OBSERVATION OF COMBUSTION PROCESS IN SI ENGINES

[1]Pradip Kumr, [2]Vikas Kumar Tyagi, [3]Rakesh Kumar Yadav, [4]Santosh Kumar Singh

[1]Assistant Professor in Mechanical Engineering Department, Monad University NH-9 Delhi Hapur road, Hapur

[2]Associate Professor in Mechanical Engineering Department, Monad University NH-9 Delhi Hapur road, Hapur

[3]Assistant Professor in Mechanical Engineering Department, Monad University NH-9 Delhi Hapur road, Hapur Hapur

[4]Assistant Professor in Mechanical Engineering Department, Monad University NH-9 Delhi Hapur road, Hapur

ABSTRACT

This paper presents an overall view of combustion process with main a focus on stages of combustion and factors affecting the flame propagation in S.I. To increase the efficiency and performance of the engine we need well understanding of stages of combustion and factors affecting the combustion process. After observation we see that air fuel ratio, compression ratio, load on engine, turbulence and engine speed are affecting the performance of S.I. engine. After controlling these parameters, the performance and efficiency can be increased of S.I. engine.

Keyword - *Stages of Combustion, Factors Affecting the Flame Propagation.*

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Introduction:- Combustion can be defined as a relatively rapid chemical combination of fuel having hydrogen & carbon with oxygen in air resulting in liberation of energy in the form of heat. Following conditions are necessary for combustion to take place:

1. The presence of combustible mixture
2. Some means to initiate mixture
3. Stabilization and propagation of flame in Combustion Chamber

In S I Engines, carburetor supplies a combustible mixture of petrol and air and spark plug initiates combustion.

Richard Theory of Combustion:

Sir Ricardo, known as father of engine research describes the combustion process may be imagined as if it is developing in two stages:

1. Growth and development of a self-propagating nucleus flame. (Ignition lag)
2. Flame is spread through the combustion chamber.

Three Stage of Combustion:

According to statement of Ricardo, There are three stages of combustion in SI Engine as shown:

1. Ignition lag stage

2. Flame propagation stage

3. After burning stage

1. Ignition Lag Stage:

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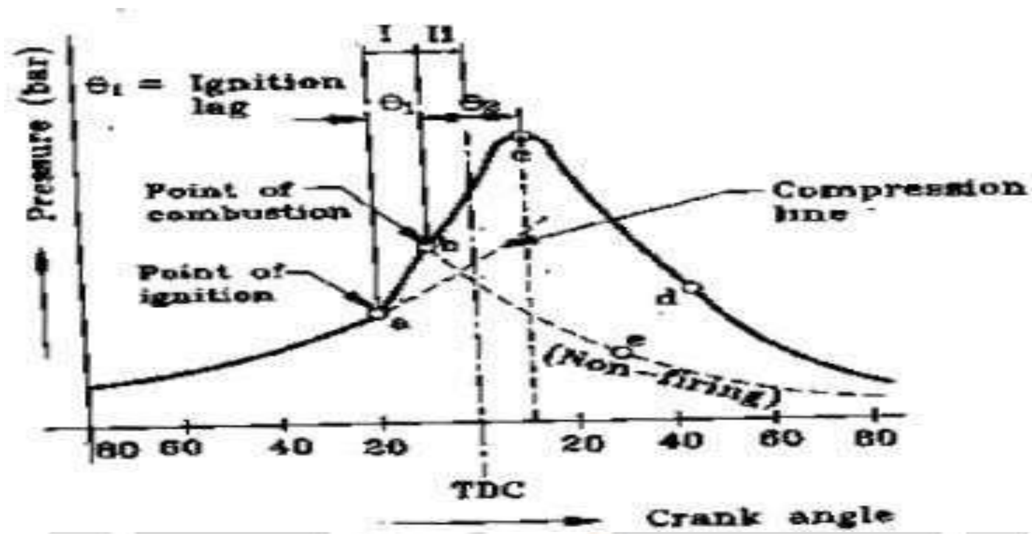


2 A certain time interval between instant of spark & instant of flame where there is a noticeable rise in pressure due to combustion. This time lag is called Ignition Lag. Ignition lag is time interval in the process of chemical reaction during which the molecules gets heated up to self ignition temperature and produce a self propagating nucleus of flame.

3 The ignition lag is commonly expressed in terms of crank angle (θ1). The time period of ignition lag is shown by path (a-b) in the above figure. Ignition lag is small and lies between 0.00015 to 0.0002 seconds. An ignition lag of 0.002 seconds corresponds to 35 deg of crank rotation when the engine is running at 3000 RPM. This is a chemical process and depends upon the nature of fuel, temperature and pressure, proportions of exhaust gas and rate of oxidation or burning.

2. Flame propagation stage:

When the flame is formed at "b", it should be self sustained and must be able to propagate through the mixture. This is possible only when the rate of heat generated by burning of fuel is greater than heat lost by flame to surrounding. After the point "b", the propagation of flame is abnormally low at the beginning because heat lost is more than heat generated. Due to this pressure rise is also slow because mass of mixture burned is small. Therefore, it is necessary to give angle of advance (30-35) degrees, if the peak pressure is attained (5-10) degrees after TDC. The time necessary for crank to rotate through an angle ((θ_2) is known as combustion period in which propagation of flame takes place.

SI engine flame propagation Entrainment-and-burn model:-

Rate of entrainment:

$$\frac{dm_e}{dt} = \rho_u A_f S_L + \rho_u A_f u_T (1 - e^{-t/\tau_b})$$

Laminar diffusion through flame front — Turbulent entrainment

Rate at which mixture burns:

$$\frac{dm_b}{dt} = \rho_u A_f S_L + \frac{m_e - m_b}{\tau_b} \; ; \qquad \tau_b = \frac{\ell_T}{S_L}$$

Laminar frontal burning — Conversion of entrained mass into burned mass

Critical parameters: u_T and ℓ_T

3. After burning:

In after burning combustion will not stop at point “c” but continue after attaining peak pressure. This commonly happens when the rich mixture is supplied to engine.

Factors Affecting the Flame Propagation:

The flame propagation rate affects the combustion process in SI engines. The higher flame propagation velocities may be achieved higher combustion efficiency and fuel economy. Unfortunately flame velocities for most of fuel range lies between [10-30](m/second).

The factors that affect the flame propagations are:

1. Air fuel ratio.

2. Compression ratio.

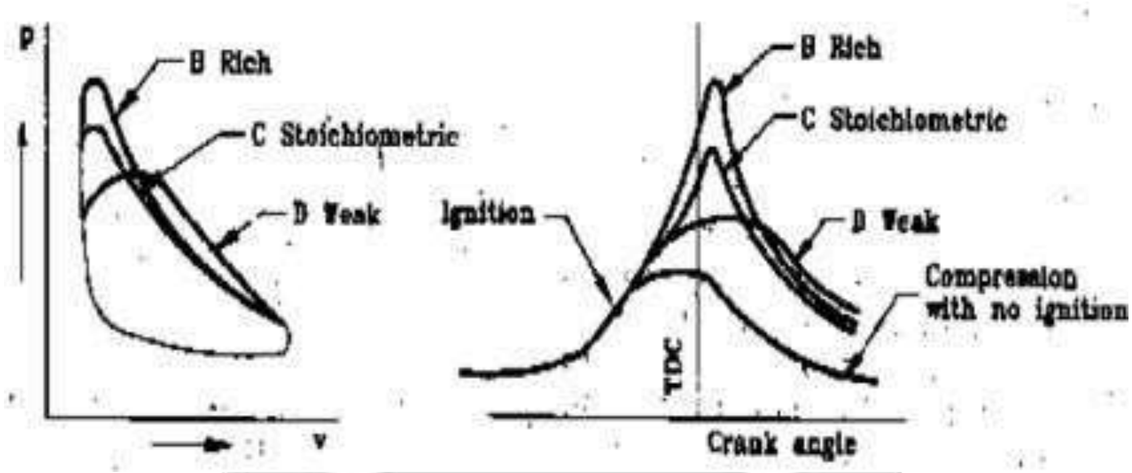
3. Load on engine.

4. Turbulence and engine speed.

5. Other factors.

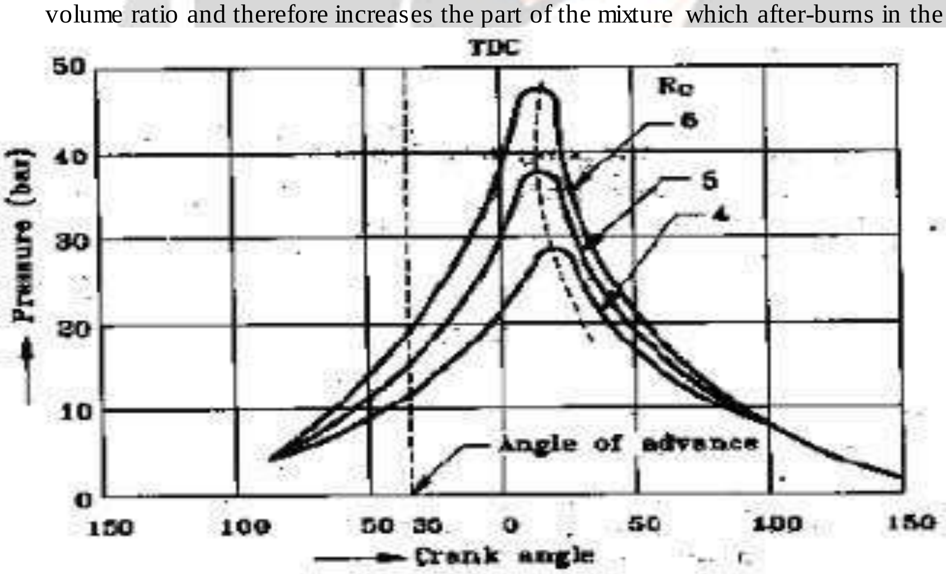
1. A/F ratio:

The rate of combustion and amount of heat generated depends upon the mixture strength. At nearly 10% rich mixture, the maximum flame speed for all hydrocarbon fuels occurs. Flame speed is slow in both for lean and as well as for very rich mixture. Lean mixture generated less heat and a result of this lower flame temperature and lower flame speed. In very rich mixture, incomplete combustion occurred and also results in less heat generated and flame speed remains low. The effects of (A/F) ratio on P-v diagram and P-θ diagram are shown below, (where is θ crank angle):



2. Compression ratio:

The high value of compression ratio increases the pressure and temperature of the mixture and also decreases the concentration of residual gases. These factors reduce the ignition lag and help to increase in speed up and attained second phase of combustion. Both the maximum pressure of the cycle and mean effective pressure of the cycle increases with increase in compression ratio. In figure below shows the effect of compression ratio on pressure (indirectly on the speed of combustion) with respect to crank angle for same (A/F) ratio and same angle of advance. High value of compression ratio increases the surface to volume ratio and therefore increases the part of the mixture which after-burns in the third phase.



3. Load on Engine:

The cycle pressures increase and the flame speed also increases with increase in load. The power developed by an S.I. engine is controlled by throttling. At lower load and higher the throttle, the initial pressure and final pressure of the mixture after compression is decrease and the mixture is also diluted with the more residual gases. This decreases the flame propagation and prolongs the ignition lag. This is the reason, the advance mechanism is also provided to the engine with change in load. This problem can be partly overcome by giving rich mixture at part loads but this definitely increases the chances of afterburning. The after burning is prolonged with rich mixture. Poor combustion at part loads and necessity of providing rich mixture are the main disadvantages of S.I engines which causes wastage of fuel and generation of large amount of CO with exhaust gases.

4. Turbulence:

Turbulence plays important role in combustion of fuel because the flame speed is directly proportional to the turbulence of the mixture. Due to this the turbulence increases the mixing and heat transfer rate between the burned and unburned mixture. The turbulence of the mixture can be increased at the end of compression by design of the combustion chamber (geometry of cylinder head and piston crown). Insufficient turbulence gives low flame velocity and incomplete combustion and decreases the power output. But excess turbulence is also not desirable because it increases the combustion and leads to detonation. Excess turbulence cool the flame generated and flame propagation is decreased. Moderate turbulence is mostly desirable because it accelerates the chemical reaction, decreases ignition lag, increases flame propagation and even allows weak mixture to burn efficiently.

(a) Engine Speed:

When engine speed increases, the turbulence of the mixture increases. Due to this, the flame speed almost increases linearly with engine speed. If the engine speed becomes doubled, flame to travel the combustion chamber is halved. At double the original speed and half the original time gives the same number of crank degrees for flame propagation. The crank angle is required for the flame propagation, which is main phase of combustion will remain almost constant at all speeds. This is an important feature of all petrol engines.

(b) Engine Size:

Engines of similar design commonly run at the same piston speed. This is achieved by the using small engines with larger RPM and larger engines with smaller RPM. Because of same piston speed, the inlet velocity, degree of turbulence and flame speed are mostly same in similar engines regardless of the size. In small engines the flame travel is small and in large engines flame travel is large. Therefore, if the engine size becomes doubled the time required for propagation of flame through combustion chamber is also doubled. But with low RPM of large engines the time period of flame propagation in terms of crank would be mostly same as in small engines. In other words, the number of crank degrees necessary for flame travel will be about the same irrespective of engine size provided the engines are similar.

3. Other Factors:

Among the other factors, the factors which increase the flame speed are supercharging of the engine, spark timing and residual gases left in the engine at the end of exhaust gases. The humidity of air also affects the flame velocity but its exact effect is not known. Anyhow, its effect is not large as compared with (A/F) ratio and turbulence.

REFERENCES:-

1) Almena, A.; Bueno, L.; Díez, M.; Martín, M. Integrated biodiesel facilities: Review of glycerol-based production of fuels and chemicals. Clean Technol. Environ. Policy 2018, 20, 1639–1661. [CrossRef]

2) B.L.singhal, "I.C.Engines and Compressors" Tech-Max Publications,Pune.

3) Emberson, D.R.; Wyndorps, J.; Ahmed, A.; Bjørgen, K.O.P.; Løvås, T. Detailed examination of the combustion of diesel and glycerol emulsions in a compression ignition engine. Fuel 2021, 291, 120147. [CrossRef]

4) G Bansal, HG Im Autoignition and front propagation in low temperature combustion engine environments Combust Flame, 158 (2011), pp. 2105-2112

5) Rychter, T., Teodorczyk, A., „Teoria silników tłokowych" , Wydawnictwa Komunikacji i Łączności, ISBN 83-206-1630-1, Warsaw 2006, PolandHariprasad.N , International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056 Volume: 07 Issue: 02 | Feb 2020.
6) Sliwinski, K.; Marek, W. The Use of Glycerine as Motor Fuel. Combust. Engines 2019, 178, 166–172. [CrossRef]
7) V Ganesan"Internal Combustion Engines", Tata Mcgraw Hill Education(India) Private Limited, New Delhi. 4th edition.