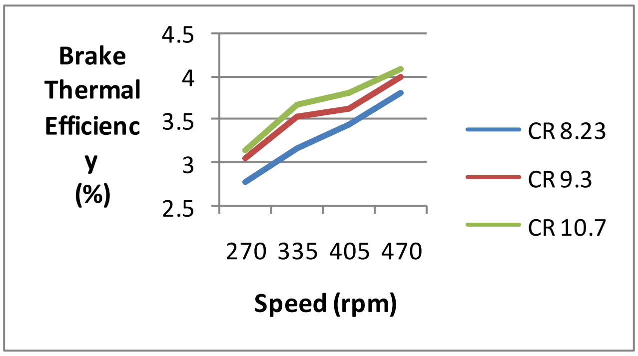

FIGURE 6.12:- SPEED Vs BRAKE THERMAL EFFICIENCY AT LOAD=4 kg

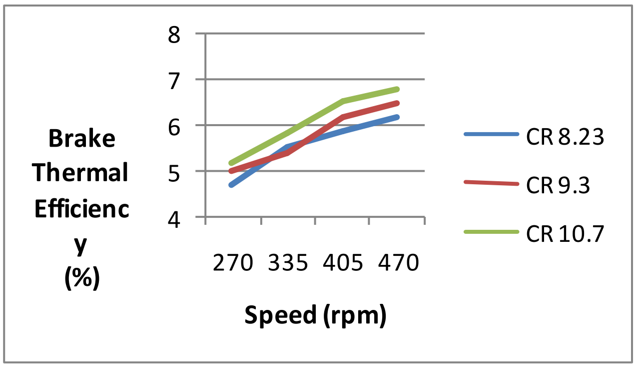

FIGURE 6.13:- SPEED Vs BRAKE THERMAL EFFICIENCY AT LOAD=7 kg

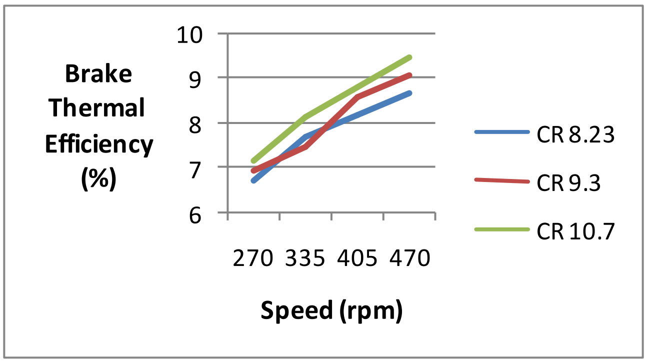

FIGURE 6.14:- SPEED Vs BRAKE THERMAL EFFICIENCY AT LOAD=10 kg

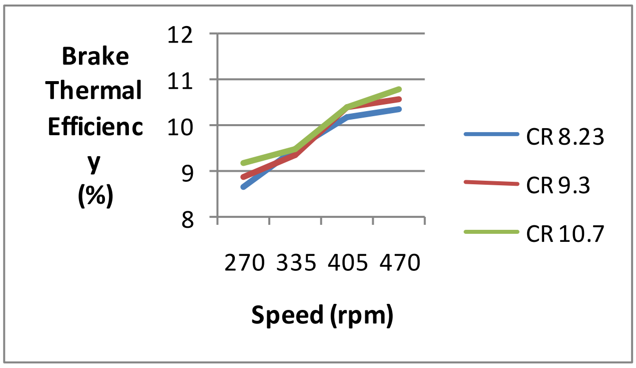

FIGURE 6.15:- SPEED Vs BRAKE THERMAL EFFICIENCY AT LOAD=13 kg

Maximum thermal efficiency occurred at C.R 10.7 by compressing the available air and fuel mixture into a smaller space with the heat of compression causes better mixing and evaporation of the fuel (see fig. 7.31 to 7.34). Greater combustion efficiency from increasing CR means that the combustion of fuel plays greater dividends by more energy release from the fuel. The net result is that increase in energy available is greater.

As the CR increases, the fuel mixture is sufficiently compressed thereby increasing the thermal efficiency, so that less fuel is required to produced same amount of energy .Fuel consumption is reduced at higher CR from 9.3 to 10.7.

VII. RESULT

[NOTE: '+' indicates **INCREMENT IN VALUES**, '-' indicates **DECREMENT IN VALUES**]

The following results obtained at load=13 kg

Table 7.1:- Comparison of M_f

Sr. No.	Speed (rpm)	M_f 10^{-4} (kg/s)	M_{f1} 10^{-4} (kg/s)	M_{f2} 10^{-4} (kg/s)	% Change M_f & M_{f1}	% Change M_f & M_{f2}	% Change M_{f1} & M_{f2}
1	270	1.209	1.244	1.173	-2.89	2.97	57.07
2	335	1.404	1.386	1.386	-1.28	1.28	0.00
3	405	1.529	1.564	1.529	-2.28	0.00	22.37
4	470	1.742	1.778	1.706	-2.06	2.06	40.49

Table 7.2:- Comparison of M_a

Sr. No.	Speed (rpm)	M_a 10^{-3} (kg/s)	M_{a1} 10^{-3} (kg/s)	M_{a2} 10^{-3} (kg/s)	% Change M_a & M_{a1}	% Change M_a & M_{a2}	% Change M_{a1} & M_{a2}
1	270	1.469	1.697	1.341	-15.52	8.71	20.97
2	335	1.697	1.897	1.587	-11.78	6.48	16.34
3	405	1.897	2.078	1.800	-9.54	5.11	13.37
4	470	2.245	2.323	1.990	-3.47	11.35	14.33

Table 7.3:- Comparison of η_{bth}

Sr. No.	Speed (rpm)	η_{bth} (%)	η_{bth1} (%)	η_{bth2} (%)	% Change η_{bth} & η_{bth1}	% Change η_{bth} & η_{bth2}	% Change η_{bth1} & η_{bth2}
1	270	8.89	8.64	9.16	2.81	-3.07	-6.01
2	335	9.36	9.41	9.48	-0.50	-1.28	-0.74
3	405	10.40	10.17	10.40	2.21	0.00	-2.26
4	470	10.58	10.37	10.81	1.98	-2.17	-4.24

Table 7.4:- Brake Power

From table 7.1 and 7.2 it is observed that mass of fuel and air consumption decreases for **CR 10.7**.
From table 7.3 it is observed that Thermal efficiency of **CR 10.7** is more as compared to **CR 8.23** and **CR 9.3**.
Table 7.4 shows the variation of Brake Power at different loads.

VIII. CONCLUSION

There is percentage change in the brake specific fuel consumption, brake thermal efficiency, mass of fuel consumed for different Speeds and loads as-

Percentage change in mass of fuel consumed on an average between **CR 9.3 & CR 8.23 = 2.13%**
Percentage change in mass of fuel consumed on an average between **CR 9.3 & CR 10.7 = 1.58%**

Percentage change in mass of fuel consumed on an average

Sr. No.	SPEED (rpm)	BRAKE POWER (kW)			
		AT 4 Kg	AT 7 Kg	AT 10 Kg	AT 13 Kg
1	270	0.138	0.243	0.346	0.451
2	335	0.172	0.301	0.430	0.559
3	405	0.208	0.364	0.520	0.676
4	470	0.242	0.422	0.603	0.784

between **CR 8.23 & CR 10.7 = 29.98%**
Percentage change in mass of air consumed on an average between **CR 9.3 & CR 8.23 = 10.08%**
Percentage change in mass of air consumed on an average between **CR 9.3 & CR 10.7 = 7.91%**
Percentage change in mass of air consumed on an average between **CR 8.23 & CR 10.7 = 16.25%**
Percentage change in brake thermal efficiency on an average between **CR 9.3 & CR 8.23 = 1.88%**
Percentage change in brake thermal efficiency on an average between **CR 9.3 & CR 10.7 = 1.63%**
Percentage change in brake thermal efficiency on an average between **CR 8.23 & CR 10.7 = 3.31%**

APPENDIX

CALCULATIONS OF MASS OF FUEL CONSUMED:-

$$M_f = \frac{mf \times \rho f}{1000 \times t}$$

BRAKE POWER:-

$$BP = 2\pi NT/ (60\times1000)\ (kW)$$

Where-

TORQUE, T = 9.81 × F × r

r = Radius of drum of wheel.

= 0.125

BRAKE THERMAL EFFICIENCY CALCULATION:-

$$\eta_{bth} = BP / (M_f \times CV)$$

Where-

CV = 42500 kJ/kg

BP = Brake Power

M_f = Mass of fuel consumed.

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