UPPSC-AE 2025

Uttar Pradesh Public Service Commission

Combined State Engineering Services Examination

Assistant Engineer

Mechanical Engineering

Energy Conversion

Well Illustrated **Theory** *with*
Solved Examples and **Practice Questions**

MADE EASY PUBLICATIONS

Energy Conversion

Contents

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CHAPTER 1

Combustion in SI and CI Engines

1.1 Introduction

Combustion is a chemical reaction in which certain elements of the fuel like hydrogen and carbon combine with oxygen liberating heat energy and causing an increase in temperature of the gases. The conditions necessary for combustion are the presence of combustible mixture and some means of initiating the process. The process of combustion takes place either in a homogeneous (in petrol engines) or a heterogeneous (in diesel engines) fuel vapor-air mixture.

1.2 Ignition Limits

- Ignition limits correspond to those mixture ratios at lean and rich ends where the heat released by spark is no longer sufficient to initiate combustion.
- For most hydrocarbon fuels, the stoichiometric air fuel ratio is about 14.8 : 1. The ignition limits must lie between (A/F) 30 : 1 and 7 : 1.

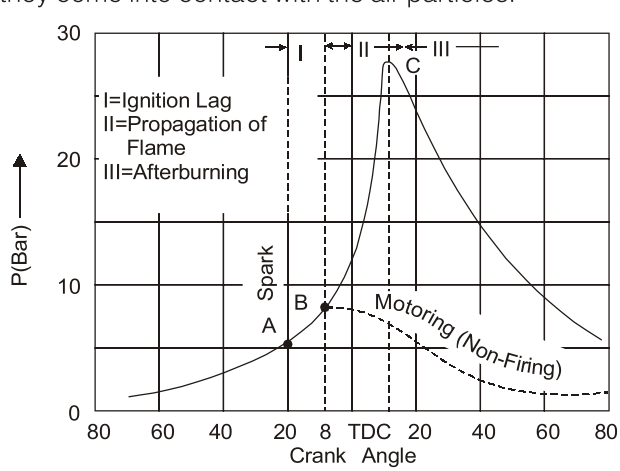
NOTE: Equivalence ratio (ϕ) is the ratio of actual F/A ratio to the stoichiometric F/A ratio. If $\phi > 1$, mixture is rich and if $\phi < 1$, mixture is lean. $\phi = 1$ corresponds to the correct or stoichiometric mixture.

1.3 Stages of Combustion in SI Engine

Stage I - Ignition lag: Time for development of nucleus of flame after spark is ignition lag. It is preparation phase for flame propagation

Stage II - Flame propagation: Due to turbulence, the nucleus of the flame fastly travels most of the length of the cylinder. It is flame propagation. Its start is the point of sudden rise of pressure in the cylinder.

Stage III - After burning: It is the after burning phase in which the remaining unburnt fuel particles start burning as soon as they come into contact with the air particles.



1.3.1 Effect of Engine Variables on Ignition Lag

- The first phase is not a period of inactivity but is a chemical process.
- The ignition lag in terms of crank angle is 10° to 20° and in terms of seconds, 0.0015 seconds.

The duration of ignition lag depends on the following factors:

(i) **Fuel:** Ignition lag depends on the chemical nature of fuel. The higher the self ignition temperature of the fuel, the longer the ignition lag. In SI engines, longer ignition lag is desired.

(ii) **Mixture ratio:** Ignition lag is smallest when mixture is about 10% richer than stoichiometric. This mixture gives maximum temperature.

(iii) **Initial temperature and pressure:** Rate of chemical reaction depends upon the temperature. The ignition lag therefore decreases with an increase in temperature and pressure of the gas.

(iv) **Compression ratio (CR):** As $CR \uparrow$, temperature of mixture $\uparrow$ $\therefore$ Ignition lag $\downarrow$

(v) **Retarding the spark:** It means spark is made near the TDC. It will increase temperature of the mixture and hence ignition lag decrease.

(vi) **Turbulence:** Ignition lag (I.L) is not much affected by turbulence. Turbulence is directly proportional to engine speed. So, increase in speed does not affect much the I.L measured in milliseconds but if measured in degrees of crank rotation I.L increases linearly with engine speed.

NOTE

(i) Due to the reason mentioned in (vi), it becomes necessary to advance the spark timing at higher speeds.

(ii) As load $\downarrow$, temperature of mixture $\downarrow$ (due to throttling) $\therefore$ I.L $\uparrow$

1.3.2 Importance of Electrode Gap

- If the gap is too small, quenching of the flame nucleus may occur. Development of a flame nucleus is not smooth.
- As Compression Ratio (CR) decrease, Electrode gap required increase
- Voltage require to produce spark, V

$$V \propto \text{A/F ratio}$$
$$\propto \text{CR}$$
$$\propto \text{Engine load}$$
$$\propto \text{Age of engine}$$

So, the summary of the above variables is

Parameter	Effect on ignition lag
Self ignition temperature	Increases
Initial temperature and pressure	Decreases
Turbulance	Increases
Compression ratio	Decreases
Speed	Increases
Advancing spark	Decreases

1.3.3 Effect of Engine Variables on Flame Propagation

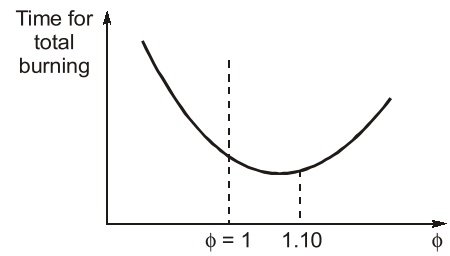
- The second stage is a mechanical one.
- This is the most important stage as the flame velocity influences the rate of pressure rise in the cylinder and affects the auto ignition of the fuel.

Effect of various variables on this phase:

(i) F/A ratio: Maximum flame velocity is at 10% rich mixture

– Linear mixture → less thermal energy → flame temperature decrease → flame speed decrease

– Richer mixture → Incomplete combustion → less thermal energy → flame temperature decrease → flame speed decrease



(ii) Compression ratio: As C.R increase, temperature and pressure of mixture increase

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Flame speed increase

– Also, As C.R increase, I.L decrease

– So, total ignition angle is reduced.

(iii) Intake temperature (*T*) and pressure (*P*): As temperature and pressure increase, Flame speed increase.

(iv) Load: As load increase, temperature and pressure increase, Flame speed increase

(v) Turbulence: With turbulence, flame speed increases.

– Turbulence accelerates chemical action. Hence it allows ignition advance to be reduced and so weak mixtures can be burnt.

– Excessive turbulence is undesirable as it increases the heat loss to the cylinder walls.

(v) Engine speed: The higher the speed, the greater is the turbulence. So, flames speed increases almost linearly with engine speed.

– If the engine speed is doubled, the time required in milliseconds for the flame to traverse the combustion space would be halved.

– Double the original speed and hence half the original time would give the same number of crank degrees for flames propagation.

– Thus, the crank angle required for the flame propagation which is the main phase of combustion will remain almost constant at all speeds.

– However, the increase in engine speed would lead to ignition advance due to first phase of combustion.

So, summary of the above variables is:

Parameter increased	Effect on flame propagation (Flame speed)
Compression ratio	Increases
Initial temperature and pressure	Increases
Engine load	Increases
Turbulance (not excessive)	Increases
Speed	Increases

1.4 Abnormal Combustion

- In normal combustion the flame started by the spark travels across the combustion chamber in a fairly even way.

- Under certain engine operating conditions abnormal combustion may take place which affects the engine performance.
- The important abnormal combustions are 'detonation or knock', 'preignition', 'run-out' etc. Of these detonation is most important because it puts a limit on the compression ratio.

Detonation or Knocking

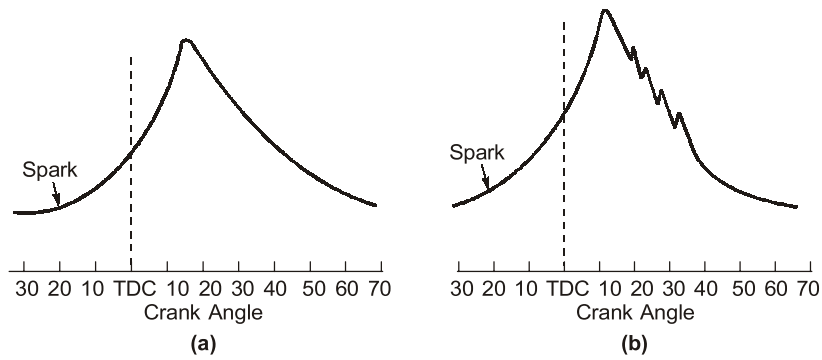


Figure: (a) Combustion without detonation (b) Combustion with detonation

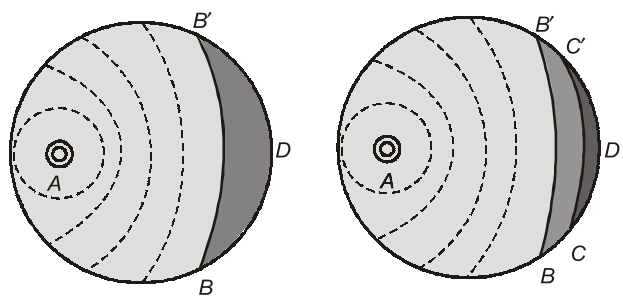


Figure: (a) Flame propagation before self ignition (b) Flame propagation after self ignition

- In this, the end charge auto-ignites before the flame front reaches it.
- In order to auto-ignite, the last unburnt portion of the charge must reach above a certain 'critical temperature' and remain at this temperature for a certain length of time. During this period certain chemical reactions take place which prepare the charge for 'auto-ignition'. This time period is called 'ignition delay'.
- If the flame front can proceed and consume the unburnt charge in a normal manner prior to completion of the delay period, there will be no detonation.

NOTE

In the context of diesel engines, knocking has rather different meaning. Knocking or detonation in SI engines always occur near the end of combustion (i.e., IInd phase) whereas in CI engines it occurs in the beginning of combustion.

1.4.1 Effects of Detonation

- Detonation leads to noise, mechanical damage, carbon deposits, heat loss, preignition.
- Preignition due to detonation is caused by the local overheating, especially of the spark plug, which results in temperature high enough to ignite the charge before the passage of spark.

NOTE: Pre-ignition can also be caused by reasons other than detonation.

1.4.2 Theories of Detonation

1.4.2.1 Auto Ignition Theory

- Flame velocity is normal before auto ignition.
- During delay period some chemical reactions called pre-flame reactions occur which prepare the mixture for auto ignition.

1.4.2.2 Detonation Theory

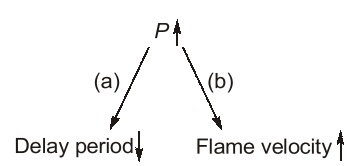
A true detonating wave or shock wave formed by pre-flame reactions has been proposed as the mechanism for auto ignition.

1.4.3 Effect of Engine Variables on Knocking

- In order to avoid detonation a high auto ignition temperature and a long ignition delay are desirable qualities for SI engine fuels.
- Also the end gas should have low temperature and low density,

Factors affecting Detonation are:

1. **Compression ratio:**
   - As C.R increase, T and P increase, Delay period decrease, Knocking increase.
   - For a given engine setting and fuel there will be a critical compression ratio above which knocking occurs. This compression ratio is called highest useful compression ratio (HUCR).
   - Materials with high heat conductivity such as aluminium alloys are desirable for high compression cylinders.
2. **Supercharging:** As T and density of charge increase, knocking increase.
3. **Inlet temperature:** As T increase, delay period decrease, knocking increase
4. **Advancing the spark timing:**
   - When the spark is advanced, burning gas is compressed by the rising piston and therefore both temperature and pressure are increased.
   - Thus knocking increases with advanced spark timing and decreases with retarded spark timing.
5. **Inlet pressure:**



Effect (a) dominates, so knocking increase.

6. **Speed:**
   - As speed decrease, turbulence decrease,
     ∴ flame speed decrease, knocking increase.
   - Hence tendency to knock is increased at lower speeds.
7. **Fuel-Air Ratio:**
   - When $\phi = 1.1$, Ignition L $\rightarrow$ minimum and flame velocity $\rightarrow$ maximum.
   - But effect of Ignition L dominates, so at $\phi = 1.1$ (i.e., 10% richer), knocking is maximum.
   - When mixture is leaner or richer, knocking reduces.
8. **Humidity Ratio:** As humidity ratio increase, reaction time decrease. ∴ knocking increase

9. Spark plug location

- A spark plug which is centrally located in the combustion chamber has minimum tendency to knock as the flame travel is minimum. The flame travel can be reduced by using two or more spark plugs.
- The exhaust valve should be located close to the spark plug so that it is not in the end gas region, otherwise there will be tendency to knock.

10. Octane rating

- It is the measure of resistance to knock.
- Higher the octane number, lesser is the tendency to knock.

The summary of the important variables and their effect on detonation is given below:

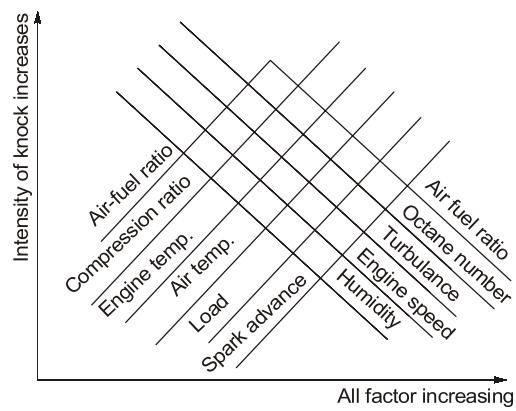


Table: Summary of Variable Affecting Knock in SI Engines

Increase in variable	Major effect on unburned charge	Action to be taken to reduce knocking	Can operator usually control?
Fuel	Self ignition temperature	high	No
Spark timing	Temperature and density	retard	Yes
Compression ratio	Increases temperature and pressure	reduce	No
Mass of charge inducted	Increases pressure	reduce	Yes
Inlet temperature of air	Increases temperature	reduce	In some cases
Circulating water temperature	Increases temperature	reduce	In some cases
A/F ratio	Increase pressure and temperature	fuel-rich mixture	Yes
Load on the engine	Temperature and density	reduce	Yes
Turbulence	Decreases time	reduce	No
Engine speed	Decreases time factor	increase	Yes
Humidity	Reaction time	increase	No
Length of flame travel	Increase time factor	reduce	No

1.4.4 Detection of Detonation

1. By hearing, if speed is low.
2. High temperature of spark plug gasket indicates detonation.
3. By using knock meter to measure vibrations.
4. Presence of intermittent puffs of gray smoke in exhaust indicated detonation.

1.5 Surface Ignition

- It is the initiation of a flame front by a hot surface & not by the spark. The hot surface may be spark plug, electrode, exhaust valve head etc. This is mainly caused by carbon deposits.
- The normal combustion knock or detonation is called spark knock. Knocking cause by surface ignition is called abnormal combustion knock.
- It may occur before (pre-ignition) or after (post-ignition) normal ignition.
- Surface ignition caused by spark plug electrode can only be pre-ignition and not post ignition.
- Surface ignition (both pre and post) may or may not cause knocking.

1.6 Detection of Pre-ignition

- After shutting off the engine, if engine continuous firing then there may be pre-ignition.
- Sudden loss of power with no mechanical evidence indicated pre-ignition.
  NOTE: Pre-ignition is maximum at 10-15% rich mixture.

Squish: Squish is the rapid ejection of gas trapped between the piston and cylinder head. It induces turbulence which decreases knocking tendency.

1.7 Combustion Chamber Design Principle

- Large inlet valve to achieve high volumetric efficiency.
- High surface–volume ratio to reduce flame propagation time.
- Exhaust valve should be small and should not be in end region to prevent surface ignition. It should be near spark plug.

1.7.1 Type of Combustion Chambers

- **T-Head combustion chamber:** It is long combustion chamber which causes high knocking tendency.
- **L-Head combustion chamber:** It is also called side valve combustion chamber. It is used for low compression ratio engine. Extremely prone to detonation.
- **I-Head combustion chamber:** It is also known as overhead valve combustion chamber. It is mainly used for high compression ratio. It has following properties-low surface to volume ratio, higher volumetric efficiency, less losses, less flame travel length etc.
- **F-Head Combustion chamber or Wedge type:** It possess almost all the requirements of combustion chamber viz. high volumetric efficiency, compression ratio and thermal efficiency.

1.7.2 Detonation tendency

L Head > T Head > I Head > F Head

1.8 CI Engines

- In CI engine air is compressed through a large compression ratio (12 : 1 to 22 : 1) during compression stroke raising its temperature to pre-ignition point. Then fuel is injected through fuel pump. So the air and fuel mix with each other and self ignite.

- As it is impossible to inject the fuel droplets uniformly through the combustion space, the fuel-air mixture formed is essentially heterogeneous.
- It is, therefore, essential to impart an orderly and controlled movement to air called SWIRL.

NOTE: In SI engine also air movement is required, but in SI engine it is called turbulence which is a disordered air motion. In CI engine, it is called SWIRL.

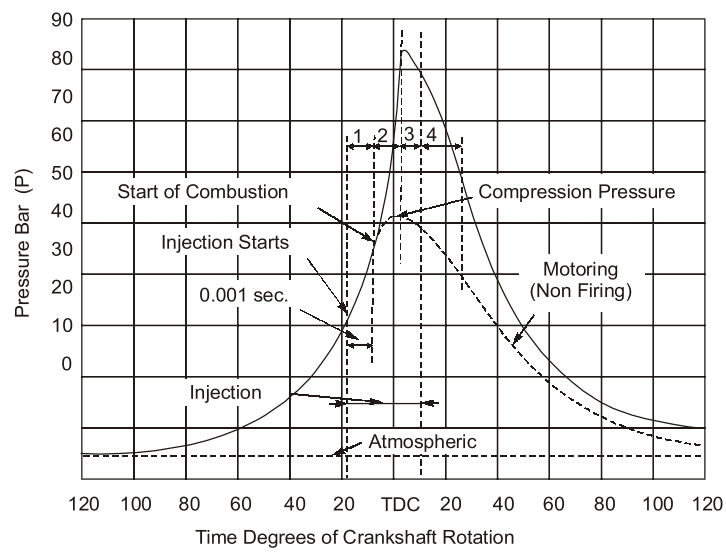
1.9 Air Fuel Ratio in CI engine

- In SI engine A/F ratio remains nearly stoichiometric from no load to full load.
  In CI engine, it may vary from 80% at no load to 20% at full load.
- Due to heterogeneous mixture there is tendency to smoke in CI engines if operated near stoichiometric ratio at full load. So, CI engines must always operate with excess air (A/F ratio 20 to 23).

1.10 Stages of combustion

I. Delay Period

- In CI engines the delay period is divided into physical delay and chemical delay. Physical delay is the time between start of injection and attainment of chemical reaction conditions. During this period fuel is atomized, vaporized and is mixed with air.
- Chemical delay for CI engines is the same as ignition delay for SI engines. During this phase reaction start slowly and ignition takes place.



NOTE

(i) Ignition lag in SI engine is basically equivalent to chemical delay in CI engine. There is no component like physical delay in SI engine.

(ii) The delay period in CI combustion affects rate of pressure rise and hence knocking.

II. Rapid or Uncontrolled Combustion

During the ignition delay period more and more fuel droplets come out of the injector and get collected in the combustion chamber. As soon as the delay period is completed these droplets start burning together. This produces uncontrolled or rapid combustion at the beginning of combustion in CI engines.

III. Controlled Combustion

After some gap of time the temperature of combustion chamber is so high that as soon as the fuel droplets enter the combustion chamber, they start burning. Hence this phase is known as controlled combustion.

IV. After Burning

This phase involves combustion of less volatile fuel particles which have not yet burnt. As soon as they come into contact with air particles they will start burning leading to after burning phase.

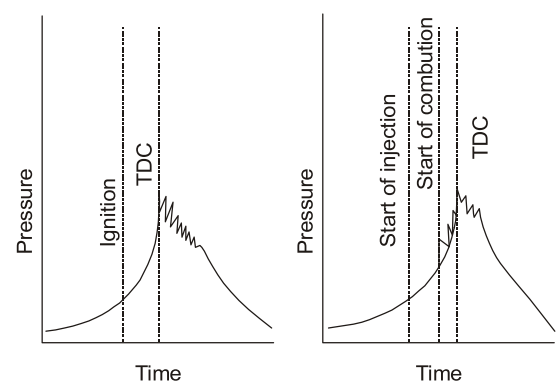
1.11 Effect of Variable on Delay Period

Effect of Variable on delay period is define in below table:

S.No	Increase in variable	Effect on delay period	Reasons
1.	Cetane number of fuel	Reduces	Reduces self-ignition temperature
2.	Injection pressure	Reduces	Greater surface-volume ratio hence less physical delay.
3.	Injection advance angle	Increases	Pressure and temperature lower when injection begins.
4.	Compression ratio	Reduces	Increases air temperature and pressure and reduce auto-ignition temperature
5.	Intake temperature	Reduces	Increases air temperature
6.	Jacket water temp	Reduces	Increases wall and hence air temperature
7.	Fuel temperature	Reduces	Better vaporization and increases chemical reaction
8.	Intake pressure (supercharging)	Reduces	Increase in density reduces auto-ignition temperature
9.	Speed	Reduces in milliseconds, increases in crank angle	Less loss of heat more crank angle in a given time
10.	Load (fuel-air-ratio)	Decreases	Opening temperature increases
11.	Engine size	Little effect in milliseconds but crank angle decreases	Low rpm
12.	Type of combustion chamber	Lower for pre-combustion chambers.	

1.11.1 Knocking in CI engine

- If the delay period is long a large amount of fuel will be collected in the combustion chamber before ignition starts. The auto-ignition of this large amount of fuel may cause high rate of pressurerise which causes knocking in diesel engines.
- All the factors which increases delay period are the cause of knocking in CI engine.



(a) SI engine (b) CIengine

1.12 Compression Ratio in CI Engines

- In CI engines the compression space is already very small and the necessity of providing working clearance leaves some unused air. This decreases the power and volumetric efficiency.
- Also due to high compression ratio, mechanical efficiency decreases due to increase in weight of reciprocating parts.
- So, in practice the CI engine designer uses the lowest compression ratio which would satisfy the needs of cold starting and light load running at high speeds. In SI engines highest possible compression ratio is used limited only by detonation.

1.13 Comparison in Knocking Phenomenon of SI Engine and CI Engine

Table define comparison between SI engine and CI Engine:

SI engine	CI engine
Knocking occurs in the end of combustion.	Knocking occurs in the begining of combustion.
Rate of pressure rise is very high due to homogeneous mixture.	Rate of pressure rise is less due to hetrogeneous mixture.
Knocking occurs due to short delay period.	Knocking occurs due to long delay period
Knocking is easily distinguishible	Knocking is not easily distinguishible
Pre - ignition is possible	Pre - ignition is not possible

The factors that reduces knocking tendency in SI engine increases the knocking tendency in CI engine and vice versa. So to avoid knocking, factors should be controlled as follows:

Factors	SI engine	CI engine
Self ignition temperature	High	Low
Delay period	Long	Short
Compression ratio	Low	High
Inlet temperature	Low	High
Speed	High	Low
Octance number	High	Low
Cetane number	Low	High

1.14 Turbulence

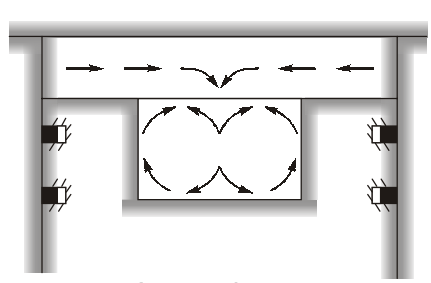
It is a disordered air motion in engine with no direction of flow to break flame nucleus so as to induce flame propagation.

1.14.1 Swirl

It is the orderly movement of air with a particular direction of flow to supply fresh air to burning droplet of fuel and wash away the products of combustion which otherwise would suffocate the burning droplet.

1.14.2 Squish

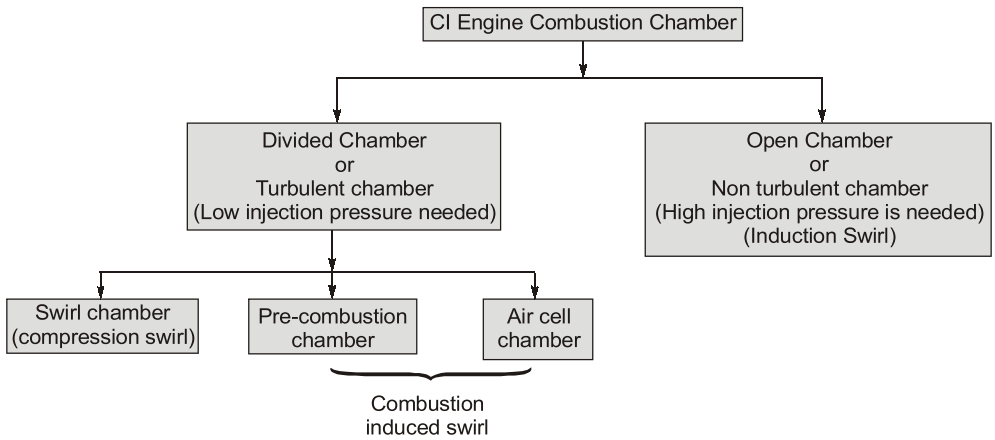
It is the secondary air movement. It is the flow of air radially inwards towards the combustion recess by squeezing it out from between the piston and cylinder head as they approach each other at the end of the stroke.



Squish in Cylinder

1.15 CI Engine Combustion Chamber

The basic function of the combustion chamber in CI engine is to provide swirl to have better mixing of fuel air and proper combustion.



1.15.1 Induction swirl with open combustion chamber

- With multiple orifice injector and by directing the flow of the air during its entry to the cylinder, swirl is created in the combustion chamber.
- These are very useful for cold starting and large low speed engine. It is not good for variable speed range.

1.15.2 Compression swirl with divided combustion chamber

With single pintle injector (due to self cleaning property of the injector) and by forcing the air through a tangential passage into a separate swirl chamber during the compression stroke, swirl is created.

This type of combustion chamber is compression swirl with divided combustion chamber. This is very useful for variable speed operation and has higher volumetric efficiency. Cold starting is problem in it and it is costly.

1.15.3 Pre combustion chamber

In this, the turbulence is created by combustion of small amount of fuel in a prechamber. Here single hole pintle type of nozzle is used. It has multifuel capability. The main disadvantage is the heat loss.

1.15.4 Glow Plug

It is an electric heater which is used to heat the combustion chamber before the starting of engine. It is used mostly in cold countries to aid cold starting of engines.

Example - 1.1 In a petrol engine the knocking tendency decreases with

(a) Increase in charge temperature
(b) Increase incylinder diameter
(c) Increase in compression ration
(d) Decrease in atmospheric humidity

Solution: (a)

In this question, all the rest options increase the knocking. Also in option (a) charge temperature is increased which increases the flame speed and reduces knocking.

Example - 1.7 If in a diesel engine petrol is used then the engine will

(a) run at low speed
(b) explode
(c) run at high speed
(d) run with high knocking

Solution: (d)

Due to high self ignition temperature of fuel, ignition delay will be more and hence knocking will increase.

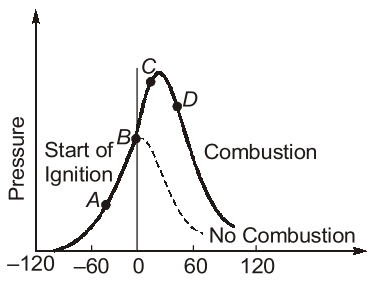
Student's Assignment

Q.1 Knocking tendency in a SI engine reduces with increasing
(a) Compression ratio
(b) Wall temperature
(c) Supercharging
(d) Engine speed

Q.2 For minimizing knocking tendency in SI engines, the spark plug should be located
(a) near the inlet valve
(b) away from the inlet valve
(c) near the exhaust valve
(d) midway between inlet and exhaust valve

Q.3 Pre-ignition in a SI engine may be detected by
(a) increase in speed
(b) sudden loss of power
(c) Exhaust coloration
(d) rise in exhaust temperature

Q.4 Hypothetical pressure diagram for a compression ignition engine is shown in the given figure. The diesel knock is generated during the period



(a) AB
(b) BC
(c) CD
(d) after D

Q.5 Consider the following:
1. Increased cetane number.
2. Increased compression ratio.
3. Increased injection advance.
4. Increased air turbulence.

Which of the above factors reduce physical delay in the diesel engine?
(a) 1, 2 and 3 only
(b) 2 and 4 only
(c) 2, 3 and 4 only
(d) 1, 2, 3 and 4

Q.6 The turbulence in diesel engines ensures
(a) higher volumetric efficiency
(b) higher fuel consumption
(c) intimate mixing of air
(d) reduce engine vibrations

Q.7 Which one of the following is the richest mixture for SI engines, when fuel air ratio is
(a) 1 : 10
(b) 1 : 13
(c) 1 : 14
(d) 1 : 17

Q.8 The delay period in a petrol engines is of the order of
(a) 0.001 sec
(b) 0.002 sec
(c) 0.01 sec
(d) 0.05 sec

Q.9 The function of fuel injector is to:
(a) Pump the fuel at high pressure
(b) Mix diesel with air
(c) Atomise the fuel
(d) Ignite the fuel

Q.10 The function of carburettor is to:
(a) Refining the fuel
(b) Increase the pressure of fuel vapours
(c) Inject petrol in cylinder
(d) Atomise and vapourise the fuel and to mix it with air in proper ratio

Q.11 In S.I. engine, the throttle valve of carburettor controls the quantity of:
(a) Fuel
(b) Air
(c) Fuel and air mixture
(d) Lubricating oil

Q.12 With increase in compression ratio flame speed:
(a) Increases
(b) Remains same
(c) Decrease
(d) First increases and then remain constant

Q.13 Scavenging means:
(a) Using fresh air for compressor
(b) To reduce detonation
(c) Using air for throwing burnt gases out of cylinder during exhaust stroke.
(d) Using correct air fuel mixture

Q.14 Duration between the time of injection and time of ignition in a diesel engine is called:
(a) Lead period
(b) Delay period
(c) Combustion period
(d) Period of compression

Q.15 Consider the following statements in respect of an S.I. engine :
1. The maximum speed occurs when the fuel mixture is about 10% richer than the stoichiometric value.
2. An increase in compression ratio decreases the flame speed.
3. An increase in intake temperature increases the flame speed.

Which of the statements given above are correct ?
(a) 1 and 2 only (b) 2 and 3 only
(c) 1 and 3 only (d) 1, 2 and 3

Q.16 Consider the following statements in respect of a C.I. engine :
1. An increase in compression ratio reduces the delay period.
2. An increase in injection advance angle increases the delay period.
3. An increase in jacket water temperature reduces delay period.

Which of the statements given above are correct ?
(a) 1 and 2 only (b) 2 and 3 only
(c) 1 and 3 only (d) 1, 2 and 3

Q.17 Consider the following statements:
Knock in the SI engine can be reduced by
1. Supercharging.
2. Retarding the spark.
3. Using a fuel of long straight chain structure.
4. Increasing the engine speed.

Which of these statement are correct?
(a) 1, and 2 (b) 2 and 3
(c) 1, 3 and 4 (d) 2 and 4

Q.18 Knocking in the SI engine decreases in which one of the following orders of combustion chamber designs?
(a) F head, L head, I head
(b) T head, L head, F head
(c) I head, T head, F head
(d) F head, I head, T head

Q.19 Consider the following statements:
Detonation in the SI engine can be suppressed by
1. Retarding the spark timing.
2. Increasing the engine speed.
3. Using 10% rich mixture.

Which of these statements are correct?
(a) 1 and 3 (b) 2 and 3
(c) 1, 2 and 3 (d) 1 and 2

Q.20 Preignition in SI engines results in
1. Increase in the work of compression
2. Increase in the network of the process cycles
3. Decrease in fuel efficiencies
4. Decrease in fuel loss from the engine

(a) 1, 2 and 3 (b) 1, 3 and 4
(c) 1 and 3 only (d) 2 and 4 only

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ANSWER KEY / STUDENT'S ASSIGNMENT

1. (d)	**2.** (c)	**3.** (b)	**4.** (b)	**5.** (b)
6. (c)	**7.** (a)	**8.** (b)	**9.** (c)	**10.** (d)
11. (b)	**12.** (a)	**13.** (c)	**14.** (b)	**15.** (c)
16. (d)	**17.** (d)	**18.** (c)	**19.** (c)	**20.** (c)

HINTS & SOLUTIONS / STUDENT'S ASSIGNMENT

1. (d)

In SI engine, the higher the speed, the greater is the turbulence. So, flame speed increases almost linearly with engine speed. Hence knocking tendency in SI engine decreases.

2. (c)

The spark plug in SI engine should be located near to the exhaust valve so that the flame front travels from hottest to the coolest part which ensure the lower end charge temperature and hence no self ignition of end charge.

3. (b)

Hot spots from detonation, improper heat range spark plugs and glowing carbon deposits from lean mixtures are common cause of pre-ignition.
Pre-ignition will cause a sudden loss of power as the affected cylinder is working against normal rotation of engine.

4. (b)

In CI engines knocking occurs at the start of combustion (BC).

5. (b)

Increase in the compression ratio reduces the delay period as it raises the temperature.
The air turbulence also reduces the physical delay in the diesel engine.

6. (c)

In diesel engine, fuel in the form of small particle is sprayed into the cylinder after the air has been compressed, thus mixing takes places within the cylinder. If each particle of fuel is to be surrounded by sufficient air to burn it completely, the air in combustion space must be in motion. This air motion is called turbulence.

8. (b)

The time difference between injection of fuel and combustion of fuel in cylinder is called delay period. The delay period is of the order of 0.002 sec.

9. (c)

The function of fuel injector is to spray atomized fuel into the combustion chamber of an internal combustion engine. The spray from a fuel injector can be continuous or intermittent.

10. (d)

- The main function of carburettor is to mix air and gasoline and provides a high combustion mixture.
- It controls the engine speed.
- It also regulates the air-fuel ratio.

11. (b)

The throttle valve controls the amount of air.

12. (a)

As compression ratio increases, the temperature and pressure of mixture increases. Thus flame speed increases.

13. (c)

The scavenging is the process of replacing the burnt gases during exhaust stroke with the fresh air/fuel mixture for the next cycle.

14. (b)

In CI engines the delay period is divided into physical delay and chemical delay. The physical delay is the time between start of injection and attainment of chemical reaction condition.
The chemical delay for CI engine is the same as the ignition delay for SI engine. During this phase, reaction start slowly and ignition take place.

15. (c)

With the increase in compression ratio, the peak pressure and temperature increases so that the total combustion duration is reduced. Thus engines having higher compression ratios have higher flame speeds.