**Model Question Paper 1**

**Fluid Systems**

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**Note: Attempt any five questions including Q. No. 1 which is compulsory.**

Q1. How are the fluid machines classified?

Sol. Classification Based on Fluid Used

The fluid machines use either liquid or gas as the working fluid depending upon the purpose. The machine transferring mechanical energy of rotor to the energy of fluid is termed as a pump when it uses liquid, and is termed as a compressor or a fan or a blower, when it uses gas. The compressor is a machine where the main objective is to increase the static pressure of a gas. Therefore, the mechanical energy held by the fluid is mainly in the form of pressure energy. Fans or blowers, on the other hand, mainly cause a high flow of gas, and hence utilize the mechanical energy of the rotor to increase mostly the kinetic energy of the fluid. In these machines, the change in static pressure is quite small. For all practical purposes, liquid used by the turbines producing power is water, and therefore, they are termed *as water turbines or hydraulic turbines*. Turbines handling gases in practical fields are usually referred to as *steam turbine, gas turbine, and air turbine* depending upon whether they use steam, gas (the mixture of air and products of burnt fuel in air) or air.

Q 2.The force exerted by a 25mm diameter jet against a flat plate normal to the axis of the jet is 650N. What is the flow in m3/s?



Sol. From the question, djet = 0.025m FTx = 650 N

Force normal to plate is

FTx = ρQ( 0 - u1x )

650 = 1000\*Q ( 0 - u )

Q = au = (πd2/4)u

650 = -1000au2 = -1000Q2/a

650 = -1000Q2/(π0.0252/4)

Q = 0.018m3/s

Q 3.Explain dynamic force exerted by fluid on fixed and moving flat plates.

Sol. ***Plate normal to jet***

A fluid jet issues from a nozzle and strikes a flat plate with a velocity *v*. The plate is held stationary and perpendicular to the centre line of the jet.



Applying the following equation :



The minus sign on right hand side of the equation indicates that the velocity is decreasing, while this sign used with indicates that the force is acting in the negative direction of x-axis. Now the force exerted by the fluid on the plate is given by " Newton's Law of Action and Reaction" which will be equal and opposite,



***Force on moving flat plate***

Let the plate in Fig.1 move with a velocity u in the same direction as the jet, then the jet with velocity v has struck the plate. The change in velocity is ( u-v ). Thus



Where a: cross-sectional area. w: velocity of jet relative to the motion of plate. v: absolute velocity of jet. Force exerted on the fluid by the vane Fxis equal to



And force exerted by the fluid on the vane is



Here the distance between plate and nozzle is constantly increasing by u m/s. A single moving plate is, therefore, not a practical case. If, however, a series of plates as shown in figure, were so arranged that each plate appeared successively before the jet in the same position always moving with a velocity u in the direction of jet, then whole flow from the nozzle is utilized by the plates.





Q 4. Explain the construction of peltonturbinewith suitable diagram.

Sol. ***Introduction***

The Pelton wheel turbine is a pure impulse turbine in which a jet of fluid leaving the nozzle strikes the buckets fixed to the periphery of a rotating wheel. The energy available at the inlet of the turbine is only kinetic energy. The pressure at the inlet and outlet of the turbine is atmospheric. The turbine is used for high heads ranging from (150-2000) m. The turbine is named after L. A. Pelton, an American engineer.

***Parts of the Pelton turbine***

***Nozzle and flow control arrangement***

The water from the reservoir flows through the penstocks at the outlet of which a nozzle is fitted. The nozzle converts the total head at the inlet of the nozzle into kinetic energy. The amount of water striking the curved buckets of the runner is controlled by providing a spear in the nozzle. The spear is a conical needle which is operated either by a hand wheel or automatically in an axial direction depending upon the size of the unit.

***Runner and buckets***

The rotating wheel or circular disc is called the runner. On the periphery of the runner a number of buckets evenly spaced are fixed. The shape of the buckets is of a double hemispherical cup or bowl. Each bucket is divided into two symmetrical parts by a dividing wall which is known as the splitter. The jet of water strikes on the splitter. The splitter then divides the jet into two equal parts and the water comes out at the outer edge of the bucket. The buckets deflect the jet through an angle between (160o-165o) in the same plane as the jet. Due to this deflection of the jet, the momentum of the fluid is changed reacting on the buckets. A bucket is therefore, pushed away by the jet.

***Casing***

The casing prevents the plashing of the water and discharges the water to tail race. The spent water falls vertically into the lower reservoir or tail race and the whole energy transfer from the nozzle outlet to tail race take place at a constant pressure. The casing is made of cast iron or fabricated steel plates.

***Breaking jet***

To stop the runner within a short time, a small nozzle is provided which directs the jet of water on to the back of the vanes. The jet of water is called the "breaking jet ". If there is no breaking jet, the runner due to inertia goes on revolving for a long time.



Q5. What is cavitation? Write down the effects and precaution of cavitation?

Ans**. Cavitation** is defined the phenomenon of formation of vapour bubbles of a flowing liquid in a region where the pressure of the liquid falls below its vapour pressure and sudden collapsing of these vapour bubbles in a region of higher pressure . when the vapour bubbles collapse, a very high pressure is created. The metallic surfaces , above which these vapour bubbles collapse, is subjected to these high pressures, which cause pitting action on the surface . thus cavities are formed on the metallic surface and also considerable noise and vibrations are produced.

**Effects :-**

* The metallic surfaces are damged and cavities are formed on the surfaces.
* Due to sudden collapse of vapour bubble, considerable noise and vibrations are produced.
* The efficiency of a turbine decreases due to cavitation .

**Precaution:-**

* The pressure of the flowing liquid in any part of the hydraulic system should not be allowed to fall below its vapour pressure. If the flowing liquid is water, then the absolute pressure head should not be below 2.5m of water.
* The special materials or coatings such as aluminium-bronze and stainless steel, which are cavitation resistant materials, should bs used.

Q6. A Kaplan turbine runner is to be designed to develop 9100kW.the net available head is 5.6m. if the speed ratio=2.09, flow ratio=0.68, overall efficiency=86% and the diameter of the boss is 1/3 the diameter of the runner. Find the diameter of the runner, its speed and the specific speed of the turbine.

* Ans. Given:
* Power, P=9100kW
* Net head, H=5.6m
* Speed ratio=2.09
* Flow ratio=0.68
* Oerall efficiency, ƞ=86%=0.86
* Diameter of boss = diameter of runner
* Or

**Q 7**.



***Q 8. Explain cavitation in pumps. What is NPSH?***

***Cavitation in pump*** When the liquid is flowing in the pump, it is possible that the pressure at any part of the pump may fall below the vapor pressure, then the liquid will vaporize and the flow will no longer remain continuous. The vaporization of the liquid will appear in the form of bubbles released in the low pressure region of the pump. These bubbles are carried along with water stream and when these pass through a region of high pressure, these collapse suddenly. When the bubbles collapse on a metallic surface such as tips of impeller blades, the cavities are formed. Successive bubble collapsing at the same metallic surface produces pitting since penetration in the grain boundaries take place. Once the pitting takes place, the liquid rushes to fill the pits causing mechanical destruction and the liquid hits the blades with such a great force that it damages the impeller. This phenomena is known as "Cavitation". A great noise is experienced due to cavitation leading to vibration of the pumping set.Since the cavitation occurs when the pressure falls below atmospheric, the trouble is experienced mainly at the impeller vane inlet due to high suction lift which must be brought within limits.

***Net Positive Suction Head (NPSH)*** (NPSH) is the head required at the pump inlet to keep the liquid from cavitation or boiling. The pump inlet or suction side is the low pressure point where cavitation will first occur.



Where Pvapis the vapor pressure of the liquid. NPSH is also defined as a measure of the energy available on the suction side of the pump. NPSH is a commercial term used by the pump manufactures and indicates the suction head which the pump impeller can produce. In other words, it is the height of the pump axis from the water reservoir which can be permitted for installation.