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MODIFICATION OF TWIN CYLINDER FOUR STROKE FLAT ENGINE TO INCREASE THE EFFICIENCY

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ABSTRACT

The main objective of this concept is converting a 49cc FA-300 Twin Cylinder four-stroke boxer engine into sport bike and racing bike engine. A boxer engine of 49 cc volume, 4.7 bhp and producing a maximum torque of 8.92 N-m @ 3750 rpm into a racing bike of 70 cc volume and power of 8 bhp producing a torque of 11.2 N-m 5000 rpm. Also introducing a simple gear train to increase the output performance of the engine. This may bring a marvelous change in the field of bike racing and creates a revolution in this field.

KEYWORDS: *Flat Engine, Torque, RPM, Efficiency, Sprocket*

I. INTRODUCTION

1.1 Twin Cylinder Four-Stroke Flat Engine

A flat-twin is a two-cylinder internal combustion engine with the cylinders on opposite sides of the crankshaft. It is a flat engine with two horizontally-opposed cylinders. Typically, the layout has cylinders arranged in two banks on either side of a single crankshaft and is otherwise known as the boxer, or horizontally-opposed engine. Used in motorcycles for more than a century, Flat-twins have also been used in automobiles, light aircraft and household appliances.

The boxer configuration is the only configuration in common use that does not have unbalanced forces with a four-stoke cycle regardless of number of cylinders, as long as both banks have the same number of cylinders. They do not require a balance shaft or counterweights on the crankshaft to balance the weight of the reciprocating parts, which are required in most other engine configurations.

The overall operation is completed in four-stroke of the piston or two revolutions of the crankshaft. During the four strokes, there are five events to be completed, viz., suction, compression, combustion, expansion and exhaust. Each stroke consists of 180˚ of crankshaft rotation and hence a four-stroke cycle is completed through 720 ˚ of crank rotation. The cycle of operation for an ideal four-stroke SI engine consists of the following four strokes: (i) suction or intake stroke; (ii) compression stroke; (iii) expansion or power stroke and (iv) exhaust stroke. In twin-Flat four-stroke engine a pistons are moving together in opposite direction balancing all counter forces.

1.1.1 Suction or intake stroke:

Suction starts when both the pistons is at the top dead centre and about to move bottom dead centre. The inlet valve is open instantaneously and at this the exhaust valve is in the closed position. The Inlet value is lifted up 0.43in and the exhaust valve is closed. The mixture of Air and petrol is inserted in suction stroke. The crankshaft rotates complete 180˚ at the end of this stroke.

1.1.2 Compression stroke:

The charge taken into the cylinder during the suction stroke is compressed by the return stroke of the pistons. During the compression stroke both the valves are closed. The mixture which fills the entire cylinder volume is now compressed into the clearance volume. At the end of the compression stroke the mixture is ignited with the help of a spark plug located on the cylinder head.

1.1.3 Expansion or Power stroke:

The high pressure of the burnt gases forces the piston towards the Bottom dead centre. Both the valves are in closed position. Both the pressure and temperature decrease during expansion.

1.1.4 Exhaust Stroke:

The piston travelling from BDC to TDC pushes out the product of combustion. The exhaust valve is open 0.360in and the intake valve is closed during this stroke. At the end of this stroke all the burned mixture is sweep out, only the mixture in clearance volume remains in the cylinder.

1.2 Ignition system in Twin-Flat Engine

Boxer-twin engines are well suited to the wasted spark ignition system, a distributor-less ignition system using a double-ended coil firing both spark plugs on each revolution, that is, on both the compression stroke and exhaust stroke.
This system requires only a single contact breaker and single coil to run two cylinders.

II. WORKING

When the piston moves from top dead centre to bottom dead centre, the fresh air and fuel mixture enters the crank chamber through the valve. The mixture enters due to the pressure difference between the crank chamber and the outer atmosphere. The process of intake or suction stroke, compression stroke, power stroke and exhaust stroke take place in systematic way and rotate the crankshaft 720˚ after completion of all four processes.

2.1 ENGINE USED - FA-300 Twin Cylinder four-stroke boxer engine
2.2 Specifications

Engine type	: 4 stroke Air cooled
	Twin Cylinder four-stroke boxer engine
Displacement	: 49cc (2 X 24.5cc)
Bore	: 34mm
Stroke	: 28mm
Maximum Power	: 3.504 KW (4.7bhp)
Maximum Torque	: 5.0 N-m @ 3,750 rpm
Maximum RPM	: 3,750 rpm
Weight	: 1,750 grams

III. DESCRIPTION OF COMPONENTS

Identification of major Engine components makes it easier to understand its working principle. Some major engine components are cylinder Block, piston, piston rings, connecting rod, cylinder head, crankcase, crankshaft etc. Modification in Engine can be done by altering changes in these components. Major components that are modified in FA-300 Twin Cylinder four-stroke boxer engine are:

3.1 Engine Cylinder Block

A cylinder block is an integrated structure comprising the cylinder of the reciprocating engine and often some or all of their associated surrounding structures. Engine block is basically a block in which the piston moves from and all the four process suction stroke, compression stroke, power stroke and exhaust stroke take place in systematic way.

Most widely used material used for Engine Cylinder Block is aluminum alloy.

3.2 Cylinder Head

Cylinder head sits above the cylinders on top of the cylinders on top of the cylinder block. It closes in the top of the cylinder, forming the combustion chamber. The joint is sealed by a head gasket. In most engines, the head is sealed by a head gasket. The valves, spark plugs and fuel injector are placed in the cylinder head. Cylinder head design has come a long way in recent years.
On the performance/economy engine we particularly need to keep gas speed up. Otherwise the fuel will drop out of suspension and dribble into the combustion chamber in non-combustible droplets. The inlet/exhaust valve holes size in cylinder head is calculated by measuring the mass flow rate for engine to generate required power.

3.3 Piston and Piston Rings

A piston is a cylindrical engine component that slides back and forth in the cylinder bore by forces produced during the combustion 5 process. The piston acts as a movable end of the combustion chamber.
The stationary end of the combustion chamber is the cylinder head. Pistons are commonly made of a cast aluminum alloy for excellent and lightweight thermal conductivity. Thermal conductivity is the ability of the material to conduct and transfer heat. Aluminum expands when heated, and proper clearance must be provided to maintain free piston movement in the cylinder bore. Insufficient clearance can cause the piston to seize in the cylinder. Excessive clearance can cause a loss of compression and an increase in piston noise.
A piston pin bore is a through hole in the side of the piston perpendicular to piston travel that receives the piston pin. A piston pin is a hollow shaft that connects the small end of the connecting rod to the piston. The skirt of a piston is the portion of the piston closet to the crankshaft that helps align the piston as it moves in the cylinder bore.
A ring groove is a recessed area located around the perimeter of the piston that is used to retain a piston ring. Ring lands are the two parallel surfaces of the ring groove which function as the sealing surface for the piston ring. Ring lands are the two parallel surfaces of the ring groove which function as the sealing surface foe the piston ring. A piston ring is an expandable split ring used to provide a seal between the piston and the cylinder wall. Piston rings are commonly made from cast iron. Cast iron retains the integrity of its original shape under heat, load and other dynamic forces. Piston rings seal the combustion chamber, conduct heat from the piston to the cylinder wall, and return oil to the crankcase. Piston ring size and configuration vary depending on the engine design and cylinder material.

3.4 Spark Plug

The ignition is a primary system within all small gas engines. It produces and delivers the high voltage spark that ignites the furl-air mixture to cause combustion.

No spark means no combustion, which means your engine doesn’t run.

IV. ALTERATIONS

Our project consist of variable automobile parts and here I were going to alter some parts of the engine. They are,

4.1 Engine bore

4.2 Intake Port size

4.3 Introducing an sprocket (simple gear train on output shaft)

Basically, all the alteration is done to maximize the output Hp, Torque, RPM, Efficiency etc.

V. RESULT OF ALTERATION

5.1 Volume of the cylinder

The volume of the cylinder is increased by increasing the diameter of the cylinder bore from 34mm to 39mm. Generally, the volume has been the source of brake horsepower and torque. It is directly proportional to the power and torque. Here the volume of the cylinder is increased by using manual boring in lathes and by add grinding to increase the fuel inlet port and exhaust port. This will increase the fuel intake and exhaust, also will increase the horse power and torque of the engine.
Horsepower = (Torque X RPM) / 5252
As the max rpm of the engine is increasing, this automatically increases the horsepower of the engine. The bore size of the engine is increased and also the inlet port diameter is increased, this increase the amount of thermal energy converting into mechanical energy going to crankshaft. More the air injecting in the cylinder higher will be the power generated in power stroke.
Larger the quantity of mixture taking place during combustion, larger will be the thermal energy generated and increases the energy transfer to the crankshaft and therefore, higher efficiency. As the work output has been increased and the amount thermal energy is increased which is converted to mechanical energy, this will increase the efficiency of the engine.
Efficiency = (Work Output) / (Heat Supplied)

5.2 Intake/Exhaust Ports Alteration

The Intake port of any engine decides the quantity of mixture and rate of the mixture which comes inside the combustion chamber during suction stroke. The original Inlet port of FA-300 Twin Cylinder four-stroke boxer engine was 6.4mm and later it is altered to 10mm. The alteration is done after calculating the amount of mixture required in suction stroke, as the combustion chamber is being altered by changing the bore size and also we require high air-fuel mixture supply to the engine in order to increase the performance. I was using a TV max 100 carburetor, max 100 carburetor is capable of having 19mm fuel intake diameter and throttle has been set to its extreme level and hence the fuel mixture on maximum throttle will be more while accelerating.
The increased port is designed after measuring the valve diameter, as with round ports the port must not be more than 0.82 times the valve diameter and with rectangular or oval ports the port area must not be more than 0.67 times the valve diameter. I opt to alter the port size because the valve lift were fixed due to cam profile and the lift of inlet and exhaust valves were fixed to 0.43in and 0.36in respectively. I alter the port diameter to 10mm which is 0.79 times the diameter of the inlet valve. Same in case of Exhaust port, as the combusted mixture is increased there is need to eject the whole combusted mixture from the cylinder chamber and to do so the exhaust port is been increased. I alter the exhaust port diameter from 10mm to 12mm which is .81 times the diameter of the exhaust valve.
Engine volumetric Efficiency = (Volume of air taken into cylinder / maximum possible volume)

5.3 Introducing a sprocket

Gear ratios are familiar in automobile field, and basically they are used to alter the output results including RPM, torque, angular velocity etc. For the same reason and to alter the max rpm obtain at output shaft (crankshaft), we introduced a sprocket on the crankshaft which linked to the second sprocket on the second shaft. The modification in engine is done and the output results we got are good hence we introduced the sprocket to increase the max RPM of the engine.
I opt the gear ratio of 1.5 and the primary sprocket at crankshaft is having 12 teeth and the secondary sprocket at second shaft is having 18 teeth. The max RPM we getting before introducing the sprocket was 5000rpm and now it is increased to 7500rpm. The output toque is somehow decreased but still the output torque is higher approximately 6.4 Nm.
The concept of introducing a sprocket can bring a very big change in the field of opposed cylinder engines and opposed piston engines. Let,
RPM at primary sprocket and secondary sprocket be N_1 and N_2.
Angular velocity at primary sprocket and secondary sprocket be ω_1 and ω_2.
No. of teeth at primary sprocket and secondary sprocket be T_1 and T_2.
Diameter at primary sprocket and secondary sprocket be D_1 and D_2.
$N_2 / N_1 = \omega_2 / \omega_1 = T_1 / T_2 = D_1 / D_2 = 1.5$

VI. CALCULATIONS FOR ALTERATION

The Engine initially has 49cc capacity and the cylinder diameter of 34mm. To calculate the Stroke length let, suppose the height of TDC to BDC be 'h'.
Volume = π X (radius)^2 X 'h' X (no. of cylinders)
49 X 4 = 2 X π X 3.4 X 3.4 X h; h = 2.76 cm or 2.8 cm approximately
Now, when the bore is increased to 39 mm, the capacity of engine will also increase. Let 'V' be the new capacity volume of the engine.
'V' = 2 X 3.14 X 1.95 X 1.95 X 2.8; V = 66.86 cm^3 or 67 cc approximately.
Here we have neglected the clearance volume in the calculations. When the Engine Capacity is increasing the Clearance volume will also increases and the new engine capacity tends to 70 cc approximately.
Compression Ratio = (SV + CV) / (CV)
The Compression Ratio for FA-300 Twin Cylinder four-stroke boxer engine is fixed at 8.4 approximately when there were no alterations in the Engine. From here we can calculate the Clearance Volume of the Engine before modification.
8.4 = (49 + CV) / CV; CV = 6.621 cm^3. At this Clearance Volume the efficiency of engine calculated is,
Thermal Efficiency = 1 – (1 / CR)$^{(\Upsilon - 1)}$; here Υ = 1.4 for air and CR denotes of Compression Ratio.
Thermal Efficiency = 57.32 %. And now as the Compression Ratio after modification is increased hence increasing the Thermal Efficiency of the engine after modification.
Horsepower of engine plays very important role and after the modification of the engine the Horsepower of the engine changes and gives better result.
Horsepower = (Torque X RPM) / 5252
Before Alteration, Hp = (6.57 X 3750) / 5252; Hp = 4.7 bhp.
After Alteration, Hp = (8.26 X 5000) / 5252; Hp = 8 bhp.
Note that, the RPM of the crankshaft is measured by using Tachometer.

Features

The output after the modification of Engine are good enough to compare the modified Engine with above high performance engines in this segment. Overall all result shows that is modification can lead a new way in the field of Flat Engines.

6.1 Engine specification and comparison:

The output results are very effective and can bring a revolutionary change in the field of automobile sector. Also, the cost of modified engine not high as compared to others and can be afford easily.

	Before	After
Displacement	49cc	70cc
Bore	34mm	39mm
Stroke	28	28
Inlet bore size	6.4mm	10mm 0.79 times the valve diameter
Exhaust bore size	10mm	12mm 0.81 times the valve diameter
Weight	1,750 grams	1700 grams
RPM	3750 rpm	5000 rpm
Horse power	4.7 bhp	8 bhp
Torque	8.92 Nm	11.2 Nm

6.2 Altered sprocket specification:

	Primary sprocket	Secondary sprocket
Chain #	420	420
Pitch	0.500in	0.500in
Roller diameter	0.3125	0.3125
Roller width	0.2500	0.2500
Sprocket thickness	0.227	0.227
No. of teeth	18	12
Sprocket diameter	2.8793in	1.9318in

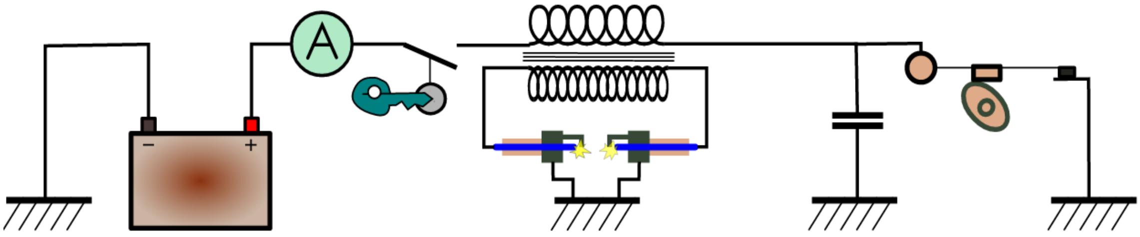

Fig. 1: (a)Ignition System of Twin-Flat Engine

Fig. 1: (b) Altered piston

Fig. 1: (c) TVS Max 100 carburetor used

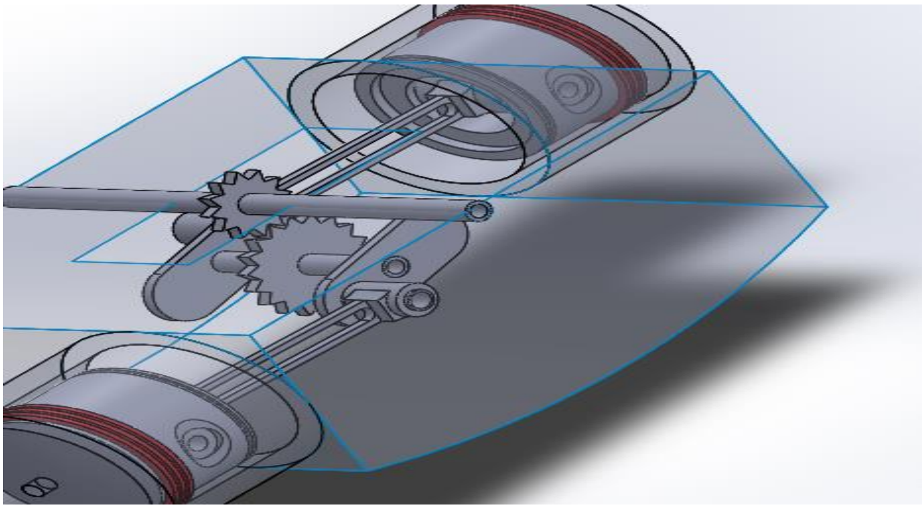

Fig. 1: (d) Introducing a Simple Gear Train in FA-300 Twin Cylinder four-stroke boxer engine

6.3 Output at secondary shaft after introducing Simple Gear Train

	At Primary shaft	At secondary shaft
Max RPM	5000 rpm	7500rpm
Max Torque	11.2 N-m	7.5 N-m
Angular Velocity	523.33 rad/sec	785 rad/sec
Horsepower	8 bhp	7.89 bhp

VII. CONCLUSION

The project carried out by me made an impressing task in the field of automobile industries. It is very useful for sports rider to ride at power implemented engine vehicle. The project has also reduced the cost involved in the manufacturing high performance flat engines by altering changes in low engines and can obtain better outputs. Project has been designed to perform the entire requirement task which has also been provided. Generally the sport vehicle price is quite higher than the normal bike, but due to this advantage, it can be achieved at lower cost and with better output in performance.

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NOMENCLATURE

BDC	-	Bottom Dead Centre
CC	-	Cubic Capacity (cm^3)
CR	-	Compression Ratio
CV	-	Clearance Volume
HP	-	Horsepower
RPM	-	Revolutions per Minute
SV	-	Swept Volume
TDC	-	Top Dead Centre

REFERENCE

[1]. V Ganesan, Internal Combustion Engines 4th Edition, Mc Graw Hill Education.
[2]. Modern Engine Tuning, A. Graham Bell, Haynes Publishing.

[3]. Beelen, A., Sargeant, A.J., 1991. Effect of fatique on maximal power output at different contraction velocities in humans. Journal of applied phisology 71, 2332}2337.

[4]. Faria, I., sjojaard, G., Bonde- Petersen, F., 1982. Oxygen cost during different pedaling speed for constant power output. Journal of sports medical physical fitness 22, 295}299.

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