# IC Engine

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## Otto Diesel & Dual Cycle & Performance Parameter

An engine is a device which transforms one form of energy into another form. Normally, most of the engines convert thermal energy into mechanical work and therefore they are called 'heat engines'.

Heat engines can be broadly classified into two categories:

(i) Internal Combustion Engines (IC Engines)

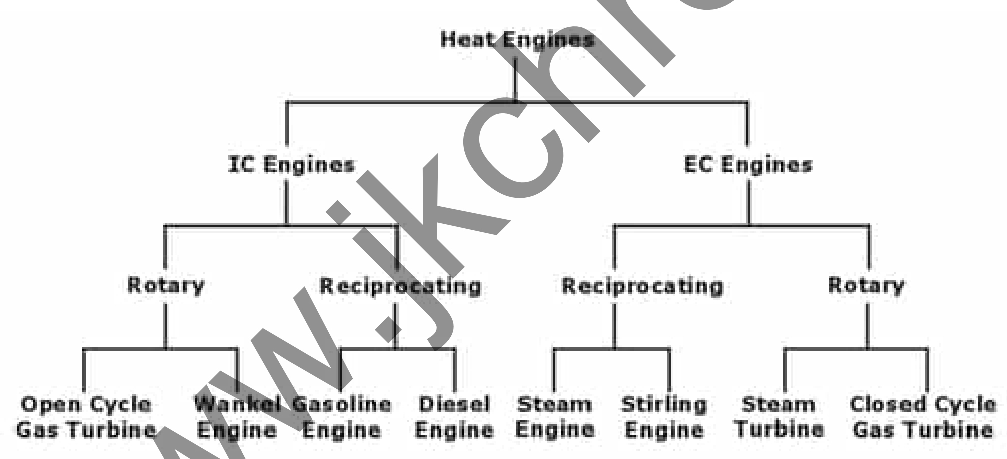
(ii) External Combustion Engines (EC Engines)

### CLASSIFICATION OF HEAT ENGINE

Engines whether Internal Combustion or External Combustion can be classified into two types,

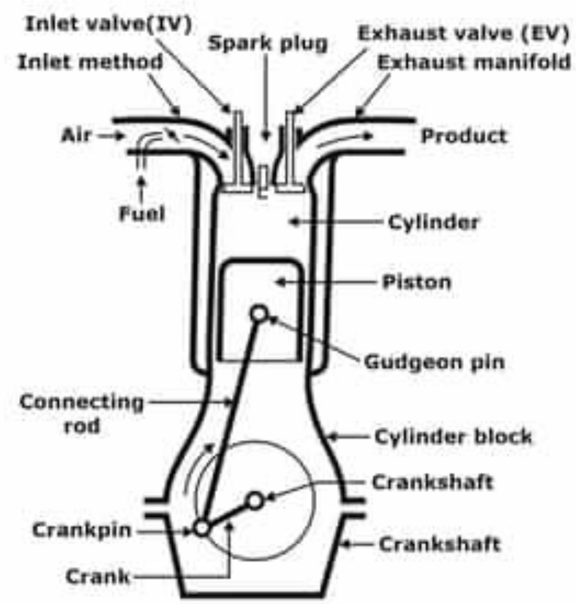
(i) Rotary engines

(ii) Reciprocating engines




### BASIC ENGINE COMPONENTS

An engine is made up of by combining several components out of which some important components are discussed below.




**NOMENCLATURE**

**(i) Cylinder Bore(d)**

The nominal inner diameter of the working cylinder is called the cylinder bore and is designated by 'd'.

**(ii) Piston Area (A)**

The cross-sectional area of cylinder is called the piston area and is designated by 'A'.

$$A = \frac{\pi}{4} d^2$$

**(iii) Stroke (L)**

The nominal distance through which a working piston moves between two successive reversals of its direction of motion is called the stroke.

**(iv) Dead Centre**

The position of the working piston at the moment when the direction of the piston motion is reversed at either end of the stroke is called the dead centre. There are two dead centres in the engine

(a) Top Dead Centre

(b) Bottom Dead Centre

**(a) Top Dead Centre (TDC):** Dead centre when the piston is farthest from the crankshaft or nearest to the cylinder head is known as Top Dead centre.

**(b) Bottom Dead Centre (BDC):** Dead centre when the piston is nearest to the crankshaft or farthest from the cylinder head is known as Bottom dead centre.

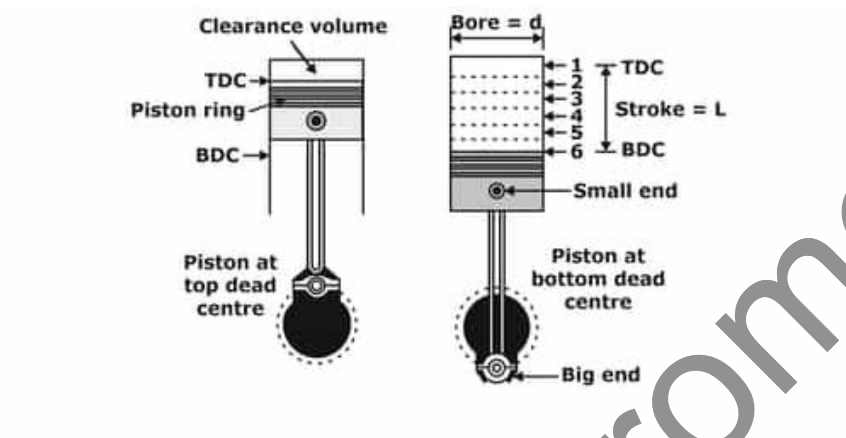



**Fig.: Nomenclature of an Internal Combustion Engine**

**(v) Displacement or Swept Volume ($V_s$)**

The volume swept by the piston when travelling between both dead centres is called the displacement volume.

**(vi) Compression Ratio (r)**

It is the ratio of the total cylinder volume when the piston is at the bottom dead centre, $V_{Total}$, to the clearance volume, $V_C$.

$$r = \frac{V_{Total}}{V_C} = \frac{V_C + V_s}{V_C} = 1 + \frac{V_s}{V_C}$$

The three cycles of great practical importance in the analysis of piston engine performance are

(i) Constant Volume or Otto Cycle

(ii) Constant Pressure or Diesel Cycle

(iii) Dual Combustion or Limited pressure Cycle.

**Constant Volume or Otto Cycle**

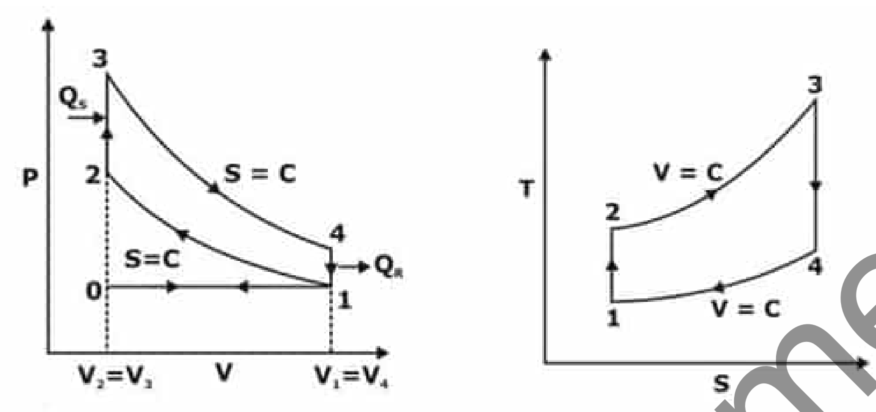



**Fig.: P-V & T-S diagram of Otto Cycle**

**Working of Otto cycle** –

When the engine is working on full throttle, the processes 0→1 and 1→0 on the p-V diagram represents suction and exhaust processes and their effect is nullified.

**Process 1→2** represents isentropic compression of the air when the piston moves from bottom dead centre to top dead centre and charge (mixture of fuel and air) is compressed to a higher pressure.

**Process 2→3** heat is supplied reversibly at constant volume.

This process corresponds to spark-ignition and combustion in the actual engine starts.

**Processes 3→4** represent isentropic expansion were the product of expands & piston moves from top dead centre to bottom centre.

**Process4→1** represent constant volume heat rejection in which the piston is stays at the bottom dead centre.

## Thermal Efficiency

The thermal efficiency of the Otto cycle can be written as,

$$\eta_{Otto} = \frac{W_{net}}{Q_S}$$

$$W_{net} = Q_S - Q_R$$

$$\eta_{Otto} = \frac{Q_S - Q_R}{Q_S}$$

$$\eta_{otto} = 1 - \frac{1}{r^{(\gamma-1)}}$$

From the above expression, we can see that the thermal efficiency of the Otto cycle is a function of compression ratio r and the ratio of specific heats γ.

Further, the efficiency is independent of heat supplied and pressure ratio.

The use of gases with higher γ values would increase the efficiency of the Otto cycle.

Shows the effect of γ and r on the efficiency.

Thus, it can be seen that the work output is directly proportional to the pressure ratio, $r_p$.

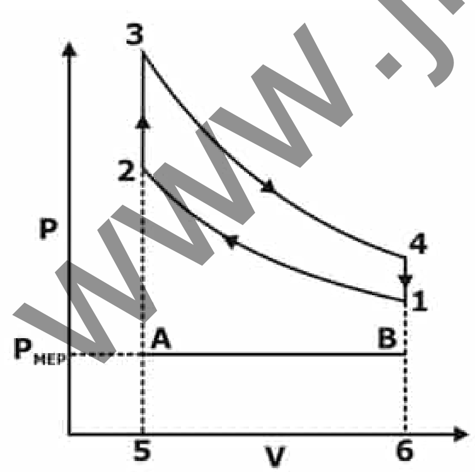



**Fig.: Mean Effective Pressure**

The mean effective pressure of the cycle is given by,

$$P_{MEP} = \frac{\text{Work output}}{\text{Swept volume}}$$

The mean effective pressure which is an indication of the work output increases with a pressure ratio at a fixed value of compression ratio and the ratio of specific heats.

**CONSTANT PRESSURE OR DIESEL CYCLE:**

**Process 1→2** represents isentropic compression of the air when the piston moves from bottom dead centre to top dead centre and air is compressed to a higher pressure.

**Process 2→3** heat is supplied reversibly at constant pressure.

This process corresponds to injection of fuel through fuel injector and combustion due to self-ignition of fuel

**Processes 3→4** represent isentropic expansion were the product of expands & piston moves from top dead centre to bottom centre.

**Process4→1** represent constant volume heat rejection in which the piston stays at the bottom dead centre.

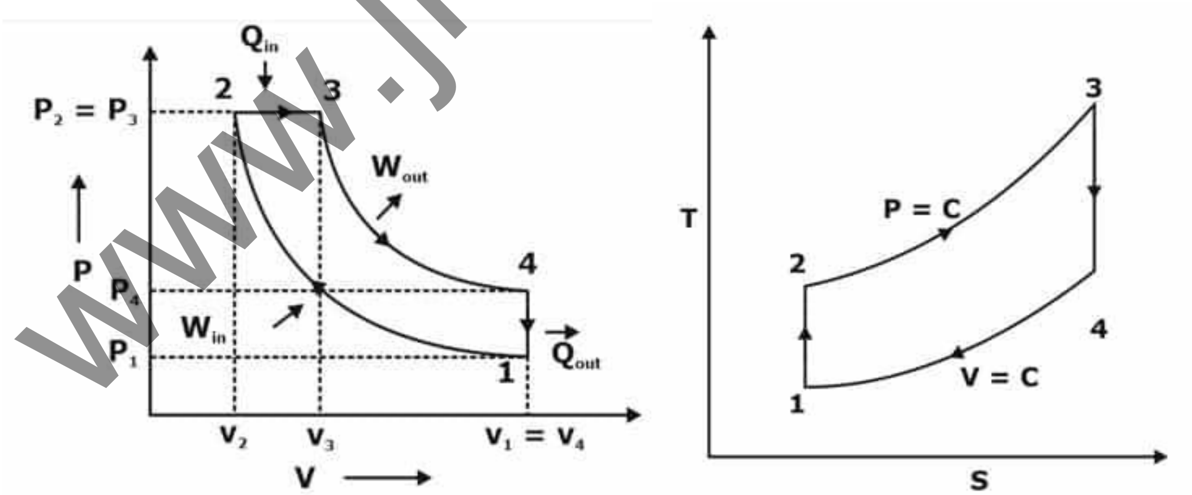



**Fig.: P-V & T-S diagram of Diesel cycle**

The difference between Otto and Diesel cycles is in the process of heat addition.

In the Otto cycle, the heat addition takes place at constant volume whereas in the Diesel cycle it is at constant pressure.

For this reason, the Diesel cycle is often referred to as the constant-pressure cycle.

**Thermal Efficiency**

$$\eta_{Diesel} = 1 - \frac{1}{r^{(\gamma-1)}}\left[\frac{r_c^{\gamma} - 1}{\gamma(r_c - 1)}\right]$$

From the above expression, we can see that the efficiency of the Diesel cycle is different from that of the Otto cycle only in the bracketed factor.

This factor is always greater than unity. Hence for a given compression ratio. the Otto cycle is more efficient.

In diesel engines, the fuel cut-off ratio, $r_c$, depends on output, for maximum output $r_c$ maximum.

Therefore, unlike the Otto cycle, the air-standard efficiency of the Diesel cycle depends on the output.

**Mean effective pressure**

The mean effective pressure of the cycle is given by,

$$p_{MEP} = \frac{\text{Work output}}{\text{Swept volume}}$$

**DUAL COMBUSTION OR MIXED OR LIMITED PRESSURE CYCLE**

The name dual combustion is derived from the fact that it incorporates into it the features of both Otto and Diesel cycles.

Heat addition at constant volume tends to increase the efficiency of the cycle whereas switching over to constant pressure heat addition limits the maximum pressure.

Hence, this cycle is also called limited pressure cycle.

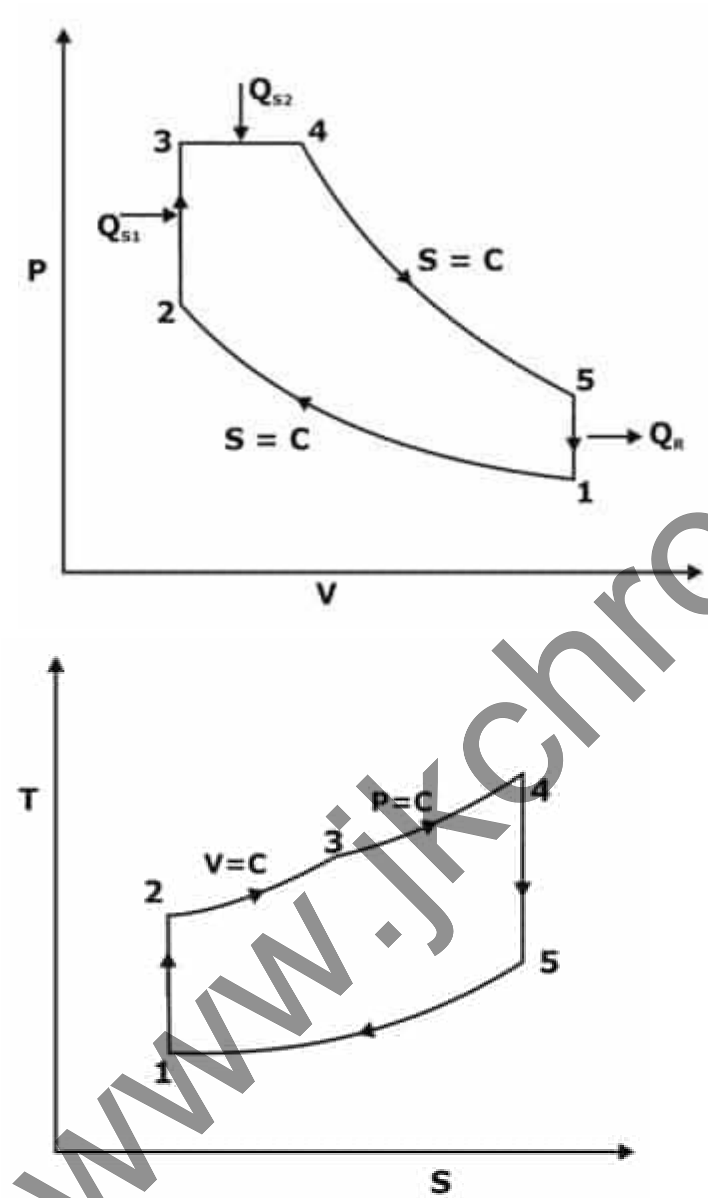



**Fig.: P-V & T-S diagram of Dual cycle**

$$\eta_{Dual} = 1 - \frac{1}{r^{(\gamma-1)}}\left[\frac{r_p r_c^{\gamma} - 1}{(r_p - 1) + r_p \gamma (r_c - 1)}\right]$$

## COMPARISON OF OTTO, DIESEL, AND DUAL CYCLES

In order to compare the performance of the Otto, Diesel and Dual combustion cycles some of the variable factors must be fixed.

**(i) For same compression ratio and same heat addition:**

**(ii) Same Compression Ratio and Heat Rejection:**

$$\eta_{otto} > \eta_{dual} > \eta_{diesel}$$

**(iii) Same Peak Pressure, Peak Temperature and Heat Rejection:**

$$\eta_{otto} < \eta_{dual} < \eta_{diesel}$$

**(iv) Same Maximum Pressure and Heat Input:**

**(v) For same maximum pressure and work output:**

$$\eta_{otto} < \eta_{dual} < \eta_{diesel}$$

**Variables Affecting Knock in an SI & CI Engine:**

| S. No. | Characteristics | SI Engine | CI Engine |
|---|---|---|---|
| 1. | Ignition temperature of fuel | High | Low |
| 2. | Ignition delay | Long | Short |
| 3. | Compression ratio | Low | High |
| 4. | Inlet temperature | Low | High |
| 5. | Inlet pressure | Low | High |
| 6. | Combustion wall temperature | Low | High |
| 7. | Speed, rpm | High | Low |
| 8. | Cylinder size | Small | Large |

## ENGINE POWER

The energy flow through the engine is expressed in three distinct terms.

They are indicated power, IP, friction power FP and brake power, BP.

Indicated power can be computed from the measurement of forces in the cylinder and brake power may be computed from the measurement of forces at the crankshaft of the engine. The friction power can be estimated by motoring the engine or other methods.

It can also be calculated as the difference between the IP and BP if these two are known, then,

IP = BP +FP

FP = IP – BP

**Indicated Mean Effective Pressure ($P_{im}$)**

It is a mean value expressed in N/m$^2$, which, when multiplied by the displacement volume, $V_s$,

Gives the same indicated network as is actually produced with the varying pressures.

$$P_{im} = \frac{\text{Net work of cycle}}{V_1 - V_2}$$

$$IP = \frac{P_{im} V_s n k}{1000 \times 60}$$

Where IP = indicated power (kW)

$P_{im}$ = indicated mean effective pressure (N/m$^2$)

L= length of the stroke (m)

A = area of the piston (m$^2$)

N = speed in revolutions per minute,

n = number of power strokes per minute= N/2 for a four-stroke engine N for a two-stroke engine

K =number of cylinders

**Brake Power (BP)**

This power is interchangeably referred to as brake power, Shaft power or delivered power'.

In general, only the term brake power, bp, has been used in this book to indicate the power actually delivered by the engine.

$$BP = \frac{2\pi NT}{60000} kW$$

**ENGINE EFFICIENCIES:**

Apart from expressing engine performance in terms of power, it is also essential to express in terms of efficiencies.

**AIR-STANDARD EFFICIENCY:**

The air-standard efficiency is also known as thermodynamic efficiency mainly a function of compression ratio and other parameters.

**INDICATED AND BRAKE THERMAL EFFICIENCIES:**

The indicated and brake thermal efficiencies are based on the ip and bp of the engine respectively.

**MECHANICAL EFFICIENCY:**

The mechanical efficiency, $\eta_m$ of the engine can be expressed as the ratio of $b_{mep}$ to $i_{mep}$.

$$\eta_m = \frac{BP}{IP} = \frac{b_{mep}}{i_{mep}}$$

Mechanical efficiency takes into account the mechanical losses in an engine.

Mechanical in general, the mechanical efficiency of engines varies from 65 to 85%.

**RELATIVE EFFICIENCY:**

The relative efficiency or efficiency ratio as it is sometimes called is the ratio of the actual efficiency obtained from an engine to the theoretical efficiency of the engine cycle

$$\text{Relative efficiency} = \frac{\text{Actual brake thermal efficiency}}{\text{Air} - \text{standard efficiency}}$$

**VOLUMETRIC EFFICIENCY:**

Volumetric efficiency is defined as the ratio of the actual mass of air drawn into the engine during a given period of time to the theoretical mass which should have been drawn in during that same period of time, based upon the total piston displacement of the engine, and the temperature and pressure of the surrounding atmosphere.

$$\eta_v = \frac{m_{act}}{m_{th}}$$

## Engine Combustions & Lubrication

**INTRODUCTION**

Spark-ignition engines normally use volatile liquid fuels. Preparation of fuel-air mixture is done outside the engine cylinder and formation of a homogeneous mixture is normally not completed in the inlet manifold. Fuel droplets which remain in suspension continue to evaporate and mix with air even during suction and compression processes.

**CARBURETION**

The process of formation of a combustible fuel-air mixture by mixing the proper amount of fuel with air before admission to the engine cylinder is called carburetion and the device which does this job is called a carburettor. The process of mixture preparation is extremely important for spark-ignition engines. The time purpose of carburetion is to provide a combustible mixture of fuel and air in the required quantity and quality for efficient operation of time engine under all conditions.

## FACTORS AFFECTING CARBURETION

Of the various factors, the process of carburetion is influenced by

- The engine speeds
- The vaporization characteristics of the fuel
- The temperature of the incoming air
- The design of the carburetor

## AIR-FUEL MIXTURES

An engine is generally operated at different loads and speeds. For this, a proper air-fuel mixture should be supplied to the engine cylinder. Fuel and air are mixed to form three different types of mixtures.

(i) chemically correct mixture

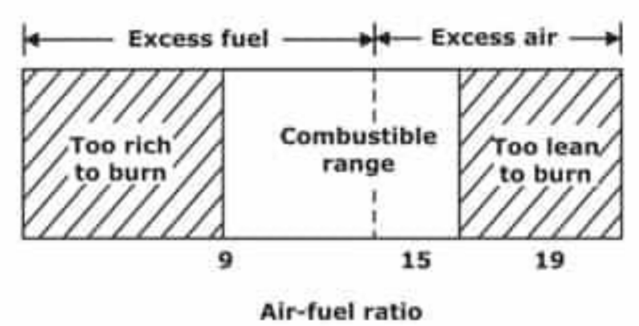
(ii) rich mixture and

(iii) lean mixture

Chemically correct or stoichiometric mixture is one in which there is just enough air for complete combustion of the fuel. For example, to burn one kg of octane ($C_8H_{18}$) completely 15.12 kg of air is required. Hence chemically correct A/F ratio for $C_8H_{18}$ is 15.12:1; usually approximated to 15:1.It is always computed from the chemical equation for complete combustion for a particular fuel. Complete combustion means all carbon in the fuel is converted to $CO_2$ and all hydrogen to $H_2O$.

A mixture which contains less air than the stoichiometric requirement is called a rich mixture (example, A/F ratio of 12:1, 10:1 etc.).

A mixture that contains more air than the stoichiometric requirement is called a lean mixture (example, A/F ratio of 17:1, 20:1 etc.)




## INTRODUCTION TO COMBUSTION

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 a combustible mixture and some means of initiating the process.

## STAGES OF COMBUSTION IN SI ENGINES

## ABNORMAL COMBUSTION

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 front its normal course leading to loss of performance and possible damage to the engine. This type of combustion may be termed abnormal combustion or knocking combustion. The consequences of this abnormal combustion process are the loss of power, recurring preignition and mechanical damage to the engine.

## PHENOMENON OF KNOCK IN SI ENGINES

A definite flame front that separates the fresh mixture from the products of combustion travels from the spark plug to the other end of the combustion chamber. Heat-release due to combustion increases the temperature and consequently the pressure, of the burned part of the mixture above those of the unburned mixture. In order to effect pressure equalization the burned part of the mixture will expand, and compress the unburned mixture adiabatically thereby increasing its pressure and temperature. This process continues as the flame front advances through the mixture and the temperature and pressure of the unburned mixture are increased further.

If the temperature of the unburnt mixture exceeds the self-ignition temperature of the fuel and remains at or above this temperature during the period of flame reactions (ignition lag), spontaneous ignition or autoignition occurs at various pin-point locations. This phenomenon is called knocking. The process of autoignition leads towards engine knock.

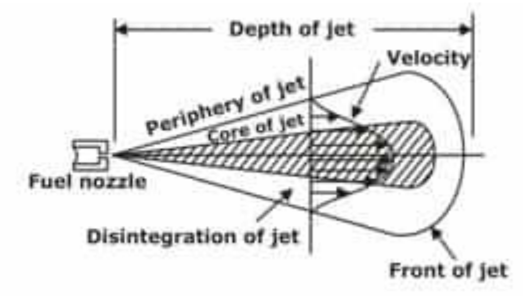
| **Increase in variable** | **Major effect on unburned reduce charge** | **Action to be taken to knocking** | **Can operator usually control?** |
|---|---|---|---|
| Compression ratio | Increases temperature & pressure | Reduce | No |
| Mass of charge inducted | Increases pressure | Reduce | Yes |
| Inlet temperature | Increases temperature | Reduce | In sine case |
| Chamber wall temperature | Increases temperature | Reduce | Not ordinarily |
| Spark advance | Increases temperature & pressure | Retard | In some cases |
| A/F ratio | Increases temperate & pressure | Make very rich | In some cases |
| Turbulence | Decreases time factor | Increases | Somewhat (through engine speed) |
| Engine speed | Decreases time factor | Increases | Yes |
| Distance of flame travel | Increases time factor | Reduce | No |



**COMBUSTION IN COMPRESSION-IGNITION ENGINES**

- In the CI engine, only air is compressed through a high compression ratio (16:1 to 20:1) raising its temperature and pressure to a high value.

- Fuel is injected through one or more jets into this highly compressed air in the combustion chamber. Here, the fuel jet disintegrates into a core of fuel surrounded by a spray envelope of air and fuel particles.




- This spray envelope is created both by the atomization and vaporization of the fuel. The turbulence of the air in the combustion chamber passing across the jet tears the fuel particles from the core. A mixture of air and fuel forms at some location in the spray envelope and oxidation starts.

- The liquid fuel lets evaporate by absorbing the latent heat of vaporization from the surrounding air which reduces the temperature of a thin layer of air surrounding the droplet and sometimes elapses before this temperature can be raised again by absorbing heat from the bulk of air.

- As soon as this vapour and the air reach the level of the autoignition temperature and if the local A/F ratio is within the combustible range, ignition takes place.

**THE PHENOMENON OF KNOCK IN CI ENGINES**

- In CI engines the injection process takes place over a definite internal of time. Consequently, as the first few droplets to be injected are passing through the ignition delay period additional droplets are being injected into the chamber.

- If the ignition delay of the fuel being injected is short, the first few droplets will commence the actual burning phase in a relatively short time after injection and a relatively small amount of fuel will be accumulated in the chamber when actual burning commences. As a result, the mass rate of mixture burned will be such as to produce a rate of pressure rise that will exert a smooth force on the piston.

- If the ignition delay is longer, the actual burning of the first few droplets delayed and a greater quantity of fuel droplets gets accumulated in the chamber. When the actual burning commences, the additional fuel can cause too rapid a rate of pressure rise, resulting in jamming of forces against the piston and rough engine operation. If the ignition delay is quite long, so much fuel can accumulate that the rate of pressure rise is almost instantaneous. Such a situation produces extreme pressure as differentials and violent gas vibrations known as knocking and is evidenced by an audible knock.

The factors that tend to increase autoignition reaction time and prevent knock in SI engines promote knock in CI engines. Also, good fuel for a spark-ignition engine is a poor fuel for the compression-ignition engine. The spark-ignition fuel has a high octane rating of 80 to 100 and a low cetane rating of about 20, whereas diesel fuels have a high cetane rating of about 45 to 65 and a low octane rating of about 30.

| S.No. | Characteristics | SI Engine | CI Engine |
|---|---|---|---|
| 1. | Ignition temperature of the fuel | High | Low |
| 2. | Ignition delay | Long | Short |
| 3. | Compression ratio | Low | High |
| 4. | Inlet temperature | Low | High |
| 5. | Inlet pressure | Low | High |
| 6. | Combustion wall temperature | Low | High |
| 7. | Speed, rpm | High | Low |
| 8. | Cylinder size | Small | Large |

**Lubrication of Engine Components:**

The method of reducing friction by introducing the substance called lubricant between the mating parts is called lubrication.

**Objectives**

- Reduce friction thus increase efficiency.
- Reduce wear and tear of moving parts.
- Carry away heat.

- Provides sealing action between the cylinder and piston rings, thereby it reduces blow-by.
- Provide protection against corrosion.
- Lubrication film acts as a cushion and reduces vibration.
- Carrying away the grit & other deposits and provide cleaning.
- Reduce noise.

**The main component of the IC engine to be lubricated.**

- Piston & cylinder
- Main crankshaft bearings
- Small and big end bearings of the connection rod
- Cam, camshaft and its bearing
- Valve and valve operating mechanism
- Timing gears

**Lubricating Oil**

**Types of lubricants**

- Solid (e.g. Graphite molybdenum, Mica)
- Semi-Solid (e.g. Heavy greases)
- Liquid (e.g. Mineral oils, Vegetable Oils, Animal Oils)

**Properties of lubricates.**

**Viscosity**

- It is a measure of resistance to the flow of oil. It is measured in Saybolt Universal Seconds (SUS).

**Viscosity Index**

- The variation of viscosity of oil with change in temperature is measured by viscosity index.
- Smaller the variation of viscosity, the higher the VI.
- VI of Paraffin oil is 100 (small change) and VI of Naphthenic oil VI is 0 (large change).

**Cloud Point**

- The temperature at which the oil starts solidifying is called cloud point.

**Pour Point**

- It is the temperature just below which the oil sample will not flow under certain prescribed conditions.
- The sample is cooled until no movement of the oil occurs for 5 sec after the tube is tilted from the vertical to the horizontal.

**Flash Points**

- The flashpoint is defined as the lowest temperature at which an oil will vaporize sufficiently to form a combustible mixture of oil vapour and the air above the surface of the oil.
- It is found by heating a quantity of the oil in a special container while passing a flame above the liquid to ignite the vapour. A distinct flash of flame occurs when the flashpoint temperature is reached.

**Fire Points**

- The fire point is obtained if the oil is heated further after the flashpoint. The fire point is the temperature at which the oil, once lit with flame, will be burnt steadily at least for 5 seconds.
- Fire point temperature is usually 10°C higher than flash point temperature.

**Oiliness**

- The property of an oil to cling to the metal surface by molecular action and then to provide a very thin layer of lubricant under boundary lubrication condition is called the oiliness or lubricity or film strength.

**Carbon residue**

- It is the quantity of carbon residue which remains after evaporation of a simple oil under specified conditions.

**Detergency**

- To prevent the formation of deposits, the engine oil has the property of detergency to clean the deposits.

- It has also the ability to disperse the particles, preventing them from clotting and keeping them in a finely divided state.

**Foaming**

- Any violent agitation in the crankcase engine oil to foam. It is because of the presence of air bubbles in the oil. This action accelerates oxidation and reduces the mass flow of oil to the bearing and other moving parts causing insufficient lubrication.

**Additives**

These are the compound added to lubricant oils to promote and improve their desired properties.

**Major classes of engine oil additives and their primary function**

- Detergent Dispersant (Metallic Salts, Organic acids)
- Anti-wear
- Anti-rust (Metal Sulphonates, Fatty acids, Amines)
- VI improver (Butylene Polymers, Polymerized Olefins, Iso-olefins)
- Pour point depressant (Phenols, Easters, Alkylated Naphthalene)
- Anti-foam (Silicone Polymers)
- Antioxidant (Zinc Dithiophosphate, Sulphur and Phosphorous compounds, Amine & Phenol Derivatives)

**Comparison Between Air and Water Cooling**

| S. No. | Air cooling | Water cooling |
|---|---|---|
| 1. | No danger of water freezing at low temperature. | There is a danger of water freezing at low temperatures. |
| 2. | Maintenance is low and the design is simple. | Maintenance is high due to the radiator and the design of the engine is more complicated. |
| 3. | The engine warms up quickly. | Engine warm-up takes comparatively more time. |
| 4. | Lower specific fuel consumption. | Higher specific fuel consumption. |

| | | |
|---|---|---|
| 5. | The weight to power ratio is low. | The weight to power ratio is high. |
| 6. | Suitable for low-capacity engines. | Suitable for high-capacity engines. |
| 7. | Regulation of cylinder temperature is not possible. | Regulation of cylinder temperatures is possible. |
| 8. | Volumetric efficiency is low. | Volumetric efficiency is high. |
| 9. | Cooling is not even. | More even cooling is achieved. |

1. Steam enters a turbine at 30 bar, 300 °C (u = 2750 kJ/kg, h = 2993 kJ/kg) and exits the condenser as saturated liquid at 15 kPa (u = 225 kJ/kg. h = 226 kJ/kg). Heat loss to the surrounding is 50kJ/kg of steam flowing through the turbine. Neglecting changes in kinetic energy and potential energy, the work output of the turbine (in kJ/kg of steam) is ________

   A. 2600     B. 2620

   C. 2717     D. 2537

Ans. C

Sol. Enthalpy of saturated liquid at exit from the condenser = $h_4$ = 226 kJ/kg

Enthalpy of steam at exit from the turbine= $h_2 = h_4 + Q_{rej}$ = (226 + 50) = 276 kJ/kg

Enthalpy of steam at entry into the turbine = $h_1$ = 2993 kJ/kg

Work output of the turbine = $h_2 - h_1$ = (2993 - 276) = 2717 kJ/kg

2. For minimum work in a reciprocating compressor, the compression process should be ____

   A. adiabatic     B. isothermal

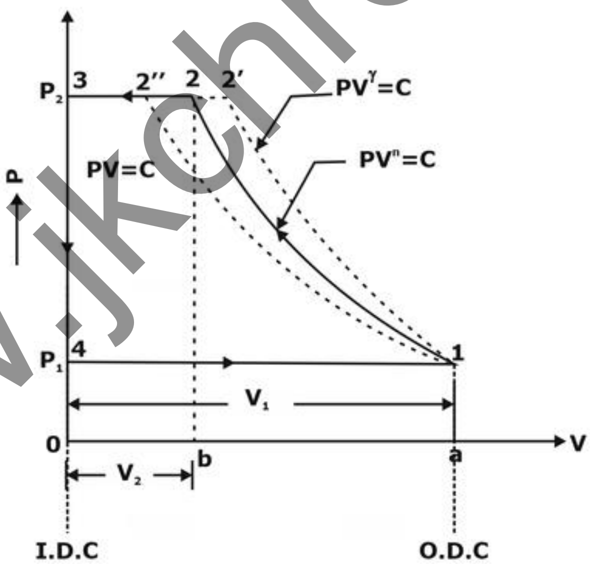
   C. isochoric     D. isobar

Ans. B

Sol.

- In reciprocating compressor,

  Compression work will be minmum when the process isothermal compression.




3. For a gas turbine working on Brayton cycle, if $T_1$ is the temperature at inlet of compressor, $T_4$ is exit temperature of turbine, then work ratio ( $R_w$ ) is represented by

   A. $\gamma_w = 1 - T_1/T_4$     B. $\gamma_w = 1 + T_1/T_4$

   C. $\gamma_w = 1 + T_4/T_1$     D. $\gamma_w = 1 - T_4/T_1$

Ans. A

Sol.

$$\gamma_w = \frac{W_{net}}{W_T} = \frac{W_T - W_C}{W_T} = 1 - \frac{W_C}{W_T}$$

$$\gamma_w = 1 - \frac{C_p(T_2 - T_1)}{C_p(T_3 - T_4)} = 1 - \frac{T_1\left(\frac{T_2}{T_1} - 1\right)}{T_4\left(\frac{T_3}{T_4} - 1\right)}$$

For ideal brayton cycle, $\frac{T_2}{T_1} = \frac{T_3}{T_4} \Rightarrow \frac{T_2}{T_3} = \frac{T_1}{T_4}$

$$\gamma_w = 1 - \frac{T_1}{T_4} = 1 - \frac{T_2}{T_3}$$

4. In a gas turbine plant operating on Brayton cycle, select the incorrect statement regarding the effect of reheating

A. No change is compressor input is required

B. The work output of turbine increases

C. Efficiency of the cycle increases

D. Both mean temperature of heat addition and mean temperature of heat rejection increases

Ans. C

Sol. During reheating in the Brayton cycle:

1. Cycle efficiency decreases.

2. Both mean temperature of heat addition and mean temperature of heat rejection increases.

3. No change is compressor input is required

5. Which of the following is a boiler accessory?

A. Safety Valve

B. Pressure Gauge

C. feed pump

D. fusible plug

Ans. C

Sol. Boiler Mountings-These are the equipment in absence of which power-plant will not work.

Accessory- These are the equipment in absence of which power-plant will not work efficiently.

Feed pump is an accessory, rest options are boiler mountings

6. In the fuel mixture of iso octane and n-heptane, the % of n-heptane by volume is 40. The octane no. of fuel is

A. 40

B. 60

C. 24

D. 100

Ans. B

Sol. The octane no. of a fuel is the % of iso octane by volume in a mixture of iso octane and n-heptane which produces the same knock intensity as the given fuel.

% of iso octane = 100-40 =60%

Octane no. = 60

7. Rotary compressors are used in those cases where

A. High discharge rate at low pressure is required

B. Low discharge rate at high pressure is required

C. Low discharge rate at low pressure is required

D. None of the above

Ans. A

Sol. * Rotary compressors are used in those cases where High discharge rate at low pressure is required.

* Rotary-screw compressors are generally used to supply compressed air for larger industrial applications. They are best applied in applications that have a continuous air demand such as food packaging plants and automated manufacturing systems.

8. An engine has a swept volume of 100 $cm^3$ and a clearance volume of 20 $cm^3$. The mechanical efficiency is 0.8 and volumetric efficiency is 0.75. The volume taken in per stroke will be

A. 80 $cm^3$ B. 75 $cm^3$

C. 60 $cm^3$ D. 25 $cm^3$

Ans. B

Sol. Given,

Swept volume $V_s$ = 100 $cm^3$

Clearance volume $V_C$ = 20 $cm^3$

Mechanical efficiency =0.8

Volumetric efficiency = 0.75

Volumetric efficiency = Actual intake volume/Swept volume

Actual intake volume = Volumetric efficiency × Swept volume

Actual intake volume = 100 x 0.75 $cm^3$= 75 $cm^3$

9. Rankine cycle consists of __________.

A. Two isentropic processes & two constant volume processes

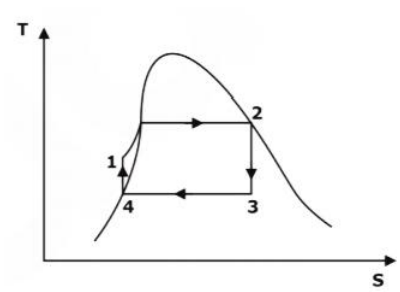
B. Two isentropic processes & two constant pressure processes

C. Two isothermal processes & two constant volume processes

D. Two isentropic processes and two constant temperature processes

Ans. B

Sol. **Rankine Cycle:** The Rankine cycle or Rankine Vapor Cycle is the process widely used by power plants such as coal-fired power plants or nuclear reactors.




1–2 → Constant pressure heat addition

2–3 → Reversible adiabatic expansion

3–4 → Constant pressure heat rejection

4–1 → Reversible adiabatic compression

10. Which of the following mixture / ratio requires during idling condition in petrol engine ___________?

A. Rich mixture

B. Lean Mixture

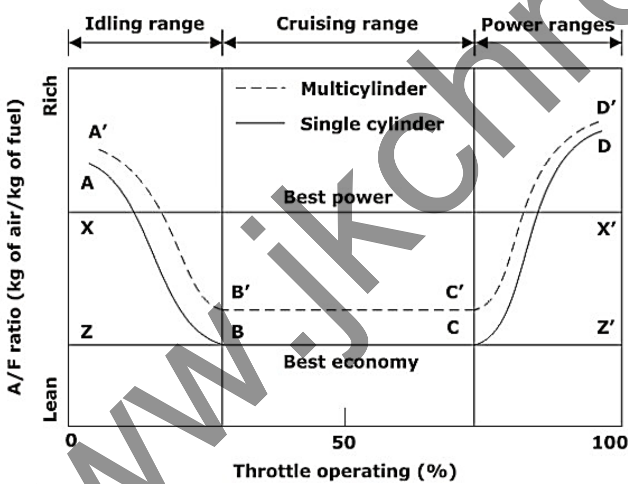
C. Stoichiometric ratio

D. None of the above

Ans. A

Sol.

- An idling engine is one which operates at no load and with nearly closed throttle.
- The final mixture of fuel and air is diluted by the exhaust gases. Thus, to sustain combustion it is necessary to provide more fuel thus making the air-fuel mixture rich.




11. Which type of boilers are called drum-less boilers ________?

A. Natural circulation boilers

B. Fire tube boilers

C. Once through boiler

D. Forced circulation boiler

Ans. C

Sol.

- In Once through boilers, water enters the bottom of the tubes and completely transforms into steam as it passes through the tubes and reaches at the top.
- Thus, these boilers do not need a steam drum and hence often referred as drum-less boilers.
- These operate at a pressure above of 221.2 bar (supercritical pressure).

12. For same maximum pressure and heat input, correct relation for air standard efficiencies is ________.

A. $\eta_{otto} > \eta_{diesel} > \eta_{dual}$ B. $\eta_{otto} < \eta_{diesel} < \eta_{dual}$

C. $\eta_{otto} < \eta_{dual} < \eta_{diesel}$ D. $\eta_{otto} > \eta_{dual} > \eta_{diesel}$

Ans. C

Sol. For the same maximum pressure and heat input, the order of efficiency is as follows:

$\eta_{otto} < \eta_{dual} < \eta_{diesel}$

13. Match the following:

List-I

A. Boiler

B. turbine

C. Condenser

D. pump

List-II

1) reversible adiabatic expansion of steam

2) constant pressure heat addition

3) reversible adiabatic compression

4) constant pressure heat rejection

A. A-2 B-1 C-4 D-3 B. A-3 B-1 C-4 D-2

C. A-2 B-4 C-1 D-3 D. A-1 B-2 C-4 D-3

Ans. A

Sol.

A. Boiler= 2) constant pressure heat addition

B. turbine =1) reversible adiabatic expansion of steam

C. Condenser= 4) constant pressure heat rejection

D. pump = 3) reversible adiabatic compression

14. Which of the following represents correct relationship between mean effective pressure of Carnot cycle and Stirling cycle for same swept volume_____?

A. $(mep)_{Carnot} > (mep)_{Stirling}$ B. $(mep)_{Stirling} > (mep)_{Carnot}$

C. $(mep)_{Carnot} = (mep)_{Stirling}$ D. None of the above

Ans. B

Sol.

Mean effective pressure = $\frac{\text{Work done}}{\text{Swept volume}}$

Since work output of Carnot is less than that of Stirling, so for same swept volume mean effective pressure of Stirling is more than Carnot.

15. Degree of reaction in a turbine is the ratio of ________.

A. Enthalpy drop in fixed blade to total enthalpy drop

B. Enthalpy drop in moving blade to total enthalpy drop

C. Enthalpy drop in fixed blade to enthalpy drop in moving blade

D. Enthalpy drop in moving blade to enthalpy drop in fixed blade

Ans. B

Sol.

- Degree of reaction in a turbine is the ratio of enthalpy drop in moving blade to total enthalpy drop.
- Degree of reaction (R)= $\frac{Enthalpy\ drop\ in\ rotor}{Enthalpy\ drop\ in\ stage}$

16. Which one of the following modifications of the simple ideal Rankine cycle increases the thermal efficiency and reduces the moisture content of the steam at the turbine outlet?

A. Decreasing the condenser pressure.

B. Increasing the boiler pressure.

C. Decreasing the boiler pressure.

D. Increasing the turbine inlet temperature.

Ans. D

Sol. Due to increase of the turbine inlet temperature, quality of the stream at outlet of the turbine improves. Which increases the thermal efficiency and reduces the moisture content of the steam at the turbine outlet.

17. The cycle generally used for gas turbines is:

A. Otto cycle B. Brayton cycle

C. Carnot cycle D. Dual cycle

Ans. B

Sol. The Brayton cycle is a thermodynamic cycle named after George Bailey Brayton that describes the workings of a constant pressure heat engine. The original Brayton engines used a piston compressor and piston expander, but more modern gas turbine engines and airbreathing jet engines also follow the Brayton cycle

18. The cycle in which heat is supplied at constant volume and rejected at constant pressure is known as

A. Dual combustion cycle B. Diesel cycle

C. Atkinson cycle D. Rankine cycle

Ans. C

Sol. In case of **diesel cycle,** heat addition taken place at constant pressure and heat rejection taken place at constant volume.

In case of **Rankine cycle,** heat addition and heat rejection taken place at constant pressure.

In case of **dual combustion,** heat addition taken place at constant volume and constant pressure and heat rejection taken place at constant volume.

19. Throttling is_____.

A. irreversible adiabatic process B. Reversible isenthalpic process

C. irreversible isenthalpic process D. isentropic process

Ans. C

Sol.

During throttling process, enthalpy remains const. Thus isenthalpic

Throttling results in decrease in pressure and increase in entropy.

$h_1 = h_2$

$\Delta S > 0$

20. If a reheater is added to a Rankine Cycle then usually

A. The net-work increases but the efficiency may increase or decrease.

B. The net-work & efficiency decrease

C. The net-work remains same & efficiency increases

D. Net-work increases & efficiency remains same

Ans. A

Sol.

- Reheat Rankine Cycle is employed when high pressure turbine are used and dryness fraction at outlet of turbine will reduce below acceptable limit (88% usually).
- To avoid this condition the steam is partially expanded in high pressure turbine and then reheated to same initial temperature.
- Further it is expanded in low pressure turbine which increases the net work output but increase the dryness fraction, the efficiency may increase or decrease.

21. For CI engines, fuels most preferred are _______.

A. Paraffins B. Napthalene

C. Aromatics D. Olefins

Ans. A

Sol.

- For C.I. engines fuel most preferred are paraffins and for S.I. engines fuel most preferred are aromatics.
- The paraffins is more preferred due to its high antiknocking tendency.

22. An engine is required 150 kW brake power. The mechanical efficiency of the engine is 75%. The frictional power is

A. 150 kW B. 200 kW

C. 50 kW D. 25 kW

Ans. C

Sol. Frictional power (FP) is

FP = IP – BP

$\eta_{mech} = \frac{BP}{IP}$

$IP = \frac{150}{0.75} = 200$ kW

FP = 200 – 150 =50kW

23. Ideal regenerative rankine cycle_____.

A. Increases efficiency B. Increases work output

C. Increases the heat supplied D. does not affect efficiency

Ans. A

Sol.

- Feedwater is preheated so as to decrease the fuel consumption which increases efficiency.

24. The volumetric analysis of dry products of combustion_____.

A. Bomb calorimeter
B. Viscosity meter
C. Orsat apparatus
D. Calorimeter

Ans. C

Sol.

- Volumetric analysis of dry product is done by with the help of Orsat apparatus.
- Analysis of fossil fuel gas is done by Orsat apparatus.

25. Nozzle efficiency is described as.......

A. Isentropic heat drop/useful heat drop
B. useful heat drop/isentropic heat drop
C. saturation temperature/supersaturation temperature
D. supersaturation temperature/saturation temperature

Ans. B

Sol. Nozzle efficiency is defined as the ratio of actual heat drop to isentropic heat drop

$$\eta_N = \frac{\textit{actual heat drop}}{\textit{isentropic heat drop}} = \frac{\Delta h}{\Delta h_s}$$

$$\eta_N = \frac{V_2^2 - V_1^2}{V_{2s}^2 - V_1^2} \quad \textit{(if velocity at the inlet is zero)}$$

$$\eta_N = \frac{V_2^2}{V_{2s}^2}$$

26. A single cylinder four stroke spark ignition engine has mechanical efficiency of 75%. If frictional power is estimated to be 20 KW. Find the brake power of engine in KW ___?

A. 80 KW
B. 40 KW
C. 60 KW
D. 30 KW

Ans. C

Sol. Given,

Mechanical efficiency = 75%

Frictional power = 20 KW

$$\text{Mechanical efficiency} = \frac{\text{Brake power}}{\text{Indicated power}}$$

$$0.75 = \frac{BP}{IP}$$

Frictional Power = IP − BP = 20 KW

IP − 0.75IP = 20 KW

0.25IP = 20 KW

IP = 80 KW

27. Which of the following factors does NOT contribute towards detonation in an engine?

A. Engine overheating
B. High compression ratio
C. Stoichiometric fuel mixture
D. Wrong position of spark plug

Ans. C

Sol.

Following Factors causes detonation in Engine

- Engine overheating
- Compression ratio is high
- Wrong position of spark plug
- Use of lean mixture in fuel

28. Which of the following statement is TRUE for work output of an ideal Otto cycle?

A. Increases with an increase in adiabatic index.
B. Increases with an increase in compression ratio.
C. Increases with an increase in pressure ratio
D. All option are correct

Ans. D

Sol.

All points describe the basic characteristics of OTTO CYCLE.

The four processes that make up the Otto cycle are

(1) isentropic compression,
(2) constant volume heat addition,
(3) Isentropic expansion
(4) constant volume heat rejection

$$\eta = \frac{W_{net}}{\text{heat supplied}} = 1 - \frac{1}{r^{\gamma-1}}$$

from the expression,

as specific heat ratio $\gamma$ increases, work output will increase.

as compression ratio,r increases, work output will increase.

$$P_{mep} = \frac{W_{net}}{V_s}$$

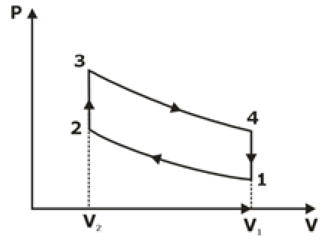
as the pressure ratio $r_p$ increases, mean effective pressure will increase and so the work output will increase

29. The minimum and maximum volumes in an air standard otto cycle are 100cc and 800cc. Thermal efficiency of the cycle approximately will be

A. 57%
B. 37%
C. 67%
D. 46%

Ans. A

Sol. Given




$V_1$ = 100cc = $V_C$

$V_2$ = 800cc = $V_S + V_C$

⇒ Compression ratio(r)

$$= \frac{V_s + V_c}{V_c} = \frac{V_1}{V_2} = \frac{800}{100}$$

r = 8

$$\eta = 1 - \frac{1}{r^{\gamma-1}} \Rightarrow 1 - \frac{1}{8^{0.4}} = 0.564$$

η = 56.4%

30. A calorically perfect gas (specific heat at constant pressure 1000 J/kg.K) enters and leaves a gas turbine with the same velocity. The temperatures of the gas at turbine entry and exit are 1100 K and 400 K, respectively. The power produced is 4.6 MW and heat escapes at the rate of 300 kJ/s through the turbine casing. The mass flow rate of the gas (in kg/s) through the turbine is

A. 6.14 B. 7.00

C. 7.50 D. 8.00

Ans. B

Sol. Given that,

$C_p$ = 1000 J/kgK

$T_1$ = 1100K, P= 4.6MW

$T_2$ = 400K, $Q_L$ = 300kJ / s

$$\dot{E}_{in} = \dot{E}_{out}$$

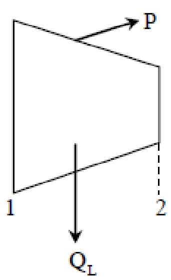
$$h_1 + \frac{V_1^2}{2} + gz_1 = h_2 + \frac{V_2^2}{2} + gz_2 + Q_L + P$$

$\therefore V_1 = V_2, Z_1 = Z_2$

So, $h_1 - h_2 = Q_L + P$

$$\dot{m} = \frac{(300 \times 10^3) + (4.6 \times 10^6)}{1000 \times (1100 - 400)}$$

$\dot{m}$ = 7kg / sec



31. Which of the following methods are used to increase efficiency of a Brayton cycle?

A. Regeneration
B. Increasing pressure ratio
C. Heat exchanger
D. All of the mentioned

Ans. D

Sol.

- A heat exchanger that acts as a counter-flow energy recovery device positioned within the supply and exhaust air streams of an air handling system, in order to recover the waste heat.

32. Consider an Otto Cycle:

Match List I with List II and select the correct answer using the code givenbelow the Lists:

| List 1 | List 2 |
|---|---|
| A. Most Efficient Working fluid | 1. Polyatomic gas |
| B. Detonation | 2. Monatomic gas |
| C. Octane Reading | 3. Auto ignition |
| | 4. Knock Resistance |

A. A-2, B-3, C-4
B. A-2, B-4, C-3
C. A-1, B-3, C-4
D. A-1, B-4, C-3

Ans. A

Sol.

- Efficiency of otto cycle increased with adiabatic exponent (γ). Monatomic gas has maximum γ.
- Premature ignition/Auto ignition of fuel leads to noise called engine knock or detonation.
- Octane reading implies the knock resistance of the fuel.

33. Direct system of cooling air is one in which

A. cooling water flows by gravity
B. hot water is continuously cooled and circulated
C. hot water is simply discharged
D. water is allowed to evaporate in the cylinder jacket

Ans. C

Sol.

Direct system of cooling air is one in which hot water is simply discharged.

With direct cooling, ambient air is taken in to cooled hot water discharge.

34. A gas turbine operating on Brayton cycle has the maximum temperature of 1200 k and the minimum temperature of 300 k . the cycle efficiency for the maximum work capacity will be

A. 75%
B. 60%
C. 50%
D. 25%

Ans. C

Sol. The Maximum net work is obtained when the pressure ration is equal to the square root of maximum theoretical pressure ratio.

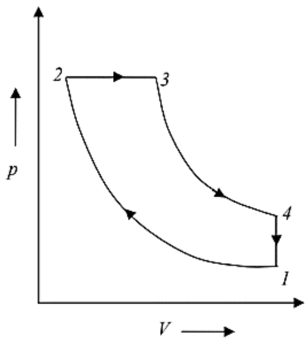
$r_p = \sqrt{r_{pmax}}$

$so\ \eta_{max\ net\ work} = 1 - \sqrt{\frac{T_{min}}{T_{max}}}$

$= 1 - \sqrt{\frac{300}{1200}}$

$= 1 - \frac{1}{2} = 50\%$

35. Shown below is the P-V diagram of a diesel cycle. Which of the following represents the cut-off ratio?




A. $\frac{V_3}{V_1}$

B. $\frac{V_2}{V_1}$

C. $\frac{V_3}{V_2}$

D. $\frac{V_2}{V_3}$

Ans. C

Sol. The cutoff ratio of the diesel cycle is given by :

$\rho = \frac{V_3}{V_2}$

36. Select the correct statement for 50% reaction stage in a steam turbine _________.

A. The rotor blade is symmetric.

B. The stator blade is symmetric.

C. The absolute inlet flow angle is equal to absolute exit flow angle.

D. The absolute exit flow angle is equal to inlet angle of rotor blade.

Ans. D

Sol. In Parsons Reaction Turbine (50% reaction):

$\alpha_1 = \beta_2\ and\ \alpha_2 = \beta_1$

and $V_1 = V_{r2}\ \ and\ V_{r1} = V_2$

37. The main purpose of fan in a liquid cooling system is to

A. disperse engine fumes

B. pump cold air over the hot water

C. cool the external surface of the engine

D. a belt driven water impeller

Ans. B

Sol. The main purpose of fan in a liquid cooling system is to pump cold air over the hot water for higher coefficient of convection.

38. For an air-standard Diesel cycle,

A. heat addition is at constant pressure and heat rejection is at constant pressure

B. heat addition is at constant volume and heat rejection is at constant pressure

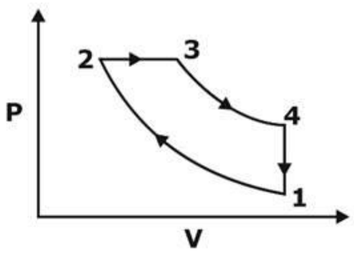
C. heat addition is at constant volume and heat rejection is at constant volume

D. heat addition is at constant pressure and heat rejection is at constant volume

Ans. D

Sol.

Air standard diesel cycle




Process 1-2: Isentropic compression

Process 2-3: Constant pressure heat addition

Process 3-4: Isentropic expansion

Process 4-1: Constant volume heat rejection.

39. Which of the following factors aids in increasing detonation in SI engine?

1) Increase in spark advance

2) Higher speed

3) Increased air-fuel ratio on the far side of stoichiometric strength

4) Higher compression ratio.

Select the exact answer from below options:

A. 1 and 3

B. 2 and 4

C. 1, 2, & 4

D. 1 and 4

Ans. D

Sol. Detonation in the S.I. engines is augmented by increasing spark advance and Increase in compression ratio. The increased speed and lean mixtures do not have much influence.

40. What is the main purpose of supercharging of the engine?

A. To increase the power output of the engine.

B. Volumetric Efficiency of the engine increases.

C. Brake Power per unit mass increases

D. All of the above

Ans. D

Sol. Supercharging is a process in which an air compressor is used to increase the pressure or density of air supplied to an internal combustion engine.

Due to supercharging of IC Engines

- Power output of the engine increases.
- Volumetric efficiency of the engine increases.
- Brake power per unit mass increases

41. Lenoir cycle consists of constant -------------------heat addition and constant ----------------- heat rejection.

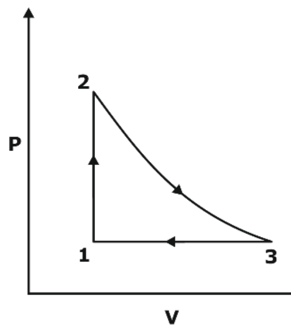
A. volume, pressure B. pressure, volume

C. temperature, pressure D. temperature, volume

Ans. A

Sol.

- Lenoir cycle consists of constant volume heat addition (process 1 to 2) and constant pressure heat rejection (process 3 to 1) and isentropic expansion (process 2 to 3).
- The Lenoir cycle is an idealized thermodynamic cycle often used to model a pulse-jet engine.




42. Which of the following statement is/are true.

(a) Generally, the chemical delay is larger than physical delay.

(b) At high temperatures, the physical delay is smaller than chemical delay.

(c) Ignition lag in SI engine is equivalent to chemical delay.

(d) All of above

A. a, b B. b, c

C. a, c D. d

Ans. C

Sol.

- The physical delay is the time between the beginning of injection and attainment of chemical reaction conditions.
- During chemical delay reactions starts slowly and then accelerates.Hence generally chemical delay is more but as temperature increases chemical reactions are faster and hence physical delay are larger than chemical delay.

43. In case of Rankine cycle, Heat rate is given is given by _____________. (where, η is the efficiency of Rankine cycle).

A. $\eta$ B. $\eta^2$

C. $1/\eta^2$ D. $1/\eta$

Ans. D

Sol.

$$Heat\ rate = \frac{Heat\ supplied\ in\ kW}{Power\ in\ kW}$$

$$= \frac{\dot{m}_s \times Heat\ supplied}{\dot{m}_s \times Net\ work}$$

$$= \frac{Heat\ supplied}{Net\ work} = \frac{1}{\eta}$$

44. An example of a water tube boiler is a:

A. Locomotive boiler
B. Lancashire boiler
C. Babcock-Wilcox boiler
D. Cochran boiler

Ans. C

Sol. If water passes through the tubes and hot gases surround the tubes, then it is called a water tube boiler. Eg. Babcock and Wilcox boiler.

45. Which of the following relation holds when a diesel cycle and an otto cycle have the same efficiency and same compression ratio (r), the cutoff ratio of diesel cycle is ($r_c$). (Specific heat ratio = γ)

A. $\gamma(r-1) + r_c^{\gamma} + 1 = 0$
B. $\gamma(r_c-1) + r^{\gamma} + 1 = 0$
C. $\gamma(r_c-1) - r_c^{\gamma} + 1 = 0$
D. $\gamma(r_c-1) + r_c^{\gamma} - 1 = 0$

Ans. C

Sol.

$$\eta_{otto} = 1 - \frac{1}{r^{\gamma-1}},\quad \eta_{Diesel} = 1 - \frac{1}{r^{\gamma-1}}\left(\frac{r_c^{\gamma}-1}{\gamma(r_c-1)}\right)$$

$\eta_{otto} = \eta_{diesel}$

$$\frac{r_c^{\gamma}-1}{\gamma(r_c-1)} = 1$$

$$\gamma(r_c-1) - r_c^{\gamma} + 1 = 0$$

46. Which one of the following safety device is used to protect the boiler when the water level falls below a minimum level?

A. Safety valve
B. Water level indicator
C. Fusible plug
D. Blow off cock

Ans. C

Sol.

- Fusible plug is a small device installed in small horizontal fire tube boilers between furnace and boiler water drum for protection of boiler while lower water level in drum.
- When water level reduces lower than predefined level, the higher temperature of the steam melts the lead of fusible plug so water from the drum fall in to the furnace and shell of boiler, wetting the fire tube and disrupting combustion in the furnace and thus preventing any damage to the boiler.

47. In Brayton Cycle, the work ratio is 0.65. What is the back work ratio of this Brayton Cycle?

A. 2.53
B. 0.65
C. 0.35
D. 1.53

Ans. C

Sol.

For a Brayton Cycle:

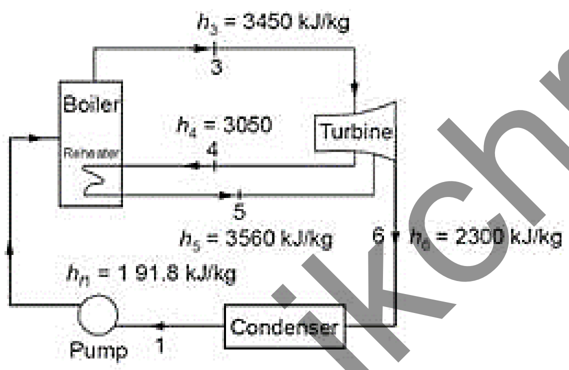
Work ratio ($r_w$)+ Back work ratio ($r_{bw}$) = 1

Therefore:

$r_{bw} = 1 - r_w = 1 - 0.65 = 0.35$

48. A steam power plant operates on a theoretical reheat cycle as shown below. Steam enters high pressure turbine at 150 bar and 550 °C ($h_3$ = 3450 kJ/kg) and expands upto 40 bar ($h_4$ = 3050 kJ/kg). It is reheated at constant pressure of 40 bar to 550 °C ($h_5$ = 3560 kJ/kg) and expands through the low pressure turbine to a condenser at 0.1 bar ($h_6$ = 2300 kJ/kg). Also given, $h_{f1}$ (at 0.1 bar) = 191.8 kJ/kg.

Thermal efficiency (in %) and steam rate (kg/kWh) of the plant neglecting pump work respectively are:




A. 44.05 and 4.34
B. 48.10 and 5.12
C. 42.10 and 3.10
D. 44.05 and 2.17

Ans. D

Sol. Given,

enthalpy at 150 bar and 550 °C ($h_3$) = 3450 kJ/kg

enthalpy of steam after expansion in high pressure turbine to 40 bar ($h_4$)= 3050 kJ/kg

enthalpy at 40 bar and 550 °C ($h_5$)= 3560 kJ/kg

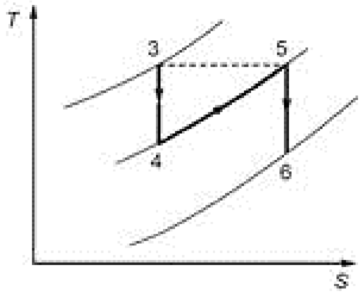
enthalpy of steam after expansion in low pressure turbine to 0.1 bar ($h_6$ ) = 2300 kJ/kg

$$Q_s = (h_3 - h_{f1}) + (h_5 - h_4)$$

$$= (3450 - 191.8) + (3560 - 3050)$$

$$= 3768.2 \text{ kJ/kg}$$

$$W = (h_3 - h_4) + (h_5 - h_6)$$




$= (3450 - 3050) + (3560 - 2300)$

$= 1660 \text{ kJ/kg}$

$\eta_{cycle} = \dfrac{W}{Q_s} = \dfrac{1660}{3768.2} = 44.05\%$

Steam rate $= \dfrac{3600}{W}$

$= \dfrac{3600}{1660}$

$= 2.17 \text{ kg/kWh}$

49. The clearance ratio of a 4- stroke single cylinder I.C. engine is 10 % of swept volume. The compression ratio of the engine is ________.

A. 9 B. 10

C. 11 D. 12

Ans. C

Sol.

Given: $V_c = 0.10\ V_s$

Compression ratio is given by:

$$r_k = \frac{V_s + V_c}{V_c}$$

$$r_k = \frac{V_s + 0.10V_s}{0.10V_s} = 11$$

50. In a centrifugal compressor as fluid moves through impeller, there is_____?

A. Increase in pressure and decrease in velocity.

B. Increase in both pressure and velocity.

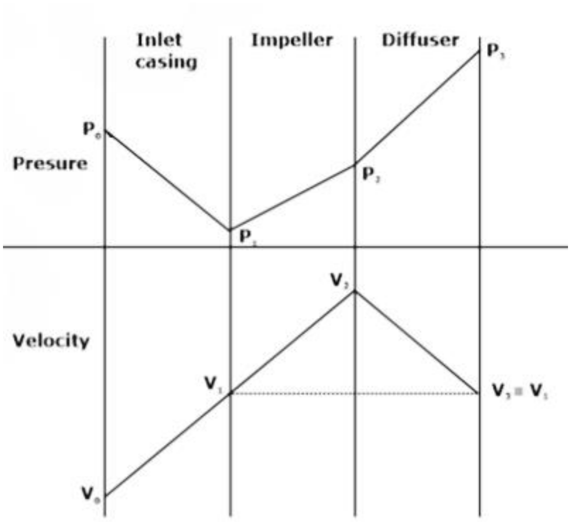
C. Decrease in pressure and increase in velocity.

D. Decrease in both pressure and velocity.

Ans. B

Sol. In a centrifugal compressor as fluid moves through impeller, there is increase in both pressure and velocity.

Variation of pressure and velocity is shown below.




51. Which of these gases attains the lowest thermal efficiency for the same compression ratio in an otto cycle ?

A. Any of the gases
B. Diatonic gases
C. Monoatomic gases
D. Triatomic gases

Ans. D

Sol.

efficiency of otto cycle =

$$\eta = 1 - \frac{1}{r^{\gamma - 1}}$$

ratio of specific heat

for Monoatomic $\gamma$ = 1.67

for Tri-atomic $\gamma$ = 1.33

for Di-atomic $\gamma$ = 1.4

as $\gamma$ increases, efficiency of cycle increases.

so the maximum efficiency will occur for monoatomic gas

and minimum maximum efficiency will occur for triatomic gas

52. In a dual cycle, compression ratio and expansion ratio are 15 and 10 respectively. Find cut off ratio for given cycle.

A. $\frac{2}{3}$
B. $\frac{3}{2}$
C. $\frac{4}{3}$
D. $\frac{3}{4}$

Ans. B

Sol. Given,

Compression ratio (r) = 15,

Expansion ratio ($r_e$) = 10,

$$\text{cutoff ratio} = \frac{\text{compression ratio}}{\text{expansion ratio}} = \frac{15}{10} = \frac{3}{2} = 1.5$$

53. The peak load on a power plant is 40 MW and a group of four loads having maximum demand of 15 MW, 12 MW, 18 MW and 5 MW respectively are connected to the plant. The capacity of the plant is 60 MW. What is diversity factor of the plant?

A. 1.5
B. 1.25
C. 0.8
D. 0.75

Ans. B

Sol.

- Diversity factor is the ratio of the sum of the individual maximum demands of the various subdivisions of a system to the maximum demand of the whole system under consideration.
- Usually diversity is more than one.
- $$Diversity\ factor = \frac{15+12+18+5}{40} = \frac{50}{40} = 1.25$$

54. In a three stage compressor, if the pressure at the entry of first and third stage are 1 bar and 16 bar, then the delivery pressure at the third stage will be

A. 1 bar
B. 16 bar
C. 64 bar
D. 256 bar

Ans. C

Sol. Given,

$P_1$ = 1bar , $P_3$ = 16bar

$P_4$ = ?

In a multi stage compressor

$$\frac{P_2}{P_1} = \frac{P_3}{P_2} = \frac{P_4}{P_3}$$

$$So, taking\ \frac{P_2}{P_1} = \frac{P_3}{P_2}$$

$$(P_2)^2 = 1 \times 16$$

$$P_2 = 4$$

$$Now\ taking\ \frac{P_3}{P_2} = \frac{P_4}{P_3}$$

$$P_4 = \frac{(P_3)^2}{P_2}$$

$$P_4 = \frac{256}{4} = 64\ bar$$

Hence, the correct answer is option (C).

55. For an air standard cycle, power at crank shaft is 9.6 MJ/Kg. If the Calorific value of the fuel is 42000 KJ/Kg and indicated thermal efficiency of engine is 30%. then mechanical efficiency of the engine is

A. 81%
B. 71.47%
C. 82.33%
D. 76.19%

Ans. D

Sol.

Given $\eta_{ith}$ = 30%, BP = 9.6 MJ/Kg

$CV_{fuel}$ = 42000 KJ/Kg = 42 MJ/Kg

$$\eta_{ith} = \frac{IP}{m_f \times CV} \Rightarrow 0.3 = \frac{IP}{1 \times 42}$$

IP = 12.6 MJ/Kg

Mechanical efficiency,

$$\eta_m = \frac{BP}{IP} = \frac{9.6}{12.6}$$

$\eta_M$ = 0.7619 ⇒ $\eta_M$ = 76.19%

56. The following are the results of a Morse test conducted on a four-cylinder, four-stroke petrol engine at a common constant speed in all cases:

The brake power of the engine when all the cylinders are firing is 80 kW. The brake power of the engine when each cylinder is cut-off in turn is 55 kW, 55.5 kW, 54.5 kW and 55 kW, respectively.

The mechanical efficiency of the engine when all the cylinders are firing will be

A. 90%
B. 85%
C. 80%
D. 75%

Ans. C

Sol.

$$\text{B. P.}_{All\ cylinder\ working} = 80\text{ kW}$$

$$\text{I. P.}_{1st\ cylinder\ working} = 80 - 55\text{ kW}$$

$$\text{I. P.}_{2nd\ cylinder\ working} = 80 - 55.5\text{ kW}$$

$$\text{I. P.}_{3rd\ cylinder\ working} = 80 - 54.5\text{ kW}$$

$$\text{I. P.}_{4th\ cylinder\ working} = 80 - 55\text{kW}$$

$$\eta_m = \frac{B.P}{I.P} = 80\%\ Ans$$

57. In reciprocating compressors, clearance is provided

a- To improve the volumetric efficiency of compressor

b- To accommodate valves

c- To account for thermal expansion due to temperature variation

d- To reduce power consumption of the compressor

A. (a), (b) & (c)
B. (b) & (c)
C. (a), (b), (c) & (d)
D. (b) & (d)

Ans. B

Sol.

Clearance volume or bumping clearance is the space between the top of the piston and the cylinder head of an air compressor. This clearance is an important aspect of the compressors and should be as less as practically possible to improve the volumetric efficiency of the compressor. The clearance volume should not be too less or too more. Moreover, it affects the efficiency of the machinery and thus should be checked at regular intervals of time.

58. After a test on four cylinder, two stroke gasoline engine following observations were made:

Area of the positive loop of the indicator diagram = 5.75 $cm^2$

Area of negative loop of the indicator diagram = 0.25 $cm^2$

Length of indicator diagram = 55 cm

Spring constant = 3.5 bar/cm

What will be the indicated mean effective pressure (in bar) of the engine?

A. 0.35 B. 5.5

C. 3.5 D. 4.2

Ans. A

Sol. Given,

Area of the positive loop of the indicator diagram = 5.75 $cm^2$

Area of negative loop of the indicator diagram = 0.25 $cm^2$

Net area of diagram = 5.75 - 0.25 = 5.5$cm^2$

$$P_{imep} = \frac{\text{Area of diagram}}{\text{length of diagram}} \times \text{spring constant}$$

$$P_{imep} = \frac{5.5}{55} \times 3.5 = 0.35 \text{ bar}$$

59. Economizer used in power plants is used to heat __________.

A. flue gases B. intake air

C. steam D. feed water

Ans. D

Sol.

- A common application of economizers in steam power plants is to capture the waste heat from boiler stack gases (flue gas) and transfer it to the boiler feed water. This raises the temperature of the boiler feed water, lowering the needed energy input, in turn reducing the firing rates needed for the rated boiler output.

60. A diesel engine has a compression ratio of 21 and cut-off takes place at 8% of the stroke. What is the cut – off ratio ?

A. 1.2 B. 2.2

C. 1.6 D. 2.6

Ans. D

Sol.

Given:

compression ratio, $r_k$= 21

cut off takes place = 8% of($V_1$ - $V_2$)

$$r_c - 1 = \frac{\%p}{100}\left(r_k - 1\right)$$

$$r_c - 1 = \frac{8}{100}(21 - 1)$$

$r_c$ = 2.6

61. Which of the following is correct regarding the pressure inside the cylinder during exhaust stroke?

A. equal to the atmospheric pressure

B. less than the atmospheric pressure

C. more than the atmospheric pressure

D. None of the above

Ans. C

Sol. During exhaust piston moves BDC to TDC inside cylinder, forcing all the remaining burnt air/fuel (exhaust) out. Again, depending on how restrictive the exhaust valves, ports, mufflers, etc are, the cylinder pressure in the cylinder will be somewhat higher than atmospheric.

How high the cylinder pressure is during the exhaust stroke determines how hard the engine must work to expel the burnt exhaust.

62. Which of the following parameter remain constant during Morse test of the IC engine?

A. Friction power B. Load on the dynamometer

C. Break power D. Indicated power

Ans. A

Sol. The Morse test is used to obtain the Indicated Power (IP) of a Multi-cylinder Engine. In it the load on the dynamometer is adjusted so as maintain constant speed and so frictional power (FP). FP is independent of load and proportional to engine speed.

63. The thermal efficiency of air standard diesel cycle with increasing cut off ratio keeping other parameters constant

A. Increases B. Decreases

C. Remain constant D. none of the above

Ans. B

Sol. The thermal efficiency of diesel cycle is given by

$$\eta_{diesel} = 1 - \frac{1}{r^{\gamma-1}}\left\{\frac{\alpha^{\gamma}-1}{\gamma(\alpha-1)}\right\}$$

Where,

r = compression ratio,

γ = specific heat ratio,

ɑ = cut- off ratio

It is clear that as ɑ increases the $\eta_{diesel}$ decreases.

64. Which of the following statement is INCORRECT about excess value of 'Valve overlap Period'________?

1) Burnt gases will be sucked into cylinder.

2) It may allow Fresh Charge to escape through exhaust value.

A. Only 1 B. Only 2

C. Both 1 & 2 D. None of the above

Ans. D

Sol.

o In 4 stroke SI Engine, there is a period where both inlet valve and exhaust valves are open. This period is called Valve overlap Period.

o This period should not be excessive otherwise the burnt gases will be sucked into cylinder or it may allow fresh charge to escape through exhaust valve.

65. Find the maximum work obtainable per kg of air in ideal brayton cycle working between temperature limits of 127°C and 1327°C. (Take $C_p$ = 1 kJ/kg/K)

A. 100 kJ/kg B. 200 kJ/kg

C. 300 kJ/kg D. 400 kJ/kg

Ans. D

Sol.

Given: $T_{max}$ = 627°C =1327 + 273 = 1600 K

$T_{min}$ = 127°C = 127 + 273 = 400 K

$C_p$ = 1 KJ/kg-K

Maximum work obtainable is given by:

$$W_{max} = mC_p\left(\sqrt{T_{max}} - \sqrt{T_{min}}\right)^2$$

$$W_{max} = 1 \times 1 \times (\sqrt{1600} - \sqrt{400})^2$$

$W_{max}$= $(40\text{-}20)^2$ = 400 kJ/kg

66. The ratio of the actual vacuum to the ideal vacuum in a condenser is called

A. condenser efficiency B. vacuum efficiency

C. nozzle efficiency D. boiler efficiency

Ans. B

Sol.

Due to the presence of air inside the condenser, the actual pressure inside will not be equal to the pressure corresponding to steam temperature inside the condenser. The air will exert its own partial pressure and thus lower the partial pressure of the seatm during condensation. To judge the effect of air leakage,we defined a term vacuum efficiency. The ratio of the actual vacuum to the ideal vacuum in a condenser is called vacuum efficiency.

$$\eta_{vacuum} = \frac{Actual\ vacuum\ in\ the\ condenser}{Ideal\ vaccum\ in\ condenser\ when\ no\ air\ is\ present}$$

67. Stirling Cycle has ______.

A. Two isentropic and two isochoric processes

B. Two isentropic and two isobaric processes

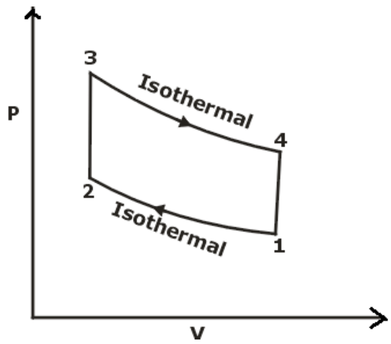
C. Two isothermal and two isochoric processes

D. Two isothermal and two isobaric processes

Ans. C

Sol.

Stirling cycle:




Stirling Cycle has Two isothermal and two isochoric processes.

Process 1-2: Isothermal compression

Process 2-3: Isochoric head addition

Process 3-4: Isothermal expansion

Process 3-4: Isochoric head rejection.

68. A gas turbine working on Brayton cycle has a back work ratio of 0.35 and net output is 250 kJ. If compressor efficiency of 90%, then find the work output by the turbine ____________?

A. 384 kJ

B. 250 kJ

C. 384.6 kJ

D. 220 kJ

Ans. C

Sol. Given:

Back work ratio: $r_{bw}$= 0.35

Back work ratio is given by:

$$r_{bw} = \frac{W_C}{W_T}$$

$0.35 = W_C/W_T$ ............... (1)

$W_{net} = W_T - W_C$ ............... (2)

$250 = W_T - 0.35\ W_T$

$0.65\ W_T = 250$

$W_T = 384.6$ kJ

69. If the enthalpy drop in the moving blades and fixed blades of a steam turbine is 10 kJ/kg and 15 kJ/kg respectively then what is the degree of reaction?

A. 67% B. 60%

C. 40% D. 33%

Ans. C

Sol. Given,

$\Delta H_{moving}$ = 10 kJ/kg,

$\Delta H_{fixed}$ = 15 kJ/kg

$$\text{Degree of reaction} = \frac{\text{Enthalpy drop across moving blades}}{\text{Total Enthalpy drops}}$$

$$= \frac{10}{10 + 15}$$

$$= 0.4 = 40\%$$

70. If m is the ratio of maximum and minimum temperature of Brayton cycle, then the efficiency corresponding to the maximum work done is given by the relation _________.

A. $\eta = 1 + \frac{1}{\sqrt{m}}$ B. $\eta = 1 - \frac{1}{\sqrt{m}}$

C. $\eta = 1 - \sqrt{m}$ D. $\eta = 1 + \sqrt{m}$

Ans. B

Sol.

Given: $m = \sqrt{\frac{T_{max}}{T_{min}}}$

For maximum work done, cycle efficiency is:

$$\eta = 1 - \sqrt{\frac{T_{min}}{T_{max}}} = 1 - \frac{1}{\sqrt{m}}$$

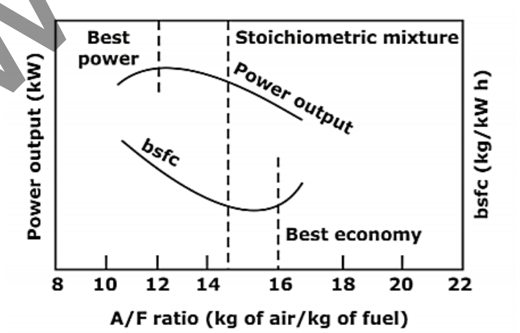
71. For maximum power generation the air fuel ratio for a petrol engine is

A. 16:1 B. 12:1

C. 15:1 D. 20:1

Ans. B

Sol. power characteristics curve of fuel



From the above figure, we can see that for maximum power output, Air to fuel ratio is to be 12:1

72. The intermediate pressure which produces minimum work also results in

A. equal discharge temperatures

B. equal work for two stages

C. equal pressure ratios in two stages

D. all of the mentioned

Ans. D

Sol. These are the results when we consider minimum work of compression

1. equal discharge temperature
2. equal pressure ratio in each stages
3. same amount of work is required in each stage of compression
4. intermediate pressure is the square root of the product of the inlet and delivery pressure

73. In an air standard cycle, indicated power is 80 KW and mechanical efficiency is 85%. Then the frictional power will be

A. 68 kW

B. 12 kW

C. 14 kW

D. 15 kW

Ans. B

Sol.

Given $\eta_M$ = 85%, IP = 80 KW

$$\eta_M = \frac{BP}{IP} \Rightarrow 0.85 = \frac{BP}{80} \Rightarrow BP = 68\ KW$$

IP = BP + FP ⇒ FP = IP – BP

= 80 – 68

FP = 12 kW

74. In SI engines for higher thermal efficiency __________.

A. compression ratio should be high

B. heat liberation during combustion should be maximum

C. surface to volume ratio should be high

D. long flame travel distance

Ans. A

Sol. Thermal efficiency of SI engine:

$$\eta = 1 - \frac{1}{r^{\gamma-1}}$$

Where r is the compression ratio. As 'r' increases efficiency increases.

75. Cetane number of alpha methyl naphthalene is assigned the value of :

A. 0

B. 15

C. 55

D. 100

Ans. A

Sol.

- *n-hexadecane*(also called cetane, n-$C_{16}H_{34}$), which has very good ignition quality, was assigned the cetane number of 100;
- *1-methylnaphthalene*, which has a poor ignition quality, was assigned a cetane number of zero.

76. an air standard otto cycle having compression ratio 8. It is compressed isentropically to a pressure 18.3bar and 690K. if the pressure and temperature at the beginning of compression is 1bar and 300K, then the efficiency of the cycle is

A. 47.5% B. 63.2%

C. 44.77% D. 56.52%

Ans. D

Sol. given,

$P_1$ = 1bar, $P_2$ = 18.3 bar

$T_1$ = 300K $T_2$ = 690K

$$\eta = 1 - \frac{1}{r^{\gamma-1}} = 1 - \frac{T_1}{T_2}$$

$$\eta = 1 - \frac{300}{690}$$

$$\eta = 0.5652 = 56.52\%$$

77. What is the effect of regeneration on mean temperature of heat addition in Brayton cycle?

A. mean temperature of heat addition decreases because of regeneration

B. mean temperature of heat addition increases because of regeneration

C. mean temperature of heat addition is not affected by use of regenerator

D. none of the above

Ans. B

Sol. Due to Regeneration, heat addition process (inlet to combustion chamber)starts at a temperature higher than the earlier whereas the exit temperature of the combustion chamber remains constant so the mean temperature(average) of heat addition increases.

78. Two special cases are formed in a dual cycle corresponding to the zero pressure ratio and zero cutoff ratio. These two cases give rise to which cycle?

1) Otto cycle

2) Diesel cycle

3) Atkinson cycle

4) Lenoir cycle

The correct statements are

A. 1&2 B. 1&3&4

C. 2&3 D. 1, 2 &4

Ans. A

Sol. In dual cycle if cut off ratio is zero, we get Otto cycle and if explosion or pressure ratio is zero then we get diesel cycle.

79. A gas turbine power plant operates on the Brayton cycle between $T_{min}$ = 300 K and $T_{max}$ = 1200 K. The ratio of maximum cycle efficiency of Brayton cycle to the efficiency of Carnot cycle, operating between the same two temperatures is ___________.

A. 0.33 B. 0.45

C. 0.67 D. 75

Ans. C

Sol. Maximum efficiency of Brayton cycle is given by:

$$(\eta_{max})_{Brayton} = 1 - \sqrt{\frac{T_{min}}{T_{max}}}$$

$$(\eta_{max})_{Brayton} = 1 - \sqrt{\frac{300}{1200}} = 0.5$$

Efficiency of Carnot cycle is given by:

$$\eta_{Carnot} = 1 - \frac{T_{min}}{T_{max}} = 1 - \frac{300}{1200} = 0.75$$

$$\frac{(\eta_{max})_{Brayton}}{\eta_{Carnot}} = \frac{0.50}{0.75} = 0.67$$

80. Which of the following statements regarding a Rankine cycle with reheating is/are TRUE_________?

(i) Increase in thermal efficiency always

(ii) Decrease in thermal efficiency always

(iii) Drier steam at the turbine exit

A. Only (i) & (iii) B. Only (ii) & (iii)

C. Only (i) D. Only (iii)

Ans. D

Sol. A Rankine cycle when subjected to reheating,

⇒ Steam quality at exit of steam turbine increases.

⇒ Efficiency of Rankine cycle may increase or decrease, it depends on the reheating pressure.

81. The ‘work ratio’ increases with

A. increase in turbine inlet pressure

B. decrease in compressor inlet temperature

C. decrease in pressure ratio of the cycle

D. all of the mentioned

Ans. D

Sol.

$$Work\ Ratio = \frac{W_{net}}{W_T} = \frac{W_T - W_C}{W_T} = 1 - \frac{W_C}{W_T}$$

$$Work\ Ratio = 1 - \frac{C_p(T_2 - T_1)}{C_p(T_3 - T_4)} = 1 - \frac{T_1}{T_4}$$

$$Work\ Ratio = 1 - \frac{T_1}{T_3} \times \frac{T_3}{T_4}$$

$$Work\ Ratio = 1 - \frac{T_1}{T_3} \times \left(r_p\right)^{\frac{\gamma - 1}{\gamma}}$$

Thus the 'work ratio' increases when the turbine inlet pressure increases, the compressor inlet temperature decreases, the pressure ratio of the cycle decreases.

82. Willian's line for the steam engine is a straight line relationship between _________.

A. the steam consumption per hour & indicated power

B. the steam consumption per hour & brake power

C. the steam consumption per hour & efficiency

D. the steam consumption per hour & pressure of steam

Ans. B

Sol. **Willian's Line method:**

- It is the method estimating the friction power of compression ignition (C.I.) engines.
- Willian's line for the steam engine is a straight line relationship between the fuel consumption per hour (on vertical axis) and brake power (on horizontal axis).
- Here, it is asked for steam engine, therefore replace fuel by steam because steam fulfills the same purpose as fuel in C.I. engines.

83. The self-ignition temperature of diesel is __________ as compared to that of petrol.

A. is higher
B. is lower
C. is same
D. cannot be determined

Ans. B

Sol.

* Self Ignition Temperature(SIT) is the lowest temperature at which a diesel/Petrol will ignite itself without the presence of a spark or flame.

*SIT of diesel is $210^0C$

* SIT of petrol is ($240^0C$ - $280^0C$)

84. For a single cylinder four-stroke oil engine, indicated power is 15 kW. calorific value of fuel is 40000 kJ/kg and fuel consumed is 0.001 kg/s. What will be the indicated thermal efficiency?

A. 62.5%
B. 40%
C. 75%
D. 37.5%

Ans. D

Sol.

Given,

Indicated Power (IP) = 15 kW

Calorific value of fuel ($C_v$) = 40000 kJ/kg

Mass of fuel used ($m_f$) = 0.001 kg/s

$$\eta_{ith} = \frac{IP}{m_f \times C_v} = \frac{15}{0.001 \times 40000} = 0.375 = 37.5\%$$

85. A steam plant has the boiler efficiency of 90%, turbine efficiency (mechanical) of 94%, generator efficiency of 98 % and cycle efficiency of 40%. If 8 % of the generated power is used to run the auxiliaries, the overall plant efficiency is

A. 34% B. 31%

C. 45% D. 25%.

Ans. B

Sol.

$\eta_{overall} = \eta_{boiler} \times \eta_{turbine} \times \eta_{generator} \times \eta_{auxillary} \times \eta_{cycle}$

$\eta_{overall} = 0.90 \times 0.94 \times 0.98 \times 0.92 \times 0.40 = 30.5\ \% \approx 31\ \%$

86. Which of the following boiler accessories utilizes the waste heat of flue gases to heat the feed water?

A. Water preheater B. Economiser

C. Feed heater D. super heater

Ans. B

Sol. Economizer is the device used to pre heat the water before entering into the boiler. basically it is a heat exchanger.

Super heater is used to superheat the steam at constant pressure.

87. In thermal power plants, the deaerator is used mainly to______

A. remove air from condenser.

B. increase feed water temperature

C. reduce steam pressure

D. remove dissolved gases from feed water,

Ans. D

Sol.

- The purpose of a deaerator is to reduce dissolved gases, particularly oxygen, to a low level and improve a plant's thermal efficiency by raising the water temperature.
- In addition, deaerators provide feedwater storage and proper suction conditions for boiler feedwater pumps.

88. The compression ratio in a diesel engine is 25 and cutoff takes place at 20% of the stroke. What is the cutoff ratio?

A. 3 B. 2.8

C. 2.4 D. 5.8

Ans. D

Sol.

Compression ratio = $V_1/V_2$ = 25

Cutoff ratio = $V_3/V_2$

Given,

$V_3 - V_2 = 0.2 \times (V_1 - V_2)$

Dividing by $V_2$

$V_3/V_2 = 1 + 0.2 \times 24 = 1 + 4.8 = 5.8$

89. For the same compression ratio, the efficiency of an air standard otto cycle is:

A. More than the efficiency of an air standard diesel cycle

B. Less than the efficiency of an air standard diesel cycle

C. Equal to the efficiency of an air standard diesel cycle

D. None of these

Ans. A

Sol. The efficiency of a standard otto cycle is more than the efficiency of an air standard diesel cycle for the same compression ratio.

90. Given a four stroke diesel engine with compression ratio 16 and cut off ratio 2.5 . Find the percentage of stroke at which cut off occur. Take γ=1.4

A. 5% B. 10%

C. 15% D. 20%

Ans. B

Sol.

Given, compression ratio:

r=16 and cut off ratio (ρ) =2.5

Let, cut off takes place at %S of stroke.

$$\rho - 1 = \frac{\%S}{100}(r-1)$$

$$2.5 - 1 = \frac{\%S}{100} \times (16-1)$$

% S= 10%

91. The cycle efficiency of diesel cycle depends upon

A. only on temperature limits

B. only on pressure limits

C. Onnly on volume compression ratio

D. on cut-off ratio and volume compression ratio.

Ans. D

Sol. The cycle effiecency of diesel cycle depends on cut-off ratio and volume compression ratio.

So the correct option is (d).

92. A large diesel engine runs on a 4 stroke cycle at 2000 rpm. The engine has a displacement of 25 litre and a brake mean effective pressure of 0.6 MN/$m^2$. It consumes 0.018 Kg/s of fuel (calorific value = 42000 kJ/Kg).

Determine the brake power.

A. 250KW
B. 225KW
C. 275KW
D. None of the above

Ans. A

Sol. N=2000 rpm

$$V_s = 25\ litre\ = 0.025\ m^3$$

$$\dot{V}_s = V_s \times \frac{N}{60 \times 2}$$

$$\dot{V}_s = 0.025 \times \frac{2000}{60 \times 2} = 0.4167\ m^3/s$$

$$B.P. = b_{mep} \times \dot{V}_s = 0.6 \times 0.4167 = 250kW$$

93. An SI engine, working on ideal Otto cycle, has a compression ratio of 8. If the ratio of specific heats is 1.45, then the air standard efficiency of the engine is ___________.

A. 61%
B. 66%
C. 71%
D. 63%

Ans. A

Sol. Efficiency of Otto cycle:

$$\eta_{otto} = 1 - \frac{1}{r^{\gamma-1}} = 1 - \frac{1}{8^{1.45-1}} = 0.6077$$

94. The equipment installed in power plants to reduce air pollution due to smoke is

A. Induced draft fans
B. De-super heaters
C. Electrostatic precipitators
D. Re-heaters

Ans. C

Sol. Electrostatic Precipitators(ESPs) are used in coal based power plant to separate flyash from flue gases in order to reduce air pollution.

95. In a steam condenser the partial pressure of Steam and Air are 0.06 bar and 0.007 bar respectively, the condensed pressure is.

A. 0.067 bar
B. 0.06 bar
C. 0.053 bar
D. 0.007 bar

Ans. A

Sol. Given,

The partial pressure of steam = 0.06 bar

The partial pressure of air = 0.007

Condenser Pressure = $P_s + P_a$

= 0.06 + 0.007 = 0.067 bar

96. The most common advantage of liquid cooling system is_____.

A. Simplicity of engine design

B. Uniform cooling

C. Dependence on water supply

D. Improve power to weight ratio

Ans. B

Sol.

- The most common advantage of liquid cooling system is uniform cooling compare to air cooled system. As water is more denser than air.

97. In dynamic compressor, rise in pressure is achieved _____?

A. Completely in Rotor

B. Completely in diffuser

C. By decreasing volume

D. Partly in rotor and partly in diffuser

Ans. D

Sol. • In dynamic compressors the rise in pressure is achieved by the dynamic action of gas.

• In turbo compressors, the kinetic energy imparted to the gas by the rotation of rotor is changed into pressure energy, partly in rotor and rest in a diffuser.

98. The knocking tendency in compression ignition engines increases with_____.

A. Increase of coolant water temperature

B. Increase of temperature of inlet air

C. Decrease of compression ratio

D. Increase of compression ratio

Ans. C

Sol.

- Decreases of compression ratio reduces temperature and increases delay period, which increases knocking tendency in CI engine.

99. A 4-storke otto cycle having mean effective pressure of 1MPa and the displacement of the engine is 5 litre. If the engine is operated at 4000 rpm, then power output of the engine is

A. 333.33 KW

B. 166.66 KW

C. 150 KW

D. 200 KW

Ans. B

Sol.

Given 4 stroke cycle ⇒ No of working strokes per minute = N/2

$P_{mep}$ = 1 MPa $V_S$ = 5 litre = $5 \times 10^{-3}$ $m^3$

N = 4000 rpm

$$\text{Power} = P_{mep} \times V_S \times \frac{N}{2 \times 60} \text{ Watt}$$

$= 1 \times 10^6 \times 5 \times 10^{-3} \times \frac{4000}{2 \times 60}$

Power = 166.66 KW

100. A thermal electric power plant produces 5000 MW of power. If the coal releases 70 x $10^5$ kJ/sec of energy, then what is the rate at which heat is rejected from the power plant?

A. 4805.6 MW

B. 2024.5 MW

C. 2000 MW

D. 1905 MW

Ans. C

Sol.

Energy released by coal $= 70 \times 10^5$ kJ/sec $= 7000$ MW

Heat released from Powerplant $= 7000 - 5000 = 2000$ MW

****