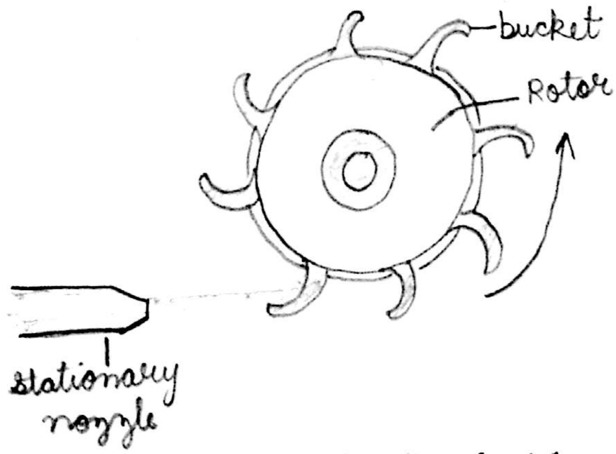
INDIAN INSTITUTE OF TECHNOLOGY

DATE 8|2|16 SHEET NO. A1

CHARACTERISTICS OF AN IMPULSE TURBINE

- **Objective:** 1. To determine the characteristic curve: Unit Power V/S Unit Speed
  2. To determine iso-efficiency curves.
- **Apparatus:** Impulse turbine setup coupled with a dynamometer.
- **Theory:** If a jet of fluid is discharged from a fixed nozzle at a high speed over a flat stationary plate, a steady force will be exerted over this plate. This force is nothing but an impulse. No work is done as the plate is fixed. But, if a number of such plates are fixed on the rim of a wheel, the wheel may be rotated due to the impulse of the jet. Curved plates are used instead of flat plates to ultilize greater amount of energy



As the high velocity jet impinges against the blades, it changes the momentum of jet causing impulsive force on the blades. The wheel is thus made to rotate in a definite direction.

Here, the kinetic energy is converted into mechanical work, only by one set of blades. It is simplest type of impulse turbine.

Parts of an impulse turbine

1. wheel or Rotor
2. Nozzle.
3. Blades
4. casing

Procedure:

1. studied the setup.
2. Selected a suitable head (H = 100 ft)
3. Setted the gate opening at 25%
4. Measured the speed of the turbine, torque for different loads in the RPM range of (800–1800)
5. Repeated step 4 for 50%, 75% and 100% gate openings

Calculations:

$$\text{Power}_{output} = \frac{\text{Torque} \times \text{RPM}}{9549.365} \text{ KW}$$

$$\text{unit Power} = \frac{\text{Power}_{output}}{H^{3/2}}$$

H → Head = 100 ft

$$\text{unit speed} = \frac{\text{RPM}}{H^{1/2}}$$

$$\text{Power Input} = \rho Q g H$$

ρ → density of fluid
Q → flow rate
g → gravitational accn.
H → Head

$$\eta = \frac{\text{Power output}}{\text{Power input}}$$

$$\eta_{max} = \frac{(\text{Power}_{output})_{max}}{\text{Power input}}$$

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- **Observations :**

TABLE 1:

25% VALVE OPENING ; $\Delta H = 14$ mm							
RPM (N)	TORQUE (Nm)	POWER OUTPUT (kW)	POWER INPUT (kW)	UNIT POWER ($W/m^{3/2}$)	UNIT SPEED ($RPM/m^{1/2}$)	EFFICIENCY (%)	Q (m^3/hr)
805	5.9	0.497	2.408	2.953	145.8	20.63	29
895	5.6	0.524	2.408	3.113	162.1	21.75	29
990	5.3	0.549	2.408	3.262	179.3	22.79	29
1095	4.82	0.552	2.408	3.280	198.3	22.91	29
1195	4.3	0.538	2.408	3.197	216.4	22.33	29
1300	4.0	0.544	2.408	3.232	235.4	22.58	29
1405	3.66	0.538	2.408	3.197	254.4	22.33	29
1490	3.48	0.542	2.408	3.220	269.8	22.50	29
1585	3.2	0.531	2.408	3.155	287.0	22.04	29
1698	2.7	0.480	2.408	2.852	307.5	19.92	29
1800	2.12	0.399	2.408	2.371	326.0	16.56	29

TABLE 2 :

50% VALVE OPENING ; ΔH = 65 mm							
RPM (N)	TORQUE (Nm)	POWER OUTPUT (KW)	POWER INPUT (KW)	UNIT POWER ($W/m^{3/2}$)	UNIT SPEED ($RPM/m^{1/2}$)	EFFICIENCY (%)	q (m^3/hr)
1105	14.6	1.689	5.149	10.030	200.1	32.79	62
1200	13.8	1.734	5.149	10.300	217.3	33.67	62
1310	12.9	1.769	5.149	10.510	237.2	34.35	62
1405	11.8	1.736	5.149	10.310	254.4	33.71	62
1503	10.5	1.652	5.149	9.817	272.2	32.08	62
1605	9.3	1.563	5.149	9.288	290.7	30.35	62
1695	8.1	1.437	5.149	8.539	307.0	27.90	62
1810	6.6	1.250	5.149	7.428	327.8	24.27	62

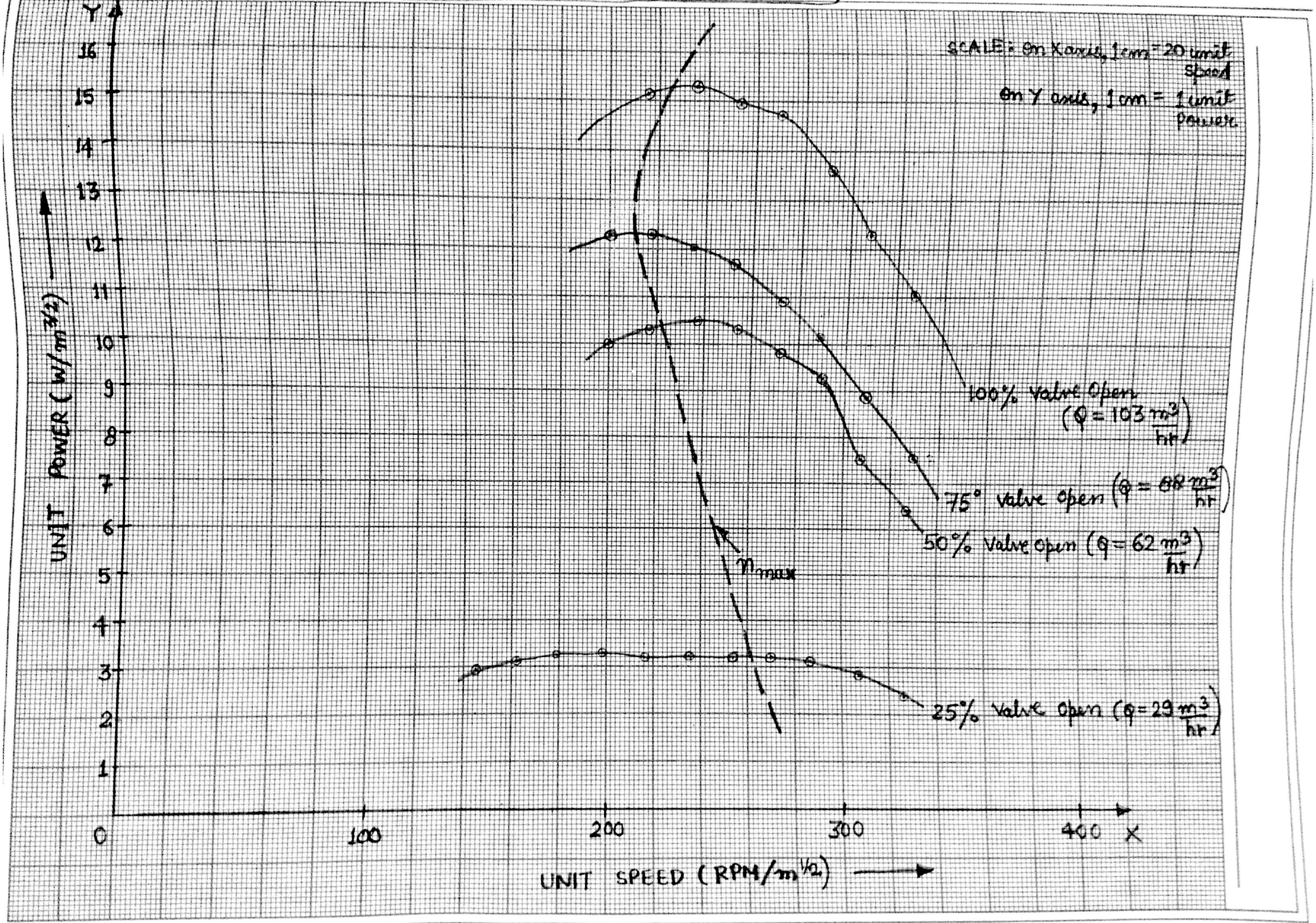
TABLE 3:

75% VALVE OPENING ; ΔH = 132 mm							
RPM (N)	TORQUE (Nm)	POWER OUTPUT (KW)	POWER INPUT (KW)	UNIT POWER ($W/m^{3/2}$)	UNIT SPEED ($RPM/m^{1/2}$)	EFFICIENCY (%)	q (m^3/hr)
1105	17.9	2.071	7.309	12.308	200.1	28.33	88
1200	16.5	2.073	7.309	12.319	217.3	28.36	88
1300	14.9	2.028	7.309	12.051	235.4	27.74	88
1395	13.5	1.972	7.309	11.718	252.6	26.98	88
1510	11.6	1.834	7.309	10.898	273.5	25.09	88
1600	10.2	1.709	7.309	10.155	289.8	23.38	88
1710	8.3	1.488	7.309	8.842	309.7	20.35	88
1810	6.7	1.269	7.309	7.541	327.8	17.36	88

TABLE 4 :

100 % VALVE OPENING ; ΔH = 172 mm							
RPM (N)	TORQUE (Nm)	POWER OUTPUT (KW)	POWER INPUT (KW)	UNIT POWER ($W/m^{3/2}$)	UNIT SPEED ($RPM/m^{1/2}$)	EFFICIENCY (%)	Q (m^3/hr)
1190	20.4	2.542	8.554	15.106	215.5	29.71	103
1300	18.9	2.572	8.554	15.284	235.4	30.06	103
1400	17.2	2.521	8.554	14.981	253.5	29.46	103
1490	15.9	2.480	8.554	14.737	269.8	28.98	103
1610	13.6	2.292	8.554	13.620	291.6	26.79	103
1700	11.6	2.065	8.554	12.271	307.9	24.13	103
1805	9.8	1.852	8.554	11.005	326.9	21.64	103

UNIT POWER VS. UNIT SPEED



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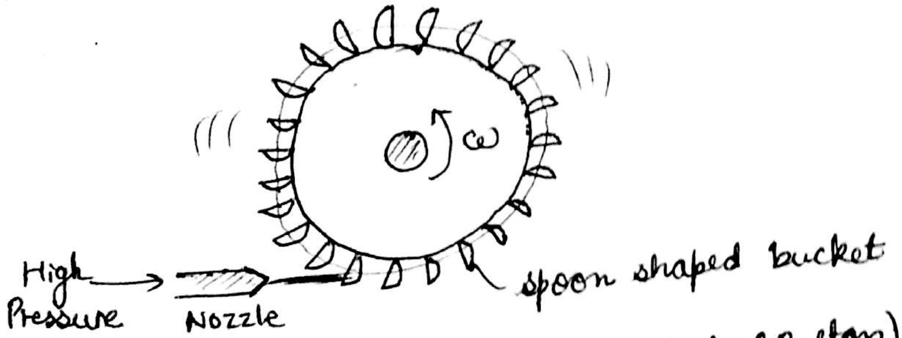
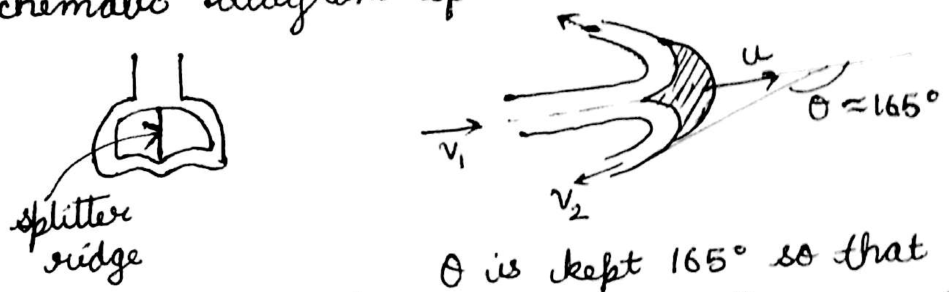
DISCUSSIONS:

1. Impulse turbine is a type of rotodynamic turbine that works on the principle of momentum change of the fluid
2. Schematic diagram of an impulse turbine (Pelton)

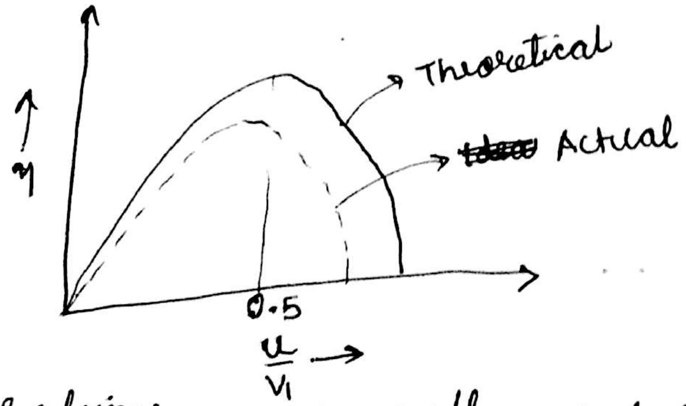


3. schematic diagram of bucket (Pelton)



θ is kept 165° so that jet going back doesn't hits the next bucket.

4. The efficiency for the rotor blade speed u and jet velocity v_1 of a turbine can be shown as:



5. Impulse turbines are generally used to run at medium to high head

6. The velocity of jet changes, the pressure throughout remaining atmospheric. Hence, water tight casing is not necessary.
7. No draft tube is used even when the turbine is installed above the tail race.
8. Impulse turbine have more hydraulic efficiency than reaction turbines.
9. Impulse turbines require low maintenance work.
10. The Unit Power increases as the unit speed is increased. After a maximum limit, further increase in the unit speed causes the unit power to decrease.
11. Higher flow rates result in higher power output as the momentum flowing at the input to the turbine is large.
12. The nature of the curve between Unit Power and Unit Speed can be attributed due to changes in operating parameters. Hence there is a particular speed at which maximum efficiency is obtained and it is desirable to run the turbine at that speed.
13. For this, iso-efficiency charts are plotted which give the various points with different flow rates and speeds having same efficiencies.

Discussion

The specific speed of turgo runners is between the francis and pelton. Single or multi nozzles can be used. Increasing the number of jets increase the specific speed of runner by square root of number of jets. Turgo turbines ~~is~~ is an impulse water turbine, designed for medium head applications. Operational turgo turbines achieve efficiencies of about 86%. There are few points to discuss about:-

(i) Power output in general increases with speed but it arbitarly decrease when reading is taken. This can be explained as the energy transfer from water jet is maximum at a certain speed, which gives best efficiency for a given data.

(ii) For a particular gate opening, the flow remains constant due to fixed input head. This condition was drawn by the reading of venturimeter. The manometer reading remained almost constant for a gate opening.

(iii) In practice, we obtain input head by the potential energy of water stored at a height. But in this experiment we used another pump to obtain this head.

(iv) Power output decreases as the gate opening decreases. It is caused by the reduction of energy flow when gate areas are reduced ~~from~~. even when the head is kept constant.

Discussions :-

- Turgo impulse turbines is an impulse water turbine designed for medium head applications. Its specific speed lies between francis and Pelton. As we increase the no. of jets, the specific speed of runner is increased by the square root of the no. of jets.

- For a given gate opening, flow remain constant due to the fixed input head, we get the reading by the use of venturimeter. Manometer reading is constant for a given gate opening. When gate opening is changed, reading also gets changed due to the different pressure changes.

- Power output generally increases with speed initially But at a particular speed, it attains maximum Value and then starts decreasing. This is because as the energy transfer from water jet is maximum at a certain (particular) speed. This speed gives best efficiency for a given data.

- Actually, input head is obtained by the potential energy of water at a certain height. But in laboratory, we get this input head by using

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a pumping device.

- As the percentage opening gate increases, power output also increases. This is because of the reduction in energy due to reduction in area when head is kept constant.