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PERFORMANCE ENHANCEMENT OF 4-STROKE SINGLE CYLINDER SI ENGINE BY VARYING INTAKE LENGTH

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Abstract - This research paper shows the effect of intake length in the engine parameters like power, torque, and volumetric efficiency of the vehicle. The vehicle we have used was bajaj discover 125st 2012 model. As we know that there is a pipe between engine and carburetor from which air fuel mixture is fed into combustion chamber. In conventional engines this length between engine and carburetor is kept fixed, this leads to a highest torque at single RPM .By varying this length there is an increase of torque and many other engine parameters. To know whether by varying length these engine parameters increases or not we have done calculations by using Chrysler ram theory and Helmholtz resonator theory. After calculating length from both the theories, we have done simulation on Lotus engine simulator to get the desired lengths for maximum torque at every 1000 rpm .After simulation we got the desired results that showed there is an increase in volumetric efficiency and decrease in BSFC (brake specific fuel consumption) and other engine parameters are also enhanced like torque, brake power. The test results shows that for low engine speeds the intake length must be large and as the speed increases the length must be shortened.

Key Words: Intake length , Engine simulation , Lotus engine simulator , volumetric efficiency.

1. INTRODUCTION

The varying length intake manifold length is to change the intake manifold length at every rpm of engine. The length of intake manifold is having key role in deciding volumetric efficiency of engine. This increases in getting optimum mileage, torque and power due to which it reduces the carbon emission. Due to low carbon emission, it follows the latest norm condition.

The length of intake manifold was varied in simulation of the engine on the LOTUS simulation software. The simulation was done on Bajaj Discover 125 ST. In that simulation, the length of intake manifold was varied at every 1000 rpm and the result are as shown in later section. The main aim is to get the knowledge of increase in performance of engine by varying it intake manifold length. Two main theories were adopted which are Chrysler Ram Theory and Helmholtz resonator theory. Both the theories explained the behavior of air-fuel mixture which is like sound wave propagation according to which perfect tuning can be done like matching of intake valve timing with the intake manifold length.

There is no vehicle which has perfectly achieved it. There are still researches going on. The main problem occurs is not proper tuning of pressure variation that occurs inside the pipe. The proper tuning gives optimum results of mileage, torque and power generation. The air-fuel mixture moving towards intake valve when valve is opened it is considered as positive and when air-fuel mixture is moving towards the valve during valve closing is considered as negative. The theories explain the right tuning gives proper results as it enhances the performance of the engine.

1.1 THEORY

The compression wave and a rare faction wave are two parts of a wave. To increase the volumetric efficiency we can make use of these waves thus the breathability of the engine increases. When the inlet valve closes the air fuel mixture gets collide with the valve and a compression wave is generated. If we properly tune the length of the intake manifold the pressure wave will get into the cylinder exactly at the opening of the inlet valve. This will increase the mass density of air entering the cylinder. Rarefaction is another part of the Wave or it can also be called as the suction wave. If we tune the inlet manifold accurately the rarefaction wave will get converted into the compression wave when the rarefaction wave collides with the inlet valve which results in compression of the rarefaction wave. If we change the length at different rpm according to the different theories stated we can get a volumetric efficiency greater than 100%. As the volumetric efficiency increases if we change the length at different rpm we will also get an enhanced result of torque ,bsfc ,bmep ,power As the length has to be changed at an interval of 1000 rpm we will use Chrysler ram theory and Helmholtz resonator theory to calculate the length at different rpm.

1.1.1 Chrysler Ram Theory

The air flow dynamics inside the inlet manifold is alike unless the inlet valve closes. When the intake valve closes the gas dynamics gets disturbed. This highly pressurized wave keeps on oscillating in the intake manifold unless the inlet valve opens, if we tune the inlet manifold length properly this highly pressurized wave will enter the cylinder when the inlet valve opens after oscillating in the inlet manifold

1.1.2 Helmholtz Resonator Theory

In this theory it is considered that the volume of air inside the intake manifold acts like a spring. Which means that as when force is applied on spring its get compressed and it expands on removal of force. Air also acts like a spring which gets compressed when the inlet valve closes and it gets expanded when the inlet valve opens. The air is considered as mass inside the combustion chamber. At mid stroke effective volume is considered to be the cylinder volume

2. LITERATURE REVIEW

Shannak B has explained that intake length between engine and carburetor plays an important role in enhancing the engine parameters like torque, brake power, volumetric efficiency etc. By varying this intake length we can see changes in engine performance. The amount of air fuel mixture is fed into combustion chamber through intake length and by increasing the length the air flow speed gets influenced by intake pipe cross sectional area. Tests were conducted on 4 stroke single cylinder DTSI engine with varying length for every 1000 rpm. The results obtained also includes there is an emission control by increasing pipe diameter which leads to decrease in unburned hydrocarbons (HC) and carbon monoxide (CO). It's not a new concept in the field of IC engine. This concept of varying intake length was first introduced by Mercedes 300sl in 1954, at that time too researches were done by engineers to tune intake length .Many researchers concluded that by proper design of intake manifold, the engine performance can been enhanced.[1]

Rodrigo caetano costa showed results from a 4 stroke, 4 cylinder, eight valve 1.0-1 engine tested on bench dynamometer fuelled with blend of 78% gasoline and 22 % ethanol. Tests were carried out in engine speed range from 1500 to 6500 rev/min. The results showed the effect of intake pipe length on air mass flow rate which further effects engine parameters. Results showed that, for lower engine speeds pipe with extended length and for higher engine speed with shortened length.[2]

Bayas Jagadihsingh G. Has explained the theories used in varying the length of intake manifold and has done the simulation in lotus engine simulation and has done experiment on kirloskar TV1, Single Cylinder 4 stroke CI engine and has shown the results in graphical manner and has concluded that volumetric efficiency, brake torque and brake power has enhanced using variable length at different rpm [3]

3. CALCULATIONS

As we conducted the simulation on bajaj discover 125st 2012 model the conventional intake length is 50mm which gives a maximum torque of 10.58 Nm at 7000 RPM

Table-1: Engine Parameters For Bajaj Discover 125st

Engine	4 stroke, single cylinder, air cooled
Bore × stroke	54.0 mm × 54.4 mm
Engine Displacement	124.6 cc
Compression Ratio	10.3
Idling speed	1400 ± 100 RPM
Max. Net Power	9.86KW at 9000 RPM
Max. Net Torque	10.58 Nm at 7000 RPM

Now we will calculate the lengths at different rpm by using the theories as stated above

Chrysler ram theory

Calculation For 2000 rpm

720^0-235^0=485^0 of crank rotation our intake valve remain closed.

At let's say 2000 rpm ,

2000/60=33.333 rev/sec

33.333 rev/sec*360^0 rev/sec =11999.88/ seconds.

$485^0/11999.88 = 0.040417$ seconds for compression wave to travel back to intake valve when it opens again.

0.040417 seconds * 343 m/s =13.8630 m.

This is the length which wave travels at speed of sound. Now wave has to travel rearward to intake valve so intake length becomes half because wave travels ascend & descend the intake which is 6.9315 m .Installing that much elongated intake is practically difficult so integer multiple (3,6,...12) of that length can be used without much affecting the perk of ram effect. So by taking integer multiple of length we get intake length of 1.25 m.

Similarly we calculated the for different rpm

Table-2: Lengths Of Chrysler Ram Theory

RPM	LENGTH (in meters)
2000	1.25
3000	0.77014
4000	0.577616
5000	0.46209
6000	0.38507
7000	0.33006
8000	0.28880
9000	0.25671

Helmholtz Resonator

$$N = \frac{13.5c}{k}\sqrt{\frac{A}{LVd}}\sqrt{\frac{CR-1}{CR+1}}$$

Where

N = Engine rotation per minute

C = speed of sound

K = constant (K = 2.6 for SI engine)

A = cross sectional area of inlet pipe

L = length of inlet pipe

V_D = swept volume

CR = compression ratio

Calculation for 2000 RPM

$$N = \frac{13.5c}{k}\sqrt{\frac{A}{LVd}}\sqrt{\frac{CR-1}{CR+1}}$$

$$2000 = \frac{13.5\,x\,340}{2.6}\sqrt{\frac{5.309\,x\,10\text{^}(-4)}{Lx\,124.6\,x\,10\text{^}(-6)}}\sqrt{\frac{10.3-1}{10.3+1}}$$

$$2000 = 1765.3846 \text{ x } \sqrt{\frac{4.2608}{L}} \text{ x } \sqrt{0.8230}$$

$$\frac{2000}{1765.3846} = \sqrt{\frac{4.2608}{L}} \text{ x } \sqrt{0.8230}$$

$$1.1329 = \sqrt{\frac{4.2608}{L}} \text{ x } \sqrt{0.8230}$$

Squaring both the sides we get

$$1.2834 = \frac{4.2608}{L} \text{ x } 0.8230$$

$$L = \frac{4.2608}{1.2834} \text{ x } 0.8230$$

$$L = 2.7323 \text{ M}$$

Similarly we calculated the lengths for different rpm

Table-3: Length Of Helmholtz Resonator Theory

RPM	LENGTH(in meters)
2000	2.7323
3000	1.2134
4000	0.6830
5000	0.4371

6000	0.3035
7000	0.2230
8000	0.1707
9000	0.1350

Now on the basis of the simulation results where we got the most appropriate results we selected that length

4. SIMULATION RESULTS

Engine simulation were carried on LOTUS ENGINE SIMULATION. Bajaj discover 125st engine was considered for this purpose and the results obtained are as follows

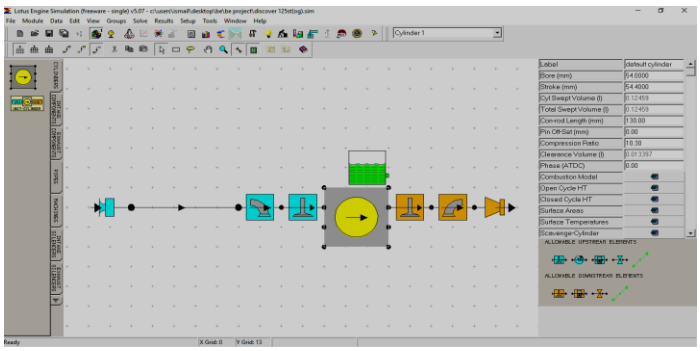

Fig-1: Engine Simulation

The graphs shown below represent the performance characteristics as follows

The brown line: power

The blue line: Torque

The green line brake specific fuel consumption (bsfc)

The red line : brake mean effective pressure (bmep)

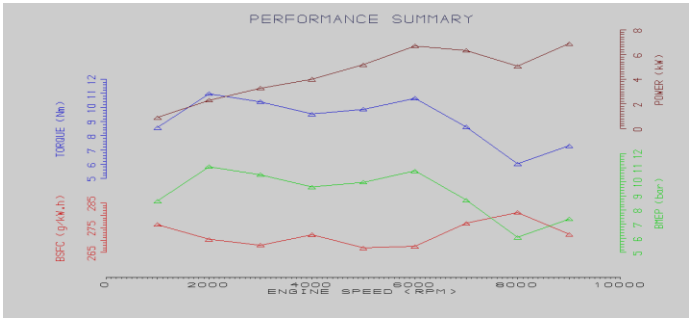

Fig-2: Graph for intake length 1250mm(2000rpm)

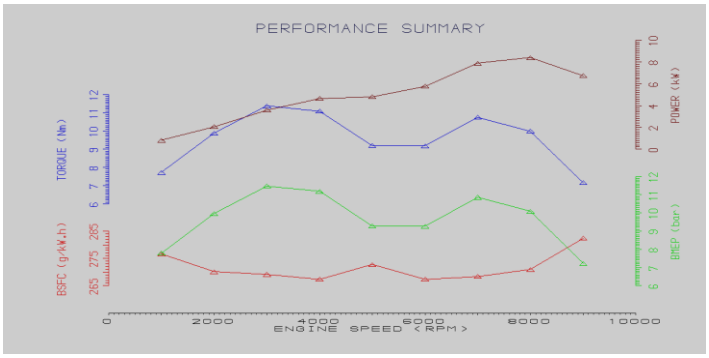

Fig-3: Graph for intake length 991.77mm(3000rpm)

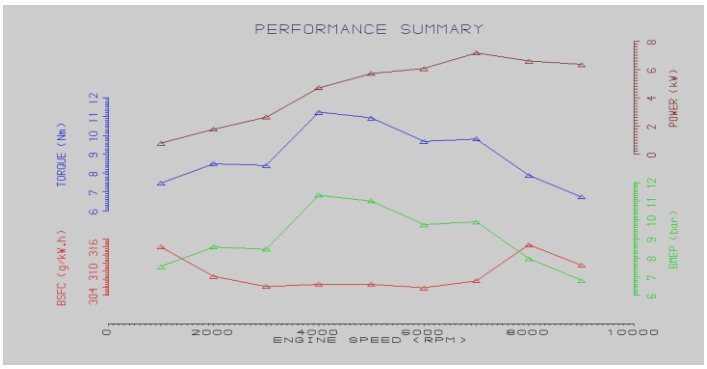

Fig-4: Graph for intake length 577.616mm(4000rpm)

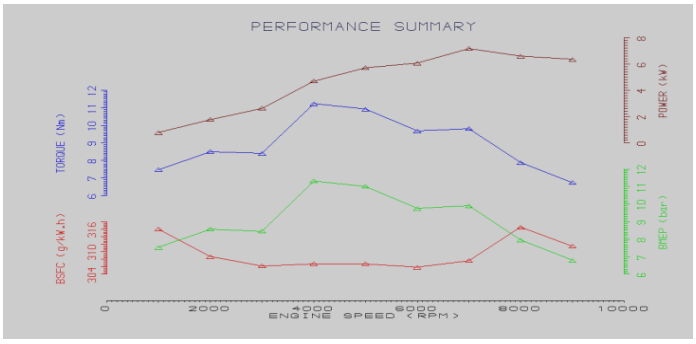

Fig-5: Graph for intake length 462.09(5000rpm)

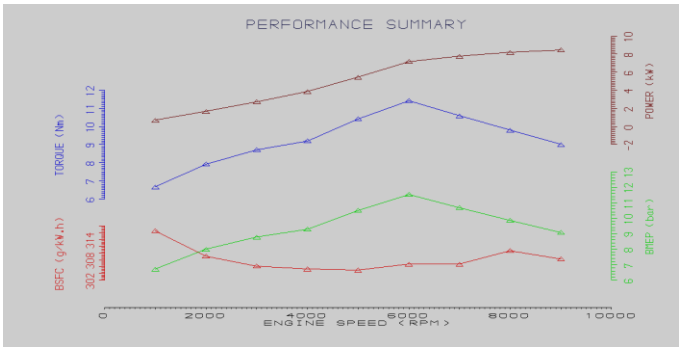

Fig-6: Graph for intake length 385.07mm(6000rpm)

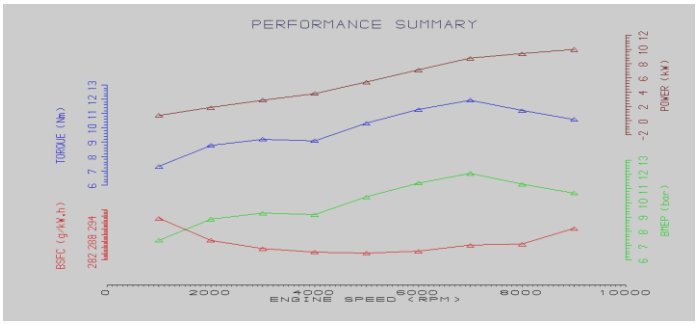

Fig-7: Graph for intake length 330.06mm(7000rpm)

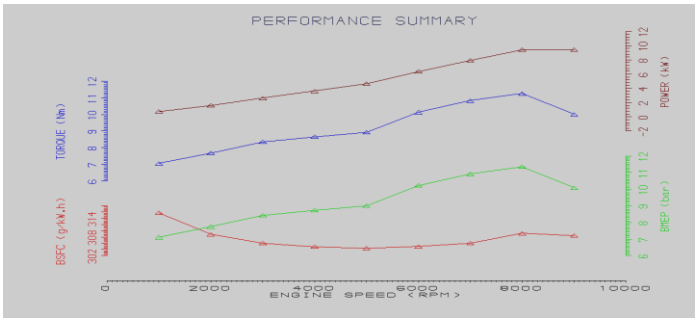

Fig-8: Graph for intake length 288.80mm(8000rpm)

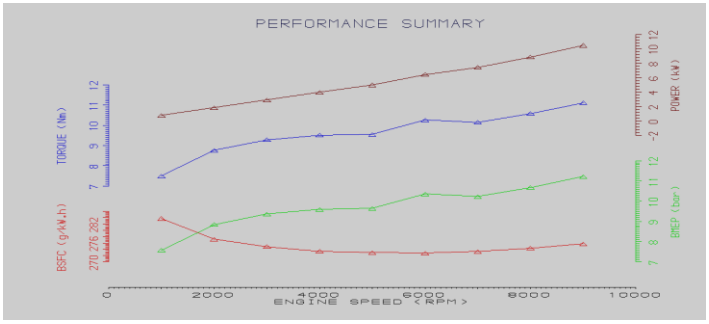

Fig-9: Graph for intake length 135.0mm(9000rpm)

Our interest is in blue line as that indicates the torque of the engine. As it can be seen from the above graphs at different rpm considering different lengths we got maximum torque at that particular rpm considering the calculated length

5. CONCLUSION

After performing simulation and practical there is increase in torque and power at different RPM. The intake manifold length is having key role in deciding the optimum volumetric efficiency region in the engines operating at different speed range. Hence, we can say that longer intake manifolds give higher torque at lower RPM and shorter intake manifold tends to give peak torque at high engine RPM. The conventional engine was to use to be a compromise between the volumetric efficiency and engine performance. The good tuning of the valve timing and intake length gives optimum results with the help of two theories Chrysler Ram Theory and Helmholtz Resonator Theory. Hence, we can understand that there is performance enhancement by varying intake manifold length.

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