International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 06 Issue: 09 | Sep 2019 www.irjet.net p-ISSN: 2395-0072

DESIGN AND SPECIFICATION OF INTERNAL COMBUSTION ENGINE

Pritam Pain[1], Deep Dewan[2]

[1]Dept. of Mechanical Engineering, University of Engineering & Management, Kolkata, West Bengal, India
[2]Dept. of Mechanical Engineering, Kingston Polytechnic College, Barasat, West Bengal, India

---***---

Abstract - *The aim of this report is to introduce the design and specification of Internal Combustion Engine. Internal Combustion (I.C) Engine typically show a characteristic efficiency profile which varies with operating load and engine speed. In under low loading condition the operating efficiency is poor. For achievement of better overall efficiency by using of an energy storing and recovering process, involving compressing air. For improvement of Engine efficiency, we have used of heat transfer from the exhaust gases to the stored compressed air.*

Key Words: Solidworks, IC Engine, 2 and 4 Stoke Engine, Piston and Cylinder.

INTRODUCTION

An internal combustion engine (ICE) is a heat engine. In an internal combustion engine, the prolongation of the high-temperature and high-pressure gases produced by combustion applies direct force to some component of the engine. The force is applied typically to pistons, turbine blades, nozzle. This force moves the component over a distance, transforming chemical energy into useful mechanical energy. The term internal combustion engine usually refers to an engine in which combustion is intermittent, such as the more familiar four-stroke and two stroke piston engines, along with variants, such as the six-stroke piston engine and the Wankel rotary engine. It also involves the thermodynamics relations that govern the processes of these engines, highlighting two main important cycles, which are: Otto cycle and Diesel cycles.

Heat Engine:

In thermodynamics, a heat engine is a system that converts the chemical energy of a fuel into mechanical energy, which can then be used to do mechanical work. It is classified into two types-

(a) External combustion engine

(b) Internal combustion engine

External Combustion Engine:

In this engine, the products of combustion of air and fuel transfer heat to a second fluid which is the working fluid of the cycle.

Examples:

1) Steam engines or steam turbine plant are an example of external combustion engine. The heat of combustion is employed to generate steam which is used in a piston engine (reciprocating type engine) or a turbine (rotary type engine) for useful work.

2) Another example is the stirling engine although this has a only a niche role at present. Some gas turbines use an external cycle this could expand rapidly with the development of super critical carbon dioxide as the working fluid.

Internal Combustion Engine:

In this engine, which generates motive power by the burning of petrol, oil, or other fuel with air inside the engine, the hot gases produced being used to drive a piston or do other work as they expand. It can be classified into the following types:

1. According to the basic engine design- (a) Reciprocating engine (Use of cylinder piston arrangement), (b) Rotary engine (Use of turbine).

2. According to the type of fuel used- (a) Petrol engine, (b) diesel engine, (c) gas engine, (d) Alcohol engine.

3. According to ignition of fuel- (a) Spark ignition engine, (b) hot spot ignition engine, (c) compression ignition engine.

4. According to the number of strokes per cycle- (a) Two stroke engine, (b) Four stroke engine, (c) Six stroke engine.

5. According to the number of cylinder- (a) Single cylinder and (b) multi-cylinder engine.

6. Method of cooling- water cooled or air cooled.

7. Type of cylinder arrangement- Vertical, horizontal, inline, radial, v-type, piston engines.

8. Method governing- Hit and miss governed engines, quantitatively governed engines and qualitatively governed engine.

Comparison Between External Combustion Engine And Internal Combustion Engine:

External combustion engine	Internal combustion engine
*Combustion of air-fuel is outside the engine cylinder (in a boiler)	* Combustion of air-fuel is inside the engine cylinder (in a boiler)
*The engines are running smoothly and silently due to outside combustion	* Very noisy operated engine
*Higher ratio of weight and bulk to output due to presence of auxiliary apparatus like boiler and condenser. Hence it is heavy and cumbersome.	* It is light and compact due to lower ratio of weight and bulk to output.
*Working pressure and temperature inside the engine cylinder is low; hence ordinary alloys are used for the manufacture of engine cylinder and its parts.	* Working pressure and temperature inside the engine cylinder is very much high; hence special alloys are used
*It can use cheaper fuels including solid fuels	*High grade fuels are used with proper filtration
*Lower efficiency about 15-20%	*Higher efficiency about 35-40%
* Higher requirement of water for dissipation of energy through cooling system	*Lesser requirement of water
*High starting torque	*IC engines are not self-starting

Fig – 1: Difference between EC & IC Engine

Main Components Of Reciprocating IC Engine

Name of the main components of IC engine are- piston, piston rings, cylinder, cylinder head, crank case, crankshaft, flywheel, connecting rod, spark plug etc.

A. Cylinder:

It is the main part of the engine inside which piston reciprocates to and fro. It should have high strength to withstand high pressure above 50 bar and temperature above 2000 ^{0}C. The ordinary engine is made of cast iron and heavy-duty engines are made of steel alloys or aluminum alloys. In the multi-cylinder engine, the cylinders are cast in one block known as cylinder block.

B. Cylinder head:

The top end of the cylinder is covered by cylinder head over which inlet and exhaust valve, spark plug or injectors are mounted. A copper or asbestos gasket is provided between the engine cylinder and cylinder head to make an air tight joint.

C. Piston:

Usually made of aluminum alloy which has good heat conducting property and greater strength at higher temperature. The main function of the piston is to transform the pressure generated by the burning air-fuel mixture into force, acting on the crankshaft.

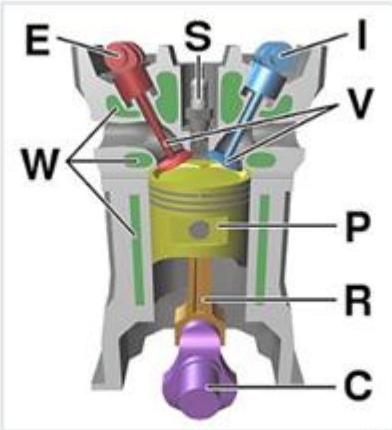

Diagram of a cylinder as found in 4-stroke gasoline engines.:
C – crankshaft.
E – exhaust camshaft.
I – inlet camshaft.
P – piston.
R – connecting rod.
S – spark plug.
V – valves. red: exhaust, blue: intake.
W – cooling water jacket.
gray structure – engine block.

Fig – 2: Different parts of IC engine

Design of piston is given below.

Fig – 3: Design of piston

D. Piston rings:

These are housed in the circumferential grooves provided on the outer surface of the piston and made of steel alloys which retain elastic properties even at high temperature. 2 types of rings- compression and oil rings. Compression ring is upper ring of the piston which provides air tight seal to prevent leakage of the burnt gases into the lower portion. Oil ring is lower ring which provides effective seal to prevent leakage of the oil into the engine cylinder.

E. Connecting rod:

It converts reciprocating motion of the piston into circular motion of the crank shaft, in the working stroke. The smaller end of the connecting rod is connected with the piston by gudgeon pin and bigger end of the connecting rod is connected with the crank with crank pin. The special steel alloys or aluminum alloys are used for the manufacture of connecting rod. Design of connecting rod is given below.

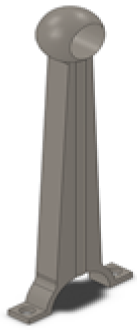

Fig – 4: Design of connecting rod

F. Crankshaft:

It converts the reciprocating motion of the piston into the rotary motion with the help of connecting rod. The special steel alloys are used for the manufacturing of the crankshaft. It consists of eccentric portion called crank.

G. Crank case:

It houses cylinder and crankshaft of the IC engine and also serves as sump for the lubricating oil.

H. Flywheel:

It is big wheel mounted on the crankshaft; whose function is to maintain its speed constant. It is done by storing excess energy during the power stroke, which is returned during another stroke. Design of flywheel is given below.

Fig – 5: Design of flywheel

Terminology Used In IC Engine:

1. Cylinder bore (D): The nominal inner diameter of the working cylinder.

2. Piston area (A): The area of circle of diameter equal to the cylinder bore.

3. Stroke (L): The nominal distance through which a working piston moves between two successive reversals of its direction of motion.

4. Dead centre: The position of the working piston and the moving parts which are mechanically connected to it at the moment when the direction of the piston motion is reversed (at either end point of the stroke).

(a) Bottom dead centre (BDC): Dead centre when the piston is nearest to the crankshaft.

(b) Top dead centre (TDC): Dead centre when the position is farthest from the crankshaft.

5. Displacement volume or swept volume (Vs): The nominal volume generated by the working piston when travelling from the one dead centre to next one and given as,

$Vs = A \times L$

6. Clearance volume (Vc): the nominal volume of the space on the combustion side of the piston at the top dead centre.

7. Cylinder volume (V): Total volume of the cylinder.

$V = Vs + Vc$

8. Compression ratio (r): $r = V_s / V_c$

Two Stroke Engine:

-No piston stroke for suction and exhaust operations

-Suction is accomplished by air compressed in crankcase or by a blower

-Induction of compressed air removes the products of combustion through exhaust ports

-Transfer port is there to supply the fresh charge into combustion chamber

Fig – 6 represents operation of two stroke engine.

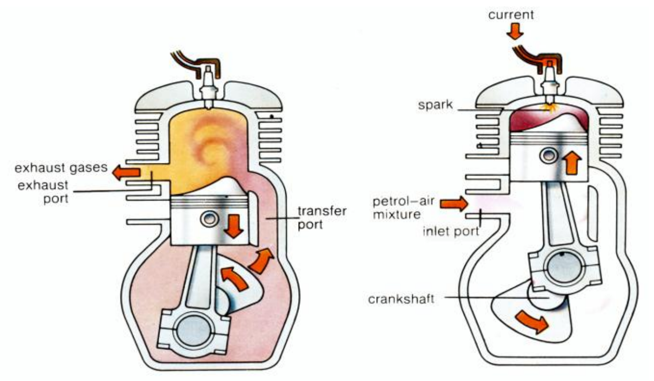

Fig – 6: Cycle of operation in two stroke engine

Four Stroke Engine:

- Cycle of operation completed in four strokes of the piston or two revolution of the piston.

(i) Suction stroke (suction valve open, exhaust valve closed)-charge consisting of fresh air mixed with the fuel is drawn into the cylinder due to the vacuum pressure created by the movement of the piston from TDC to BDC.

(ii) Compression stroke (both valves closed)-fresh charge is compressed into clearance volume by the return stroke of the piston and ignited by the spark for combustion. Hence pressure and temperature is increased due to the combustion of fuel.

(iii) Expansion stroke (both valves closed)-high pressure of the burnt gases force the piston towards BDC and hence power is obtained at the crankshaft.

(iv) Exhaust stroke (exhaust valve open, suction valve closed)- burned gases expel out due to the movement of piston from BDC to TDC.

Fig – 7 show the cycle of operation of four stroke engine.

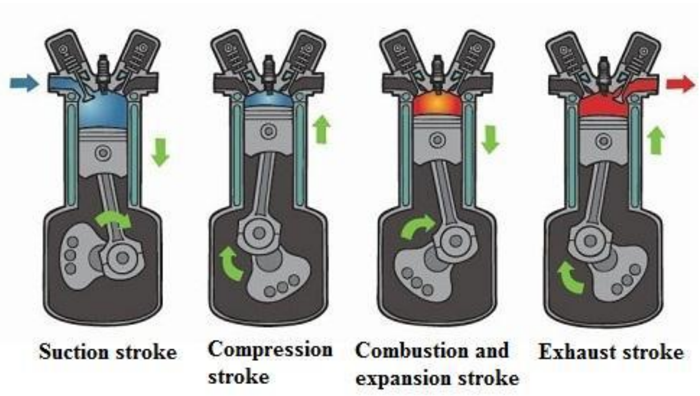

Fig – 7: Cycle of operation in four stroke engine

Comparison Of Four-Stroke And Two-Stroke Engine:

	Four-stroke engine	Two-stroke engine
1.	Four stroke of the piston and two revolution of crankshaft	Two stroke of the piston and one revolution of crankshaft
2.	One power stroke in every two revolution of crankshaft	One power stroke in each revolution of crankshaft
3.	Heavier flywheel due to non-uniform turning movement	Lighter flywheel due to more uniform turning movement
4.	Power produce is less	Theoretically power produce is twice than the four stroke engine for same size
5.	Heavy and bulky	Light and compact
6.	Lesser cooling and lubrication requirements	Greater cooling and lubrication requirements
7.	Lesser rate of wear and tear	Higher rate of wear and tear
8.	Contains valve and valve mechanism	Contains ports arrangement
9.	Higher initial cost	Cheaper initial cost
10.	Volumetric efficiency is more due to greater time of induction	Volumetric efficiency less due to lesser time of induction
11.	Thermal efficiency is high and also part load efficiency better	Thermal efficiency is low, part load efficiency lesser
12.	It is used where efficiency is important.	It is used where low cost, compactness and light weight are important.
	Ex-cars, buses, trucks, tractors, industrial engines, aero planes, power generation etc.	Ex-lawn mowers, scooters, motor cycles, mopeds, propulsion ship etc.

Fig – 8: Difference between four-stroke and two-stroke engine

CI And SI Engine:

The **diesel engine** (also known as a compression-ignition or **CI engine**), named after **Rudolf Diesel**, is an internal combustion engine in which ignition of the fuel is caused by the elevated temperature of the air in the cylinder due to the mechanical compression (adiabatic compression).

A **spark-ignition engine** (**SI engine**) is an internal combustion engine, generally a petrol engine, where the combustion process of the air-fuel mixture is ignited by a spark from a spark plug.

Comparison of SI and CI engine:

SI engine	CI engine
Working cycle is Otto cycle.	Working cycle is diesel cycle.
Petrol or gasoline or high octane fuel is used.	Diesel or high cetane fuel is used.
High self-ignition temperature.	Low self-ignition temperature.
Fuel and air introduced as a gaseous mixture in the suction stroke.	Fuel is injected directly into the combustion chamber at high pressure at the end of compression stroke.
Carburettor used to provide the mixture. Throttle controls the quantity of mixture introduced.	Injector and high pressure pump used to supply of fuel. Quantity of fuel regulated in pump.
Use of spark plug for ignition system	Self-ignition by the compression of air which increased the temperature required for combustion
Compression ratio is 6 to 10.5	Compression ratio is 14 to 22
Higher maximum RPM due to lower weight	Lower maximum RPM
Maximum efficiency lower due to lower compression ratio	Higher maximum efficiency due to higher compression ratio
Lighter	Heavier due to higher pressures

Fig – 9: Difference between SI and CI engine

Valve timing diagram:

The exact moment at which the inlet and outlet valve opens and closes with reference to the position of the piston and crank shown diagrammatically is known as valve timing diagram. It is expressed in terms of degree crank angle. The theoretical valve timing diagram is shown in Fig – 10.

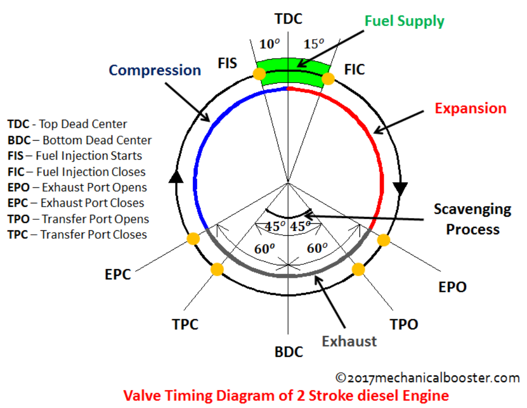

Fig – 10: Theoretical valve timing diagram

But actual valve timing diagram is different from theoretical due to two factors-mechanical and dynamic factors. Fig – 7 shows the actual valve timing diagram for four stroke low speed or high-speed engine.

Opening and Closing Of Inlet Valve

Inlet valve opens 12 to 30° CA before TDC to facilitate silent operation of the engine under high speed. It increases the volumetric efficiency.

Inlet valve closes 10-60° CA after TDC due to inertia movement of fresh charge into cylinder i.e. ram effect.

Fig – 11 represents the actual valve timing diagram for low and high-speed engine.

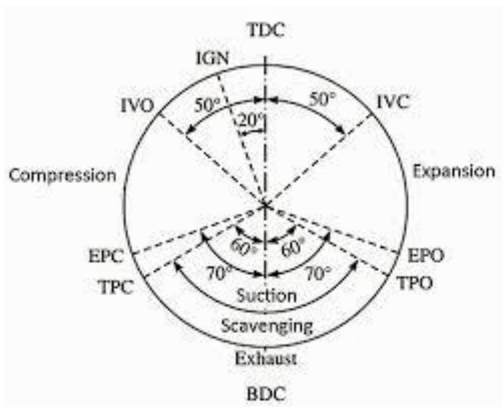

Fig – 11: Actual valve timing diagram for low and high-speed engine

Opening and Closing Of Exhaust Valve

Exhaust valve opens 25 to 55° CA before BDC to reduce the work required to expel out the burnt gases from the cylinder. At the end of expansion stroke, the pressure inside the chamber is high, hence work to expel out the gases increases.

Exhaust valve closes 10 to 30° CA after TDC to avoid the compression of burnt gases in next cycle. Kinetic energy of the burnt gas can assist maximum exhausting of the gas. It also increases the volumetric efficiency.

Valve Overlap

During this time both the intake and exhaust valves are open. The intake valve is opened before the exhaust gases have completely left the cylinder, and their considerable velocity assists in drawing in the fresh charge. Engine designers aim to close the exhaust valve just as the fresh charge from the intake valve reaches it, to prevent either loss of fresh charge or unscavenged exhaust gas.

Port timing diagram

Drawn for 2-stroke engine

No valve arrangement

3 ports- inlet, transfer and exhaust

Fig - 12 shows port timing diagram for 2-stroke engine.

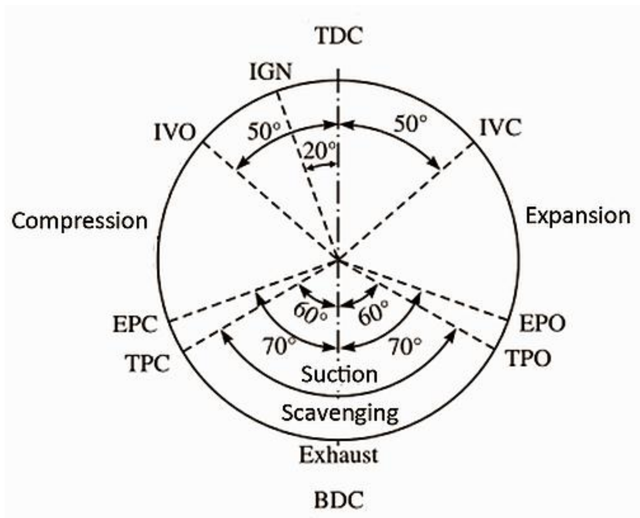

Fig – 12: Port timing diagram for 2-stroke engine

Working cycle

(a) Otto Cycle: - Thermodynamic cycle for SI/petrol engine.

Reversible adiabatic compression and expansion process.

Constant volume heat addition (combustion) and heat rejection process (exhaust).

Fig - 13 depicts the Otto cycle.

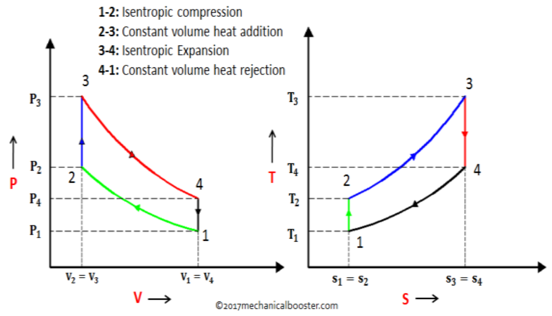

Fig – 13: Otto cycle

Heat supplied, $q_s=C_v(T_3-T_2)$

Heat rejection, $q_R=C_v(T_4-T_1)$

Compression ratio $=r_k=v_1/v_2$

Thermal efficiency, $\eta_{th} = (q_s-q_r)/q_s = [C_v(T_3-T_2)-Cv(T_4-T_1)]/Cv(T_3-T_2) = 1-[(T_4-T_1/(T_3-T_2)]$

In process 1-2, adiabatic compression process,

$T_2/T_1 = (V_1/V_2)^{\gamma-1}$

$\Rightarrow T_2 = T_1.(r_k)^{\gamma-1}$

In adiabatic expansion process, i.e. 3-4,

$T_4/T_3 = (V_3/V_4)^{\gamma-1}$

$\Rightarrow T_3 = T_4. (r_k)^{\gamma-1}$

$\eta_{th} = 1-T_4-T_1/[T_4.(r_k)^{\gamma-1}-T_1.(r_k)^{\gamma-1}]$

$= 1-[1/(r_k)^{\gamma-1}$

Work done (W):

Pressure ratio, $r_p = (P_3/P_2) = (P_4/P_1)$

$P_2/P_1 = P_3/P_4 = (V_1/V_2)^{\gamma} = (r_k)^{\gamma}$

$W = [(P_3V_3-P_4V_4)/(\gamma-1)]-[(P_2V_2-P_1V_1)/(\gamma-1)]$

$1/(\gamma-1)[P_4V_4\{(P_3V_3/P_4V_4)-1\}-P_1V_1\{(P_2V_2/P_1V_1)-1\}]$

$=1/(\gamma-1)[P_4V_1(r_k^{\gamma-1}-1)-P_1V_1(r_k^{\gamma-1}-1)]$

$=P_1V_1/\gamma-1[r_p(r_k^{\gamma-1}-1)-(r_k^{\gamma-1}-1)]$

$=P_1V_1/\gamma-1[r_k^{\gamma-1}-1)(r_p-1)]$

Mean effective pressure, P_m = work done/swept volume =work done-(V_1-V_2)

$P_m =[P_1V_1/\gamma-1\{(r_k\gamma-1-1)(r_p-1)\}]/V_1-V_2$

$=[P_1r_k\{r_k-1-1)(r_p-1)\}]/(\gamma-1)(r_k-1)$

(b) Diesel Cycle: - Thermodynamic cycle for low speed CI/diesel engine.

-Reversible adiabatic compression and expansion process.

-Constant pressure heat addition (combustion) and heat rejection process (exhaust).

Fig – 14 depicts the diesel cycle.

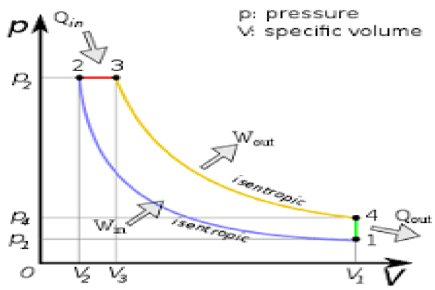

Fig – 14: Diesel Cycle

Heat supplied, $Q_1 =C_p(T_3-T_2)$

Heat rejection, $Q_2 = C_v(T_4-T_1)$

Compression ratio, $r_k = v_1/v_2$

Cut off ratio, $r_c = v_3/v_2$

Thermal efficiency,

$\eta_{th} = (Q_1-Q_2)/Q_1 = [C_p(T_3-T_2)-Cv(T_4-T_1)]/[C_p(T_3-T_2)] = 1-[(1/\gamma)\{(T_4-T_1)/(T_3-T_2)\}]$

In adiabatic compression process i.e. 1-2,

$T_2/T_1=(V_1/V_2)^{\gamma-1}$

$\Rightarrow T_2=T_1.(r_k)^{\gamma-1}$

In process 2-3, pressure constant, then

$T_3/T_2=V_3/V_2=r_c$

$\Rightarrow T_3=T_2.r_c=T_1.(r_k)^{\gamma-1}.r_c$

In adiabatic expansion process i.e. 3-4,

$T_4/T_3=(V_3/V_4)^{\gamma-1}=[(V_3/V_2)*(V_2/V_4)^{\gamma-1}]=(r_c)^{\gamma-1}*1/(r_k)^{\gamma-1}$

$\Rightarrow T_4=T_3.(r_c)^{\gamma-1}*1/(r_k)^{\gamma-1}=T_1.(r_k)^{\gamma-1}.r_c.(r_c)^{\gamma-1}*1/(r_k)^{\gamma-1}=T_1.r_c$

$\eta_{th} = 1-[(1/\gamma).\{(T_4-T_1)/(T_3-T_2)\}]=1-[1/\gamma.(r_k)^{\gamma-1}].[\{(r_c)^{\gamma-1}\}/r_c-1]$

Work done (W):

$W=P_2(V_3-V_2)+(p_3v_3-p_4v_4)/\gamma-1-(p_2v_2-p_1v_1)/\gamma-1$

$=P_2(r_cV_2-V_2)+[(p_2r_cv_2)-(p_4r_kv_2)]/\gamma-1-[(p_2v_2)-(p_1r_kv_2)]/\gamma-1$
since $V_4=V_1$

$=P_2V_2[\{(r_c-1)(\gamma-1)+(r_c-r_c.\gamma.r_k^{-\gamma}.r_k)-(1-r_k1-\gamma)\}/\gamma-1]$

$=[P_1V_1.r_k^{\gamma-1}\{\gamma(r_c-1)-r_k^{1-\gamma}(r_c^{\gamma}-1)\}]/\gamma-1$

Mean effective pressure,

$P_m=[[P_1V_1.r_k^{\gamma-1}\{\gamma(r_c-1)-r_k^{1-\gamma}(r_c^{\gamma}-1)\}]/\gamma-1]/(V_1-V_2)$

$=[P_1r_k^{\gamma}\{\gamma(r_c-1)-r_k^{1-\gamma}(r_c^{\gamma}-1)\}]/(\gamma-1)(r_k-1)$

Comparison of Otto and Diesel Cycle

a) For constant maximum pressure and same heat input

$(\eta_{th})_{Diesel}>(\eta_{th})_{Otto}$

b) For same compression ratio and same heat input

$(\eta_{th})_{Otto}>(\eta_{th})_{Diesel}$

c) For same maximum pressure and temperature

$(\eta_{th})_{Diesel}>(\eta_{th})_{Otto}$

d) for same maximum pressure and output

$(\eta_{th})_{Diesel}>(\eta_{th})_{Otto}$

FUELS & FUEL INJECTION

In IC engines, the chemical energy contained in the fuel is converted into mechanical power by burning (oxidizing) the fuel inside the combustion chamber of the engine.

Fuels suitable for fast chemical reaction have to be used in IC engines, they are following types-

(a) Hydrocarbons fuels derived from the crude petroleum by proper refining process such as thermal and catalytic cracking method, polymerisation, alkylation, isomerisation, reforming and blending.

(b) Alternative fuels such as

-Alcohols (methanol, ethanol)

-Natural gas (methane)

-LPG (propane, butane)

-Hydrogen

Carburetion

The process of preparing a combustible fuel-air mixture outside engine cylinder in SI engine is known as carburetion.

Important factors which affect the process of carburetion are given below;

-Time available for the mixture preparation i.e. atomization, mixing and the vaporization.

-Temperature of the incoming air.

-Quality of the fuel supply.

-Design of combustion chamber and induction system.

Mixture requirements for steady state operation

Three main areas of steady state operation of automotive engine which require different air fuel ratio are discussed below,

Fig – 15: Automobile carburetor

(a) Idling and low load

-From no load to about 20% of rated power.

-No load running mode is called idling condition.

-Very low suction pressure give rise to back flow of exhaust gases and air leakage.

-Increases the amount of residual gases and hence increase the dilution effects.

-Rich mixture i.e. F/A ratio 0.08 or A/F ratio 12.5:1 provide smooth operation of the engine.

(b) Normal power range or cruising range

-From about 20% to 75% of rated power.

-Dilution by residual gases as well as leakage decreases, hence fuel economy is important consideration in this case.

-Maximum fuel economy occurs at A/F ratio of 17:1 to 16.7:1.

-Mixture ratios for best economy are very near to the mixture ratios for minimum emissions.

(c) Maximum power range

-From about 75% to 100% of rated power.

-Mixture requirements for the maximum power is a rich mixture, of A/F about 14:1 or F/A 0.07 -Rich mixture also prevents the overheating of exhaust valve at high load and inhibits detonation.

-In multi-cylinder engine the A/F ratio are slightly lower.

Mixture requirements for transient operation

-Carburetor has to provide mixture for transient conditions under which speed, load, temperature, or pressure change rapidly.

-Evaporation of fuel may be incomplete in the transient condition, quantity of fuel may be increasing and decreasing.

(a) Starting and warm up requirements

-Engine speed and temperature are low during the starting of the engine from cold.

-During starting very rich mixture about 5 to 10 times the normal amount of petrol is sulpplied i.e. F/A ratio 0.3 to 0.7 or A/F ratio 3:1 to 1.5:1.

-Mixture ratio is progressively made leaner to avoid too rich evaporated fuel-air ratio during warm up condition.

-Too high volatility may form vapour bubbles in the carburetor and fuel lines particularly when engine temperatures are high.

-Too low volatility may cause the petrol to condense on the cylinder walls, diluting and removing the lubricating oil film.

(b) Acceleration requirements

- Acceleration refer to an increase in engine speed resulting from the opening of the throttle.

-Acceleration pump is used to provide additional fuel.

Simple Carburetor

-Provide air-fuel mixture for all operating conditions.

-Carburetor depression is pressure differential in the float chamber and venture throat which causes discharge of fuel into the air stream.

-Flow is controlled by small hole of fuel passage.

-Pressure at the throat at the fully open throttle condition lies between 4 and 5 cm of Hg and seldom exceeds 8 cm Hg.

-Petrol engine is quantity governed.

-Drawback of simple carburetor is that it provides too rich and too lean mixture due to vacuum created at the throat is too high and too small which is undesirable.

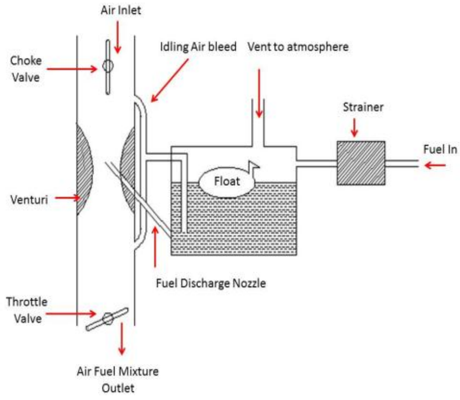

Fig – 16: Diagram of simple carburetor

Complete Carburetor

Additional systems used with simple carburetor can help the engine to operate at all conditions, which are given below,

(i) Main metering system

-Provide constant fuel-air ratio at wide range of speeds and loads.

-Mainly based upon the best economy at full throttle (A/F ratio about 15.6:1).

The different metering systems are,

Compensating jet device

-Addition to the main jet, a compensating jet is provided to provide the leanness effect.

Emulsion tube or air bleeding device

-Mixture correction is done by air bleeding alone.

-In this arrangement main metering jet is fitted about 25 mm below the petrol level which is called as submerged jet.

Back suction control or pressure reduction method

-In this arrangement large vent line connects the carburetor entrance with the top of the float chamber and another small orifice line is connected with the top of the float chambers with venture throat.

-It creates pressure differences according to engine operating conditions.

Auxiliary valve carburetor

-Valve spring of auxiliary valve lift the valve during increase of engine load which increases the vacuum at venture.

-Allows more admittance more additional air and the mixture is not over rich.

Auxiliary port carburetor

-Opening of butterfly allows more air inductance which decreases quantity of fuel drawn.

-Used in aircraft carburetors.

(ii) Idling system

-Idling jet is added for the idling and low load operation which requires rich mixture sof about A/F ratio 12:1.

-Consists of small fuel line from the float chamber to a point of throttle side.

-Gradual opening of throttle may stop the idling jet.

(iii) Power enrichment or economizer system

-This system provides the richer mixture for maximum power range of operation.

-It has meter rod economizer of large orifice opening to the main jet as the throttle is opened beyond a certain point.

-Rod is tapered or stepped.

(iv) Acceleration pump system

-Engine acceleration condition or rapid increase in engine speed may open the throttle rapidly which will not able to provide rich mixture.

-Acceleration pump of spring-loaded plunger is used for fuel supply.

(v) Choke

-Rich mixture is required during cold starting period, at low cranking speed and before the engine warmed up condition.

-Butterfly type valve or choke is used between the entrance to the carburetor and venture throat to meet the requirement.

-Spring loaded by-pass choke is used in higher speeds.

Carburetor types

(i) Open choke: Zenith, solex and carter.

Constant vacuum type: S.U. carburetor.

(ii) Updraught type.

Horizontal or downdraught: Mixture is assisted by gravity in its passage to the engine induction.

(a) Solex Carburetor

-Provide ease of starting, good performance, and reliability.

-Used in Fiat and standard cars and Willey jeep.

-Bi-starter is used for cold starting.

-Well of emulsion system is used for idling and slow running condition.

-Diaphragm type acceleration pump is used for increasing speed case.

(b) Carter Carburetor

-Downdraft type carburetor used in jeep.

-Has triple venture diffusing type choke in which smallest lies above the level float chamber, other two below the petrol level, one below other.

-Multiple venturies result in better formation of the mixture at very low speeds causing steady and smooth operation at very low and high engine speed.

-Mechanical metering method is used.

-Choke valve is provided in the air circuit for cold starting.

-Plunger type acceleration pump is used.

(c) S.U. Carburetor

-Constant air-fuel ratio is maintained due to vacuum depression.

-Has only one jet.

-No separate idling jet or acceleration pump.

-Constant high velocity air across the jet may avoid the use of idling jet.

-Jet lever arrangement provides the rich mixture in cold starting.

-Used in many British cars and Hindustan ambassador car.

Drawbacks of modern carburetor

-Improper mixture proportion in multi-cylinder engine.

-Loss of volumetric efficiency due to obstruction of flow of mixture from choke tubes, jets, throttle valve etc.

-Wear of carburetor parts.

-Freezing at low temperature.

-Surging when carburetor is tilted or during acrobatics in aircraft.

-Backfiring in fuel pipe line.

Petrol injection

-To avoid above problem of modern carburetor, petrol injection is used like in diesel engine.

-Petrol injected during the suction stroke in the intake manifold at low pressure.

-Injection timing is not much critical as like in diesel engine.

-Continuous injection and timed injection methods are used.

Continuous injection

-Fuel is sprayed at low pressure continuously into the air supply.

-Amount of fuel is governed by air throttle opening.

-In supercharged engine, fuel injected in the form of multiple spray into the suction side of the centrifugal compressor.

-Provide efficient atomization of fuel and uniform mixture strength to all cylinder.

-Higher volumetric efficiency.

-One fuel injection pump and one injector.

Timed injection system

-Similar to high speed diesel engine.

-Components are fuel feed or lift pump, fuel pump and distributor unit, fuel injection nozzles and mixture controls.

-Mixture controls are automatic for all engine operating conditions.

(i) Multiple plunger jerk pump system

-Pump with separate plunger and high injection nozzle pressure for each cylinder.

-100 to 300 bar pressure.

-Measured quantity of fuel for definite time and over definite period is delivered.

(ii) Low pressure single pump and distributor system

-Single plunger or gear pump supply fuel at low pressure to a rotating distributor.

-Pressure about 3.5 to 7 bar.

(a) Lucas petrol injection system

-Firstly, used in racing car.

-Single distributor system with novel metering device.

-Line pressure is maintained at 7 bar.

-Metering distributor and control unit distributes the required amount of fuel at correct time and interval.

-Has shuttle arrangements for metering unit.

-In aircraft engine two injectors and spark plug provided for direct injection of fuel in combustion chamber.

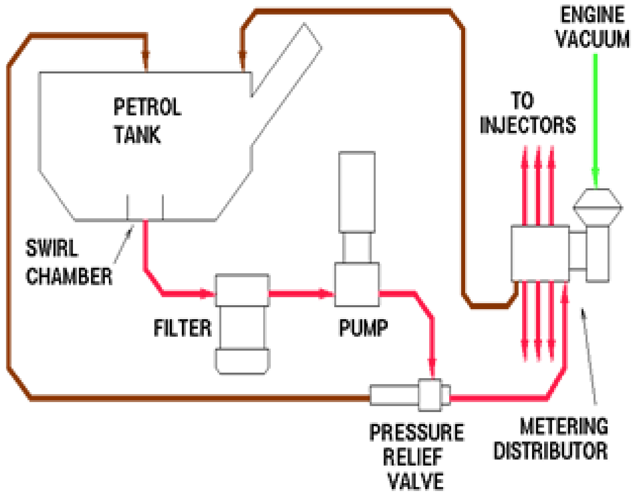

Fig – 17: Diagram of Lucas petrol injection

(b) Electronic fuel injection

Fuel delivery system:

-Electrically driven fuel pump draws fuel from tanks to distribute.

-Fuel and manifold pressure kept constant by pressure regulator.

Air induction system:

-Air flow meter generates voltage signal according to air flow.

-Cold start magnetic injection valve give good fuel atomization and also provide extra fuel during warm up condition.

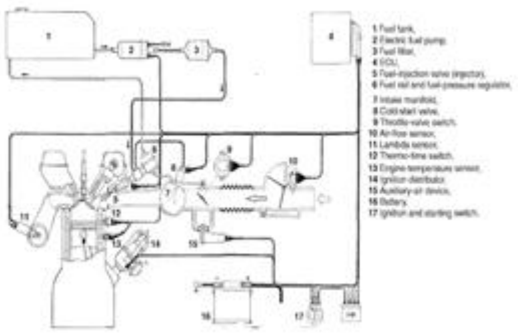

Fig – 18: Diagram of EFI

Electronic control unit (ECU):

-Sensors for manifold pressure, engine speed and temperature at intake manifold.

-Sensor measures operating data from locations and transmitted electrically to ECU.

Injection timing:

-Injected twice for every revolution of crank shaft.

-Triggering of injectors.

Diesel injection system

Requirements of diesel injection system

-Fuel must introduce precisely defined period of cycle.

-Amounts metered very accurately.

-Rate of injection meet desired heat release pattern.

-Quantities of fuel meet changing speed and load condition.

-Good atomization of fuel.

-Good spray pattern for rapid mixing of fuel and air.

-No dribbling and after injection of fuel i.e. sharp injection.

-Injection timing suits the speed and load requirements.

-Distribution of fuel in multi-cylinder should uniform.

-Weight, size and cost of fuel injection system should be less.

Types of diesel injection system

(a) Air injection system

-Fuel supplied through camshaft driven fuel pump.

-Fuel valve is also connected with high pressure airline to inject into cylinder.

-Multi-stage compressor which supply air at a pressure of about 60 to 70 bar.

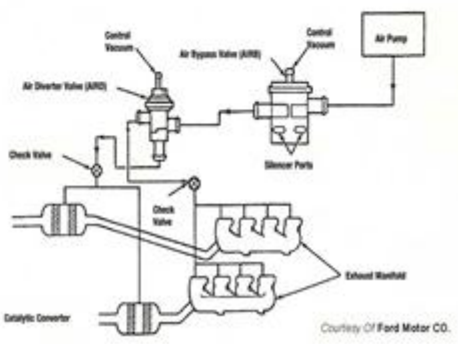

Fig- 19: Diagram of Air Injection System

-Blast air sweeps the fuel along with it.

-Good atomization results in good mixture formation and hence high mean effective pressure.

-Heavy and viscous fuels are used

-Fuel pump require small pressure.

-But it is complicated due to compressor arrangement and expensive.

-Bulky engine and low bhp.

-Overheating and burning of valve seat.

(b) Solid injection system

-Fuel directly injected to combustion chamber without primary atomization termed as solid injection.

-Also known as airless mechanical injection.

-2 units-pressurize and atomizing unit.

3 different types which are described below,

(i) Individual pump and injector or jerk pump system:

-Separate metering and compression pump are used for each cylinder.

-Reciprocating fuel pump is used to meter and set the injection pressure of the fuel.

-Heavy gear arrangements which gives jerking noise; hence name is given is jerk pump.

-Jerk pump is used for medium and high-speed diesel engines.

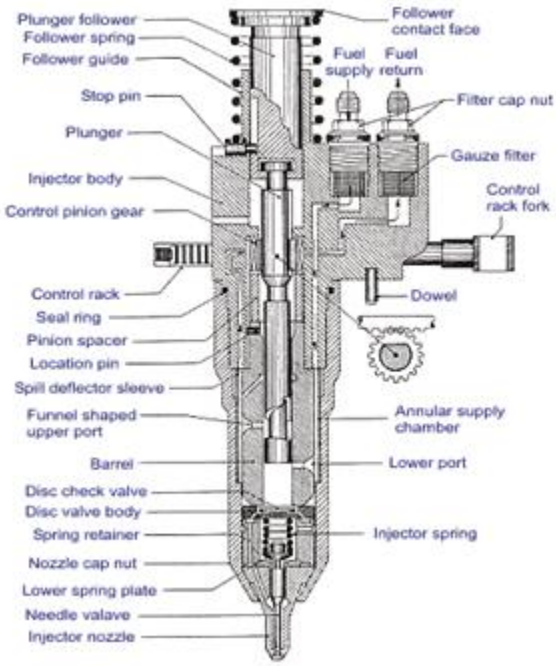

Fig – 20: Injector System

(ii) Common rail system

-High pressure fuel pump delivers fuel to an accumulator whose pressure is constant.

-Plunger type of pump is used.

-Driving mechanism is not stressed with high pressure hence noise is reduced.

-Common rail or pipe is connected in between accumulator and distributing elements.

-Separate metering and timing elements connected to automatic injector.

-Self-governing type.

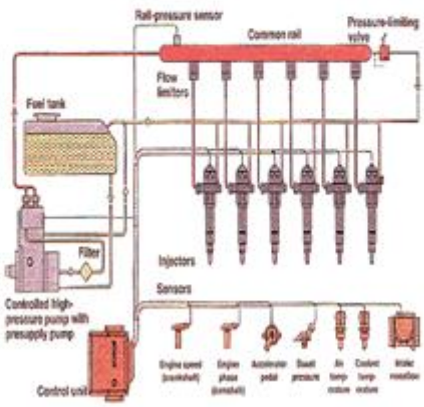

Fig – 21: Common rail system

(iii) Distributor system

-Fuel pump pressurizes, meters and times the fuel supply to rotating distributor.

-Number of injection strokes per cycle for the pump equals to the number of cylinders.

-One metering element which ensure uniform distribution.

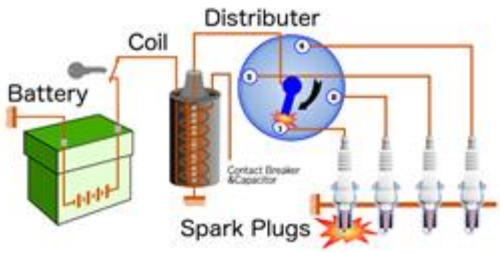

Fig – 22: Diagram of distributor system

Fuel Injectors

3 main types of fuel injectors,

Blast injector

-These are superseded by mechanically operated injectors used in air injection system.

Mechanically operated injector

-Consist of a set of camshaft, cams and rocker gear and other cams for controlling the timing of the fuel injection.

Automatic injector

-Consists of spring-loaded needle valve and operated hydraulically by the pressure of fuel.

-Quantity of fuel is metered by the fuel pump.

Types of nozzles

(a) Depends on the type of combustion chamber,

Open combustion chamber

-Fuel seeks air.

-Air swirl is created due to inclined induction port.

-Multi-hole nozzle injects fuel at a pressure of about 200 to 300 bar to slow moving air.

-Provide good cold starting performance and improved thermal efficiency.

Pre-combustion chamber

-Air velocity is very much high.

-Single hole nozzle with 65 to 100 bar injection pressure is used.

-Used in high speed engine due to rapid combustion.

-External heating device for easy starting of the engine.

(b) Open and closed type of nozzle

Open type

-Consists of fuel orifices and open to burner.

-Cheap and less efficient.

Ex- opposed piston two-stroke Junkers diesel engine

Closed type: pressure drop is minimized compared to open type.

(c) Different types of nozzle for different combustion chamber

(i) Single hole nozzle

-Used in open combustion chamber.

-Size of hole larger than 0.2 mm.

-Very high injection pressure required.

(ii) Multi-hole nozzle

-No. of hole varies from 4 to 18 and the size from 1.5 to 0.35 mm.

-Injection rate is not uniform.

(iii) Pintle nozzle

-A projection or pintle is provided in the nozzle to avoid weak injection and dribbling.

-Pintle may be cylindrical or conical shape.

-Cone angle varied from 0 to 60°.

-Provide good atomization and reduced penetration.

-Fuel pressures are lower than single and multi-hole nozzle.

(iv) Pintaux Nozzle

-Injected fuel in upstream of air.

-Development of pintle nozzle with auxiliary hole drilled in the nozzle body.

-Reduced delay period and increased thermal efficiency.

Assembly view of a V8 Engine

The complete overview V8 Engine is given above.

CONCLUSION:

Internal Combustion engines are among the most important engineering applications. The theory of applications either depends on Diesel or Otto cycles. They are categorized either according to the operating cycle, or due to the mechanism of working. Each type of engines has some advantages over the other one. Thus, the selection of the appropriate engine requires determining the conditions of applications.

REFERENCE:

1. https://www.youtube.com/watch?v=Hna4V7-FJ08

2. “INTERNAL COMBUSTION ENGINE” by V Ganesan.

3. http://www.howstuffworks.com/two-strokes.htm

4.http://www.uq.edu.au/~e4nsdja/teaching/e4213/Related/Cycles/Diesel.htm

5.http://www.uq.edu.au/~e4nsdja/teaching/e4213/Related/Cycles/Otto.htm

6. www.vssutac.in