Alpha College of engineering & Technology

Element of Mechanical Engineering (2110006)

Sr.	Questions
1	Define the following terms: Prime mover, Boundary, Latent Heat, temperature, First law of thermodynamics.
2	Explain Isothermal Process. For Isothermal process. Find expression of work done, Change in Internal Energy, Change in Enthalpy and Heat transfer. OR What is isothermal process? Derive an expression for the work done during the isothermal process.
3	0.3m^3 of air of mass 1 kg at an initial pressure of 5.5 bar expands adiabatically to a final volume of 0.5m3, $T_1 = 390$ K., Find the work done, the change in internal Energy and heat received or rejected during the process. Take Cv = 0.708 kJ/kg K and R = 0.287 kJ/kg K for air.$\gamma = 1.3$.
4	In air compressor air enters at 1.013 bar and 27 degree centigrade having volume 5.0 m3/kg and it is compressed to 12 bar isothermally. Determine (i) Work done (ii) Heat transfer and (iii) Change in internal energy.
5	Explain with neat sketch construction and working of a Cochran boiler.
6	A 4 cylinder 2-stroke engine develops 30 kW at 2500 rpm. The mean effective pressure of each cylinder is 800 kPa and mechanical efficiency = 80 %. Calculate Brake power and mass flow rate of fuel if L/D = 1.5, Brake thermal efficiency = 28% and calorific value of fuel = 44000 kJ/kg.
7	The following readings were taken during the test of single cylinder 4-stroke oil engine. Cylinder diameter = 270mm, Net load on brake = 1000 N Stroke length = 380mm, Effective diameter of brake = 1.5m Mean effective pressure = 6 bar, Fuel used = 10 kg/hr C.V. of fuel = 44400kJ/kg, Engine speed = 250 rpm Calculate: (i) Brake Power, (ii) Indicated Power (iii) Mechanical Efficiency, (iv)Indicated Thermal Efficiency
8	Define the following terms: (i) indicated thermal efficiency. (ii) Compression ratio. (iii) Scavenging.
9	Explain following terms associated with pumps i) priming in pumps ii) head iii) air chamber.
10	Compare centrifugal pump and reciprocating pump.
11	Define Pressure and explain Absolute Pressure, Gauge Pressure and Atmospheric pressure.

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Sr.	Questions
12	How prime movers are classified? Explain different sources of energy used by them.
13	(a) Differentiate between Fire tube and Water tube boiler. (b) Enlist different mountings. Explain any one with figure.
14	Differentiate petrol engine and diesel engine
15	Classify centrifugal pumps. With neat sketch explain the function of each part of centrifugal pump.
16	Define: (i) Sensible heat (ii) Latent heat (iii) Dryness fraction (iv) Enthalpy of evaporation (v) Degree of superheat.
17	With neat sketch explain construction and working of throttling calorimeter.
18	The efficiency of an Otto cycle depends upon its compression ratio. Prove it.
19	With neat sketch explain construction and working of window air-conditioner and split air-conditioner.
20	How are air compressors classified?

GUJARAT TECHNOLOGICAL UNIVERSITY

ELEMENTS OF MECHANICAL ENGINEERING (Modified on 4th Feb 2014)
SUBJECT CODE: 2110006
B.E. 1st YEAR

Type of course: Engineering Science

Prerequisite: Zeal to learn the subject

Rationale: Understanding of basic principles of Mechanical Engineering is required in various field of engineering.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
L	T	P	C	Theory Marks		Practical Marks		
				ESE (E)	PA (M)	ESE Viva (V)	PA (I)	
4	0	2	6	70	30*	30#	20**	150

L- Lectures; T- Tutorial/Teacher Guided Student Activity; P- Practical; C- Credit; ESE- End Semester Examination; PA- Progressive Assessment

Content:

Sr #	Topic	Teaching Hrs.	Module Weightage
1	**Introduction:**Prime movers and its types, Concept of Force, Pressure, Energy, Work, Power, System, Heat, Temperature, Specific heat capacity, Change of state, Path, Process, Cycle, Internal energy, Enthalpy, Statements of Zeroth Law and First law	4	
2	**Energy:** Introduction and applications of Energy sources like Fossil fuels, Nuclear fuels, Hydel, Solar, wind, and bio-fuels, Environmental issues like Global warming and Ozone depletion	3	25%
3	**Properties of gases:**Gas laws, Boyle's law, Charle's law, Combined gas law, Gas constant, Relation between Cp and Cv, Various non-flow processes like constant volume process, constant pressure process, Isothermal process, Adiabatic process, Poly-tropic process	5	
4	**Properties of Steam:**Steam formation, Types of Steam, Enthalpy, Specific volume, Internal energy and dryness fraction of steam, use of Steam tables, steam calorimeters	6	
5	**Heat Engines:**Heat Engine cycle and Heat Engine, working substances, Classification of heat engines, Description and thermal efficiency of Carnot; Rankine; Otto cycle and Diesel cycles	5	30%
6	**Steam Boilers:**Introduction, Classification, Cochran, Lancashire and Babcock and Wilcox boiler, Functioning of different mountings and accessories	-	
7	**Internal Combustion Engines:**Introduction, Classification,	4	20%

	Engine details, four-stroke/ two-stroke cycle Petrol/Diesel engines, Indicated power, Brake Power, Efficiencies		
8	**Pumps:** Types and operation of Reciprocating, Rotary and Centrifugal pumps, Priming	3	
9	**Air Compressors:**Types and operation of Reciprocating and Rotary air compressors, significance of Multistaging	3	
10	**Refrigeration & Air Conditioning:**Refrigerant, Vapor compression refrigeration system, vapor absorption refrigeration system, Domestic Refrigerator, Window and split air conditioners	4	25%
11	**Couplings, Clutches and Brakes:** Construction and applications of Couplings (Box; Flange; Pin type flexible; Universal and Oldham), Clutches (Disc and Centrifugal), and Brakes (Block; Shoe; Band and Disc)	3	
12	**Transmission of Motion and Power:** Shaft and axle, Belt drive, Chain drive, Friction drive, Gear drive	4	
13	**Engineering Materials:**Types and applications of Ferrous & Nonferrous metals, Timber, Abrasive material, silica, ceramics, glass, graphite, diamond, plastic and polymer	4	

Note: Topic No. 6 of the above syllabus to be covered in Practical Hours.

Reference Books:

1. Basic Mechanical Engineering by Pravin Kumar, Pearson
2. Thermal Science and Engineering by Dr. D.S. Kumar, S.K. Kataria & sons, Publication New Delhi
3. Fundamental of Mechanical Engineering by G.S. Sawhney, PHI Publication New Delhi
4. Elements of Mechanical Engineering by Sadhu Singh S. Chand Publication
5. Introduction to Engineering Materials by B.K. Agrawal Tata McgraHill Publication, New Delhi

Course Outcome:

After learning the course the students should be able to

1. To understand the fundamentals of mechanical systems
2. To understand and appreciate significance of mechanical engineering in different fields of engineering

List of Experiments:

1. To understand construction and working of various types of boilers.
2. To understand construction and working of different boiler mountings and accessories.
3. To determine brake thermal efficiency of an I. C. Engine.
4. To understand construction and working of different types of air compressors.
5. To demonstrate vapor compression refrigeration cycle of domestic refrigerator OR window air conditioner OR split air conditioner.

Open Ended Problems: Apart from above experiments a group of students has to undertake one open ended problem/design problem. Few examples of the same are given below.

1. Develop a prototype of gear train/drive for certain velocity ratios.
2. Develop a small boiler with different mountings.
3. Develop a hot air engine

Major Equipments: Models of Cochran, Lancashire and Babcock and Wilcox boilers, models of various mountings and accessories, Models of various types of IC engines, Single cylinder two stroke /four stroke petrol/ diesel engine, models of pumps, compressors, refrigerator/air conditioner, models of various types of brakes, coupling, clutches, drives

List of Open Source Software/learning website: http://nptel.iitm.ac.in, http://vlab.co.in/

***PA (M):** 10 marks for Active Learning Assignments, 20 marks for other methods of PA

ACTIVE LEARNING ASSIGNMENTS: Preparation of power-point slides, which include videos, animations, pictures, graphics for better understanding theory and practical work – The faculty will allocate chapters/ parts of chapters to groups of students so that the entire syllabus of Elements of Mechanical Engineering is covered. The power-point slides should be put up on the web-site of the College/ Institute, along with the names of the students of the group, the name of the faculty, Department and College on the first slide. The best three works should be sent to achievements@gtu.edu.in.

**** PA (I):** 10 marks for a case study of Systems, 10 marks for other methods of PA.

The case study of Systems: The case study should be of a working EE system, which shows the working of the concepts, included in the Syllabus.

ESE Pr (V):10 marks for Open Ended Problems, 20 marks for VIVA.

Note: Passing marks for PA (M) will be 12 out of 30.
Passing marks for ESE Pract(V) will be 15 out of 30.
Passing marks for PA (I) will be 10 out of 20

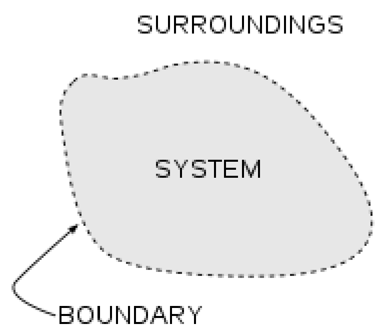
FAQ's

Que (1): Define the following terms: Prime mover, Boundary, Latent Heat, Temperature, First law of thermodynamics. **[**Nov/ Dec. 2010, June 2010, September 2009, December 08/January 09 **]**

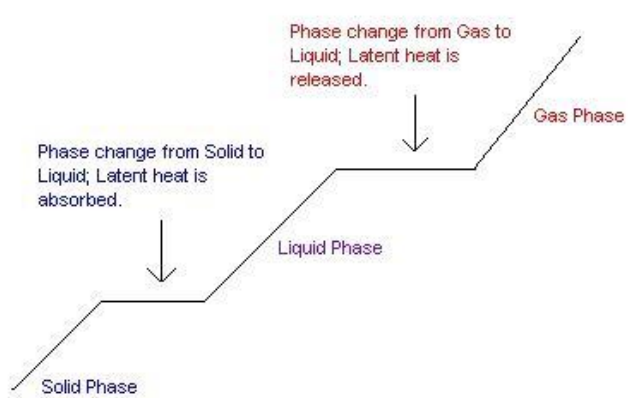
Sol.

Prime mover :- Device that imparts power or motion to another device such as a turbine that turns a generator, or an engine or motor that powers a drive train.

Boundary: -The real or imaginary surface that separates the system from its surroundings is called the boundary.



Latent Heat :- Latent heat is the energy released or absorbed by a body or a thermodynamic system during a constant-temperature process. A typical example is a change of state of matter, meaning a phase transition such as the melting of ice or the boiling of water.



First law of thermodynamics:- The first law of thermodynamics is a version of the law of conservation of energy, adapted for thermodynamic systems. The law of conservation of energy states that the total energy of an isolated system is constant; energy can be transformed from one form to another, but cannot be created or destroyed.

Que(2): Explain Isothermal Process. For Isothermal process. Find expression of work done, Change in Internal Energy, Change in Enthalpy and Heat transfer.

OR

What is isothermal process? Derive an expression for the work done during the isothermal process. (JAN-13, JUN-10)

Ans:
In isothermal process, the temperature remains constant during the process follows by Boyle's law. It also known as hyperbolic process and constant internal energy.

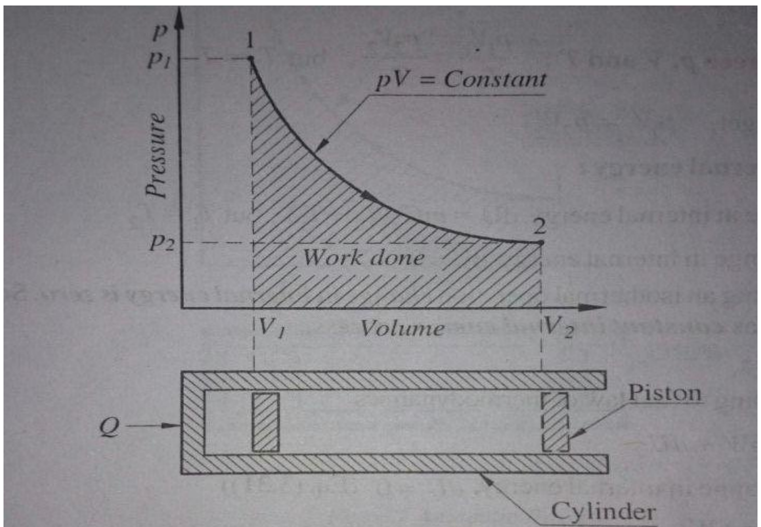


Fig. 3.6 Isothermal process.

Work done during process

$$W = \int_{V_1}^{V_2} p dV$$

For isothermal process $pV = C$, so $p = \frac{C}{V}$

$$W = \int_{V_1}^{V_2} \frac{C}{V} dV = C \log_e \frac{V_2}{V_1}$$

By substituting the value of C

$$W = P_1 V_1 \log_e \frac{V_2}{V_1}$$

$$W = P_1 V_1 \log_e r$$

$$\frac{V_2}{V_1} = r = \text{ratio of expansion}$$

$$P_1 V_1 = mRT_1$$
$$P_2 V_2 = mRT_2$$

So
Work done= $mRT_1 \log_e r = P_2 V_2 mRT_2$

Relation between P, V, T

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

But $T_1 = T_2$

$$P_1V_1 = P_2V_2$$

Change in Internal energy

$$dU = mC_v(T_2 - T_2)$$

But $T_1 = T_2$

$$dU = 0$$

Heat transfer

According to First law

$$\delta Q = \delta W + dU$$

But, $dU = 0$

$$\delta Q = P_1V_1 \log_e \frac{V_2}{V_1}$$

$$\delta Q = P_1V_1 \log_e \frac{P_1}{P_2}$$

$$\delta Q = mRT_1 \log_e \frac{P_1}{P_2}$$

Change in enthalpy

$$\Delta H = H_2 - H_2$$

But $T_1 = T_2$

So,

$$\Delta H = 0$$

Que (3): 0.3m^3 of air of mass 1 kg at an initial pressure of 5.5 bar expands adiabatically to a final volume of 0.5m3, $T_1 = 390$ K., Find the work done, the change in internal energy and heat received or rejected during the process. Take Cv = 0.708 kJ/kg K and R = 0.287 kJ/kg K for air.$\gamma = 1.3$.

[**MAY-12]**

Sol:

<u>Given data</u>

FOR ADIBATIC PROCESS

P_1 = 5.5 bar = 5.5 $\times 10^5$ N /M

V_1 = 0.3 m^3

P_2 =

V_2 = 0.5 m^3

$T_1 = 390$ K

m = 1 kg

$\gamma = 1.3$

C_v = 0.708 kJ/kg K

R = 0.287 kJ/Kg K

$$\frac{5.5 \times 10^5}{P_2} = \left(\frac{0.5}{0.3}\right)^{1.3}$$

$P_2 = 2.83 \times 10^5$ N/ m^2

$$W = \frac{(p_1V_1 - p_2V_2)}{1-\gamma}$$

$$W = \frac{(5.5 \times 10^5 \times 0.3 - 2.83 \times 10^5 \times 0.5)}{1 - 1.3}$$

$\mathbf{W = 78\ KJ}$

$$\frac{C_p}{0.708} = 1.3$$

$$C_p = 0.92 \frac{KJ}{Kg\ k}$$

$$\frac{T_1}{T_2} = \left(\frac{V_2}{V_1}\right)^{\gamma-1}$$

$$\frac{390}{T_2} = \left(\frac{0.5}{0.3}\right)^{1.3-1}$$

$T_2 = 201$ K

$\mathbf{\Delta H = mC_p(T_2 - T_1)}$

$\mathbf{\Delta H = 185.1\ KJ/Kg}$

Que.(4): In air compressor air enters at 1.013 bar and 27 degree centigrade having volume 5.0 m3/kg and it is compressed to 12 bar isothermally. Determine

(i) Work done

(ii) Heat transfer and

(iii) Change in internal energy.

Sol:

P_1 = 1.013 bar = 1.013×10^5 N/m ^{2}

$T_1 = T_2 = 300$ K

V_1 = 0.3 m^3

P_2 = 12 bar = 12×10^5 N/m ^{2}

Isothermal process

$P_1V_1 = P_2V_2$

$1.013 \times 10^5 \times 0.3 = 12 \times 10^5 \times V_2$

$V_2 = 0.02532$ m^3

$$W = P_1V_1 \log_e \frac{V_2}{V_1}$$

$$W = 1.013 \times 10^5 \times 0.3 \times \log_e \frac{0.02532}{0.3}$$

W = -76.390 kJ

$\Delta \mathbf{U} = \mathbf{0}$
Q = $\Delta \mathbf{U} + \mathbf{W}$
Q = 76.390 kJ

Que.(5):Explain with neat sketch construction and working of a Cochran boiler.
Ans:
It is one of the best types of vertical multi tubular boiler. It is fire tube boiler. It is a popular portable boiler. It occupies very small floor area.

The specifications of Cochran boiler are as follows.

Shell diameter........................: 2.75m

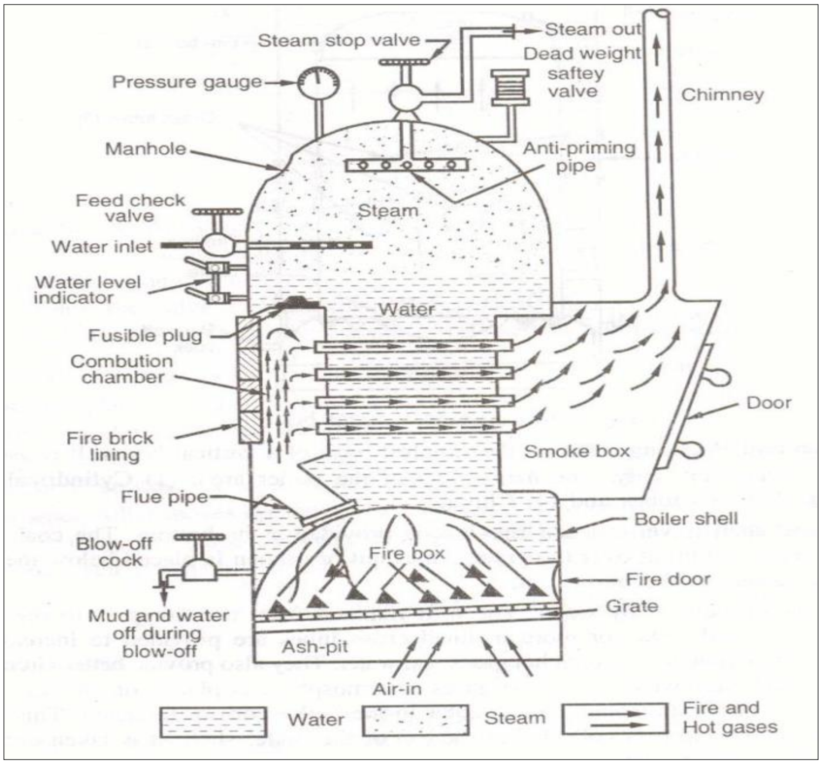
Height........................: 5.75m

Working pressure........................: 6.5 bar (Maximum 15 bar)

Steam capacity........................: 3500 kg/hr

Heating surface area........................: 120 m^2

Efficiency........................: 70% to 75%



Characteristics of Cochran boiler:

1. Vertical.
2. Portable.
3. Fire tube boiler.
4. Multi tube boiler.
5. Internally fired.
6. It has natural circulation.
7. Solid as well as liquid fuel can be burnt.

Various mountings of this boiler are Steam pressure gauge, Steam stop valve, Water level indicator, Man hole, Dead weight safety valve, Fusible plug, Feed check valve, Anti priming pipe, Blow off cock.

Working: The water is fed into the boiler through the feed check valve. The level is adjusted with the help of water level indicator. Coal is added through the fire hole to the grate and burnt. The hot gases produced are collected in the fire box. From fire box, the gases pass on to the combustion chamber through the short flue pipe with considerable velocity. The fire brick lining in the combustion chamber deflects the hot gases to pass through the horizontal tubes. From here, the hot gases through smoke box enter the chimney. The water evaporates and the steam is collected at the top. The steam is taken out for utilization through the steam stop valve.

Que.(6): A 4 cylinder 2-stroke engine develops 30 kW at 2500 rpm. The mean effective pressure of each cylinder is 800 kPa and mechanical efficiency = 80 %. Calculate Brake power and mass flow rate of fuel if L/D = 1.5, Brake thermal efficiency = 28% and calorific value of fuel = 44000 kJ/kg .

[JUNE 2011]

Solution:

Given data		**Determine**
4 cylinder,	$i = 4$	(i) **Brake Power, B.P. =?** (ii) **Mass Flow Rate of Fuel, m_f =?**
2 stroke,	$n = N$	
Engine Develops 30 kW,	I.P.= 30kW	
2500 rpm,	N = 2500 rpm	
Mean Effective Pressure of Each Cylinder,	P_m = 800 kPa	
Mechanical Efficiency,	$\eta_{mech} = 80\%$	
	L/D = 1.5	
Brake Thermal Efficiency,	η_{bth} = 28 %	
	C.V. = 44000 kJ/Kg	

(i) Brake Power, B.P.:

We know that, $\eta_{mech} = \frac{B.P.}{I.P.}$

$$\therefore B.P. = \eta_{mech} \times I.P. = 0.80 \times 30 = \mathbf{24kW}$$ ....**Ans.**

(ii) Mass Flow Rate of Fuel, m_f :

We have, $\eta_{bth} = \frac{B.P.\times 3600}{m_f \times C.V.}$

$$\therefore m_f = \frac{B.P.\times 3600}{\eta_{bth}\times C.V.} = \frac{24\times 3600}{0.28\times 44000} = \mathbf{7.012 Kg/hr}$$ ....**Ans.**

Answers:

(i) Brake Power, B.P. = 24kW
(ii) Mass Flow Rate of Fuel, m_f = 7.012Kg/hr

Que.(7):The following readings were taken duringthe test of single cylinder 4-stroke oil engine.

Cylinder diameter = 270mm | **Net load on brake = 1000 N**

Stroke length = 380mm | **Effective diameter of brake = 1.5m**

Mean effective pressure = 6 bar | **Fuel used = 10 kg/hr**

Engine speed = 250 rpm | **C.V. of fuel = 44400kJ/kg**

Calculate:

(i) Brake Power

(ii) Indicated Power

(iii) Mechanical Efficiency

(iv)Indicated Thermal Efficiency

Solution:

Given data		Determine
single cylinder,	i=1	(i) Brake Power, B.P. =?
4-stroke,	$n=\frac{N}{2}$	(ii) Indicated Power, I.P. =?
Cylinder diameter,	D=270mm=0.27 m	(iii) Mechanical Efficiency, $\eta_{mech}=?$
Net load on brake,	(W-S)=1000 N	(iv) Indicated Thermal Efficiency, $\eta_{ith}=?$
Stroke length,	L=380mm=0.38 m	
Effective diameter of brake,	D_b=1.5 m	
Mean effective pressure,	$P_m=6\text{ bar}=6\times10^5\text{ N/m}^2$	
Fuel used,	m_f=10kg/hr	
Engine speed,	N=250 rpm	
C.V. of fuel,	C.V.=44400 kJ/kg	

(i) Brake Power, B.P. :

We have, $B.P.=\frac{2\pi NT}{60},\frac{Nm}{s}$ or Watts

Here, $T=$ Braking Torque, N.m $=(W-S)\times R$, N.m

Where, (W-S)=Net (Brake) Load, N

W= Dead Weight, N

S= Spring Balance Reading, N

$R=\frac{1}{2}\times(D_b+d_r)=\frac{1}{2}\times(D_b)=\frac{1}{2}\times(1.5)=0.75m$

D_b= Brake Drum or Flywheel dia., m

d_r= Rope Dia., m If d_r is not given take, $d_r=0$.

$\therefore T=1000\times0.75=750$ N.m

$\therefore B.P.=\frac{2\times\pi\times250\times750}{60}$

$=19625\ N.\frac{m}{s}$ or Watts

$=\frac{19625}{1000}kW=\mathbf{19.625\ kW}$ .... **Ans.**

(ii) Indicated Power, I.P. :

We have, $I.P.=\frac{PmLAni}{60},\frac{Nm}{s}$ or Watts

Where, $A=\frac{\pi}{4}\times D^2, m^2$

$$=\frac{6\times10^5\times0.38\times\frac{\pi}{4}\times0.27^2\times\frac{350}{2}\times1}{60}$$

$=\mathbf{38074.92486\ watts=38.075\ kW}$ ....**Ans.**

(iii) Mechanical Efficiency, η_{mech}:

$\therefore\eta_{mech}=\frac{B.P.}{I.P.}=\frac{19.625}{38.075}=\mathbf{51.55\ \%}$ ....**Ans.**

(iv) Thermal Efficiency, η_{th}:

$\therefore\eta_{th}=\frac{B.P.\times3600}{m_f\times C.V.}=\frac{19.625\times3600}{10\times44400}=\mathbf{15.92\ \%}$..**Ans.**

Answers:

(i) Brake Power, B.P. = 19.625 kW
(ii) Indicated Power, I.P. = 38.075 kW
(iii) Mechanical Efficiency, $\eta_{mech}=$ 51.55 %
(iv) Indicated Thermal Efficiency, $\eta_{ith}=$ 15.92 %

Que (8): Define the following terms: (i) indicated thermal efficiency. (ii) Compression ratio.(iii) Scavenging.
Sol:

1. **Indicating thermal efficiency** $= \frac{\text{Indicated Power}}{\text{Heat supplied by fuel}}$

$$\eta_{ith} = \frac{I.P}{m_f \times C.V.} \quad \text{.......} (11)$$

Where, m_f = mass of fuel supplied, Kg/sec,
C.V. = calorific value of fuel J/Kg

2. **Compression Ratio (r):** It is the ratio of cylinder volume to clearance volume.

$$\left(r = \frac{V}{Vc} = \frac{(Vc + Vs)}{Vc} = 1 + \frac{Vs}{Vc} = 1 + \frac{1}{c}\right)$$

3. **Scavenging:** When exhaust port uncovers the pressurized air enters in to the cylinder from crank case through transfer port.

→ The fresh air which enters in to the cylinder pushes the burnt gases, so more amount of exhaust (burnt) gases are remove from the cylinder through exhaust port.
→ This sweeping out of exhaust (burnt) gases by incoming fresh charge is called SCAVENGING.
→ This will continue till the piston covers both the transfer and exhaust ports during next upward (BDC to TDC) stroke.

Que.(9).Explain following terms associated with pumps i) priming in pumps ii) head iii) air chamber [DEC 2010]
Answer:-
i) Priming in pumps
Priming is the process of filling the suction pipe, casing of the pump and the delivery pipe upto the delivery valve with the liquid to be pumped. If priming is not done the pump cannot deliver the liquid due to the fact that the head generated by the Impeller will be in terms of meters of air which will be very small (because specific weight of air is very much smaller than that of water). Priming of a centrifugal pump can be done by any one of the following methods:
i) Priming with suction/vacuum pump.
ii) Priming with a jet pump.
iii) Priming with separator.

ii) Head
Head - Defined
 Head is a measure of fluid energy. It is used to describe the Specific Energy of a pump.
 Specific Energy is defined as energy per unit of mass. For example, if we lift up a one-pound object by three feet, we say we have three foot-pounds of energy. It doesn’t matter whether it's a pound of lead or a pound of feathers; we still have 3 foot-pounds.
 This is why head doesn’t change with the type of liquid being pumped. Whether pumping water, alcohol, or oil, a pump’s head rating is unaffected.
 Sometimes Head is described as the resistance that a pump must overcome. While this may describe what’s going on while pumping, it is not technically correct.
Head vs Pressure
 Pressure is not Head. Pressure is a force applied to an Area. For example, PSI refers to Pounds per Square Inch. The “Square Inch” part is the big difference between Head and

Pressure. With Head, there is no Area in the calculation.

Types of Head

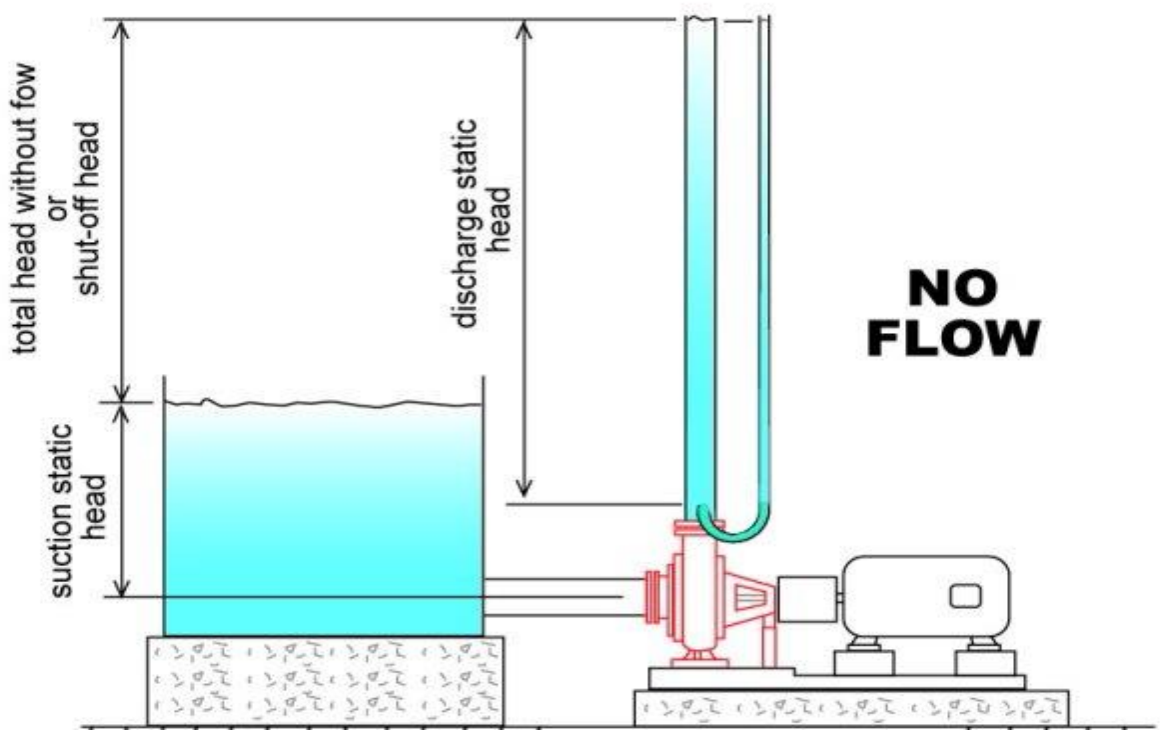
There are four types of head; Static Head, Friction Head, Pressure Head, and Velocity Head.

Static Head – Applies only to open systems, such as a waterfall in a manmade pond. It is the difference, in feet, between two water levels. So if the pump is at the bottom of our pond with a waterfall, then the Static Head is measured from the top of the pond water to the top of the waterfall (yes, the TOP of the pond water, not the bottom where the pump is sitting.) A pump's head rating is usually the maximum Static Head the pump can overcome.

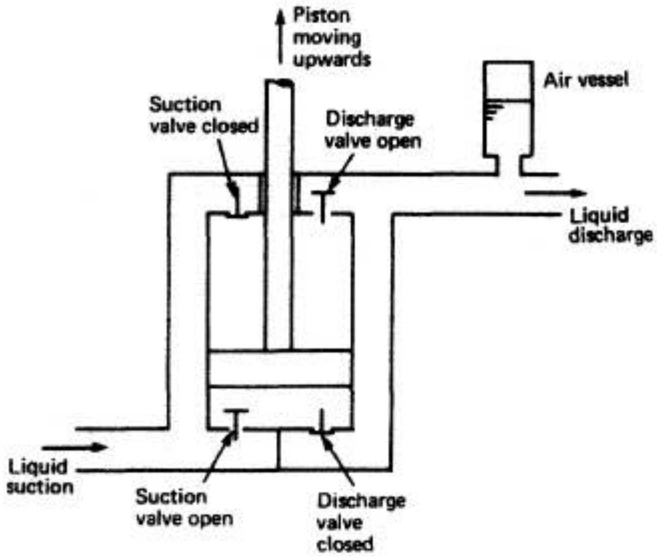
Friction Head – Also called Pressure Drop. It is the resistance to flow. When a pump pumps liquid through a component, that component creates a resistance to the flow of liquid. Typical components are tubing, radiators, fittings, and water blocks. This resistance to flow is usually expressed in feet of head.

Pressure Head – Refers to the different pressure levels between two vessels. For example, if a pump must pump rainwater (collected in an open tank) to a second tank that is closed and slightly pressurized, then in addition to Static and Friction Head, the pump must also overcome the pressure being exerted on the water in the tank. Exist in open systems only.

Velocity Head – Refers to the energy required to accelerate the fluid. Exist in open systems only.



iii) Air chamber



One major disadvantage of reciprocating pumps is the fluctuating flow. It can be reduced by fitting air cylinders (air vessels) to either the suction pipe or the delivery pipe or both. Air cylinders are closed vessels which act similarly to surge tanks. The decelerating liquid moves into the cylinder (vessel) compressing the enclosed air and thus storing energy in it. When the fluid is accelerated the energy in the air is released, thus augmenting (increasing) the accelerating force. By this process the fluctuations in the flow are smoothed out to an extent dependent upon the size of the air vessels. Figure shows an actual indicator diagram of a pump fitted with air cylinders. It shows that the effects of inertia have been largely eliminated.

Que.(10): Compare centrifugal pump and reciprocating pump. [2010, SEPT 2009]

Answer:-

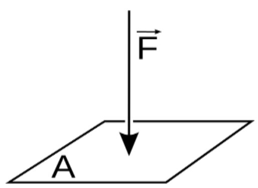
Sr. No.	Centrifugal pump	Reciprocating pump
1.	Smooth and even flow.	Pulsating flow.
2.	Low initial cost.	Initial cost as high as four times that of centrifugal pump.
3.	Compact, occupies less floor space. Vertical type requires even lesser space.	Occupies 6 to 8 times the space required for horizontal centrifugal pump.
4.	Gross weight is less.	Gross weight is considerable.
5.	Installation is easy	Installation is more difficult than centrifugal pump.
6.	Efficiency of low head pumps is high.	Efficiency of low head pumps may be as low as 40% chiefly because of relatively higher energy losses viz. frictional, valve losses etc.
7.	Construction is simplified by elimination of many parts such as non return valves, glands, air vessel etc. therefore less number of spares parts are required.	Complicated construction. Therefore number of spares parts is necessary.
8.	Low maintenance cost. Periodical check up is sufficient.	Maintenance charges are high because parts like valves require constant attention.
9.	High speed. Can be coupled directly through flanged coupling to electric motors or steam turbines.	Low speed due to separation difficulties. Belt drive indispensable.
10.	Uniform torque.	Torque not uniform.
11.	Easy handling of highly viscous fluids such as oils, muddy and sewage water, paper pulp, sugar molasses, chemicals etc.	Valves and glands cause trouble when required to transmit viscous fluids.

FAQ'SQUESTION

Que (1): Define Pressure and explain Absolute Pressure, Gauge Pressure and Atmospheric pressure. (SUMMER 2013)

Sol:-

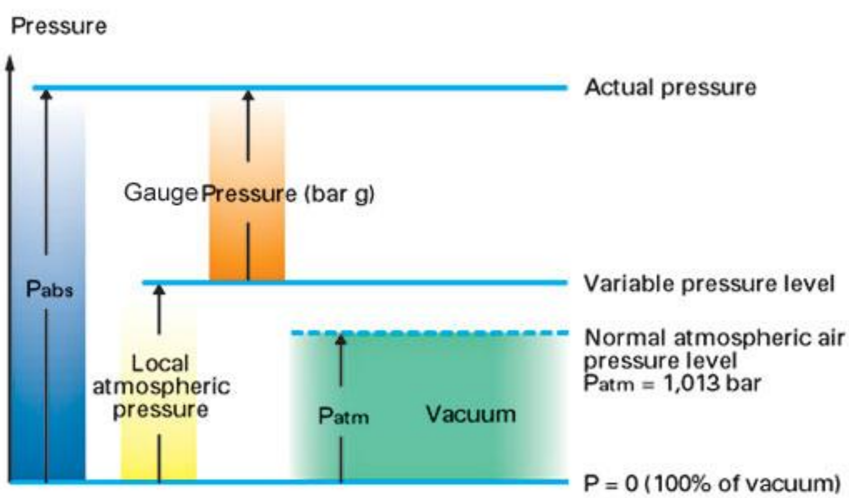
Pressure is defined as force per unit area. In other words, any object or material having a weight will exert a pressure over the area the force is acting on.



$$p = \frac{F}{A} \text{ or } p = \frac{dF_n}{dA}$$

The SI unit for pressure is the Pascal (Pa), equal to one Newton per square metre (N/m^2). This special name for the unit was added in 1971 before that, pressure in SI was expressed simply in Newton per square metre.

Other units of pressure, such as pounds per square inch (psi) and bar, are also in common use. P_{atm} =1.013 bar.



Gauge Pressure: **-** The amount by which the pressure measured in a fluid exceeds that of the atmospheric pressure is called Gauge pressure.

Absolute Pressure: **- Absolute ressure** is zero-referenced against a perfect vacuum, so it is equal to gauge **pressure** plus atmospheric **pressure**. Gauge **pressure** is zero-referenced against ambient air **pressure**, so it is equal to **absolute pressure** minus **atmospheric pressure.**

Atmospheric pressure:- Atmospheric pressure is the pressure exerted by atmosphere on us.

P_{atm} =1.013 bar

Que (2): How prime movers are classified? Explain different sources of energy used by them.

Sol.

Prime movers are often called "driving equipment" because they are the primary source of mechanical energy or power. The mechanical energy produced by the prime mover is transmitted to another machine or mechanism, such as a pump or air compressor, to do some form of useful work. The mechanism, or linkage, that transmits the mechanical power developed by the prime mover is called the drive.

Electric motors and internal combustion engines are commonly used as prime movers.

The prime movers are classified based on the sources of energy utilized by them. The classification is shown below:

1) Thermal prime movers: These are the prime movers which use the thermal energy of source to generate power. Various thermal prime movers are given below:

- Fuels (heat engines):These prime movers use various fuels like petrol, diesel, oil, gas to generate mechanical power.

- Heat engines are two types:

-*External combustion engines:*

1)Reciprocating steam engines
2)Steam turbine
3)Closed cycle gas turbine

-*Internal combustion engines:*
1)Reciprocating I.C. engines
2)Open cycle gas turbine

- Nuclear (nuclear power plant): This prime mover uses the heat energy of atoms by fission or fusion process to develop the mechanical power. It is mainly used in nuclear power plants. Various radioactive elements like uranium, thorium are used for these fission or fusion process in a nuclear reactor.

- Geothermal: In this type of prime mover the heat energy is obtained from a certain depth or the hot part of the earth below earth surface then it is converted into mechanical by proper engine.

- Bio gas: Bio gas is mainly produced from garbage or any other waste which is used to produce power by prime mover in a biogas plant.

- Solar energy: The solar energy comes to the earth in the form of radiation or electromagnetic waves. This energy trapped in with the help of solar panel made up of semiconductor material. This heat energy is then converted into power.

2) Non-thermal prime movers: These kinds of prime movers do not use the heat energy to convert it into the mechanical power. The following are the non thermal prime movers:

- Hydraulic turbines: This type of the prime mover uses the stored potential energy of water to generate power.

- Wind power: With the help of wind turbine the wind energy is converted into the power.

- Tidal power: The energy of tides from ocean is converted into the power by the use of turbine which is known as tidal power.

Que (3): (a) Differentiate between Fire tube and Water tube boiler.

(b) Enlist different mountings. Explain any one with figure. (Sep 09)

Ans : (a) Difference between fire tube & water tube boilers.

S.No.	Water tube boiler	Fire tube boiler
1	The water circulates inside the tubes which are surrounded by hot gases.	The hot gases pass through the tubes surrounded by water
2	It generates steam at high pressure upto 165 bar.	It generates steam only upto 25 bar.
3	The rate of steam generation is high i.e. upto 450 tons per hour.	The rate of steam generation is low i.e. upto 10tons per hour.
4	The operating cost is high.	The operating cost is low.
5	It is used for large power plants.	It is not suitable for large plants.
6	The direction of water circulation is well defined.	The water does not circulate in a definite direction.

(b) The fittings which are mounted on boiler for its safe and proper functioning are known as mountings. Some of the important mountings are listed below:

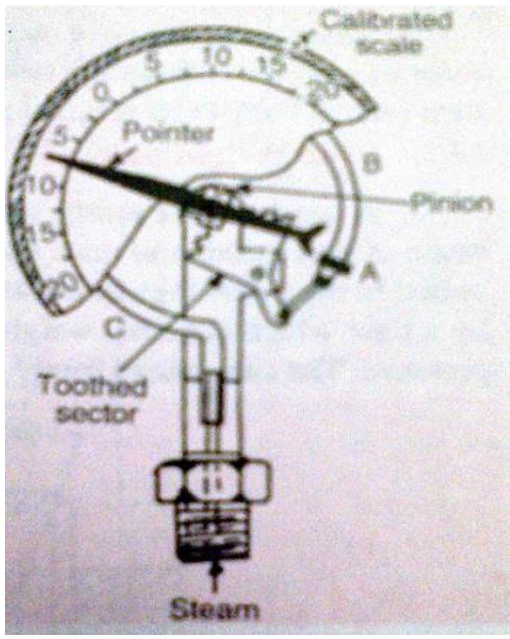
i. Water level indicator
ii. Pressure gauge
iii. Safety valves
iv. Steam stop valve

v. Blow off cock

vi. Feed check valve

vii. Fusible plug

Pressure gauge: A pressure gauge is used to measure the pressure of the steam inside the boiler. It is fixed in front of the steam boiler. The pressure gauges generally used are of Bourdon tube type.



A bourdon tube pressure gauge, in its simplest form consist of an elliptical elastic tube ABC, bent into an arc of a circle and is known as Bourdon's tube. One end of the tube is fixed and connected to the steam space in the boiler. The other end is connected to a sector through a link. As the steam at high pressure flows inside the bourdon's tube, it tends to straighten itself. With the help of a simple pinion and sector arrangement, the elastic deformation of the Bourdon's tube rotates the pointer. This pointer moves over a calibrated scale, which directly gives the pressure.

Que (4): Differentiate petrol engine and diesel engine. **(JUNE 2011,SEPT 2009,JAN 2009)**

Ans:

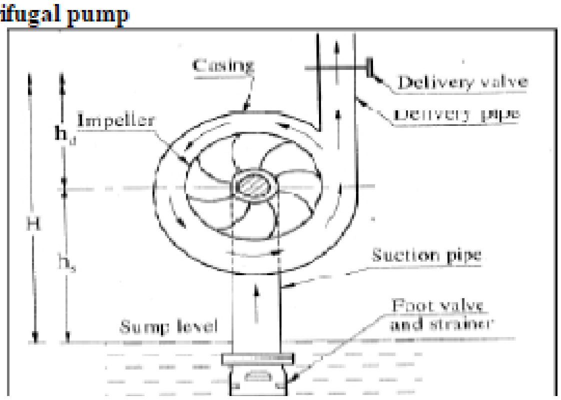
Sr. no.	Topics	PETROL or OTTO (S.I.) ENGINE	DIESEL (C.I.) ENGINE
1	**Basic (Thermodynamic) cycle**	Based on **Otto cycle**	Based on **Diesel cycle**
2	**Fuel used**	**Petrol** (Gasoline) (having higher self ignition temperature)	**Diesel** (having lower self ignition temperature)
3	**Suction Stroke(Induction)**	**Charge** (petrol + air mixture) enter	**Only air** enter
4	**Ignition device/method**	**Spark plug** (Spark Ignition)	**Injector** (Compression Ignition)
5	**Combustion process**	Constant Volume	Constant Pressure
6	**Compression ratio**	**Lower** - ranging from 6 to 10	**Higher** - ranging from 14 to 20
7	**Space occupied**	**Less**	**More**
8	**Weight of engine**	**Less** due to lower peak pressure	**More** due to higher peak pressure
9	**Starting of engine**	**Easy** Due to low C.R & low crank effort	**High** Due to high C.R & high crank effort
10	**Speed**	**High** (1000-6000 rpm)	**Low** (500-1500 rpm)
11	**Initial cost**	**Low**	**High**
12	**Running cost**	**High** due to costly fuel	**Low** due to cheap fuel
13	**Maintenance cost**	**Less**	Slightly **High**
14	**Thermal efficiency**	**Low** due to lower C.R. (Around 25%)	**High** due to higher C.R. (Around 40%)

Que (5): Classify centrifugal pumps. With neat sketch explain the function of each part of centrifugal pump. [6 marks] [JUNE-2011-2013]

Answer: - Centrifugal pumps may be classified into the following types

1. According to casing design
a) Volute pump b) diffuser or turbine pump
2. According to number of impellers
a) Single stage pump b) multistage or multi impeller pump
3. According to number of entrances to the impeller:
a) Single suction pump
b) Double suction pump
4. According to disposition of shaft
a) Vertical shaft pump
b) Horizontal shaft pump
5. According to liquid handled
a) Semi open impeller
b) Open impeller pump
6. According to specific speed
a) Low specific speed or radial flow impeller pump
b) Shrouded impeller
c) Medium specific speed or mixed flow impeller pump
c) High specific speed or axial flow type or propeller pump.
7. According to head (H)
• Low head if H<15m
• Medium head if 15<H<40m
• High head if H>40m

Components of a centrifugal pump



The main components of a centrifugal pump are:
i) Impeller ii) Casing iii) Suction pipe iv) Foot valve with strainer, v) Delivery pipe vi) Delivery valve.

Impeller: - is the rotating component of the pump. It is made up of a series of curved vanes. The impeller is mounted on the shaft connecting an electric motor.

Casing: - is an air tight chamber surrounding the impeller. The shape of the casing is designed in such a way that the kinetic energy of the impeller is gradually changed to potential energy. This is achieved by gradually increasing the area of cross section in the direction of flow.

Suction pipe: - It is the pipe connecting the pump to the sump, from where the liquid has to be lifted up.

Foot valve with strainer:- the foot valve is a non-return valve which permits the flow of the liquid from the sump towards the pump. In other words the foot valve opens only in the upward direction. The strainer is a mesh surrounding the valve; it prevents the entry of debris and silt into the pump.

Delivery pipe: - is a pipe connected to the pump to the overhead tank.

Delivery valve: - is a valve which can regulate the flow of liquid from the pump.

FAQ's

Que.(1): Define : (i) Sensible heat (ii) Latent heat (iii)Dryness fraction (iv)Enthalpy of evaporation (v) Degree of superheat (JULY-11,DEC-11,JUNE-13) (5 marks)

Ans:

Sensible heat :- It is a heat exchanged by a body or thermodynamic system that changes the temperature, and some macroscopic variables of the body, but leaves unchanged certain other macroscopic variables, such as volume or pressure.

Latent heat :- It is the energy released or absorbed by a body or a thermodynamic system during a constant-temperature process

Dryness Fraction:- It is defined as the ratio of mass of dry steam actually present to the mass of wet steam which contains it is defined (denoted) by letter x

$$x = \frac{ms}{ms + mw}$$

where , m_s = mass of dry steam

m_w = mass of wet steam

Enthalpy of evaporation:- It is define as heat required to convert water from its boiling point to dry saturated steam at constant temperature t_f or $t_{sat.}$

It is denoted by h_{fg}

Degree of superheat:- Corresponding to the given pressure the difference between the temperature of superheated steam and dry saturated steam is known as degree of superheat .

Degree of superheat = ($t_{sup} - t_{sat}$) K

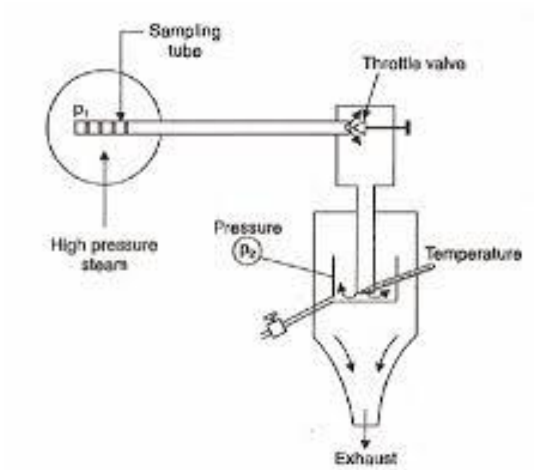
Que.(2):With neat sketch explain construction and working of throttling calorimeter (APR- 10,DEC-10,JAN-10)

Ans:

Construction:-

As shown in figure the steam is taken from the steam pipe M by the sampling tube T. The sampling tube is perforated by many small holes. The end of tube is sealed.The steam is then passed through the throttle valve . The pressure of the steam is measured with the help of pressure gauge G. before throttling . In the throttle valve V, steam throttles down to a lower pressure P_2. This throttling is done in such a way that the steam is superheated after throttling . The thermometer 'm' measures the temperature of the steam after throttling , while the manometer U measures the pressure of the steam. The steam is exhausted from outer chamber as shown in figure

Figure:-



Throttling Calorimeter

Working:-

- The stop valve from the boiler be fully open before starting the operation.
- Allow the steam to pass through the apparatus for a while till the pressure and temperature are steady .
- The steam is then throttled in the the throttle valve. After throttling pressure of steam is 1 bar or less than $t_{sat} < 100$ C.
- Note down the pressure and temperature after throttle. The pressure after throttle will be near to atmospheric pressure .
- The temperature of steam , must be more than 100 C after throttle , hence the steam is in superheated state.
- The pressure after throttling is read from the manometer . It is not very much different from atmospheric pressure.

Que(3): The efficiency of an Otto cycle depends upon its compression ratio. prove it.
[MAY-12, DEC-11,JUNE-12,SEPT-09]

ANS

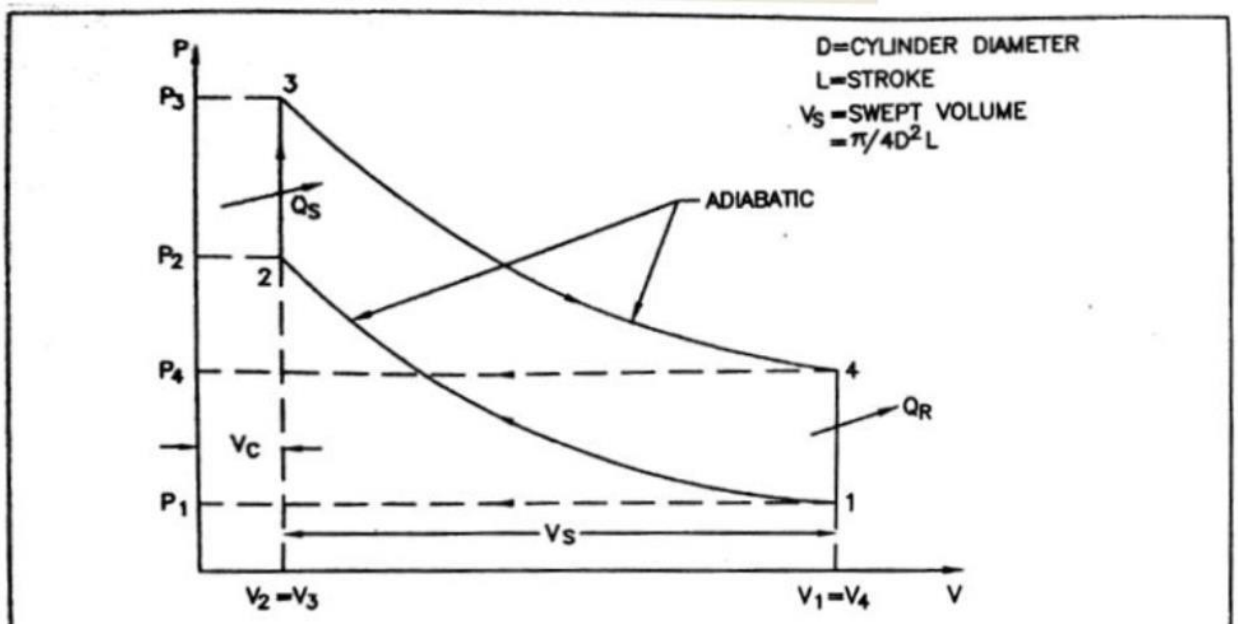


Fig. : P-V Diagram for An Ideal Otto Cycle

In fig. P–V diagram for Otto cycle is shown. While analysing it is assumed that P_1, V_1 and T_1 are known and also the ratio $\frac{V_1}{V_2}$.

Let, $\frac{V_1}{V_2} = \frac{V_4}{V_3}$ = Compression ratio = r

(1) For adiabatic compression process 1–2, we have,

$$\frac{T_1}{T_2} = \left(\frac{V_2}{V_1}\right)^{(\gamma-1)} \qquad \therefore \quad T_2 = T_1 r^{\gamma-1} \qquad \ldots (1)$$

Where, $r_c = \frac{V_1}{V_2}$ = Volume ratio of compression

$r_e = \frac{V_4}{V_3}$ = Volume ratio of expansion

But, $r_c = r_e = r$ for Otto cycle

Also $P_1 V_1^{\gamma} = P_2 V_2^{\gamma}$

$\therefore \quad P_2 = P_1 r^{\gamma}$

(2) For constant volume heat addition in process 2–3 we have,

$\therefore \quad V_3 = V_2$

$\therefore \quad \dfrac{P_3}{T_3} = \dfrac{P_2}{T_2} \qquad \therefore \quad T_3 = T_2 \cdot \dfrac{P_3}{P_2} = \dfrac{P_3}{P_2} \cdot T_1 r^{\gamma-1}$ (By using eq. (1)

(3) For adiabatic expansion process 3–4 we have,

$$\frac{T_3}{T_4} = \left(\frac{V_4}{V_3}\right) = r^{\gamma-1} \quad .... (2)$$

$$\therefore \quad T_4 = \frac{T_3}{r^{\gamma-1}} = \frac{P_3}{P_2} \cdot T_1 \frac{r^{\gamma-1}}{r^{\gamma-1}} = \frac{P_3}{P_2} \cdot T_1$$

Also, $P_4 V_4^{\gamma} = P_3 V_3^{\gamma} \qquad \therefore \quad P_4 = \dfrac{P_3}{r^{\gamma}}$

(4) For constant volume heat rejection process 4–1, we have

Also, $\dfrac{P_4}{T_4} = \dfrac{P_1}{T_1} \qquad \therefore \quad T_4 = \dfrac{P_4}{P_1} \cdot T_1 = \dfrac{P_3}{P_2} \cdot T_1$

From this we can seet that $\dfrac{P_4}{P_1} = \dfrac{P_3}{P_2}$

Heat rejected in 4–1 = $m.C_v (T_4 - T_1)$

Heat received in 2–3 = $m.C_v (T_3 - T_2)$

Work Done (W.D.) = Heat received – Heat rejected

$$\therefore \quad \eta_{airstd} = \frac{W.D.}{\text{Heat Supplied}} = \frac{m \cdot C_v (T_3 - T_2) - m \cdot C_v (T_4 - T_1)}{m \cdot C_v (T_3 - T_2)}$$

$$= 1 - \frac{T_4 - T_1}{T_3 - T_2} = 1 - \frac{T_1}{T_2}\left[\frac{\frac{T_4}{T_1} - 1}{\frac{T_3}{T_2} - 1}\right]$$

$$= 1 - \frac{\frac{P_3}{P_2} \cdot T_1 - T_1}{\frac{P_3}{P_2} \cdot T_1 r^{\gamma-1} - T_1 r^{\gamma-1}} = 1 - \frac{T_1\left(\frac{P_3}{P_2 - 1}\right)}{T_1 r^{\gamma-1}\left(\frac{P_3}{P_2 - 1}\right)}$$

$$\boxed{\eta_{airstd} = 1 - \frac{1}{r^{\gamma-1}}}$$

From the equation we can see that the efficiency of otto cycle is a function of compression ratio, *r* only.

Que.(4):With neat sketch explain construction and working of window air-conditioner and split air-conditioner. [JUNE-13, JUNE-12,DEC-10,DEC-08]

Sol:-

As this unit is mounted in a window it is known as window air conditioner.

The basic function is to provide comfort cooling by reducing temperature of air. Supply air temperature to the room is controlled by selecting desired setting with a knob placed in front of air conditioner.

The function of various parts is as under.

(1) Compressor: It compresses the vapour refrigerant from evaporator and increases its temperature and pressure.

(2) Condenser: It is used to condense the hot refrigerant gas and convert it into liquid form and thus works as a heat transfer surface.

(3) Capillary tube: It is an expansion device with very small diameter and long length. It is used to drop the pressure of refrigerant.

(4) Evaporator: It absorbs heat from the air to be cooled and gives it to refrigerant. Thus, it produces cooling effect.

(5) Condenser fan: The cold air is circulated with this fan.

(6) Evaporator fan: It controls the velocity of air entering the room. It has very low noise level.

(7) Tray : It collects the water coming out from air being cooled and dehumidified and thus controls humidity. It is placed below the evaporator

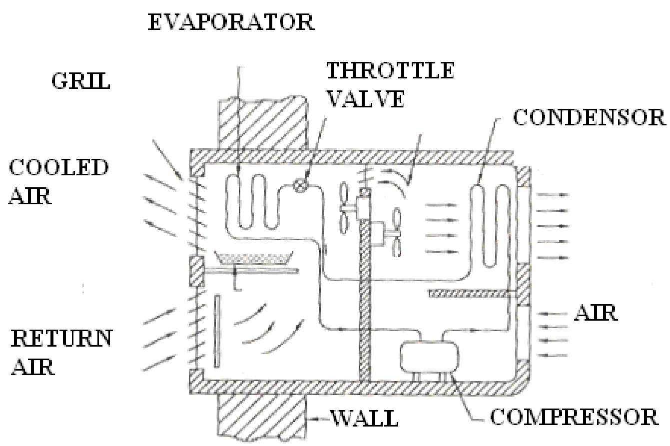


FIGURE 2. [WINDOW AIR CONDITIONER]

Que.(5):How are air compressors classified? (June-July 2011, Nov/ Dec. 2010)

Ans.

Classification of Air Compressor:

The air Compressors can be classified in number of ways.

(a) According to the method of carrying out compression:-
1. Reciprocating.
2. Rotary.
3. Cetrifugal

(b) According to the principle of operation:-
1. Positive displacement.
2. Non Positive displacement compressor or Dynamic compressor or steady flow compressor.

(c) According to the number of stages employed:
1. Single stage-delivery pressure up to 5 bar.
2. Two stage-delivery pressure 5 to 35 bar.
3. Three stage- delivery pressure 35 to 85 bar.
4. Four stage- delivery pressure-above 85 bar.

(d) According to the delivery pressure developed:-
1. Low pressure-delivery pressure up to 1 bar.
2. Medium pressure-delivery pressure 1to8 bar.
3. High pressure- delivery pressure 8to 10 bar.

(e) According to the action of piston for carrying out compression of air:-
1. Single acting
2. Double acting

(f) According to the number of cylinders used:
1. Single cylinder
2. Double cylinder
3. Multi cylinder

(g) According to the pressure rise limit:
1. Fans-Pressure ratio 1 to 1.1
2. Blower-Pressure ratio 1.1 to 2.5
3. Compressors- Pressure ratio above 2.5

(h) According to the method of cooling used:
1. Air cooled
2. Water cooled

(i) According to the nature of installation:-
(a) Stationary or fixed
(b) Semi-stationary
(c) Portable