**MOHAMED SATHAK A J COLLEGE OF ENGINEERING**
**DEPARTMENT OF MECHANICAL ENGINEERING**

Academic Year: 2022-2023 (ODD Semester)
Year / Sem: III / V
Subject code & Name: **ME8595 & THERMAL ENGINEERING - II**

**EPC Questions**

## UNIT I STEAM NOZZLES

**1. What are the effects of friction on the flow through a steam nozzle?**

- The final fraction of the steam is increased as the part of the kinetic energy gets converted into heat due to friction and absorbed by steam with n increase in enthalpy.
- The expansion is no more isentropic and enthalpy drop is reduced thereby resulting in lower exit velocity.
- The specific volume of steam is increased as the steam becomes drier due to this frictional reheating.

**2. Define nozzle efficiency and critical pressure ratio.**

**Nozzle efficiency:** It is defined as the ratio of actual enthalpy drop to the isentropic enthalpy drop.

**Nozzle efficiency** = Actual enthalpy drop / Isentropic enthalpy drop

**Critical pressure ratio**: There is only one value of the ratio (P2/P1) which produces maximum discharge from the nozzle. The ratio is called critical pressure ratio.

Critical pressure ratio P2 /P1 = (2/n+1) n/n+1

Where, P 1= Initial pressure, P 2= Throat pressure.

3. **Explain the phenomenon of super saturated expansion in steam nozzle. (Or) What is Meta stable flow**?

When the supersaturated steam is expanded in the nozzle, the condensation should occur in the nozzle. Since the steam has a great velocity, the condensation does not take place at the expected rate. So the equilibrium between the liquid and vapour phase is delayed and the steam continues to expand in a dry state.flow. The steam in such set of condition is said to be supersaturated or meta stable

**4. What are the conditions that produce super saturation of steam in nozzles?**

When the superheated steam expands in the nozzle, the condensation will occur in the nozzle. Since, the steam has more velocity, the condensation will not take place at the expected rate. So, the equilibrium between the liquid and vapour phase is delayed and the steam continues to expand in a dry state. The steam in such set of condition is said to be supersaturated or meta stable flow.

**5. What are the effects of super saturation in a steam nozzle?**

The following effects in a nozzle on steam, in which super saturation occurs, may be summarized as follows.

1. The dryness fraction of the steam is increased.
2. Entropy and specific volume of the steam are increased.
3. Exit velocity of the steam is reduced.
4. Mass of stream discharged is increased.

**6. What are the differences between supersaturated flow and isentropic flow through steam nozzles?**

| Supersaturated flow | Isentropic flow |
|---|---|
| **1.** Entropy is not constant | Entropy is constant |
| **2.** Reduce in enthalpy drop | No reduce in enthalpy drop |
| **3.** We cannot use mollier diagram to solve problems | We can use mollier diagram to solve problems. |

**7. What are the various types of nozzles and their functions?**

**Convergent nozzle:** In this type of nozzles, the area diminishes from inlet to outlet throat.

**Divergent nozzle:** In this type of nozzles, the area increases from inlet to outlet.

**Convergent Divergent nozzles:** In this type of nozzles, there is a divergent portion in addition to convergent portion. The divergent part is added to allow higher expansion ratio.

**8. What are the reasons for the drop in velocity of the steam for a given pressure drop in steam nozzle?**

- Friction between the surface of the nozzle and steam
- Due to internal fluid friction in the steam
- Due to shock losses

**9. What are the limits for super saturation in steam nozzles? Why?**

The super saturation occurs upto above 0.94 dryness fraction and beyond that the condensation of steam occurs suddenly and irreversibly at constant enthalpy and then remain in stable condition.

**10. What are the main functions of steam nozzles?**

- To supply high velocity jet of steam in steam turbine
- To inject feed water in to the boiler in a steam injector.

**11. Define indicated pressure ration in steam nozzles**

There is only one value of the ratio (P2/P1), which produces maximum discharge from the nozzle. That ratio is called Critical Pressure Ratio.

**12. What are the factors those change the fluid properties while a fluid flows through a nozzle with no work or heat transfer?**

Change in flow area, Frictional forces

## UNIT II – BOILERS

**1. How Boiler Works?**

Understanding the working of the boiler is very simple. The boiler is a closed vessel in which the water is stored. Hot gases are produced by burning fuel in the furnace. These hot gases are made to come in contact with the water vessel where the heat transfer takes place between the water and the steam. Therefore, the basic principle of the boiler is to convert water into steam by using heat energy. There are different types of boilers used for different purposes.

**2. Define Efficiency of Boiler**

The efficiency of the boiler is defined as the percentage of total heat exported by the outlet steam to the total supplied fuel.

Boiler efficiency (%)=(heat exported by outlet steam/heat supplied by the fuel)*100

**3. What are the applications of Boiler**

The boiler has a diverse applications in the following industries:

- Food processing industries
- Chemical industries
- Refineries and distilleries
- Thermal power plants

**4. Classify the Boiler**

The classification of the boiler is based on the following criteria:

**According to the relative passage of water and hot gases:**

- Water-tube boiler
- Fire-tube boiler

**According to water circulation arrangement:**

- Natural circulation
- Forced circulation

**According to the use:**

- Stationary boiler
- Portable boiler
- Locomotive
- Marine boiler

**According to the position of boilers:**

- Horizontal
- Inclined

**According to the pressure generated by steam:**

- Low-pressure boiler

- Medium pressure boiler
- High-pressure boiler
- Sub-critical boiler
- Supercritical boiler

**According to charge in the furnace:**

- Supercharged fuel
- Pulverized fuel

**5. What is the use of Water Level Indicator?**

A level indicator, whether it be a gauge glass, indirect sensing method, or independent remote, is used on a steam boiler to provide a water level reading. A gage glass is the most common form of level indicator found on steam boilers.

**6.What is safety valve? And define safety valve**

A **safety valve is a valve** that acts as a fail-safe. An example of safety valve is a pressure relief valve (PRV), which automatically releases a substance from a boiler, pressure vessel, or other system, when the pressure or temperature exceeds preset limits. Pilot-operated relief valves are a specialized type of pressure safety valve. A leak tight, lower cost, single emergency use option would be a rupture disk. Safety valves were first developed for use on steam boilers during the Industrial Revolution. Early boilers operating without them were prone to explosion unless carefully operated.

**7.Define fusible plug.**

A fusible plug is a threaded metal of cylinder usually of bronze, brass or gunmetal, with a tapered hole drilled completely through its length. This hole is sealed with a metal of low melting point that flows away if a pre-determined, high temperature is reached. The initial use of the fusible plug was as a safety precaution against low water levels in steam engine boilers, but later applications extended its use to other closed vessels, such as air conditioning systems and tanks for transporting corrosive or liquefied petroleum gasses.

**8.What are primary fuels? List some important fuels.**

Primary fuels or primary energy sources are dense sources of primary energy found as natural resources. Primary fuels are fuels that are found in nature and can be extracted, captured, cleaned, or graded without any sort of energy conversion or transformation process. This means that all processing and collecting of the fuel is done before the fuel is converted into heat or mechanical work.

**Types of Primary Fuels**

- Coal.
- Crude oil.
- Bitumen.
- Natural gas.
- Uranium.

- Thorium.

**9. Define heating value of fuel.**

The heat value of a fuel is the amount of heat released during its combustion. Also referred to as energy or calorific value, heat value is a measure of a fuel's energy density, and is expressed in energy (joules) per specified amount (e.g. kilograms).

**10. Explain various types of draughts used in usual practice**

Draught can be achieved by the use of chimney, fan, steam or air jet or a combination of these. When the draught is produced with the help of chimney only, it is known as Natural Draught and when the draught is produced by any other means except chimney it is known as Artificial Draught.

**11. Write short notes on bomb calorimeter**

The calorimeter used to determine the energy change during a reaction accurately is known as a bomb calorimeter. The modern Bomb calorimeter is a development of the original calorimeter of Berthelot. The modern bomb calorimeter is made of corrosion resisting steel in which the combination Bomb Calorimeter.

The bomb calorimeter is an instrument used to measure the heat of reaction at a fixed volume and the measured heat which is called the change of internal energy ($\Delta E$).

**12.How to working boiler injector?**

Steam injectors are used to inject live steam into feedtanks to drive off the dissolved oxygen. Considerably reducing the amount of oxygen scavenging chemicals required. Maintaining high and consistent feedwater temperature to the steam boiler.

## UNIT III – STEAM TURBINES

**1. What are the advantages and limitation of velocity compounded impulse turbine?**

**Advantages:**

- Relatively few number of stages and hence less initial cost.
- Require less space
- The system is reliable and easy to start

**Limitation:**

- The friction losses are high due to high initial velocity. Hence the efficiency is low.
- Low efficiency because blade speed ratio is less than the optimum value.
- The power developed in the later rows is only a fraction of power developed in the first row

**2. Define blade efficiency or utilization factor.**

It is the ratio of rotor blade work to energy supplied to the rotor.

**3. Define degree of reaction.**

It is defined as the ratio of the actual isentropic heat drop to the total heat drop in the entire stage.

**4. What is compounding and explain the purpose of compounding?**

Compounding is the method in which multiple system or rotors are keyed to common shaft in series and the steam pressure or jet velocity is absorbed in stages as it flows over the rotor blades.

***Purpose of compounding:*** Reduction of pressure (from boiler pressure to condenser pressure) in single results in the very high velocity entering the turbine blades. Therefore, the turbine rotor will run at a high speed about 30,000 rpm which is not useful for practical purpose. In order to reduce the rotor speed up to about 400 m/sec, compounding of steam turbine is necessary.

**5. What are the types of compounding in steam turbines?**

Velocity compounding, Pressure compounding and Pressure velocity compounding.

**6. What are the advantages and disadvantages of velocity compounded turbines?**

***Advantages:***

- The cost of turbine is less because less number of stages.
- It occupies less area.
- The system is reliable and easy to operate.
- Turbine casing is very simple and need not be very strong.

***Disadvantages:***

- The friction losses are large due to very high steam velocity in the nozzle.
- Low efficiency because blade speed ratio is less than the optimum value.
- The power developed in the later rows is only a fraction of power developed in the first row.

**7. What is governing of steam turbine and state the various methods of governing?**

Governing is the method of maintaining the constant speed of the turbine irrespective of load variation by varying the flow rate. The various methods of governing in steam turbines are Throttle governing, Nozzle control governing, by pass governing, Combinations of throttle and nozzle governing and Combinations of throttle and by pass governing.

**8. What is the fundamental difference between the operation of impulse and reaction steam turbines?**

In impulse turbine, the steam completely expands in the nozzle and its pressure remains constant during its flow through the rotor blades. In reaction turbine, the steam expands partially in the nozzle and remaining in rotor blades.

**9. What is meant by carry over loss?**

The velocity of steam at exit is sufficiently high thereby resulting in a kinetic energy loss called "Carry over loss" or "Leading velocity loss"

**10. Summarize the different losses involved in steam turbines.**

Leakage loss is different in both Impulse and reaction turbine. In Impulse turbine, leakage loss occurs between the shaft, bearings, nozzles and stationary diaphragms. For Reaction turbine, it may occur at the blade tips. This loss is due to the leakage of steam on each stage of the turbine.

**11. Write a short note on bleeding of steam turbines.**

It is the process in which expanded steam is extracted from the expansion path to utilize it for some purpose. Bleeding in a steam power plant is always performed in advance of the closing of expansion.

**12.Explain reheat factor. Why is its magnitude always greater than unity?**

Reheat factor: It is defined as the ratio of cumulative heat drop to the adiabatic heat drop in all stages of the turbine. The value of reheat factor depends on the type and efficiency of the turbine. The value of the reheat factor is of the order of 1.1 to 1.5.

## UNIT IV– COGENERATION AND RESIDUAL HEAT RECOVERY

**1. Explain the term cogeneration.**

Cogeneration or combined heat and power (CHP) is the use of a heat engine or power station to generate electricity and useful heat at the same time.Cogeneration is a more efficient use of fuel or heat, because otherwise-wasted heat from electricity generation is put to some productive use. Combined heat and power (CHP) plants recover otherwise wasted thermal energy for heating. This is also called combined heat and power district heating.

**2.Explain how cogeneration is advantageous over conventional power plant.**

If cogeneration systems use renewable options like biogas as their primary fuels, they are an environmentally friendly option for energy production. On the other side however, if a system is using diesel or other fossil fuels as their fuel source than they are not an eco-friendly choice.

**3.Describe briefly about heat wheels.**

A thermal wheel, also known as a rotary heat exchanger, or rotary air-to-air enthalpy wheel, energy recovery wheel, or heat recovery wheel, is a type of energy recovery heat exchanger positioned within the supply and exhaust air streams of air-handling units or rooftop units or in the exhaust gases of an industrial process, in order to recover the heat energy. Other variants include enthalpy wheels and desiccant wheels.

**4.What is meant by combined cycle cogeneration?**

Co-generations uses waste heat for many different processes, such as space heating or drying. Combined-cycle power generation is a two-cycle electricity generation process that uses the heat from the first cycle to run a second cycle.

**5.Explain the term heat-to-power ratio.**

One important parameter in cogeneration is the "power-to-heat ratio," which determines the proportion of electric power to heat generated in a single cogeneration system.

**6.List at least five applications of heat pipe**

Nowadays heat pipes are used in several applications, where one has limited space and the necessity of a high heat flux. Of course it is still in use in space applications, but it is also used in heat transfer systems, cooling of computers, cell phones and cooling of solar collectors

**7.Explain the principle of metallic recuperator**

A radiation recuperator consists of metallic tubes around the inner shelf where hot exhaust gases pass through. The cold incoming air is then fed to the tubes around the hot shelf and heat is radiated to the wall of the tubes

**8.List out the sources of waste heat in a diesel engine.**

The exhaust gas has the highest potential among all waste heat sources, followed by EGR, engine coolant, and CA.

**9.Write short notes on Direct Contact Heat Exchanger**

Direct-contact heat transfer involves the exchange of heat between two immiscible fluids by bringing them into contact at different temperatures. There are two basic bubbling regimes in direct-contact heat exchanger: homogeneous and heterogeneous.

**10.Explain the principle of heat pump.**

Air is blown over an evaporator coil, transferring heat energy from the air to the refrigerant. That heat energy is circulated in the refrigerant to a condenser coil, where it is released as a fan blows air across the coil. Through this process, heat is pumped from one place to another.

**11. Mention any three commercial waste heat recovery devices**

Typical WHRDS used for air preheating include recuperators, furnace regenerators, recuperative and regenerative burners, passive air preheaters, shell and tube heat exchangers, finned tube heat exchangers or economizers, rotary regenerator or heat wheel, preheating of load, waste heat boilers, and heat pumps.

**12.Explain the term topping cycle with examples.**

Topping cycle CHP is the process of using fuel to generate mechanical energy which is used to create electricity using a generator. The resulting waste heat is captured from this process to heat water for use as hot water or steam throughout the facility. Topping Cycle CHP – image US Energy Information Administration.

## UNIT V– REFRIGERATION AND AIR – CONDITIONING

**1.Define COP of refrigeration.(Dec-10)**

It is defined as the ratio of heat extracted in a given time to the work input.

COP = Ref – effect / Work input

**2.What should be the properties of ideal refrigeration? (Dec-13,14) (May-14)**

- It should be non – flammable.
- It should be non – explosive.
- It should be non – toxic.
- It should not react with lubricating oil.
- It should not contaminate the stored food products

**3.Explain adiabatic humidification of air.**

When the air is passed through an insulated chamber having spray of water maintained at a temperature higher than the dew point temperature of entering air but lower than its dry bulb temperature, hence the air will be both cooled and humidified.

**4.Define cooling with dehumidification of air in an air-condition system.**

The process implies lowering both the air temperature and the humidity ratio. The dehumidification of air only be possible when the temperature of the cooling oil is below the dew point temperature of air.

**5.Define refrigeration effect.**

Refrigeration effect is an important term in refrigeration that defines the amount of cooling produced by a system. This cooling is obtained at the expense of some form of energy.

**6.What is the function of the throttling valve in vapour compression refrigeration system?**

Throttling valves play two crucial roles in the vapor compression cycle. First, they maintain a pressure differential between low- and high-pressure sides. Second, they control the amount of liquid refrigerant entering the evaporator.

**7.Estimate the effect of super heat and sub cooling on the vapour compression cycle**

**Effect of superheating:** As shown in the figure a & b the effect of superheating is to increase the refrigerating effect, but this increase in the refrigerating effect is at the cost of increase in amount of work spent to attain upper pressure limit. Since the increase in work is more as compared to increase in refrigerating effect, therefore overall effect of superheating is to give a low value of C.O.P.

**Effect of sub-cooling:** sub-cooling is the process of cooling the liquid refrigerant below the condensing temperature for a given pressure. The effect of sub-cooling is to increase the refrigerating effect. Thus sub-cooling results in increase of C.O.P provided that no further energy has to be spent to obtain the extra cold coolant required.

**8.Point out the unit of refrigeration, with an example**

The practical unit of refrigeration is expressed in terms of tonne of refrigeration. A tonne of refrigeration effect produced by the uniform melting of one tonne (1000 kg) of ice from and at $0^{\circ}C$ in 24 hours. Since the latent heat of ice is 335 KJ/kg

**9.Evaluate the functions of Cooling load calculations**

The purpose of calculating cooling load is to choose the equipment in the cooling system cycle correctly and economically. If the cooling system elements are selected correctly, the system will work efficiently and for many years in a way that is expected.

**10.How are air-conditioning systems classified?**

**The different AC types are as follows:**

- Central Air Conditioner.
- Ductless Mini-Split.
- Window Air Conditioner.
- Portable Air Conditioner.
- Floor Mounted AC.

**11.Define ESHF**

Effective Sensible Heat Factor (ESHF) is the ratio ERSH/(ERSH + ERLH) Cooling Coil – In an air conditioning system, air gets cooled when it passes through the cooling coil. Air is also dehumidified, in case, its dew point is higher than the cooling coil temperature.

**12.Compare vapour compression and vapour absorption system**

The Vapour compression refrigeration system has parts like Compressor, receiver, condenser, refrigerant control device, and evaporator. Whereas, Vapour Absorption Refrigeration has Parts like condenser absorber, generator, rectifier, and evaporator. Here when the operation is going it produces noise.

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**EPC Questions**

## UNIT I STEAM NOZZLES

1. Derive Critical pressure ratio and condition for maximum discharge of Nozzle.**(May-18)**
2. Derive the Mass of steam discharged through nozzle of Nozzle.**(May-15,16)**
3. Dry saturated steam at a pressure of 8 bar enters a convergent divergent nozzle and leaves it at a pressureof 1.5 bar, if the flow is isentropic and if the corresponding expansion index is 1.133, find the ratio of cross section area at exit and throat for maximum discharge.**(Nov-14,15,17,18)**
4. Steam at 20 bar and 250$^0$C enters a group of convergent divergent nozzle. Pressure at the end of nozzle is0.07 bar. Assume a loss of 10% enthalpy drop available in the divergent part. Find the number of nozzlesrequired to discharge 13.6 kg/s. The throat area of each nozzle is 3.97 cm$^2$. Also determine area of exit of eachnozzle.**(May-15,16)**
5. Dry saturated steam at a pressure of 11 bar enters a convergent divergent nozzle and leaves it at a pressure of2 bar , if the flow is adiabatic and frictionless, determine i) The exit velocity of steam ii)Ratio of cross sectionof exit and throat.**(May-16,17)**

## UNIT II – BOILERS

1. Explain the function of boiler mountings. Can a boiler work without mountings.**(May-19)**
2. Explain any two types of high pressure boiler with a neat sketch.**(May-19)**
3. Give a schematic sketch of a boiler plant. What are the observations to be recorded during a boiler trial? **(Nov-19)**
4. A boiler generates 13000 kg of steam at 7 bars during a period of 24 hrs and consume 1250 kg of coal whose CV. = 30000 kJ/kg. Taking the enthalpy of steam coming out of boiler = 2507.7 kJ/kg and water is supplied to the boiler at 40°C. Find: (a) efficiency of the boiler (b) Equivalent evaporation per kg of coal.**(Nov-19)**

5. The following data were obtained in a boiler trial: Feed water supply per hour = 690 kg at 28°C ; steam produced = 0.97dry at 8 bar ; coal fired per hour = 91kg of calorific value 27255 kJ/kg ; ash and unburnt coal collected beneath fire bars = 7.5 kg/hr of calorific value 3700 kJ/kg ; mass of the flue gasses per kg of coal burnt = 17.4kg ; temperature of flue gases 325°C ; room temperature = 17 °C; specific heat of flue gases 1.005 kJ/kgK. Estimate the boiler efficiency and draw up a heat balance sheet.**(May-19)**

## UNIT III – STEAM TURBINES

1. Explain the Various types of Compounding in steam turbine**(May-18, Nov-19)**
2. Explain the Various methods of Governing in steam turbine.**(May-19,Nov-15)**
3. Explain what are the materials involved in steam turbine & brief note on Steam Turbine losses.**(May-18)**
4. A single stage impulse turbine rotor has a diameter of 1.2 m running at 3000 rpm. The nozzle angle is 18°. Bladespeed ratio is 0.42. The ratio of the relative velocity at outlet to relative velocity at inlet is 0.9. The outlet angle of theblade is 3° smaller than the inlet angle. The steam flow rate is 5 kg/s. Draw the velocity diagram and find the following :(i) Velocity of whirl (ii) Axial thrust on the bearing (iii) Blade angles (iv) Power developed**(Nov-15,16,17)**
5. In a De-Laval turbine steam issues from the nozzle with a velocity of 1200 m/s. The nozzle angle is 20°, the meanblade velocity is 400 m/s and the inlet and outlet angles of blades are equal. The mass of steam flowing through theturbine per hour is 1000 kg. Find the (i) blade angles (ii) relative velocity of steam entering the blades (iii) tangentialforce on the blades (iv) power developed (v) blade efficiency. Take the blade velocity coefficient as 0.8**(Nov-16,18)**

## UNIT IV– COGENERATION AND RESIDUAL HEAT RECOVERY

1. Explain the principle of operation of heat pipe. Discuss three examples of its industrial application. **(Nov-19)**
2. Explain any three types of recuperators**(May-19)**
3. List out the various economic aspects of heat recovery devices and their efficiency in different applications. **(May-19)**

4. Explain the various type of back pressure turbine**(Nov-19)**
5. A cogeneration plant is to generate power and 8500 kW of process heat. Consider an ideal cogeneration steam plant. Steam enters the turbine from the boiler at 10 MPa and 450°C. One- third of the steamis extracted from the turbine at 800 KPa pressure for process heating. The remainder of the steam continues to expand and exhausts to the condenser at 8 KPa. The steam extracted for the process heater is condensed in the heater and mixed with the feedwater at 800 KPa. The mixture is pumped to the boiler pressure of 10 MPa. Show the cycle on a T-s diagram with respect to saturation lines, and determine the (a) mass flow rate of steam that must be supplied by the boiler (b) net power produced by the plant and (c) utilization factor.

## UNIT V– REFRIGERATION AND AIR – CONDITIONING

1. Explain the summer and winter air conditioning system.**(May-15,18, Nov-18)**
2. Explain the VCRS with neat sketch.**(May-17, Nov-16,18)**
3. With neat diagram, explain the working ofVapour Absorption system ( Ammonia water and Lithium bromide)**(May-17,19)**
4. A $NH_3$ refrigerator produces 30 tons of ice from and at 0°C in a day of 24 hours. Thetemperature range in the compressor is from 25°C to -15°C. The vapour is dry saturated at theend of compression. Asssume a COP 60% theoretical. Calculate the power required to drivethe compressor. Assume latent heat of ice is 335 kJ/kg. For properties of ammonia

| Temperature oC | $h_f$(kJ/kg) | $h_g$(kJ/kg) | $s_f$(kJ/kg) | $s_g$(kJ/kg) |
|---|---|---|---|---|
| 25 | 298.9 | 1465.8 | 1.124 | 5.039 |
| -15 | 112.34 | 1426.5 | 0.4572 | 5.549 |

**(May-15,16, Nov-15,18)**

5. An office is to be air conditioned of 50 staff outdoor conditions are DBT 300C and 75% RH.If quantity of air supplied is 0.4m3/min /person. Find i)capacity of cooling coil in terms ofrefrigeration. ii) capacity of heating coil in kW iii) Amount of water vapour removed perhour. Assume inlet air condition is 20C DBT and 60% RH. Air is conditioned first by coolingand dehumidifying and then by heating. If the heating coil surface temperature is 25C. Find bypass factor of cooling coil.**(Nov-15,16)**