

ADVANCED IC ENGINES

UNIT I

SPARK IGNITION ENGINES

PART-A

1. Define carburetion?

The process of formation of a combustible fuel –air mixture by mixing the proper amount of fuel with air before admission to engine cylinder is called carburetion.

2. What are the essential parts, compensating device and additional system (Modern) carburetors?

Parts – fuel strainer, float chamber, main metering and idling system, the choke & the throttle.

Compensating device- Air –bleed jet, compensating jet, Emulsion tube, auxiliary valve and port, back suction control mechanism.

Additional system –Ant dieseling, richer coasting, acceleration pump and economic (or) power enrichment system.

3. List some of the important requirements of automobile carburetors?

1. Ease of starting the engine, particularly under low ambient conditions.
2. Good and quick acceleration of the engine.
3. Good fuel economy.
4. Ensuring full torque at low speeds.

4. What are the factors effecting carburetion?

1. The engine speed
2. The vaporization characteristic of fuel
3. The temperature of the in coming air
4. The design of the carburetor

5. What is the different types air –fuel mixtures?

1. Chemically correct mixture
2. Rich mixture
3. Lean mixture.

6. What are the different range of throttle operation

1. Idling
2. Cruising
3. High power.

7. What are the stages of combustion in a SI engines?

FIRST STAGE: Ignition lag (or) preparation phase

SECOND STAGE: propagation of flame

THIRD STAGE: After burning.

8. Define normal combustion & abnormal combustion its consequences?

In normal combustion, the flame initiated by the spark travels across the combustion chamber in a fairly uniform manner.

Under certain operating conditions the combustion deviates from its normal course leading to loss of performance and possible damage to the engine are termed as abnormal combustion (or) knocking combustion.

Consequences are (1). Loss of power (2). Recurring pre-ignition (3). Mechanical damage to the engine.

9. What is the method to detect the phenomenon of knocking?

The scientific method to detect the phenomenon of knocking is to use a pressure transducer. This transducer is connected, usually to a cathode ray oscilloscope. Thus pressure-time traces can be obtained from the pressure transducer.

10. List out some of the knock limited parameters?

The knock limited parameters are:

1. Knock limited compression ratio
2. Knock limited intake pressure
3. Knock limited Indicated mean effective pressure. (Klimep)

11. List the parameters which are affecting knock in SI engine?

The parameters which are directly (or) indirectly connected with knocking are inlet temperature of mixture compression ratio, mass of inducted charge, power output of the engine.

12. List the parameters in time factors that reduce the knocking?

1. Parameters are turbulence
2. Engine speed
3. Flame travel distance,
4. combustion chamber shape
5. Location of spark plug.

13. List the factors that are involved in either producing (or) preventing knock.

1. Temperature
2. pressure
3. Density of the unburned charge
4. Time factor.

14. What are the factors to be considered to obtain high thermal efficiency?

1. A high volumetric efficiency.
2. Anti knock characteristic must be improved.
3. Compact combustion chamber reduces heat loss during combustion
Increases the thermal efficiency.

15. Define performance number?

Performance number is defined as the ratio. Of Knock limited Indicated mean effective pressure with the sample fuel to knock limited Indicated mean effective pressure with ISO-OCTANE .when the inlet pressure is kept constant.

16. Write the different types of combustion chambering SI engine?

T-Head type, L- Head type, I- Head type, F- Head type.

17. What are the components required in the fuel injection system?

Components –pumping element, metering element, mixing element, distributing element, Timing control, and ambient control.

18. What are the advantages of fuel –injection in an SI engine?

1. Increased volumetric efficiency.
2. Better thermal efficiency
3. Lower exhaust emissions
4. High quality fuel distribution.

19. What are the functional requirements of an injection system?

1. Accurate mixing of the fuel injected per cycle.
2. Timing the injection of the fuel.
3. Proper atomization of fuel into fine droplets
4. Proper spray pattern.
5. No lag during beginning and end of injection.

PART-B

1. Discuss why a modern carburetor is being replaced by an injection system in SI engine?
2. Explain the factors that affect the process of carburetion?
3. What are different air –fuel mixture on which an engine can be operated?
4. Explain the following 1. Rich mixture, 2. Stoichiometric mixture 3. Lean mixture.
5. How the power and efficiency of the SI engine vary with air- fuel ratio for different load and speed conditions?
6. By means of suitable graph explain the necessary carburetor performance to fulfill engine requirements?
7. Explain why a rich mixture is required for the following 1. Idling 2. Maximum power and sudden acceleration.
8. Describe briefly the MPFI system with a neat sketch?
9. Explain port injection and throttle body injection system?
10. Describe D- MPFI and L-MPFI injection system?
11. Briefly explain the stages of combustion in SI engines elaborating the flame front Propagation
12. Explain the various factors that influence the phenomena of knock in SI engines?
13. Explain the effect of various engine variables on SI engine knock.
14. What are the various types of combustion chamber s used in SI engines? Explain them briefly?

UNIT II COMPRESSION IGNITION ENGINES

PART-A

1. What are the stages of combustion in C.I engine?

Stage I: ignition delay period (preparatory phase)

Stage II: rapid combustion.

Stage III: controlled combustion.

Stage IV: after combustion.

2. What is ignition delay period?

The fuel does not ignite immediately upon injection into the combustion chamber. There is a definite period of inactivity between the time when the first droplet of fuel hits the hot air in the combustion chamber and the time it starts through the actual burning phase. This period is known as ignition delay period.

3. What are two delays occur in ignition delay period?

Physical delay is the time between the beginning of injection and the attainment of chemical reaction conditions.

Chemical delay is the reaction starts slowly and then accelerates until the inflammation or ignition takes place.

4. List the factors affecting the delay period?

1. Compression ratio.
2. Atomization of the fuel
3. Quality of the fuel.
4. Intake temperature and pressure

5. Write the classification of combustion chamber in C.I engine?

1. Direct-injection type
2. Indirect-injection type.

6. Define direct injection type of combustion chamber and Types?

DI type of combustion chamber is also called an open combustion In this type the entire volume of the combustion chamber is located in the main cylinder and the fuel is injected into this volume.

1. Shallow depth chamber
2. Hemispherical chamber c
3. Cylindrical chamber
4. Toroidal chamber

7. What are the advantages and disadvantages of DI combustion chamber type?

Advantages:

1. Minimum heat loss during compression because of lower surface area to volume ratio.
2. No cold starting problems
3. Fine atomization because of multi hole nozzle

Disadvantages:

1. High fuel injection pressure required and hence complex design of fuel injection pump
2. Necessity of accurate metering of fuel by the injection system, particularly for small engines.

8. What is indirect injection type of combustion and Types?

IDI type of combustion chamber in which the combustion space is divided into two or more distinct compartments connected by restricted passages. This creates considerable pressure difference between them during the combustion process.

Types:

- a. Swirl chamber – in which compression swirl is generated.
- b. Precombustion chamber – in which combustion swirl is induced.
- c. Air cell chamber – in which both compression and combustion swirl are induced.

9. List the advantages and drawbacks of indirect injection chamber.

Advantages:

1. Injection pressure required is low
2. Direction of spraying is not very important

Disadvantages:

1. Poor cold starting performance requires heater plugs
2. Specific fuel consumption is high

10. What is turbo charging?

Energy available in the engine's exhaust gas is used to drive the turbocharger compressor, which raises the inlet fluid density prior to entry to each engine cylinder. This is called turbo charging.

11. What are the major parts of a turbocharger?

1. Turbine wheel
2. Turbine housing
3. Turbo shaft
4. Compressor wheel
5. Compressor housing
6. Bearing housing.

12. Explain the term turbo lag.

In case of turbo charging there is a phenomenon called turbo lag, which refers to the short delay period before the boost or manifold pressure increases. This is due to the time the turbocharger assembly takes to accelerate the turbine and compressor wheel to speed up.

13. Explain the function of waste gate.

In the turbocharger assembly there is a control unit called waste gate. It is a diaphragm-operated valve that can bypass part of the gases around the turbine wheel when manifold pressure is quite high. This unit limits the maximum boost pressure to prevent detonation in S.I engines and engine damage.

14. What is called break up length?

The liquid column bearing the nozzle disintegrates within the cylinder over a finite Length called the break up length in to drops of different sizes.

15. What are the different designs of nozzle used?

The different design of nozzle used is single orifice, multiorifice, throttle or pintle depending on the needs of the combustion system employed.

16. What are the two types of photographic technique used?

To distinguish the liquid – containing core of the jet and the extracts of the fuel vapor region of the spray, which surrounds the liquid core, two types of photographic technique used are backlighting and shadow graph.

17. Explain photographic techniques method:

1. Back lighting identifies region where sufficient liquid fuel (as ligaments or drops) is present to attenuate the light.
2. The shadowgraph technique responds to density gradients in the test section so it identifies regions where fuel vapor exists.

18. List the droplet size depends on various factors:

1. Mean droplet size decreases with increases in an i n j e c t i o n pressure and Air density.
2. Mean droplet size increases with increases in fuel viscosity.
3. Size of droplets increases with increases in the size of the orifice.

19. Define flame development angle & rapid burning angle?

The crank angle interval between the spark discharge and the time when a small but significant fraction of the cylinder mass has burned or fuel chemical energy has been released

The crank angle interval required to burn the bulk of the charge is defined as the interval between the end of the flame development stage and the end of the flame propagation process.

PART-B

1. Bring out clearly the process of combustion in CI engines and also explain the various stages of combustion. What is delay period and what are the factors that affect the delay period?
2. Explain with figures various types of combustion chambers used in CI engines.
3. Explain Turbo charging in CI engines.
4. Explain with neat sketch about the air motion.
5. What are the effects of turbo charging on CI engines?
6. Compare induction swirl with compression swirl with respect to their advantages and disadvantages.
7. What are the main factors affecting the penetration of the fuel spray in CI engines?
8. Explain about the fuel spray behavior?

UNIT III POLLUTANT FORMATION AND CONTROL

PART-A

1. List the invisible and visible emission or major exhaust emissions?

Invisible emission: Water vapour, carbon dioxide, oxides of nitrogen, unburnt hydrocarbons, carbon monoxide, adhesives.

Visible emission: Smoke, particulate.

2. What are the reasons for incomplete combustion in SI engine?

- a. Improper mixing due to incomplete mixing of the air and fuel. Some fuel particles do not find the oxygen to react with this cause the emissions.
- b. Flame quenching: As the flame goes very close to the walls it gets quenched at the walls leaving a small volume of unreacted air fuel mixture.

3. Write a short note on carbon monoxide emissions?

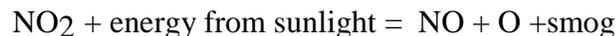
Carbon monoxide is a colourless and odourless but a poisonous gas. It is generated in an engine when it is operated with a fuel rich equivalence ratio. Poor mixing, local rich regions, and incomplete combustion will also be the source for co emissions.

4. What are soot particles?

Soot particles are clusters of solid carbon spheres. These spheres have diameter from 9nm to 90nm ($1\text{nm} = 10^{-9}$). But most of them are within the range of 15 – 30nm. The spheres are solid carbon with HC and traces of other components absorbed on the surface. Single soot particles may contain up to 5000 carbon spheres.

5. What is photochemical smog?

NO_x is the primary causes of photochemical smog, Smog is formed by the photochemical reaction of automobiles exhaust and atmospheric air in the presence of sunlight.



6. What are the causes for hydrocarbon emission from S.I engine?

The causes for hydro carbon emission from S.I engine are

1. Incomplete combustion.
2. Crevice volume and flow in crevices.
3. Leakage past the exhaust valve.
4. Valve over lap.
5. Deposits on walls.
6. Oil on combustion chamber walls.

7. Which is the most effective after treatment for reducing engine emissions?

The catalytic converter is the most effective after treatment for reducing engine emissions found on most automobiles. CO can be oxidized to CO_2 and H_2O in exhaust system and thermal converters if the temperature is held at 600- 700⁰C. If certain catalysts are present, the temperature needed to sustain these oxidation processes is reduced to 250 – 300⁰C, making for a much more attractive system.

8. What is a catalyst?

A catalyst is a substance that accelerates chemical reaction by lowering the energy needed for it to proceed. The catalyst is not consumed in the reaction and so functions indefinitely unless degraded by heat age contaminants or other factors.

9. List the materials used as catalyst ?

a. Platinum b. Palladium c. Rhodium.

10. What are the types of ceramic structure used in catalytic convertor?

Inside the container is a process ceramic structure through which the exhaust gas flows.

- a. The ceramic is a single honey comb structure with many flow passages.
- b. Some converters use loose granular ceramic with the gas passing between the packed spheres.

11. List out the drawbacks of catalytic converters?

- a. Sulphur offers unique problems for catalytic converters some catalyst promote the conversion of SO_2 to SO_3 which eventually converted to sulphuric acid. This degrades the catalytic convertor and contributes to acid rain.
- b. Catalytic converters are not very efficient when they are cold. When an engine is started after not being operated for several hours it takes several minute for the converter to reach an efficient operating temperature called as cold start up problem.

12. What is green house effect?

The trapping of the sun's warmth in a planet's lower atmosphere, due to the greater transparency of the atmosphere to visible radiation from the sun than to infrared radiation emitted from the planet's surface.

13. What is the principle of flame ionisation detector (FID)?

The flame ionisation detector (FID) is the automotive emissions industry standard method of measuring hydrocarbon (HC) concentration. The sample gas is introduced into a hydrogen flame inside the FID. Any hydrocarbons in the sample will produce ions when they are burnt. Ions are detected using a metal collector which is biased with a high DC voltage. The current across this collector is thus proportional to the rate of ionization which in turn depends upon the concentration of HC in the sample gas.

PART-B

1. Describe in detail the causes of hydrocarbon emissions from SI engines.
2. What are catalytic converters? How are they helpful in reducing HC, CO and NO_x emissions?
3. Give a brief account of emissions from CI engines.
4. Explain the internationally accepted methods of measuring the following invisible emission
5. i) Oxides of nitrogen (ii) Carbon monoxide (iii) Unburned hydrocarbons
6. What is smoke and classify the measurement of smoke?

UNIT IV ALTERNATIVE FUELS

PART-A

1. What are the commonly used alternate fuels?

Methanol, ethanol, hydrogen, natural gas, compressed natural gas, liquefied petroleum gas, alcohol, biogas, producer gas, etc.,

2. Write the sources for methanol?

Methanol can be obtained from many sources, both fossil and renewable. These include coal, petroleum, natural gas, biomass, wood landfills and even the ocean.

3. Write the source for ethanol?

Ethanol can be made from ethylene (or) from fermentation of grains and sugar. Much of it is made from sugarcane, sugarbeets, and even cellulose (wood and paper).

4. Write the advantage and disadvantage of alcohol as a fuel?

Advantages:

1. It is a high octane fuel with antiknock index number (octane number) of over 100.
2. Alcohols have low sulphur content in the fuel.
3. It produces less overall emissions when compared with gasoline

Disadvantages:

1. Alcohols have poor ignition characteristics in general.
2. There is a possibility of vapor lock in fuel delivery system.
3. It has poor cold weather starting characteristics due to low vapor pressure and evaporation.

5. What is the problem with gasoline-alcohol mixture as a fuel?

Problems with gasoline-alcohol mixture as a fuel are the tendency for alcohol to combine with any water present. When this happens the alcohol separates to locally from the gasoline, resulting in a non-homogenous mixture. This causes the engine to run erratically due to the large air-fuel ratio difference between the two fuels.

6. What are the techniques of using alcohol in diesel engine fuel?

The techniques of using alcohol in diesel engine are:

1. Alcohol diesel emulsions.
2. Dual fuel injection.
3. Alcohol fumigation.
4. Surface ignition of alcohols.

7. List the advantages and disadvantage of hydrogen as an IC engine?

Advantages:

1. Low emissions.
2. Fuel availability.
3. Fuel leakage to environment is not a pollutant
4. High energy content per volume when stored as a liquid.

Disadvantages:

1. Difficult to re fuel.
2. Fuel cost would be high at present day's technology and availability.
3. Poor engine volumetric efficiency and High NO_x emission because of high flame.

8. Write the methods for hydrogen can be used in SI engines?

1. By manifold induction
2. By direct introduction of hydrogen into the cylinder.
3. By supplementing gasoline.

9. List the advantages and disadvantages of natural gas?

Advantages:

Octane number is around 120, which makes it a very good SI engines fuel.

Low engine emissions.

Fuel is fairly abundant worldwide.

Disadvantages:

Low energy density resulting in low engine performance.

Low engine volumetric efficiency because it is a gaseous fuel.

Refueling is a slow process.

10. Write the two types of LPG used in automobiles engine?

1. Propane
2. Butane sometimes in mixture of propane and butane is used as LPG in automobile engine.

11. What are the advantages and disadvantages of LPG?

LPG mixes with air at all temperatures.

LPG has high antiknock characteristics.

There is no crack case dilution, because the fuel is in the form of vapor.

Disadvantages:

A special fuel feed system is required for liquid petroleum gas.

A good cooling system is quite necessary.

The vehicle weight is increased due to the use of heavy pressure cylinder for storing LPG.

12. Write the improvements required for the LPG vehicle in future?

Effort must be made to have more LPG filling stations at convenient locations, so that LPG tank can be filled up easily. Safety devices are to be introduced to prevent accidents due to explosion of gas cylinder.

13. Compare the Petrol and LPG?

PETROL	LIQUID PETROLEUM GAS
Octane rating of petrol is 81	Octane rating of LPG is 110.
Petrol has odours	LPG is odourless.
In order to increase octane number	LPG is lead free with high Octane number.

14. Comment on the water tolerance of alcohol blends.

Alcohol has a tendency to easily combine with any water present. This makes the engine to run erratically due to the large air-fuel ratio difference between the two fuels.

PART-B

1. Explain the reasons for looking for alternate fuels for IC engines.
2. Explain alcohols as alternate fuels for IC engines bringing out their merits and demerits.
3. Explain the possibility of using reformulated gasoline and water gasoline mixture as alternate fuel.
4. Can alcohol be used for CI engines ? Explain.
5. Explain with a neat sketch the surface-ignition alcohol engine.
6. What are the advantages and disadvantages of using hydrogen in SI engine.
7. Explain the two methods by which hydrogen can be used in CI engine.
8. What is natural gas? List the advantages and disadvantages of using natural gas as alternate fuels?
9. Give a brief account of LPG being used as an alternate fuel in SI engine?
10. What are the advantages and disadvantages of using LPG in SI engines?
11. Compare LPG and petrol as fuel for SI engines

UNIT V RECENT TRENDS

PART-A

1. What is lean burn engine?

Lean burn engine is a layout of Otto cycle engine designed to permit the combustion of lean air fuel mixture and to obtain simultaneously low emission values as high fuel economy. It is designed to operate effectively in the air fuel ratio **14:1-16:1** to **20:1-22:1**. When the lean compression ratio, combustion chamber shape, ignition system, the lean limit are successfully optimized, the engine is referred to as a lean burn engine.

2. Why lean mixture is preferred in SI engine?

1. Lower pollutants.
2. Good fuel economy.
3. Heat transfer losses to the cooling medium are reduced because of lower peak temperatures.
4. Since lean mixture are less prone to knocking

3. What are the modifications to be made to convert an existing engine as a lean burn engine?

1. Increasing the compression ratio of the engine to accurate flame propagation.
2. Increasing the swirl and turbulence of the mixture in order to increase flame speed.
3. Catalytic activation of the charge in the combustion chamber.

4. How the stratified charge engine can be characterized?

1. Relatively high compression ratio
2. Ability of direct cylinder fuel injection variations to run unthrottled.
3. Stratification of the charge mixture into distinctly different rich and lean air fuel ratio.

5. List the advantages and disadvantages of the stratified charge engine.

Advantages:

1. Load control can be achieved without air throttling
2. Quiet in operation.
3. Multi fuels give more or less equal performance.

Disadvantages:

1. Maximum output (from the air in the cylinder (i.e.) complete utilization of air) is not achieved.
2. The added cost of the injection/modified combustion systems.

3. Added complication of injection and spark ignition system.

6. Write short notes on plasma jet ignition system.

The plasma jet ignition system uses a plasma jet spark plug. This system can be considered as a form of electrical torch ignition, since the ignition source is hot jet plasma which project well away from the spark plug. The plasma jet ignition sources is turbulent and electrode less, both desirable features for igniting marginal mixtures.

7. What are the factors that influence the operation of the plasma jet plug?

The factors that can influence the operation of the plasma jet plug are the amount of the applied electrical energy, the rate of energy delivery, the cavity volume, the cavity dimensions, the orifice size, the ambient gas pressure and the quantity of fuel present in the cavity.

8. What are the types of injection systems?

1. Gasoline Direct Injection (GDI) in to the cylinder
2. Port injection (a) timed (b) continuous
3. Manifold injection

9. What are the fuels used in HCCI engines?

Diesel, gasoline, methanol, natural gas and hydrogen

10. Write the advantages and disadvantages of homogeneous charge compression ignition engine?

Advantages:

1. Lower NO_x and particulate emissions
2. High thermal efficiency

Disadvantages:

1. The major problem is controlling the ignition timing over a wide load and speed.
2. Power density is limited by combustion noise and high peak pressure.

PART-B

1. What is the necessity for gasoline injection? Explain with suitable sketch.
2. With neat sketch, explain the exhaust emissions with different air-fuel ratio lean burn spark ignition engines.
3. What do you understand by charge stratification? Explain the method of achieving the same with suitable sketches. Discuss the advantages and disadvantages of charge stratification.
4. Explain briefly plasma – jet ignition system.
5. What is a learn burn engine? What are the advantages of using learn mixture in SI engine?
6. Explain the characteristics of Homogeneous charge compression ignition engine (HCCI).
7. Explain gasoline direct injection engine.

