TWO STROKE FUEL INJECTION SYSTEM IN SI ENGINE

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ABSTRACT

A spark ignition engine, where two stroke engine is disclosed. The engine includes a crankcase with a cylinder adapted to house a piston. At least one transfer duct communicates the crankcase to the cylinder. At least one fuel injector is disposed through a wall of the transfer duct. The fuel injector is positioned to inject fuel tangentially to the cylinder. Direct injection is technology that has shown a great ability to reduce these emissions while at the same time improves fuel economy. A prototype kit has been designed for use in retrofitting existing carbureted two stroke engines to direct injection.
To optimize the power and intake port flow produce by the engine modification were through a very limited value. The value is limited due to the restricted area of the engine production by the manufacturer. Hence modification must be planned carefully as over modification of the inlet port can end up with a device slower than its stock counterpart. It was found out experimentally that mechanical thermal efficiency was improved after modification. In other words fuel economy was improved after using the injector.

Key word: *Carburetor, engine test rig, gear ratio, load, Two-stroke petrol engine.*

1.INTRODUCTION

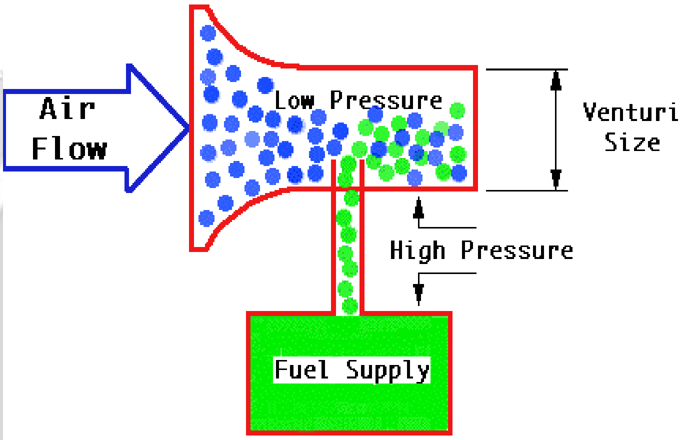
Two stroke petrol engines are widely used for two wheelers as a source of mechanical power. Various designs are available for two stroke petrol engine for variety of automotive applications. A two stroke engine works by using an up stroke and down stroke of the piston to complete the process cycle in one revolution of the crankshaft. This is accomplished with the use of both the end of the combustion stroke and the beginning of the compression stroke to simultaneously perform the intake and exhaust functions, also known as scavenging. This engine is air-cooled and design is based on aerodynamic application special engine fixing arrangement is made for testing purpose. Engine is coupled to rope brake dynamometer through Universal joints. Four speeds are available on engine so that wide speed variation is possible. Air- inlet quantity is measured through orifice meter and air tank. Air tank is designed considering the pulsating flow characteristics of two stroke engine.

Volumetric efficiency of the engine can be measured. Special accelerator level arrangement is used to lock the accelerator cable at specific position by locking nut. So that constant speed can be maintained. Temperature at engine exhaust gas, calorimeter inlet and outlet can be measured by thermocouple type temperature sensor with digital indicator. Water inlet and outlet temperature at calorimeter is maintained by mercury thermometer in which the researcher change main jet of carburetor follow above all conditions by changing different size. i.e. 85, 90, 95 respectively.

1.1 Carburetion system of SI engine

Mixture requirements are different for idling, low, medium and high load operations. At idling condition a rich mixture is required to obtain adequate combustion stability. This is due to the internal charge dilution of fresh mixture with residual gases and poor mixing conditions. At part operating conditions, for good fuel economy, it is advantageous to use a lean mixture. We can dilute the fuel air mixture either with excess air or with recycled exhaust gas.
This dilution improves the fuel conservation efficiency for three reasons:

1) The expansions stroke work for a given expansion ratio increases as a result of change in thermodynamic properties of the burned gases.
2) For a given mean effective pressure, the intake pressure increases with increasing dilution ,so pumping work decreases.
3) The heat losses to the walls are reduced because the burned gas temperature are low. In the absence of strict engine NOX emission requirements. Excess air is the obvious diluents, and at part, throttle, engines have traditionally operated lean.



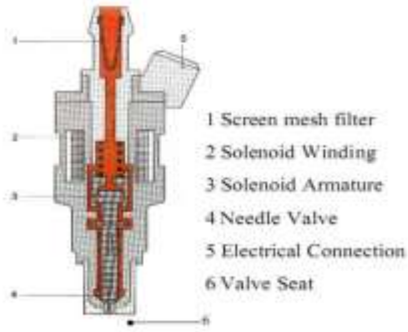
When tight control of NOx, HC, CO, emission is required, operation of engines with a stoichiometric mixture is advantageous so that a three way catalytic converter can be used to clean up the exhaust. The appropriate diluents is then recycled exhaust gases which significantly reduces NOx emissions from the engine itself. As load increases charge dilution with residual gases decreases and mixture conditions are improved. Increasing the amount of air slows down the combustion process which gives rise to large cycle variations. At full load conditions maximum power is the main issue so the mixture required is slightly rich.

1.2. Fuel Injection System

On petrol engines, fuel injection replaced carburetors from the 1980s onward. The primary difference between carburetors and fuel injection is that fuel injection atomizes the fuel through a small nozzle under high pressure, while a carburetor relies on suction created by intake air accelerated through a Venturie tube to draw the fuel into the airstream.

Benefits of fuel injection include smoother and more consistent transient throttle response, such as during quick throttle transitions, easier cold starting, more accurate adjustment to account for extremes of ambient temperatures and changes in air pressure, more stable idling, decreased maintenance needs, and better fuel efficiency.

Fuel injection also dispenses with the need for a separate mechanical choke, which on carburetor-equipped vehicles must be adjusted as the engine warms up to normal temperature. Furthermore, on spark ignition engines, fuel injection has the advantage of being able to facilitate stratified combustion which have not been possible with the process of determining the necessary amount of fuel, and its delivery into the engine, are known as fuel metering. Early injection systems used mechanical methods to meter fuel, while nearly all modern systems use electronic metering.



Fuel is transported from the fuel tank and pressurized using fuel pump. Maintaining the correct fuel pressure is done by a fuel pressure regulator. Often a fuel rail is used to divide the fuel supply into the required number of cylinders. The fuel injector injects liquid fuel into the intake air.

Unlike carburetor-based systems, where the float chamber provides a reservoir, fuel injected systems depend on an uninterrupted flow of fuel. To avoid fuel starvation when subject to lateral G-forces, vehicles are often provided by an anti-surge vessel, usually integrated in the fuel tank, but sometimes as a separate, small anti-surge tank.

1.3 ENGINE SPECIFICATIONS

- Rated power output:- 5HP at 4000 rpm
- Rated RPM at crankshaft:- 4000
- No. of cylinder:- ONE
- Stroke:- 57 mm
- Bore :- 57mm
- No of reductions through gearbox:- 4
- Swept volume:- 145.45
- Compression ratio:- 6.7:1
- Type of dynamometer:- rope break type
- Orifice diameter of air :-12mm
- Sp.weight of fuel:- 780Kg/m^3
- Fuel oil:- petrol
- Fuel tank capacity:- 7 litres
- Length:- 2500mm
- Width:- 1400mm
- Height:- 2000mm
- Displacement:- 98 cc
- Max. Power:- 7.8 bhp
- GEARS:- 4 gear all front down.
- Engine Type:- 2 Stroke

2.EXPERIMENTAL SETUP

The experiment consists of components such as two stroke petrol engine, carburetor, air filter, injector, fuel tank, silencer, spark plug, ignition coil, fuel pump, battery, flywheel, varying loads.
At first, the engine is mounted on the stand. The silencer and additional components are assembled as experimental kit.
The flywheel of the engine is coupled with the pulley by using shaft with the help of universal joint. The coupled flywheel is connected to the varying loads at various turns.
The fuel injection system in the SI engine is by using the injector. The replacement of injector with carburetor is the modification in the experiment.

3.WORKING

Air from the atmosphere is absorbed by the air filter and fuel is supplied to carburetor from the fuel tank in the proper mixture of 14:1 in order to achieve the actual performance of the engine.

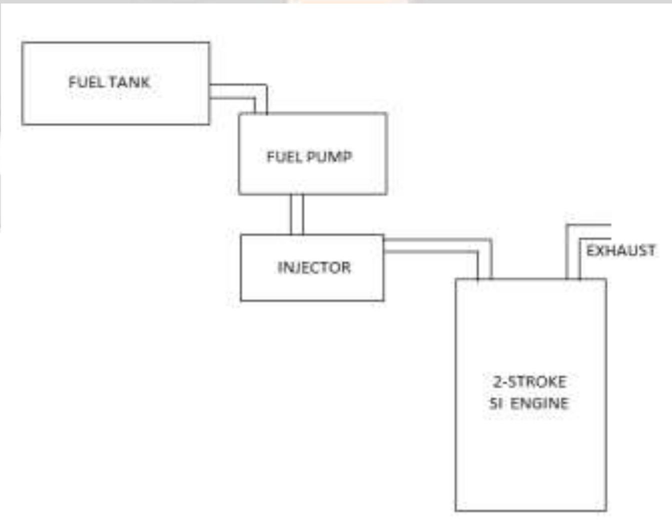
The engine is allowed to operate with two modifications in order to check the characteristics of the engine. In the first process, the engine is operated with the carburetor and then its performance and emission is observed.

At the second process, the engine is replaced with the injector and fuel pump instead of carburetor, the section is isolated from the engine and injector is installed along the path of air inlet to engine. thus the same operation is held in the engine and also its performance and emission is observed.
The engine's performance can be calculated by applying variable loads at different values.

The flywheel of the engine is connected with the pulley attached with the loads. By applying various loads the engine's efficiency can be measured.

the modifications made in the engine will differ with each other. Thus the comparison is done between the engine operated in carburetor and the engine operated in replacement of injector.

Then the emission of NOx, HC and CO gases from the engine are measured for both modification systems and the minimal emission of pollutant gases from the experiment are identified.



CYLINDER SWEPT VOLUME (VC):

$$V_c = Cylinder\ \ Area \times Stroke\ Length$$

$$V_c = A_c \times L = (\frac{\pi}{4} d_c^2) \times L$$

where:

Vc= cylinder swept volume [cm3 (cc) or L]
Ac = cylinder area [cm2 or cm2/100]
dc = cylinder diameter [cm or cm/10]

L = stroke length (the distance between the TDC and BDC)

ENGINE SWEPT VOLUME (VE):

$$V_e = Total\ Cylinders'\ Sewpt\ Volumes\ of\ the\ Engine$$
$$V_e = n \times V_c$$
$$V_e = n \times A_c \times L = n \times (\frac{\pi}{4} d_c^2) \times L$$

where:

Ve = engine swept volume [cm3 (cc) or L]
n = number of cylinders
Vc = cylinder swept volume [cm3 (cc) or L]
Ac = cylinder area [cm2 or cm2/100]
dc = cylinder diameter

COMPRESSION RATIO (R):

$$r = \frac{Cylinder\ Volume\ at\ BDC}{Cylinder\ Volume\ at\ TDC}$$
$$r = \frac{(Cylinder\ Volume + Cylinder\ Clearance\ Volume)}{Cylinder\ Clearance\ Volume}$$
$$r = \frac{V_s + V_c}{V_c} = 1 + \frac{V_s}{V_c}$$

where:

r = compression ratio
Vs = cylinder swept volume (combustion chamber volume) [cc, L, or m3]
Vc = cylinder volume

ENGINE VOLUMETRIC EFFICIENCY (HV):

$$\eta_V = \frac{Volume\ of\ air\ taken\ into\ cylinder}{Maximum\ possible\ volume\ in\ the\ cylindre}$$
$$\eta_V = \frac{V_{air}}{V_s}$$

where:

hV = volumetric efficiency
V air = volume of air taken into cylinder [cc, L, or m3]
Vc = cylinder swept volume

ENGINE INDICATED TORQUE (TI):

$$T_i = \frac{Work\ (W)}{angle\ (\theta)} = \frac{Work\ per\ one\ revolution}{angle\ of\ one\ revolution} = \frac{Force \times dis\tan ce}{2\pi} \times n$$
$$T_i = \frac{(imep \times A_c) \times L \times n}{2\pi \times z} = \frac{imep \times V_e}{2\pi \times z}$$

where:

Ti = engine indicated torque [Nm]

imep = indicated mean effective pressure [N/m2]
Ac = cylinder area [m2]
L = stroke length [m]
z = 1 (for 2 stroke engines), 2 (for 4 stroke engines)
n = number of cylinders
θ = crank shaft angle [1/s]

ENGINE INDICATED POWER (PI):

$$P_i = \frac{imep \times A_c \times L \times n \times N}{z \times 60}$$

$$P_i = \frac{imep \times (A_c \times L) \times n \times N}{z \times 60} = \frac{imep \times (V_c \times n) \times N}{z \times 60}$$

$$P_i = \frac{imep \times V_e \times N}{z \times 60}$$

$$P_i = T_i \times \omega = T_i \times \frac{2\pi N}{60}$$

,

where:

imep = is the indicated mean effective pressure [N/m2]

Ac = cylinder area [m2]

L = stroke length [m]

n = number of cylinders

N = engine speed [rpm]

z = 1 (for 2 stroke engines), 2 (for 4 stroke engines)

Vc = cylinder swept volume [m3]

Ve = engine swept volume [m3]

Ti = engine indicated torque [Nm]

ω = engine angular speed [1/s]

Measurable Gases	Resolution	Error	Measurable range
HCs (C_3H_8)	1 ppm	± 30 ppm	0–20,000 ppm
CO	0.01%vol.	± 0.2%	0–10%
NOx (NO)	1 ppm	± 10 ppm	0–5000 ppm

ENGINE THERMAL EFFICIENCY (HTH):

$$\eta_{th} = \frac{brake\ power}{fuel\ power}$$

$$\eta_{th} = \frac{3600\ P_b}{FC \times CV}$$

where:

hth = thermal efficiency

Pb = brake power [kW]

FC = fuel consumption [kg/h = (fuel consumption in L/h) x (ρ in kg/L)]

CV = calorific value of kilogram fuel [kJ/kg]

ρ = relative density of fuel [kg/L]

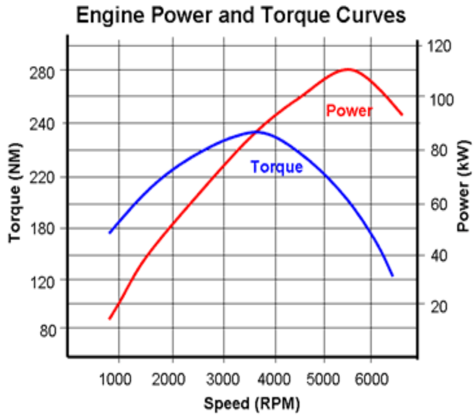
4. EXHAUST GAS ANALYZER

An exhaust gas analyzer is used in this experiment. The exhaust analyzer is used to measure exhaust gases. It is a small and lightweight analyzer. Its response time is 15 s and flow rate approximate 1.2 l/min. This analyzer can measure Carbon monoxide (CO), Carbon dioxide (CO_2), Hydrocarbons (HCs), Oxygen (O_2) and Nitric oxide (NO). Complete information about its resolution. The excess air (lambda) calculated from Brettschneider formula can also be determined by this analyzer. Using lambda and stoichiometric air to fuel ratio, we are able to calculate the actual air to fuel ratio.

5. RESULT AND DISCUSSION

The dynamic fuel injection quantity of the injector is influenced by engine speed, fuel pressure, injection duration, injector supply voltage and injection dead time. The amount of fuel injected is obtained by measuring the quantity of fuel injected for a period of 60 seconds at different fuel pressure (0.55 bar to 5 bar), different injection duration (2msec to 20msec) and different speeds (750,1500 and 3000 rpm).

Experiments were conducted at three various engine speeds of 750, 1500 and 3000 rpm. The injection duration was varied from 2 to 20 ms. Fuel pressure was maintained at 0.5 to 5 bar and injector supply voltage was maintained at 12 volt DC. As the speed increases, the fuel injection quantity also increases linearly.



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