THERMAL AND FLUID POWER ENGINEERING

LAB MANUAL

T.E. (Mechanical)

Sem-VI

Department of Mechanical Engineering

SIES Graduate School of Technology

RISE WITH EDUCATION

SIES GST, Nerul, Navi Mumbai

GENERAL INSTRUCTIONS

1. Always carry the workbook, calculator, graph pages, pen, pencil, eraser and scale when coming for practicals.
2. Keep your working laboratory bench clean of everything. Nothing should be lying on the bench.
3. Don’t eat or drink or talk while working in the lab.
4. No equipment is to be operated until the approval of the instructor has been obtained at the start of class. Only the equipment pertaining to the assigned experiment is to be operated. Further no operating equipment will be left unattended.
5. The laboratory floor must be kept dry, clean and uncluttered at all times. Any spills should be cleaned up immediately.
6. Be aware of possible electrical hazards. All electrical devices should be properly grounded. Frayed or otherwise hazardous electrical cords should be reported and replaced or repaired.
7. Any accident or hazardous situation must be reported to the Laboratory Supervisor immediately.
8. Wash hands before and after performing an experiment with disinfectant soap.
9. Students shall conduct themselves safely and responsibly.

CONTENT

*Experiment Beyond the Syllabus

Experiment: 1

Aim: To study the constructional detail of Pelton wheel and determine the efficiency of Pelton turbine at different speed and at different head

Apparatus: Model of Pelton wheel Turbine, Tachometer

Introduction:

Hydro -power is one of major cheap source of power available on earth, and hence it is widely used for generation of electric power worldwide. Water stored in the dam contains potential energy. The water flows through the turbine, so that power is generated by impact of water or reaction of water flow. The turbine drives the generator which delivers electrical power. Thus, turbines are of great importance.

Turbines are basically of two types, viz. impulse turbines and reaction turbines. In impulse turbines, water coming from high head acquires high velocity. The high velocity water jet strikes the buckets of the turbine runner and causes it to rotate by impact. In reaction turbine, total head of water is partly converted into velocity head as it approaches turbine runner and it fills the runner and pressure of water gradually changes as it flows through runner. In impulse turbine, the only turbine used now-a-days is Pelton Wheel Turbine. In reaction turbines, Francis Turbine and Kaplan Turbine are the examples.

The Pelton wheel turbine consists of runner mounted over the main shaft. Runner consists of buckets fitted to the disc. The buckets have a shape of double ellipsoidal cups. The runner is encased in a casing provided with a Perspex window for visualization. A nozzle fitted in the side of casing directs the water jet over the 'Splitter' or centre ridge of the buckets. A spear operates inside the nozzle to control the water flow. On the other side of the shaft, a rope brake is mounted for loading the turbine.

SPECIFICATIONS: -

1) **Turbine Power** –1 H.P., speed 600 rpm, fitted with 18 No of buckets, mounted over the sump tank provided with nozzle and spear.

2) **Pump**- 5 H.P. Monoblock Pump, Head - 30 meter, Discharge - 7.4 lps provided with D.O.L. starter.

3) Measurements –

a) Venturimeter with mercury manometer for discharge measurement.

b) Rope brake pulley dia. 0.250m with spring balance of 20 kg. Capacity & Belt thickness- 6 mm.

c) Pressure gauge to note down the pressure 0-7 kg /cm2 capacity.

PRECAUTIONS:-

1) Priming is must before starting the pump. Pump should never run dry.
2) Use clean water in the sump tank.
3) Use all the controls and switches carefully.
4) Do not disturb the pressure gauge connections.
5) Drain all the water from the sump tank after the experiment is completed.

EXPERIMENTAL PROCEDURE: -

1) Fill up sufficient water in the sump tank.
2) Keep the venturimeter valves closed.
3) Close nozzle by operating the spear. Press 'Green' button of starter, so that pump starts running.
4) Observe direction of pump rotation during starting. It should be clockwise, as seen from fan end. If it is reverse, interchange any two phases in supply line. If direction pump is correct, pressure gauge will read the pressure about 4 - 4.5 kg / cm^2. If it is reverse, pressure gauge will read l -2 kg/ cm^2
5) First open air valves then open the venturimeter valves, remove all the air bubbles and close the air valves slowly and simultaneously so that mercury does not run away into water. Slowly open the nozzle. Turbine will start rotating. Adjust the spear so that turbine is rotating at 1000 rpm.
6) Put the load using loading stud. Open the nozzle, so that turbine is again rotating at 1000 rpm.
7) Note down the readings in observation table.
8) Repeat the procedure for different speeds, say 800 rpm, 600rpm, 500 rpm.

9) Release the entire load. Keep at 1/4 opening. Load the rope brake with 0.5 kg load. Note down the speed.
10) Go on adding the load, without disturbing spear position. Note down head, speed, discharge and load each time.
11) Repeat the procedure for 1/2, 3/4 and full spear opening. This is a constant head test.

<u>OBSERVATION TABLE</u>: -

<u>Constant Head Test</u> - Total no of rotation of Spear is 10.

Sr. No	Spear Position	Actual weight kg	Turbine Speed R.P.M	Manometer Height mm of Hg	Manometer Height (h_w) mm of water	Pressure Gauge kg/cm^2
1	1/4	0				
		0.5				
		1				
		1.5				
		2				
2	1/2	0				
		0.5				
		1				
		1.5				
		2				

Constant Speed Test:-

Sr. No	Turbine Speed R.P.M	Actual weight kg	Manometer Height mm of Hg	Manometer Height (h_w) mm of water	Pressure Gauge kg/cm^2
1	1000	0			
		1			
		2			
2	800	0			
		1			
		2			
3	600	0			
		1			
		2			

SAMPLE CALCULATIONS:-

1) **Head over the turbine** -

Since 10 m. of water head corresponds to $1 kg/cm^2$

$\therefore$ H = Pressure Gauge Reading kg / cm^2 x 10 m.

2) **Water flow rate -**

$$Q = C_d \times \frac{a_1 \times a_2}{(a_2^2 - a_1^2)^{0.5}} \times (2gh_w)^{0.5} \quad m^3/sec$$

Where,

a_1 = Inlet area of Venturi meter at dia. = 0.05m = 1.963×10^{-3} m^2

a_2 = Throat area of Venturi meter at dia. = 0.035m = 0.02749 m^2

C_d = Co - efficient of discharge = 0.98

h_w = Water head across venturi

= Manometer difference (h) x 13.6 mm of water.

3) <u>Power supplied to turbine</u> -

P_{in} = WQH x 9.81 Watt

Where,
W = Specific weight of water = 1000 kg/m^3

4) <u>Brake Power</u> -

T= (spring balance diff. kg) x 9.81x (0.125 + 0.006) Nm

(radius of drum + thickness of belt)

$$\text{Brake Power} = \frac{2\pi NT}{60} \quad \text{Watts}$$

Note - i) Turbine speed is to be noted with the help of tachometer

ii) Belt thickness is 0.6 cm, (i.e. 0.006 m)

5) <u>Overall efficiency of turbine -</u>

$$\eta = \frac{B.P}{P_{in}} \times 100 \quad \%$$

<u>Graphs</u>: -

1) <u>Constant head test</u> -

Plot the graph of speed N vs. B.P and

N vs. Overall efficiency for various spear opening

Conclusion:-

Experiment: 2

Aim: - To study the variable speed and constant speed characteristic of Francis turbine and determine the efficiency of Francis turbine at different speed and at different guide vane position

Apparatus: - Model of Francis Turbine, Tachometer

Introduction:-

Hydro – power plant are one of the major sources of power in the world now-a-days. To convert potential energy of water into mechanical power, turbines are used. Depending upon the head and quantity of water available, various turbines are installed. When water is available at high heads, normally Impulse turbines i.e. Pelton Wheel turbines are used. For low head and greater quantity of water, reaction turbines are used. Francis turbine is one of reaction turbines widely used. In reaction turbine, pressure of the water changes gradually as it flows through the runner. In Francis turbine, water from the penstock enters the scroll casing, which completely surrounds the runner. From scroll casing, water passes through a series of guide vanes, which are provided around the periphery of the runner. The guide vanes direct the water to runner at an appropriate angle and also regulate the flow of water through runner. The guide vanes are of streamlined shape.

From the guide vanes, water enters the runner radially. After flowing through the runner passages and having imparted all the energy to the runner, water leaves the runner axially. Normally, negative head is established at the exit of the runner, hence a draft tube of divergent section is fitted at exit of the runner. The lower end of the draft tube is always submerged in the water. Due to divergent section of the draft tube, it converts a large portion of velocity energy into pressure energy thus makes it possible to install the turbine above the tail race without loss of head.

The unit essentially consists of a spiral casing, outer bearing pedestal and rotor assembly with runner, shaft and brake drum, all mounted on a suitable sturdy cast iron base plate. A straight conical draft tube is provided for the purpose of regaining the kinetic energy from the exit water and also facilitating easy accessibility of the turbine due to its location at a higher level than the tail race. A rope brake arrangement is provided to load the turbine. The output of the turbine can be controlled by adjusting the guide vanes for which a hand wheel and a suitable link mechanism is provided The net supply head on the turbine is measured by a pressure gauge and for the measurement of speed, use hand tachometer.

Specifications:-

1. Rated speed … 1500 rpm.
2. Power output … 0.75 kW (1 HP)
3. Brake drum diameter … 190 mm.
4. Belt thickness ... 6 mm.
5. Pump set … 5 H.P.
6. Venturimeter Inlet … 78 mm
7. Throat diameter … 53 mm.

The Turbine is placed on sturdy sump tank at suitable height. The supply pump set mounted on sump, draws water from the same and supplies it to the turbine. The Venturimeter and Manometer arrangement are mounted as shown to measure the flow rate.

A gate valve is provided just above the inlet of the turbine to regulate the discharge and supply head on the turbine in relation to the guide vane settings. A set of guide vanes are provided around the periphery of the runner to control the load, the whole of the guide vane mechanism being operated through a hand wheel by suitable link mechanism.

The flow measuring unit, venturimeter and manometer, is so arranged and mounted that the readings can be conveniently taken. The discharge from the turbine is directly led into the sump tank.

Precautions:-

a) Before switching off the supply pump set, first remove the entire load.

b) Close the cooling inlet water gate valve.

c) Slowly close the guide vanes to its full closed position. Then close the gate valve just above the turbine.

d) Switch off the supply of pump set. Never switch off the supply of pump set when the turbine is working under load.

Experimental Procedure:-

1) Fill up sufficient water in the sump tank.

2) Pump to be primed while starting the turbine.

3) Keep the venturimeter valve closed.

4) Insure that there should not any load on the turbine. Close gate valve (Top of the turbine) & guide vane pointer should be in zero position

5) Slowly open the venturimeter valve and remove the air bubble. Then slowly open the gate valve.

7) Adjust the guide vanes so that turbine will start rotating.

8) Open the valve for the cooling water to the loading drum.

9) Take the readings at different load by maintaining the turbine speed constant. (To maintain constant speed use guide vanes.)

10) Note down the readings in observation table.

11) Repeat the procedure for different speeds.

12) This is a constant speed test.

13) Repeat the procedure for constant guide vane position.

OBSERVATION TABLE:-

Constant Guide Vane Position:-

Sr. No	Guide vane position	Actual weight (Spring balance difference) kg	Turbine Speed R.P.M	Manometer Height mm of Hg	Manometer Height (h_w) mm of water	Pressure Gauge kg/cm^2	Suction Vaccum mm of Hg
1	0	0					
		0.5					
		1					
		1.5					
		2					
2	4	0					
		0.5					
		1					
		1.5					
		2					
3	8	0					
		0.5					
		1					
		1.5					
		2					

Constant Speed Test:-

Sr. No	Turbine Speed R.P.M	Actual weight or load kg	Manometer Height mm of Hg	Manometer Height (h_w) mm of water	Guide vane Position	Pressure Gauge kg/cm^2	Suction Gauge mm of Hg
1	3400	0					
		0.5					
		1					
2	3000	0					
		0.5					
		1					

SAMPLE CALCULATIONS:-

1) **Head over the turbine** -

Since 10m of water head corresponds to 1 kg/cm^2

$\therefore$ H_1 = Pressure gauge reading kg/cm^2 x 10 m.

H_2 = Vaccum gauge reading x 13.6 mm

Total Head = $H_1 + H_2$

2) **Water flow rate -**

$$Q = C_d \times \frac{a_1 \times a_2}{(a_2^2 - a_1^2)^{0.5}} \times (2gh_w)^{0.5} \quad m^3/sec$$

Where,

a_1 = Inlet area of Venturi meter at dia. = 0.078m = 4.778 x 10^{-3} m^2

a_2 = Throat area of Venturi meter at dia. = 0.053m = 2.206 x 10^{-3} m^2

C_d = Co - efficient of discharge = 0.98

h_w = Water head across venturi

= Manometer difference (h) x 12.6 mm of water.

3) **Power supplied to turbine** -

$P_{in} = \rho QH \times 9.81$ Watt

Where,

ρ = density of water = 1000 kg/m^3

4) **Brake Power** -

T= (spring balance diff. kg) x 9.81x (0.095 + 0.006) Nm

(radius of drum + thickness of belt)

$$\text{Brake Power} = \frac{2\pi NT}{60} \quad \text{Watts}$$

Note - i) Brake drum diameter is 190 mm (0.190 m)

ii) Belt thickness is 0.6 cm, (i.e. 0.006 m)

5) Overall efficiency of turbine -

$$\eta = \frac{B.P}{P_{in}} \times 100 \ \%$$

Graphs: -

Plot the graph of B.P vs. overall efficiency

Conclusion:-