DAV UNIVERSITY

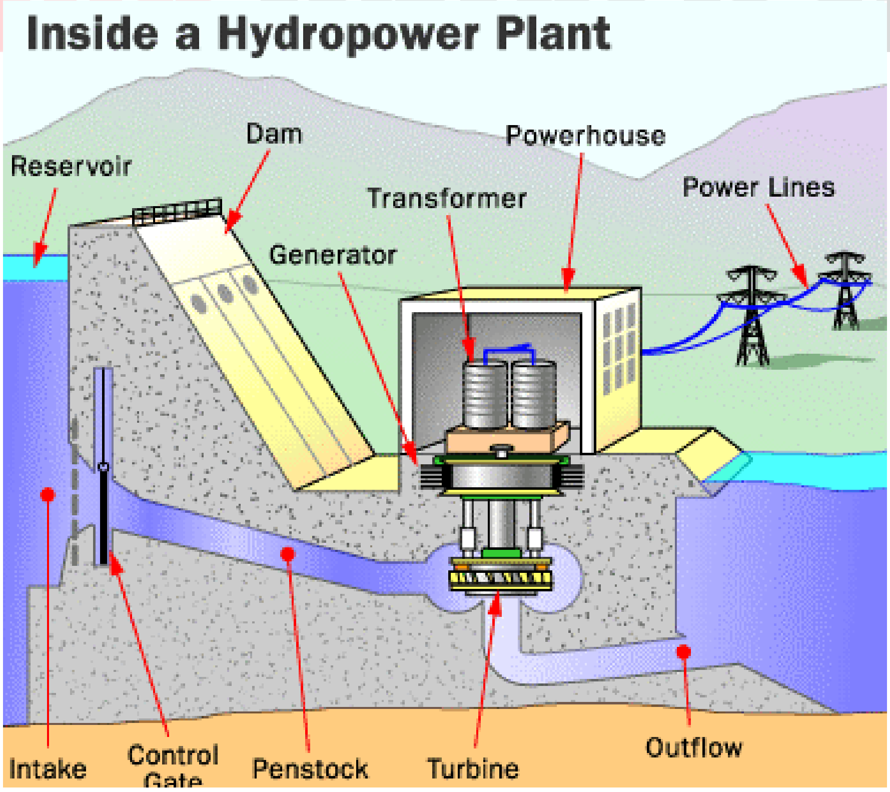
(Empowering Students with 21st Century Skills)

DEPARTMENT OF MECHANICAL ENGINEERING

LAB MANUAL

FOR

Fluids Machinery Lab (MEC361)



Vision of the Department

The Mechanical Engineering Department aims to be recognized as an outstanding educational centre to develop innovative engineers who are proficient in advanced fields of engineering and technology and can contribute effectively to the industry as well as for socio-economic upliftment of the society.

Mission of the Department

M1: To impart outcome-based education with a research orientation to the students to develop them as globally competitive engineers.

M2: To imbibe the students with academic, leadership and entrepreneurship skills needed by the industry in particular and society in general.

M3: To adopt flexibility and dynamism in designing the programme structures to cope up with emerging market needs.

M4: Establishment of liaison with top R & D organizations/Industries and leading educational institutions for practical exposure of the students and faculty as well as to the state of the art.

Programme Educational Outcomes (PEOs)

After the successful completion of undergraduate course, Mechanical Engineering, Graduates will be able to:

PEO1: Plan, design, construct, maintain and improve mechanical engineering systems that are technically sound, economically feasible and socially acceptable.

PEO2: Apply analytical, computational and experimental techniques to address the challenges faced in mechanical and allied engineering streams.

PEO3: Communicate effectively using conventional platforms as well as innovative / online tools and demonstrate collaboration, networking & entrepreneurial skills.

PEO4: Exhibit professionalism, ethical attitude, team spirit and pursue lifelong learning to achieve career, organizational and societal goals.

Program Outcomes (POs) - B. Tech. Mechanical Engineering

PO1: Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO2: Problem analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO3: Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO4: Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO5: Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

PO6: The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues, and the consequent responsibilities relevant to the professional engineering practice.

PO7: Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PO8: Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

PO9: Individual and teamwork: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO10: Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

PO11: Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments

PO12: Life-long learning: Recognize the need for and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Program Specific Outcomes (PSO) - B. Tech. Mechanical Engineering

PSO1: Apply mechanical and interdisciplinary knowledge to analyze, design and manufacture products to address the needs of the society.

PSO2: Apply state of the art tools and techniques to conceptualize, design and introduce new products, processes, systems and services.

DAV UNIVERSITY

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Department of Mechanical Engineering

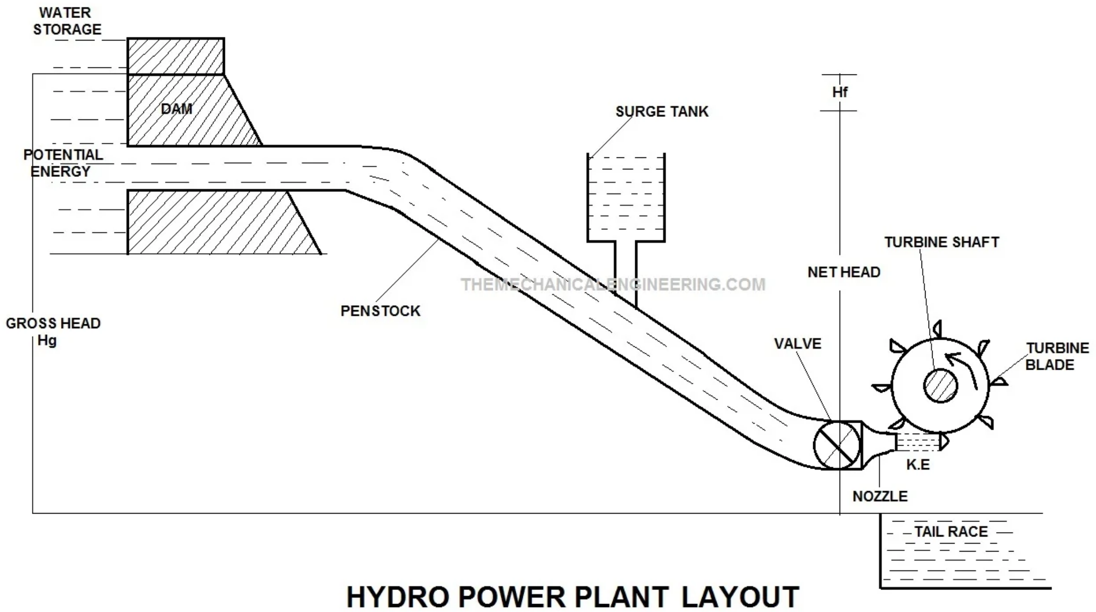
L	T	P	Credits
0	0	2	1

Course Code	MEC361								
Course Title	**Fluids Machinery Lab**								
Course Outcomes	On the completion of the course the student will be able to: CO1: Understand the structure and properties of the fluid CO2: Use and apply dimensional analysis techniques to various physical fluid phenomena. CO3: Recognize basic components of turbo machines and understand related fundamental laws/ principles and apply these for calculation of various parameters like work done, force efficiency etc. CO4: Understand constructional details, working and design aspects of runner/wheel. CO5: Evaluate the performance of various turbines like Pelton, Francis, Kaplan, Centrifugal and Reciprocating pump								
Examination Mode	Practical								
Assessment Tools	Continuous Assessment (CA)				MSE	MSP	ESE	ESP	Total
	Quiz	Assignment/ Project Work	Attendance	Lab Performance					
Weightage	-	-	-	20%	-	30%	-	50%	100

S. No.	LIST OF EXPERIEMENTS	CO Mapping
1.	To study the model of Hydro power plant and draw its layout.	CO1
2.	To study the constructional details of a Centrifugal Pump and draw its characteristic curves.	CO1
3.	To study the constructional details of a Reciprocating Pump and draw its characteristics curves.	CO2
4.	To study the performance characteristics of Pelton turbine and draw constant head, constant speed and constant efficiency curves.	CO2
5.	To study the construction details of a Gear oil pump and its performance curves.	CO3
6.	To draw the constant head, constant speed and constant efficiency performance characteristics of Francis turbine.	CO3
7.	To study the constructional details of a Hydraulic Ram and determine its various efficiencies.	CO4
8.	To draw the constant head, speed and efficiency curves for a Kaplan turbine.	CO4
9.	Study and perform test on a Torque Convertor.	CO5

EXPERIMENT NO. 1

AIM: To study the model of hydroelectric power plant and Draw its layout.



HYDRO POWER PLANT LAYOUT

Apparatus: Model of hydroelectric power plant.

Hydro Power Plant Definition:

Hydro Power Plant is an electricity-producing plant in which the water is an essential fuel, the potential energy is being converted into kinetic energy and kinetic energy is further converted into mechanical and into electrical energy with the help of a turbine and motor.

Hydro Power Plant Layout or Construction:

The following Construction or Layout of Hydro Power Plant:

a) Headpond or Reservoir
b) Control gate
c) Penstock
d) Turbine
e) Draft Tube
f) Tail Race
g) Transmission Line
h) Generator
i) Transformer
j) Power House

Hydro Power Plan Site Selection:

The factor which includes for selection of Hydro Power plant are:

a) Environmental effect
b) The water availability
c) Water storage
d) Head of water
e) Site accessibility
f) Distance from the load center
g) Types of the land of the site
h) Water Pollution
i) Geological Investigation

Hydro Power Plant Advantages:

The following advantages of Hydro Power plant are:

a. Hydro-generation has a unique and significant role to play particularly in the operation of interconnected power systems.

b. The operating cost of the hydroelectric plant including auxiliaries is considerably low when compared with thermal plants. The annual operating and maintenance cost of a thermal plant is approximately 5- 6 times that of a hydro plant of equal capacity.
c. These are simple in design easy to maintain, pollution-free with zero fuelling cost.
d. The cost of power generation is less.
e. The life expectancy of a hydroelectric power plant is more. The useful life of a thermal plant is 20-25 years as against 100-125 years for the hydro plants.
f. There is no problem with handling the fuel and ash and no nuisance of smoke exhaust gases and spots and no health hazards due to air pollution.
g. The fuel needed for the thermal plant has to be purchased, whereas in Hydro-plant the fuel cost is totally absent.
h. Hydroelectric plants are quick to respond to the change of load compared with thermal Power Plant or nuclear plants.
i. The rapidly fluctuating loads are served most economically by Hydro-plant.
j. The machines used in hydel plants are more robust and generally run at low speeds at 300-400 RPM, whereas the machines used in thermal plants run at a speed of 3000- 4,000 RPM.
k. The efficiency of the hydro plants does not change with age, but there is a considerable reduction in the Efficiency of thermal as well as a nuclear power plant with age.
l. In a hydroelectric plant, there are no standby losses, whereas these are unavoidable for thermal plants and the number of operations required is considerably small compared with the thermal power plant.
m. It does not contribute to air and water pollution to the greenhouse effect
n. Usually, the hydro station is situated away from the developed area therefore the cost of land is not a major problem.

Hydro Power Plant Disadvantages:

The following disadvantages of Hydro Power plant are:

a. The capital cost (cost per kilowatt capacity) installed) of the hydro plant is considerably more than the thermal plant.
b. It takes a considerable long time for its erection compared with thermal plants.
c. Power generation by the hydro plant is only dependent on the quantity of water available which in turn depends on the natural phenomenon of rain. The dry year is more serious for the hydroelectric project.
d. The site of Hydroelectric station is selected on the criterion of water availability at economical head such sites are usually away from the load center.
e. The transmission of power from the power station to the load center requires along transmission lines. Therefore, investment required for long transmission lines and loss of power during transmission is an unfavourable factor for the economical selection of hydro plants.

<u>EXPERIMENT NO. 2</u>

OBJECTIVE:

Study of centrifugal pump characteristics.

AIM:

1. To conduct a test on single stage centrifugal pump at variable speed to study the pump characteristics.
2. To plot the operating characteristics curves.

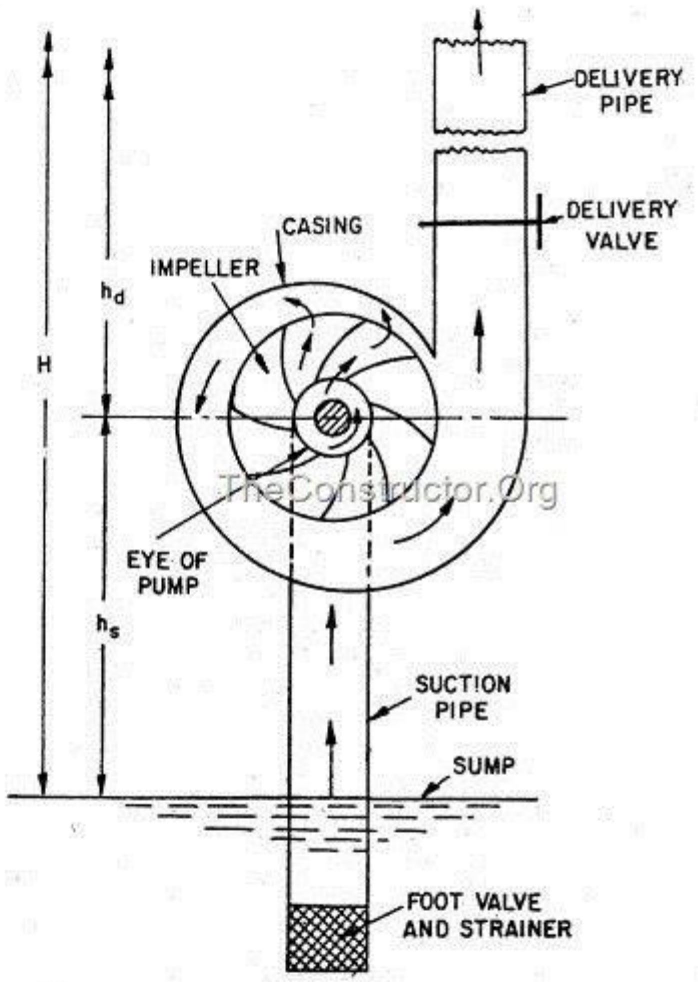
INTRODUCTION:

The hydraulic machines, which convert the mechanical energy into hydraulic energy, are called pumps. The hydraulic energy is in the form of pressure energy. If the mechanical energy is converted into pressure energy by means of centrifugal force acting on the fluid, the hydraulic machine is called centrifugal pump.

THEORY:

The centrifugal pump acts as a reserved of an inward flow reaction turbine. This means that the flow in centrifugal pumps in the radial outward directions. The centrifugal pump works on the principle of forced vortex flow, which means that an external torque rotates a certain mass of liquid, the rise in pressure head of the rotating liquid takes place. The rise in pressure head at any point of the rotating liquid is proportional to the square of tangential velocity of (i.e. rise in pressure head = $\mathbf{V^2/2g}$ **or** $\mathbf{\omega^2 r^2/2g}$) the liquid at that point. Thus at the outlet of the impeller where radius is more, the rise in pressure head will be more and the liquid will be discharged at the outlet with high pressure head. Due to this high pressure head, the liquid can be lifted to a high level.

Centrifugal pump is a mechanical device, which consists of a body, impeller and a rotating mean i.e. motor, engine etc. Impeller rotates in a stationary body and sucks the fluid through its axes and delivers through its periphery. Impeller has an inlet angle, outlet angle and peripheral speed, which affect the head and discharge. Impeller is rotated by motor or IC engine or any other device.



EXPERIMENTAL PROCEDURE:

STARTING PROCEDURE:

1. Clean the apparatus and make all tank free from dust.
2. Close the drain valves V_5 and V_6.
3. Fill sump tank ¾ with clean water and ensure that no foreign particles are there.
4. Open flow control valve V_1 given on the water discharge line and control valve V_2 given on suction line.
5. Ensure that all ON/OFF switches given on the panel are at OFF position. Switch on the motor.
6. Set the desired RPM of pump with the speed control knob provided at the control panel.
7. Operate the flow control valve V_1 to regulate the flow of water discharged by the pump.
8. Operate the control valve V_2 to regulate the suction of the pump.
9. Record discharged pressure by means of pressure gauge, provide on discharge line.
10. Record discharged pressure by means of vacuum gauge, provide at suction of the pump.
11. Record the time for 10-20 pulses by means of energy meter and stop watch.
12. Measure the discharged water by using measuring tank and stop watch.
13. Repeat the same procedure for different discharged with constant speed.
14. Repeat the same procedure for different speed of pump.

CLOSING PROCEDURE:

1. When experiment is over, open valve V_1 provide on discharge line.
2. Reduce the RPM of the pump with the help of DC Drive to zero.
3. Switch OFF the pump.
4. Switch OFF power supply to panel.
5. Drain the tanks by valve $V_5$and V_6.

OBSERVATION AND CACULATION:

Data:	
Acceleration due to gravity=9.8m/sec^2	Area of measuring tank A=0.128m^2
Energy meter constant EMC=3200 Pulses/kW-hr	Density of water P_w =1000kg/m^3
Height of pressure gauge from suction of pump h_{pg}=1 m	Motor efficiency η_m=0.8

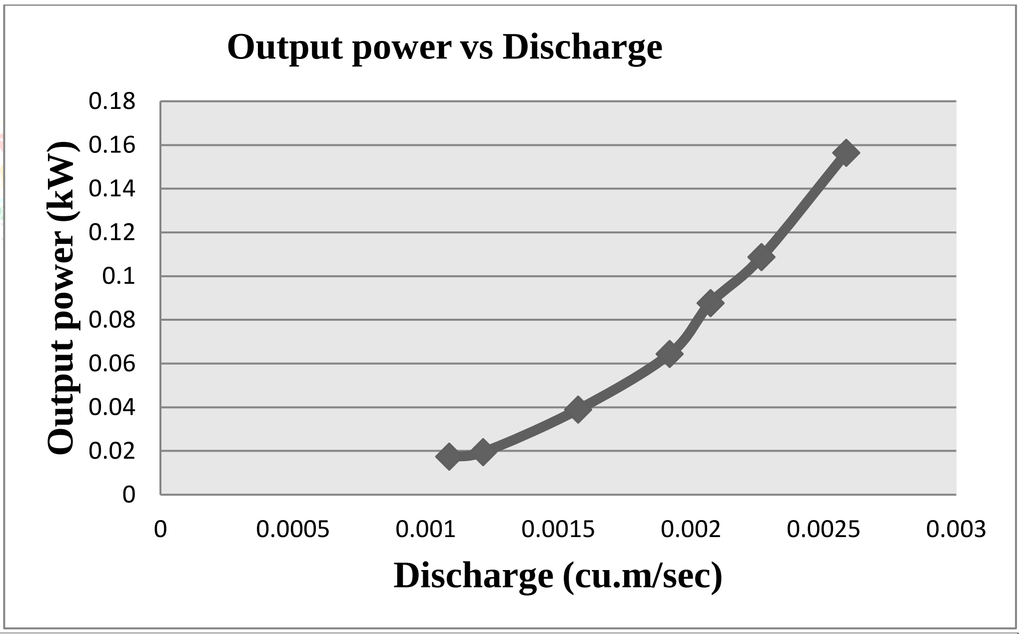
OBSERVATION TABLE:

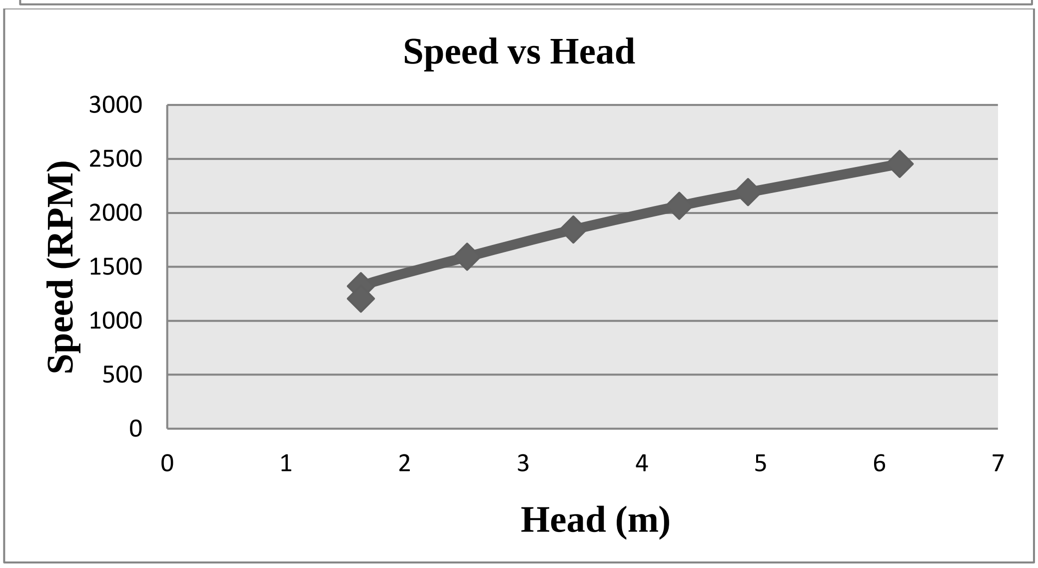
S.No.	N (RPM)	P_d (kg/cm^2)	P_s (mmHg)	R_1(cm)	R_2(cm)	t(s)	P	t_p(s)
1	2453	0.3	165	5	25.2	10	10	21.7
2	2190	0.225	125	25.2	42.9	10	10	26
3	2064	0.2	100	15	31.2	10	10	29.5
4	1844	0.15	70	16	31	10	10	37
5	1592	0.1	40	15	27.3	10	10	48.7
6	1320	0.05	10	14	23.5	10	10	71
7	1205	0.05	10	19	27.5	10	10	79

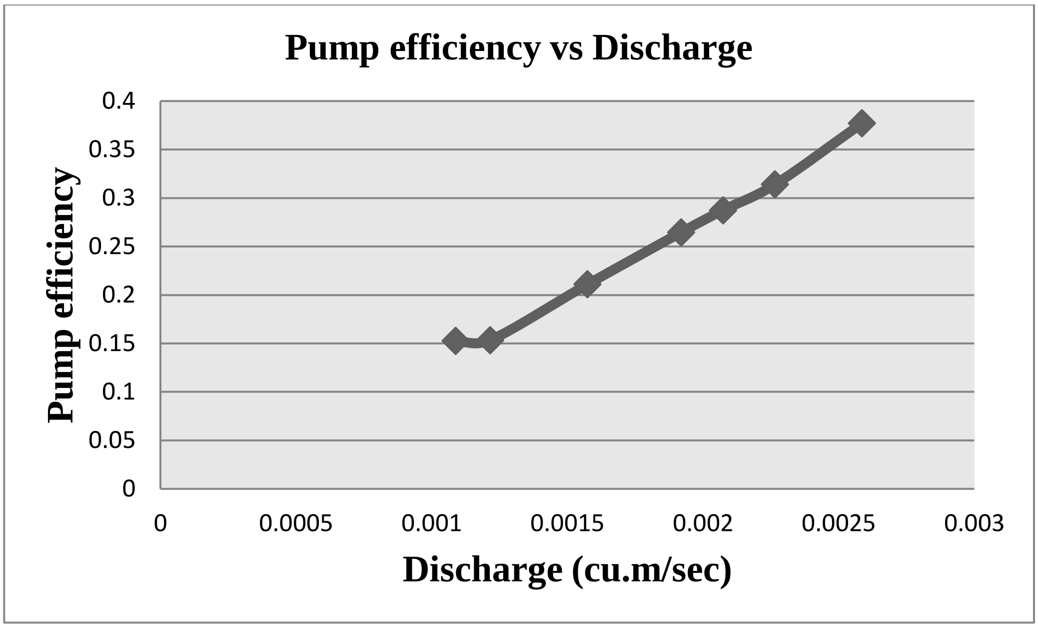
CALCULATION TABLE:

S.No.	H (m)	Q (m^3/sec)	R (m)	E_i (kW)	E_s (kW)	E_o (kW)	η_o	η_p
1	6.171053	0.0025856	0.202	0.518433	0.414747	0.156368	0.3016166	0.37702
2	4.894737	0.0022656	0.177	0.432692	0.346154	0.108677	0.2511648	0.313956
3	4.315789	0.0020736	0.162	0.381356	0.305085	0.087702	0.22997409	0.287467
4	3.421053	0.00192	0.15	0.304054	0.243243	0.064371	0.2117091	0.264637
5	2.526316	0.0015744	0.123	0.231006	0.184805	0.038979	0.16873588	0.21092
6	1.631579	0.001216	0.095	0.158451	0.126761	0.019443	0.1227067	0.153383
7	1.631579	0.001088	0.085	0.142405	0.113924	0.017397	0.12216565	0.152707

OPERATING CHARACTERISTIDS CURVE







PRECAUTION AND MAINTENANCE INSTRUCTION:

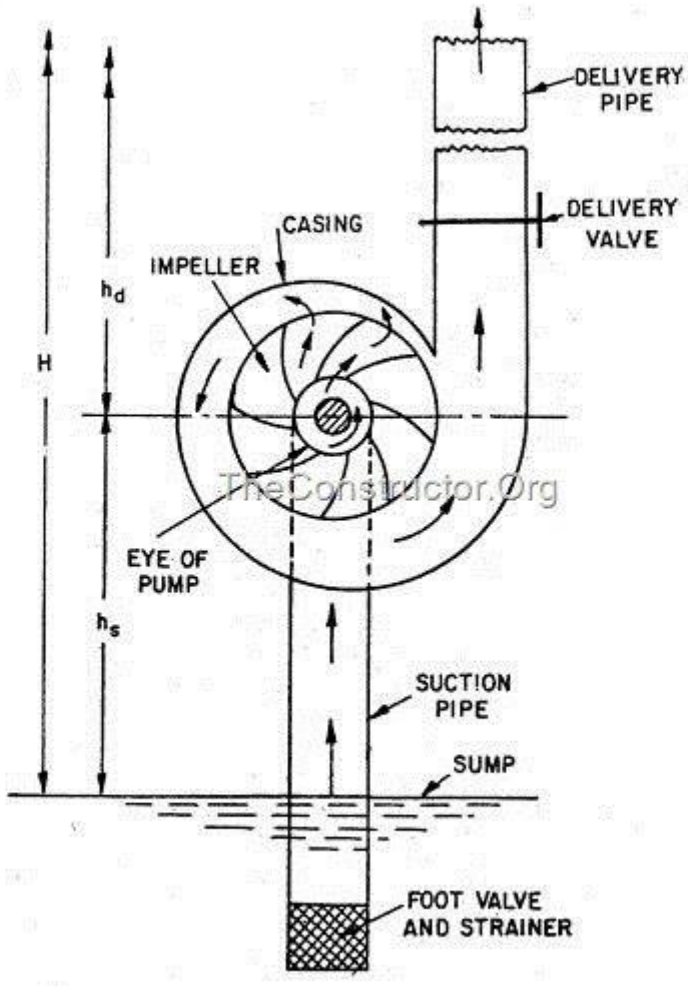
1. Never run the apparatus if power supply is less than 200v and more than 230v.
2. Never fully close the delivery line valve V_1.
3. To prevent clogging of moving parts, run pump at least once in a fortnight.

EXPERIMENT NO. 3

OBJECTIVE:
Study of centrifugal pump characteristics.
AIM: -

1. To conduct a test on single stage centrifugal pump at constant speed to study the pump characteristics.
2. To plot the operating characteristics curves.

INTRODUCTION:
The hydraulic machines, which convert the mechanical energy into hydraulic energy, are called pumps. The hydraulic energy is in the form of pressure energy. If the mechanical energy is converted into pressure energy by means of centrifugal force acting on the fluid, the hydraulic machine is called centrifugal pump.
THEORY:
The centrifugal pump acts as a reserved of an inward flow reaction turbine. This means that the flow in centrifugal pumps in the radial outward directions. The centrifugal pump works on the principle of forced vortex flow, which means that an external torque rotates a certain mass of liquid, the rise in pressure head of the rotating liquid takes place. The rise in pressure head at any point of the rotating liquid is proportional to the square of tangential velocity of (i.e. rise in pressure head = $\mathbf{V^2/2g}$ **or** $\boldsymbol{\omega^2 r^2/2g}$) the liquid at that point. Thus at the outlet of the impeller where radius is more, the rise in pressure head will be more and the liquid will be discharged at the outlet with high pressure head. Due to this high pressure head, the liquid can be lifted to a high level.
Centrifugal pump is a mechanical device, which consists of a body, impeller and a rotating mean i.e. motor, engine etc. Impeller rotates in a stationary body and sucks the fluid through its axes and delivers through its periphery. Impeller has an inlet angle, outlet angle and peripheral speed, which affect the head and discharge. Impeller is rotated by motor or IC engine or any other device.



EXPERIMENTAL PROCEDURE:

STARTING PROCEDURE:

1. Clean the apparatus and make all tank free from dust.
2. Close the drain valves V_5 and V_6.
3. Fill sump tank ¾ with clean water and ensure that no foreign particles are there.
4. Open flow control valve V_1 given on the water discharge line and control valve V_2 given on suction line.
5. Ensure that all ON/OFF switches given on the panel are at OFF position. Switch on the motor.
6. Set the desired RPM of pump with the speed control knob provided at the control panel.
7. Operate the flow control valve V_1 to regulate the flow of water discharged by the pump.
8. Operate the control valve V_2 to regulate the suction of the pump.
9. Record discharged pressure by means of pressure gauge, provide on discharge line.
10. Record discharged pressure by means of vacuum gauge, provide at suction of the pump.
11. Record the time for 10-20 pulses by means of energy meter and stop watch.
12. Measure the discharged water by using measuring tank and stop watch.
13. Repeat the same procedure for different discharged with constant speed.
14. Repeat the same procedure for different speed of pump.

CLOSING PROCEDURE:

1. When experiment is over, open valve V_1 provide on discharge line.
2. Reduce the RPM of the pump with the help of DC Drive to zero.
3. Switch OFF the pump.
4. Switch OFF power supply to panel.
5. Drain the tanks by valve $V_5$and V_6.

OBSERVATION AND CACULATION:

Data:	
Acceleration due to gravity=9.8m/sec^2	Area of measuring tank A=0.128m^2
Energy meter constant EMC=3200 Pulses/kW-hr	Density of water P_w =1000kg/m^3
Height of pressure gauge from suction of pump h_{pg}=1 m	Motor efficiency η_m=0.8

OBSERVATION TABLE:

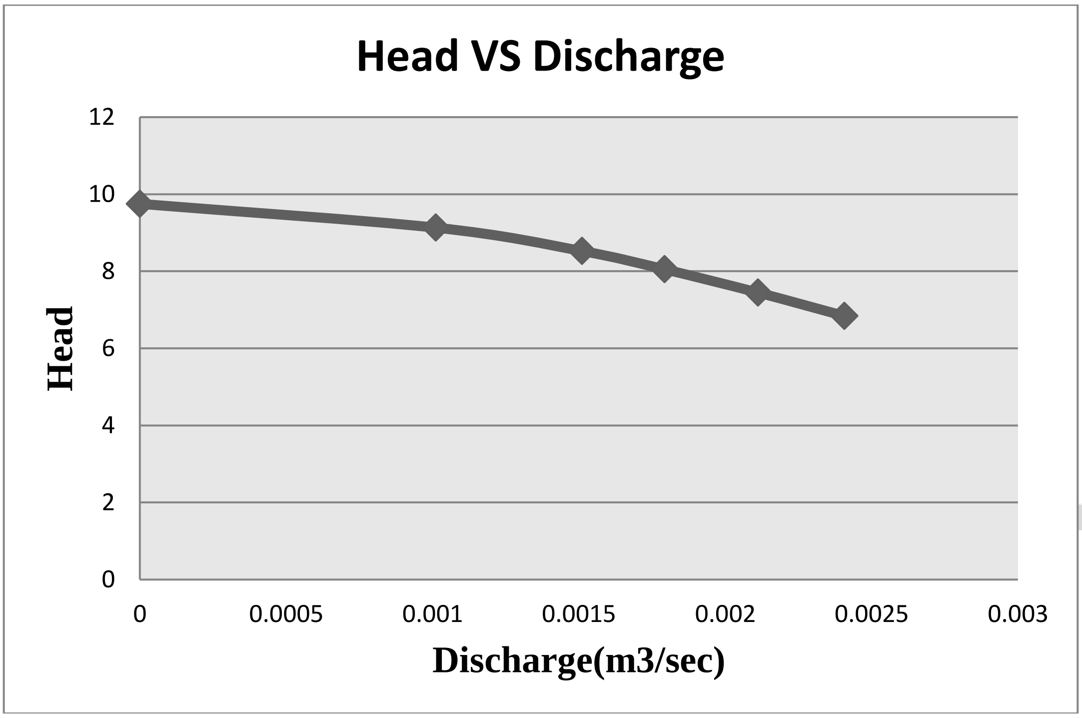
S.No.	P_d (kg/cm^2)	P_s (mmHg)	R_1(cm)	R_2(cm)	t(s)	P	t_p(s)
1	0.875	0	0	0	10	10	38.3
2	0.8	10	8	15.9	10	10	35.1
3	0.7	40	15.9	27.7	10	10	26.3
4	0.6	80	14	28	10	10	24.2
5	0.5	110	13.5	30	10	10	22.9
6	0.4	140	12.2	31	10	10	22

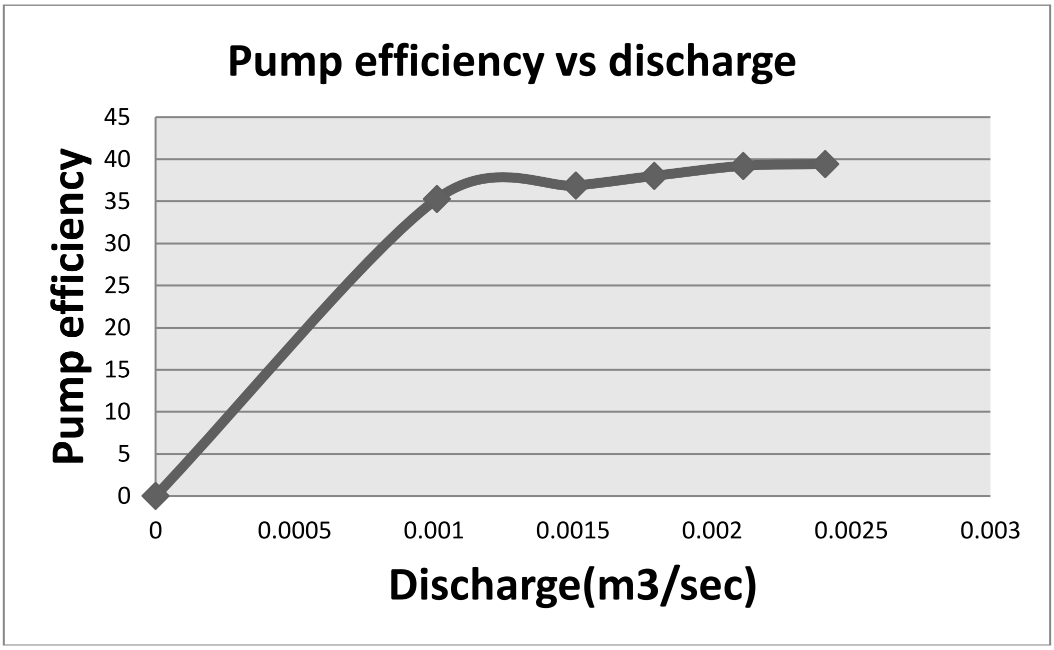
CALCULATION TABLE:

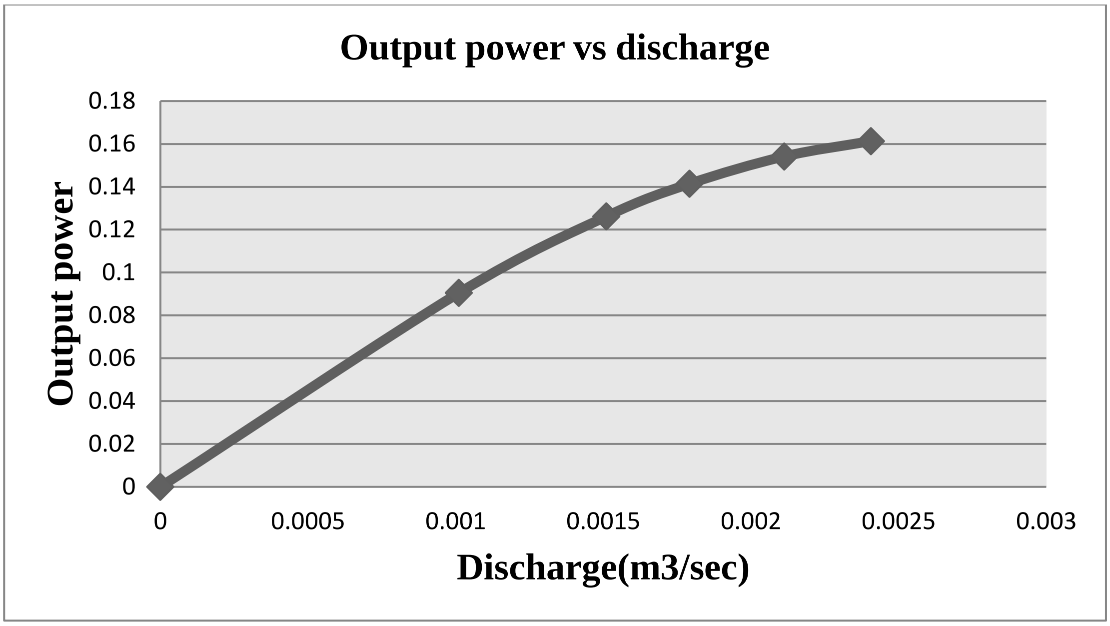
S.No.	H (m)	Q (m^3/sec)	R (m)	E_i (kW)	E_s (kW)	E_o (kW)	η_o	η_p
1	9.75	0	0	0.293734	0.234987	0	0	0

2	9.131579	0.001011	0.079	0.320513	0.25641	0.090474	28.22784	35.2848
3	8.526316	0.00151	0.118	0.427757	0.342205	0.126172	29.49631	36.87039
4	8.052632	0.001792	0.14	0.464876	0.371901	0.141417	30.42039	38.02549
5	7.447368	0.002112	0.165	0.491266	0.393013	0.154143	31.37659	39.22074
6	6.842105	0.002406	0.188	0.511364	0.409091	0.161329	31.54871	39.43589

OPERATING CHARACTERISTICS CURVE







PRECAUTION AND MAINTENANCE INSTRUCTION:

1. Never run the apparatus if power supply is less than 200V and more than 230V.
2. Never fully close the delivery line valve V_1.
3. To prevent clogging of moving parts, run pump at least once in a fortnight.

EXPERIMENT NO. 4

OBJECTIVE:
Study of centrifugal pump in series and parallel.
AIM:
1. To conduct a test on centrifugal pump in parallel at constant head.
2. To plot the operating characteristics curve.

INTRODUCTION:
The hydraulic machines, which convert the mechanical energy into hydraulic energy, are called pumps. The hydraulic energy is in the form of pressure energy. If the mechanical energy is converted into pressure energy by means of centrifugal force acting on the fluid, the hydraulic machine is called centrifugal pump.
THEORY:
The centrifugal pump acts as a reversed of an inward radial flow reaction turbine. This means that the flow in centrifugal pumps is in the radial outward directions. The centrifugal pump works on the principle of forced vortex flow, which means that an external torque rotates a certain mass of liquid, the rise in pressure head at any point of the rotating liquid is proportional to the square of tangential velocity of (i.e. rise in pressure head =$\mathbf{V^2/2g}$ **or** $\mathbf{\omega^2 r^2/2g}$) the liquid at that point. Thus at the outlet of the impeller where radius is more, a high- pressure head. Due to this high-pressure head, the liquid can be lifted to a high level.
Centrifugal pump is a mechanical device, which consists of a body, impeller and a rotating mean i.e. motor, engine etc. Impeller rotates in a stationary body and sucks the fluid through its axes and delivers through its periphery. Impeller has an inlet angle, outlet angle and peripheral speed. Which affect the head and discharge . Impeller is rotated by motor or i.e. engine or any other device.

MULTISTAGE CENTRIGUGAL PUMP:
A centrifugal pump consisting two or more impellers; the pump is called a multistage centrifugal pump. A multi stage pump is having the following two important functions:
1. To produce a high head.
2. The discharge a large quantity of liquid.

If a high head is to be developed, the impellers are connected in series while for discharging large quantity of liquid; the impellers are connected in parallel.
DESCRIPTION:
The present centrifugal pump Test Rig is a self-contained unit operated on closed circuit basis containing a sump tank. The set-up consists of two Centrifugal pumps. Both pumps are coupled with individual DC motors are varied by means of Thyristor controlled DC Drives to vary the RPM of motor. Two RPM Indicator with Proximity sensor indicates the RPM of each Pump separately. Flow of water is measured by using tank and stop watch. Vacuum Gauges are fitted on suction line and Pressure Gauges are fitted on delivery line of each pump to measure the pressure. Valves are provided at the outlets and inlets of pump to change the mode (i.e. Single Pump, Pumps in Parallel and Pumps in Series).

Valve Operating to change mode are given in the following table:

Mode	**V_1**	**V_2**	**V_3**	**V_4**	**V_5**	**V_6**
Single Stage,pump1	open	open	close	close	Open	close
Two Stage, Parallel	open	open	open	close	Open	open
Two Stage, Series	open	close	open	open	Open	close

EXPERIMENTAL PROCEDURE:

STARTING PROCEDURE:

1. Clean the apparatus and make all tanks free from dust.
2. Close the drain valve V10 and V11 are provided.
3. Fill sump tank 3/4th with clean water and ensure that no foreign particles are there.
4. Select mode of operation (Single Stage, Parallel or Series) and open valves as per selected mode.
5. Ensure that all On/Off switches given on the panel are at OFF position.
6. Now switch on the main power supply (220 V AC,50Hz) and switch on the pump.
7. Set the desired RPM of pump.
8. Operate the flow control valve V_1 to regulate the flow of water discharged by the pump.
9. Record discharge pressure by partially open the valve V_7.
10. Record suction pressure by partially open valves V_8 and V_9.
11. Record the time for 10-20 Pulses by energy meter and stop watch.
12. Measure the discharged by measuring tank and stop watch.
13. Repeat the same procedure for different discharged with constant speed.
14. Repeat the same procedure for different speeds of pump.

CLOSING PROCEDURE:

1. When the experiment is over, open valve V_1.
2. Reduce the RPM of the pump with the help of DC drive.
3. Switch OFF the pump.
4. Switch OFF the power supply to panel.

OBSERVATION AND CALCULATION:

DATA:	
Area of measuring tank A=0.296 m^2	Acceleration due to gravity g=9.81m/s^2
Motor efficiency η_m=0.8	Energy meter constant EMC=3200Pulses/kW-hr
Density of water ρ_w=1000kg/m^3	Height of pressure gauge from suction of pump $h_{\rho g}$=1m

OBSERVATION TABLE:

Two stage parallel pump										
S.No.	**N_1 (RPM)**	**P_{s1} (mmHg)**	**N_2 (RPM)**	**P_{s2} (mmHg)/ (kg/cm^2)**	**P_d (kg/cm^2)**	**R_1 (cm)**	**R_2 (cm)**	**t(s)**	**P**	**t_p (s)**
1	2460	120	2460	1	0.2	6	22.5	10	10	12
2	2460	100	2460	1	0.4	11.5	26.5	10	10	13
3	2460	80	2460	0.7	0.5	11.5	25	10	10	13
4	2460	60	2460	0.2	0.6	11.5	23	10	10	14

Two stage series pump

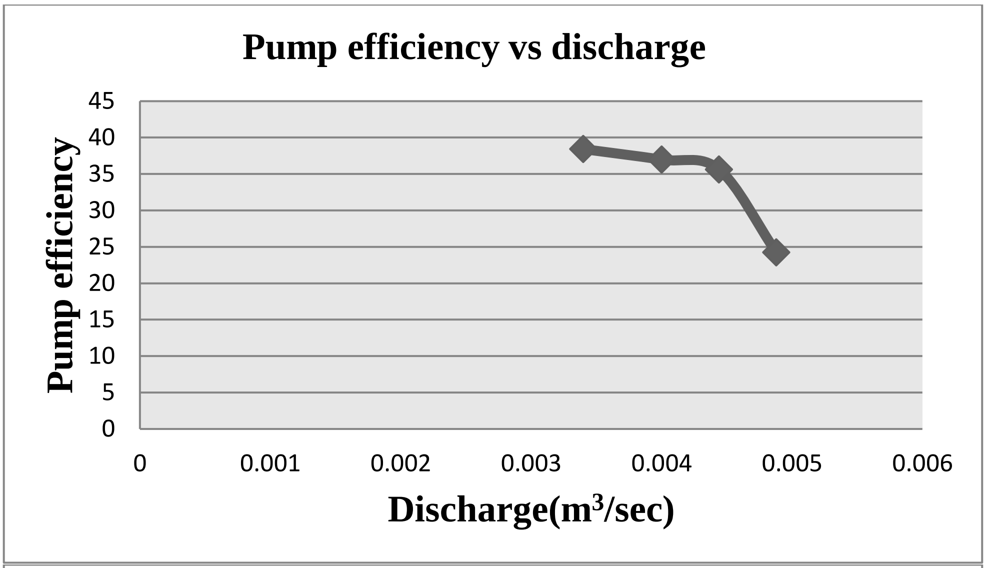
S.No.	N_1 (RPM)	P_{s1} (mmHg)	N_2 (RPM)	P_{s2} (mmHg)/ (kg/cm^2)	P_d (kg/cm^2)	R_1 (cm)	R_2 (cm)	t(s)	P	t_p (s)
1	2460	150	2460	0.7	0.2	9.5	17.5	10	10	12
2	2460	160	2460	0.75	0.2	10	11	10	10	13
3	2460	150	2460	0.6	0.3	10	11	10	10	13
4	2460	125	2460	0.3	0.6	9.5	17	10	10	14

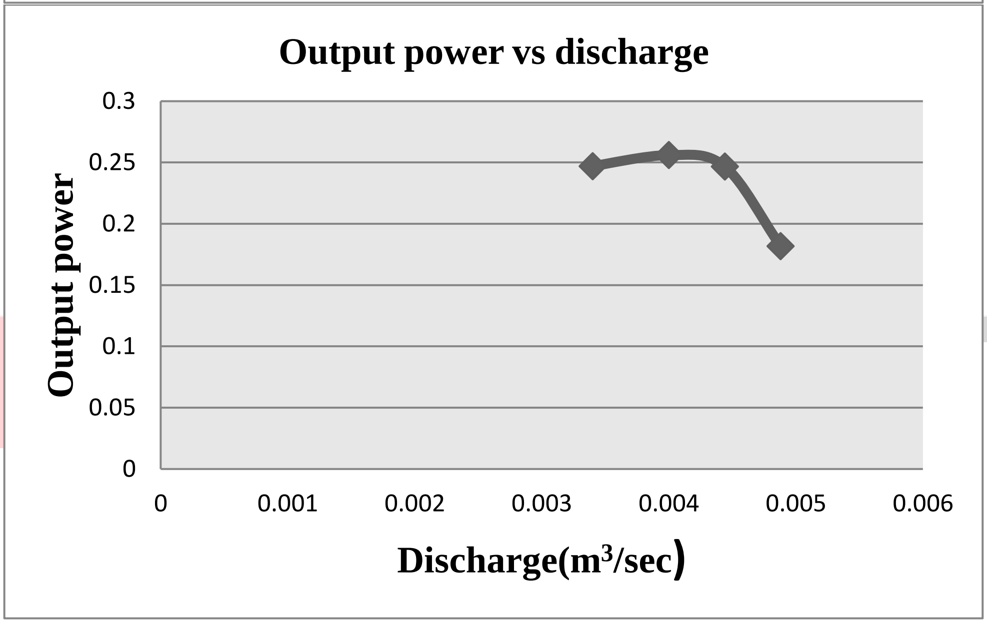
CALCULATION TABLE:

Two stage parallel pump								
S.No.	R(m)	Q(m^3/sec)	H(m)	E_i(kW)	E_s(kW)	E_o(kW)	η_o(%)	η_p(%)
1	0.165	0.00488	3.79605263	0.938	0.75	0.18187663	19.4001734	24.2502167
2	0.15	0.00444	5.66447368	0.865	0.692	0.24672408	28.5103383	35.6379229
3	0.135	0.004	6.53092105	0.865	0.692	0.25601707	29.5841946	36.9802433
4	0.115	0.0034	7.39605263	0.804	0.643	0.24697816	30.73506	38.418825

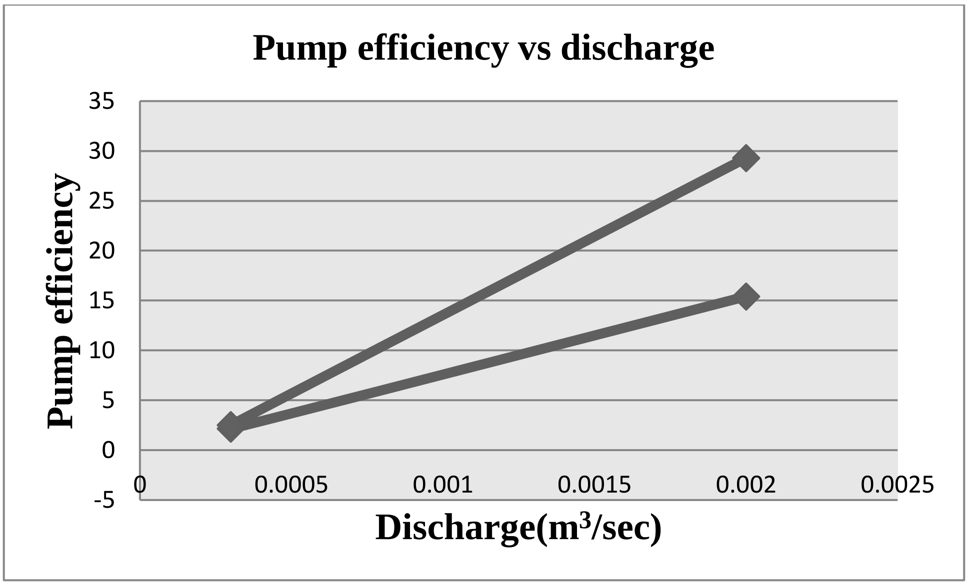
Two stage series pump								
S.No.	R(m)	Q(m^3/sec)	H(m)	E_i(kW)	E_s(kW)	E_o(kW)	η_o(%)	η_p(%)
1	0.08	0.002	4.97368421	0.938	0.75	0.116	12.32	15.41
2	0.01	0.0003	5.10526316	0.865	0.692	0.015	1.713	2.141
3	0.01	0.0003	5.97368421	0.865	0.692	0.017	2.004	2.506
4	0.075	0.002	8.64473684	0.804	0.643	0.188	23.43	29.29

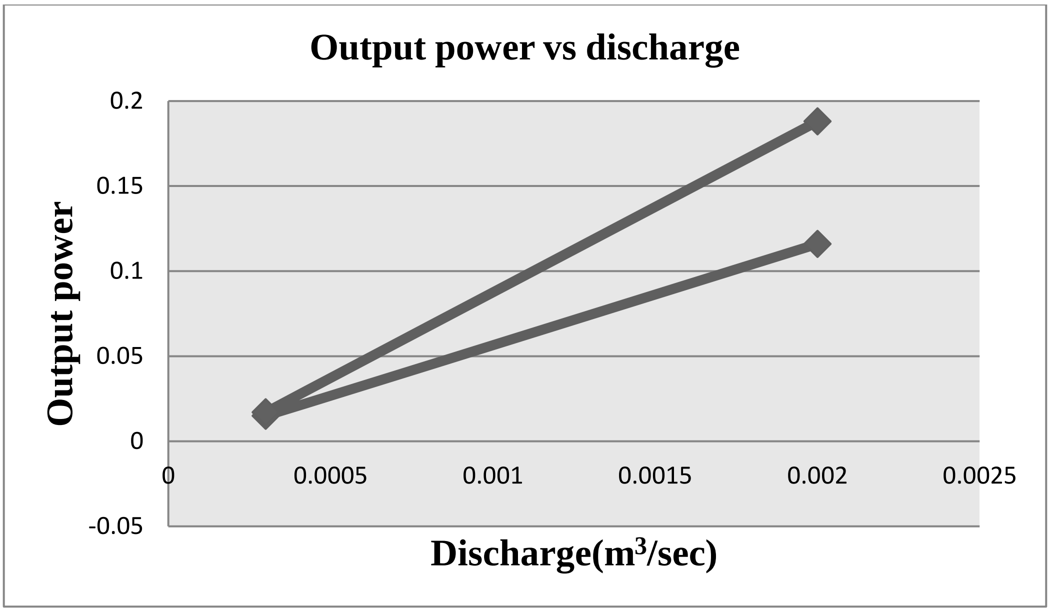
PERFORMANCE CHARACTERISTICS CURVE:
FOR PARALLEL PUMP:





FOR SERIES PUMP:





PRECAUTION AND MAINTENANCE INSTRUCTION:

1. Never run the apparatus if power supply is less than 200V and more than 230V.
2. Never fully close the delivery line valve V_1.
3. To prevent clogging of moving parts, run pump at least once in a fortnight.

EXPERIMENT NO. 5

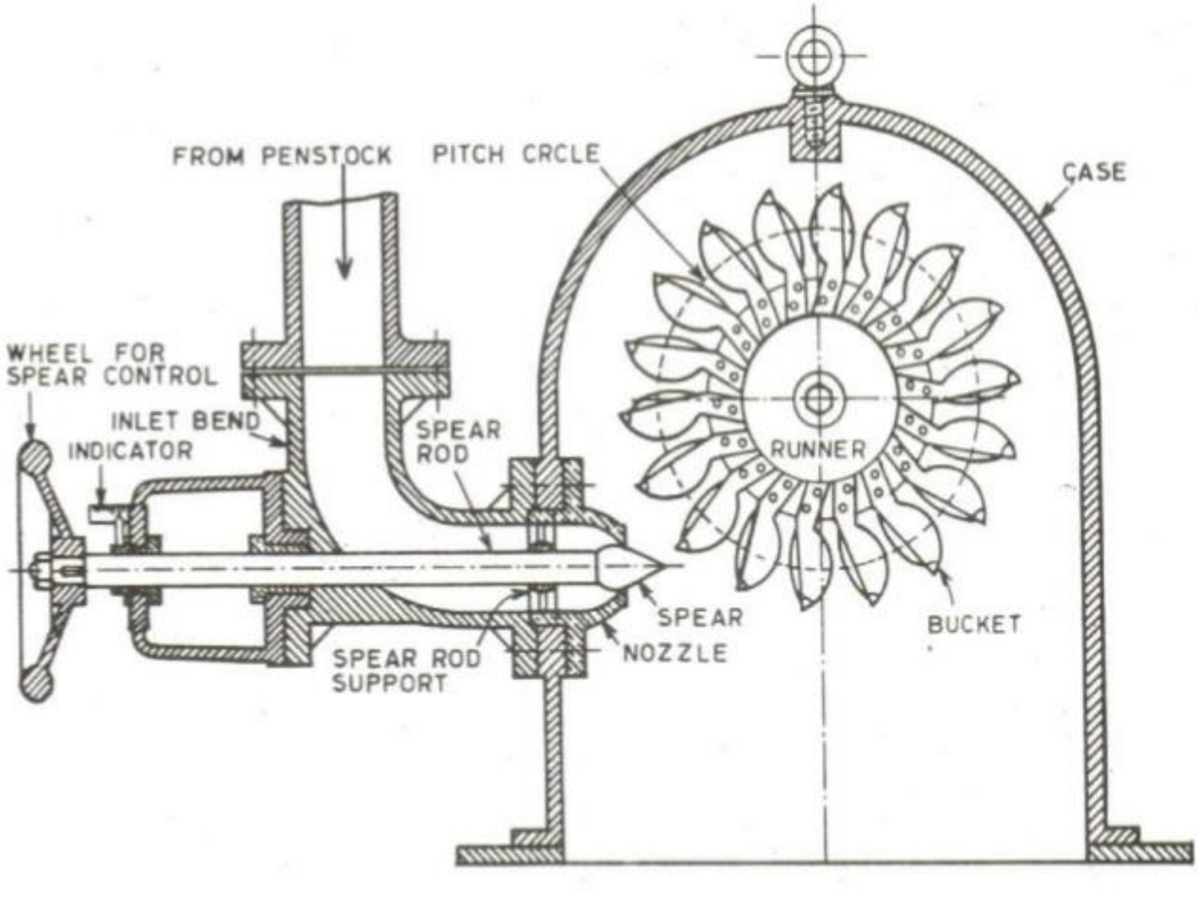
OBJECTIVE:
To study the operation of a Pelton Turbine at constant Head.

AIM:
1. To determine the output power of Pelton Turbine.
2. To determine the efficiency of the Pelton Turbine.

INTRODUCTION:
A turbine is a machine which converts the fluid energy into mechanical energy which is then utilized to run the electric generator of a power plant. Fluid used can be water or steam. The Pelton wheel is a tangential flow impulse turbine. The water strikes the bucket along the tangent of the runner. The pressure at the inlet and outlet of the turbine is atmospheric. The turbine is used for high head.

THEORY:
Pelton turbine is an impulse turbine. In an impulse turbine, all the available energy of water is converted into kinetic or velocity head by passing it through a contracting nozzle provided at the end of the penstock. The water coming out of the nozzle is formed into a free jet, which strikes on a series of buckets of the runner thus causing it to revolve. The runner revolves freely in air. The water contacts only a part of the runner at a time, and throughout its action on the runner.

DESCRIPTION:
The set up consists of centrifugal pump, turbine unit, and sump tank, arranged in such a way that the whole unit works as re-circulating water system. The centrifugal pump supplies the water from sump tank to the turbine. The loading of the turbine is achieved by eddy current dynamometer. The turbine unit can be visualized by a large circular transparent window kept at the front. A bearing pedestals rotor assembly of shaft, runner and dynamometer, all mounted on suitable cast iron base plate. Discharge is measured by venture and manometer.



EXPERIMENTAL PROCEDURE:

SARTING PROCEDURE:
1. Clean the apparatus and make tank free from dust.
2. Close the drain valve V3.

3. Fill sump tank 3/4th with the clean water and ensure that no foreign particles are there.
4. Fill manometer fluid i.e. Hg in manometer.
5. Connect inlet water supply to the dynamometer and outlet from dynamometer to drain.
6. Supply water to the dynamometer for cooling purposes with the help of Valve V2.

   (**NOTE:-Maintain the preesure of water at 1kg/cm^2**)
7. Ensure that there is no load on the dynamometer.
8. Fully open the By pass valve V1.
9. Switch ON the MCB.
10. Switch ON the Pump with the help of starter.
11. Open the air release valve V6.V7 and valves for venture V4,V5 provided on the manometer, slowly to release the air from manometer. This should be done vey carefully.
12. When there is no air in the manometer, close the air release valves V6 and V7.
13. Now turbine is in operation.
14. Maintain the flow rate of water with the help of by pass valve V1.
15. Apply load on dynamometer with the help of knob provided on the control panel.
16. Maintain the maximum RPM of turbine by regulating the spear.
17. Note the manometer reading and pressure gauge reading.
18. Note the RPM of the turbine.
19. Note the load with the help of digital load indicator.
20. Repeat the same experiment for different load.
21. Repeat the same experiment for different discharge.

CLOSING PROCEDURE:

1. When the experiment is over, first remove load from the dynamometer.
2. Close the valves V4 and V5 provided on manometer.
3. Switch OFF Pump with the help of starter.
4. Switch OFF main power supply.
5. Shut the water supply to the dynamometer.
6. Drain water from sump tank by drain valve V3.

OBSERVATION AND CALCULATION:

<table>
<tr><td colspan="2">DATA:</td></tr>
<tr><td>Co-efficient of venture C_d= .97</td><td>Diameter of pipe D= 0.052m</td></tr>
<tr><td>Acceleration due to gravity g= 9.81m/s^2</td><td>Diameter of throat at venture D_t= 0.035m</td></tr>
<tr><td>Density of water ρ_w= 1000kg/m^3</td><td>Effective radius of dynamometer R_e= 0.145m</td></tr>
<tr><td colspan="2">Density of manometer fluid (Hg) ρ_m= 13600kg/m^3</td></tr>
</table>

OBSERVATION TABLE FOR CONSTANT HEAD:

<table>
<tr><td>h1=2.5cm</td><td>h2=20.2cm</td><td>h=2.2302m</td><td>P_d=3.2kg/cm^2</td><td>H=32m</td></tr>
<tr><td>S.NO.</td><td colspan="2">Load(KN)</td><td colspan="2">Speed (RPM)</td></tr>
<tr><td>1</td><td colspan="2">0.07</td><td colspan="2">1590</td></tr>
<tr><td>2</td><td colspan="2">0.42</td><td colspan="2">1540</td></tr>
<tr><td>3</td><td colspan="2">1.37</td><td colspan="2">1468</td></tr>
<tr><td>4</td><td colspan="2">2.05</td><td colspan="2">1405</td></tr>
<tr><td>5</td><td colspan="2">2.77</td><td colspan="2">1348</td></tr>
<tr><td>6</td><td colspan="2">3.57</td><td colspan="2">1282</td></tr>
<tr><td>7</td><td colspan="2">4.25</td><td colspan="2">1221</td></tr>
<tr><td>8</td><td colspan="2">4.46</td><td colspan="2">1156</td></tr>
<tr><td>9</td><td colspan="2">4.98</td><td colspan="2">1100</td></tr>
<tr><td>10</td><td colspan="2">5.74</td><td colspan="2">1031</td></tr>
</table>

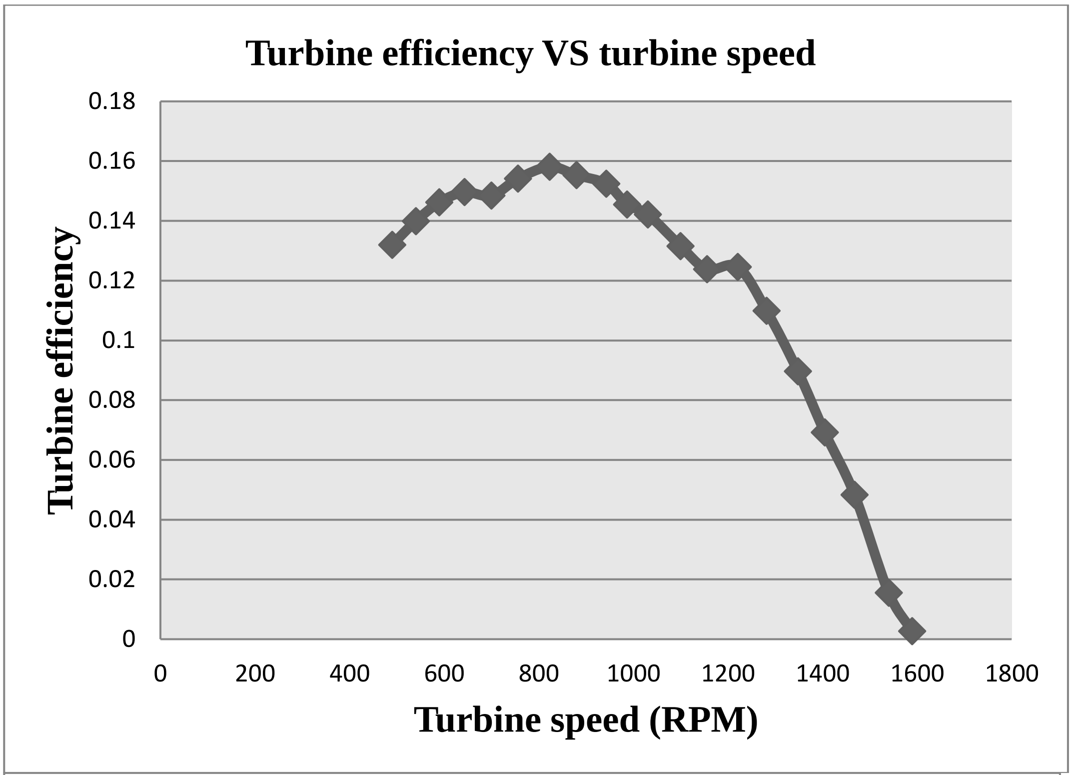
11	6.14	987
12	6.73	943
13	7.35	880
14	8.0	823
15	8.49	756
16	8.83	700
17	9.69	643
18	10.32	590
19	10.79	540
20	11.22	490

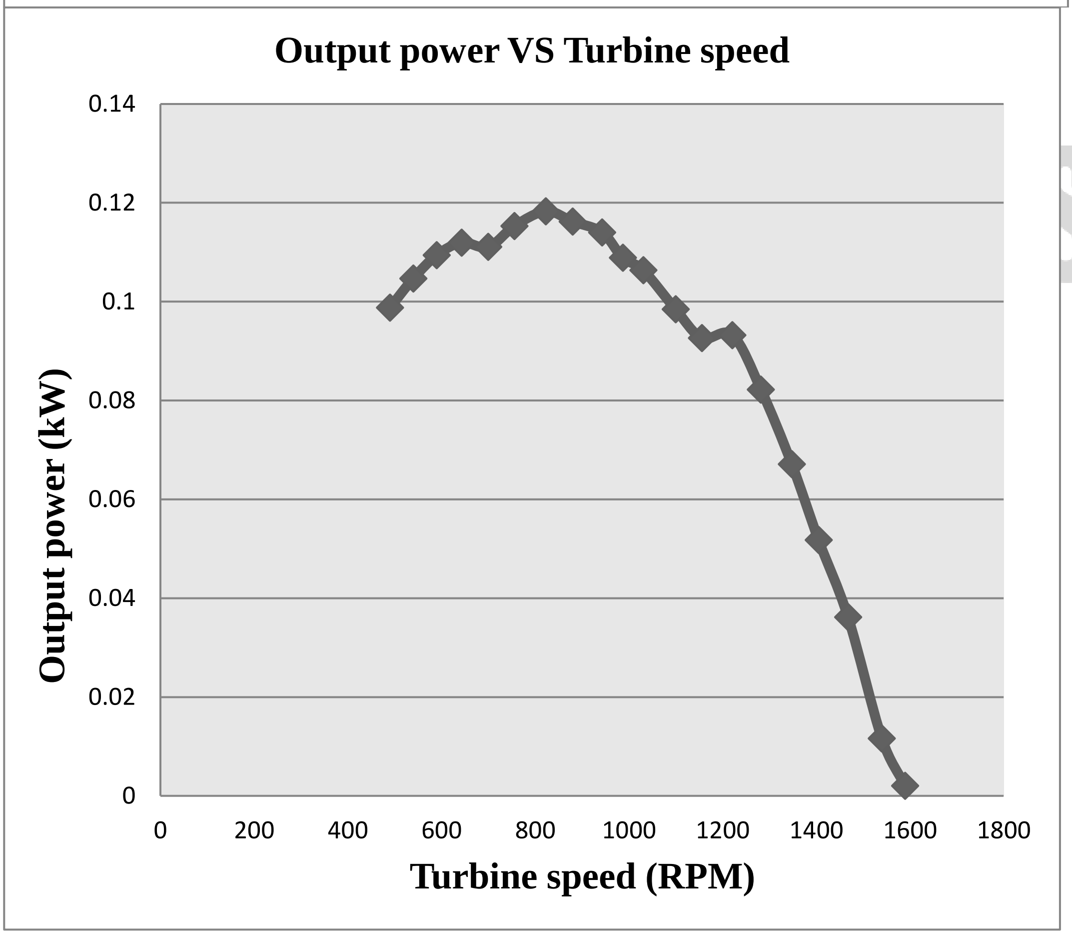
CALCULATION TABLE:

1. A_t=0.027475m^2
2. A_p=0.04082m^2
3. Q=0.238369m^3/sec
4. E_t=74.82885kW

S.NO.	T(N-m)	E_o(kW)	η_t
1	0.012017	0.002	0.002673
2	0.072104	0.011622	0.015532
3	0.235195	0.036138	0.048294
4	0.351934	0.051754	0.069163
5	0.47554	0.067094	0.089664
6	0.61288	0.082238	0.109901
7	0.729619	0.093244	0.124609
8	0.765671	0.092642	0.123805
9	0.854942	0.098432	0.131543
10	0.985415	0.106337	0.142107
11	1.054085	0.108893	0.145523
12	1.155373	0.114036	0.152396
13	1.261811	0.116221	0.155316
14	1.3734	0.118306	0.158102
15	1.457521	0.115331	0.154126
16	1.51589	0.111064	0.148424
17	1.663531	0.111957	0.149617
18	1.771686	0.109408	0.14621
19	1.852373	0.104696	0.139914
20	1.926194	0.098788	0.132019

PERFORMANCE CHARACTERISTICS CURVE:





PRECAUTION AND MAINTENANCE INSTRUCTION:

1. Never run the apparatus if power supply is less than 200V and more than 230V.
2. Never fully close the delivery line valve V_1.
3. To prevent clogging of moving parts, run pump at least once in a fortnight.

EXPERIMENT NO. 6

OBJECTIVE:

To study the operation of a Pelton Turbine at constant Speed.

AIM:

3. To determine the output power of Pelton Turbine.
4. To determine the efficiency of the Pelton Turbine.

INTRODUCTION:

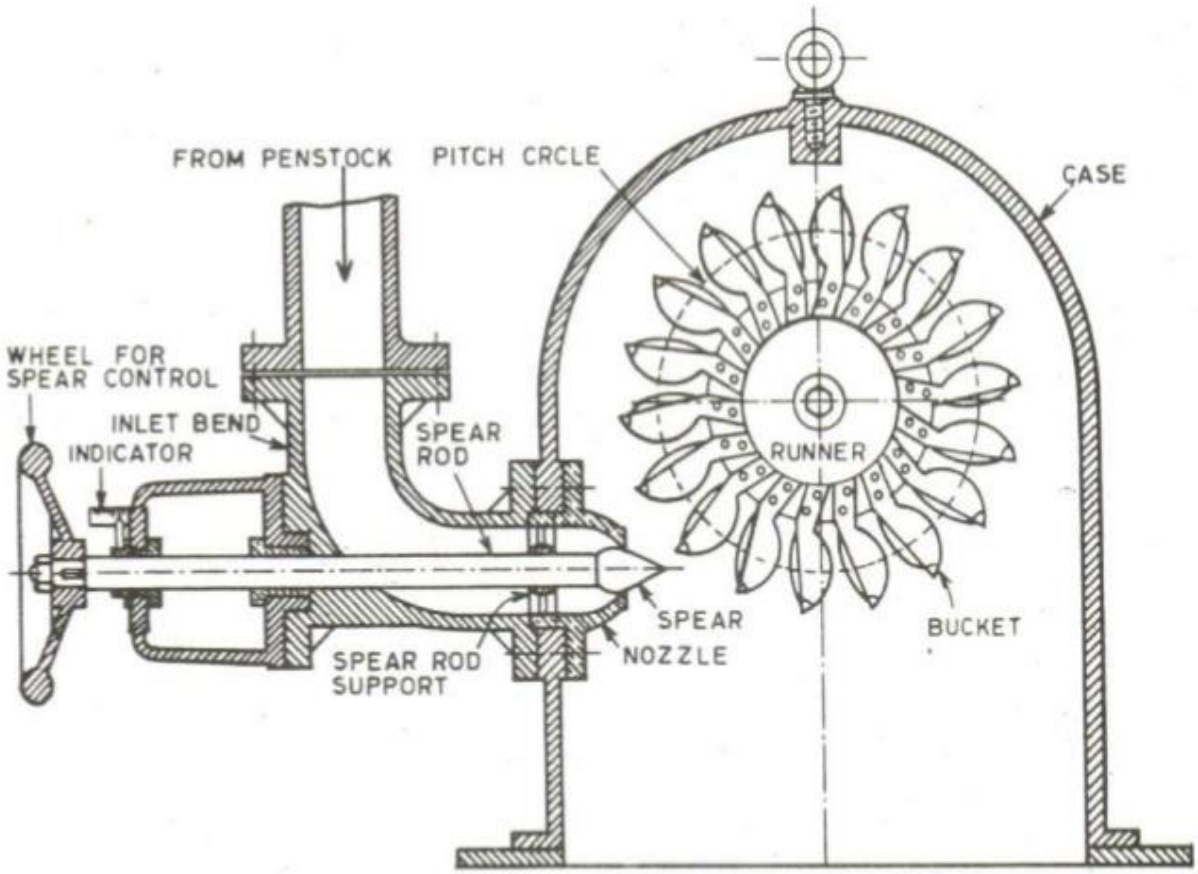
A turbine is a machine which converts the fluid energy into mechanical energy which is then utilized to run the electric generator of a power plant. Fluid used can be water or steam. The Pelton wheel is a tangential flow impulse turbine. The water strikes the bucket along the tangent of the runner. The pressure at the inlet and outlet of the turbine is atmospheric. The turbine is used for high head.

THEORY:

Pelton turbine is an impulse turbine. In an impulse turbine, all the available energy of water is converted into kinetic or velocity head by passing it through a contracting nozzle provided at the end of the penstock. The water coming out of the nozzle is formed into a free jet, which strikes on a series of buckets of the runner thus causing it to revolve. The runner revolves freely in air. The water contacts only a part of the runner at a time, and throughout its action on the runner.

DESCRIPTION:

The set up consists of centrifugal pump, turbine unit, and sump tank, arranged in such a way that the whole unit works as re-circulating water system. The centrifugal pump supplies the water from sump tank to the turbine. The loading of the turbine is achieved by eddy current dynamometer. The turbine unit can be visualized by a large circular transparent window kept at the front. A bearing pedestals rotor assembly of shaft, runner and dynamometer, all mounted on suitable cast iron base plate. Discharge is measured by venture and manometer.



EXPERIMENTAL PROCEDURE:

SARTING PROCEDURE:

22. Clean the apparatus and make tank free from dust.
23. Close the drain valve V3.
24. Fill sump tank 3/4th with the clean water and ensure that no foreign particles are there.
25. Fill manometer fluid i.e. Hg in manometer.
26. Connect inlet water supply to the dynamometer and outlet from dynamometer to drain.
27. Supply water to the dynamometer for cooling purposes with the help of Valve V2.

    (**NOTE:-Maintain the preesure of water at 1kg/cm^2**)
28. Ensure that there is no load on the dynamometer.
29. Fully open the By pass valve V1.
30. Switch ON the MCB.
31. Switch ON the Pump with the help of starter.
32. Open the air release valve V6.V7 and valves for venture V4,V5 provided on the manometer, slowly to release the air from manometer. This should be done vey carefully.
33. When there is no air in the manometer, close the air release valves V6 and V7.
34. Now turbine is in operation.
35. Maintain the flow rate of water with the help of by pass valve V1.
36. Apply load on dynamometer with the help of knob provided on the control panel.
37. Maintain the maximum RPM of turbine by regulating the spear.
38. Note the manometer reading and pressure gauge reading.
39. Note the RPM of the turbine.
40. Note the load with the help of digital load indicator.
41. Repeat the same experiment for different load.
42. Repeat the same experiment for different discharge.

CLOSING PROCEDURE:

7. When the experiment is over, first remove load from the dynamometer.
8. Close the valves V4 and V5 provided on manometer.
9. Switch OFF Pump with the help of starter.
10. Switch OFF main power supply.
11. Shut the water supply to the dynamometer.
12. Drain water from sump tank by drain valve V3.

OBSERVATION AND CALCULATION:

DATA:	
Co-efficient of venture C_d= .97	Diameter of pipe D= 0.052m
Acceleration due to gravity g= 9.81m/s^2	Diameter of throat at venture D_t= 0.035m
Density of water ρ_w= 1000kg/m^3	Effective radius of dynamometer R_e= 0.145m
Density of manometer fluid (Hg) ρ_m= 13600kg/m^3	

OBSERVATION TABLE:

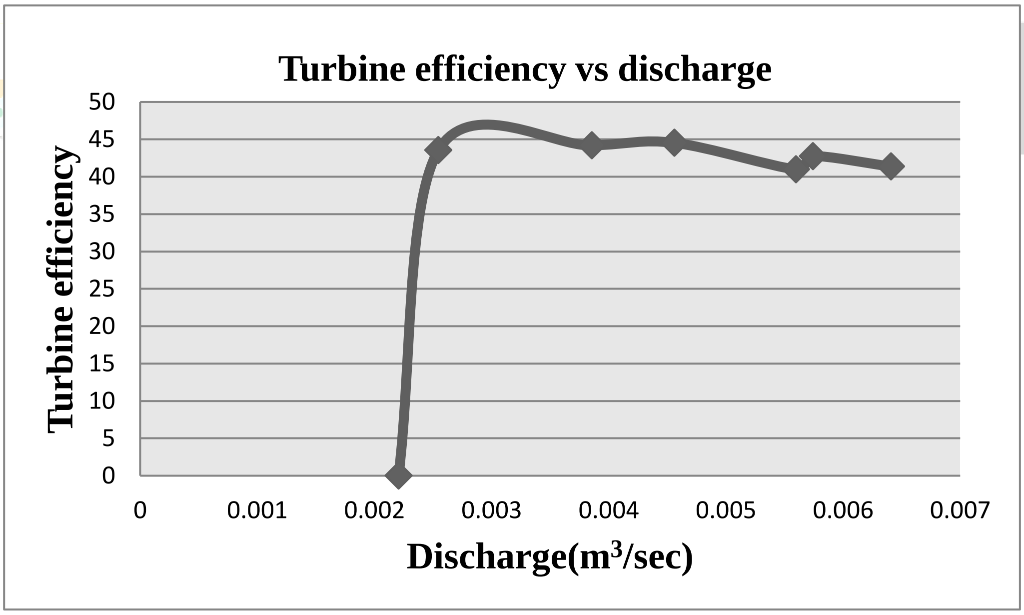
S.NO.	RPM N	h1 (cm)	h2 (cm)	h (m)	LOAD W(kg)	PRESSURE (kg/cm^2)
1	500	10.4	12.2	0.2268	0	4
2	500	10	12.4	0.3024	5.74	3.8
3	500	8.5	14	0.693	8.35	3.6
4	500	7.8	15.5	0.9702	9.68	3.5
5	500	5.4	17	1.4616	10.62	3.4
6	500	5.3	17.5	1.5372	11.03	3.3

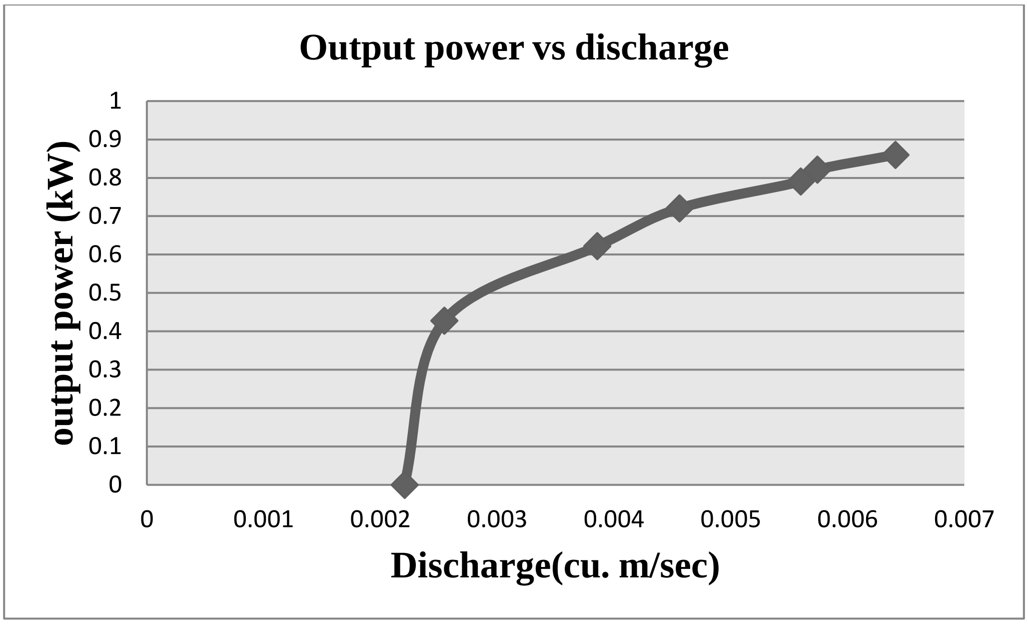
7	500	3.5	18.7	1.9152	11.55	3.2

CALCULATION TABLE:

S.NO.	**TOTAL HEAD** (m of water)	**DISCHARGE** (m3/s)	**INPUT POWER** Ei(kW)	**TORQUE** T(Nm)	**OUTPUT POWER** E_O(kW)	**TURBINBE EFFICIENCY** η_T(%)
1	41.32	0.002206	0.894169	0	0	0
2	39.254	0.002547	0.980872	8.164863	0.427294	43.56271
3	37.188	0.003856	1.406718	11.87746	0.621587	44.18704
4	36.155	0.004562	1.618216	13.76932	0.720594	44.53015
5	35.122	0.0056	1.929439	15.10642	0.790569	40.97405
6	34.089	0.005743	1.920512	15.68962	0.82109	42.75372
7	33.056	0.00641	2.078715	16.4293	0.8598	41.36209

OPERATING CHARACTERISTIC CURVES:





PRECAUTION AND MAINTENANCE INSTRUCTION:

1. Never run the apparatus if power supply is less than 390V and more than 420V.
2. To prevent clogging of moving parts, run pump at least once in a fortnight.
3. Always keep apparatus free from dust.

EXPERIMENT NO. 7

OBJECTIVE:

To study the operation of a Francis Turbine.

AIM:

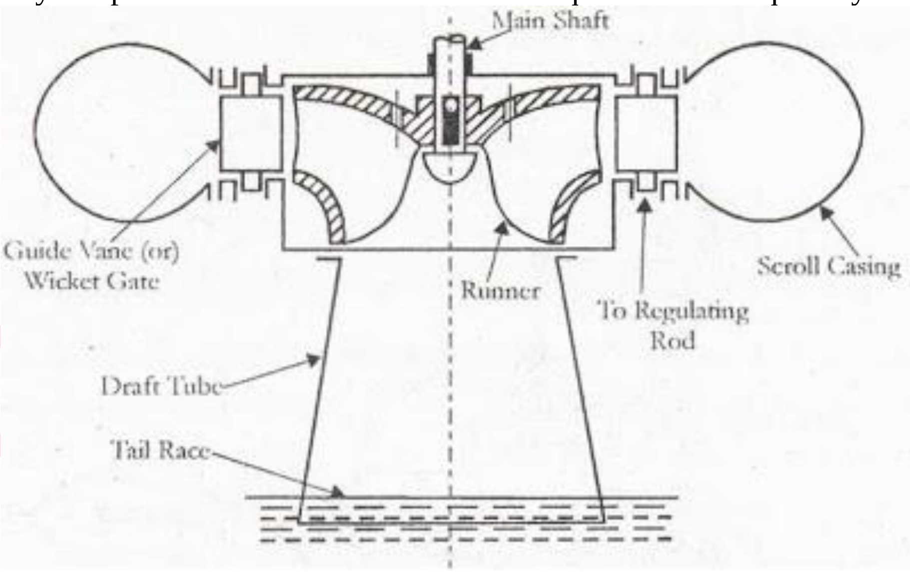
1. To determine the output power of Francis Turbine.
2. To determine the efficiency of the Francis Turbine.

INTRODUCTION:

Francis Turbine, named after James Bichens Francis, is a reaction type of turbine for medium high to medium low heads and medium small to medium large quantities of water. The reaction turbine operates with its wheel submerged in water. The water before entering the turbine has pressure as well as kinetic energy. The moment on the wheel is produced by both kinetic and pressure energies. The water leaving the turbine has still some of the pressure as well as kinetic energy.

THEORY:

Originally the Francis turbine was designed as a purely radial flow type reaction turbine but modern Francis turbine is a mixed flow type in which water enters the runner radially inwards towards the centre and discharged out axially. It operates under medium heads and requires medium quantity of water.



DESCRIPTION:

The present set-up consists of a runner. The water is fed to the turbine by means of Centrifugal Pump, radially to the runner. The runner is directly mounted on one end of a central SS shaft and other end is connected to a brake arrangement. The circular window of the turbine casing is provided with a transparent acrylic sheet for observation of flow on to the runner. This runner assembly is supported by thick cast iron pedestal. Load is applied to the turbine with the help of Eddy Current Dynamometer so that the efficiency of the turbine can be calculated. A draft tube is fitted on the outlet of the turbine. The set-up is complete with guide mechanism. Pressure and Vacuum gauges are fitted at the inlet at the inlet and outlet of the turbine. RPM indicator is provided for measurement of rotations. Discharge is measured by manometer.

EXPERIMENTAL PROCEDURE:

STARTING PROCEDURE:

NOTE:- Don't operate the turbine without supplying water to the dynamometer.

1. Close the drain valve V7.
2. Fill sump tank ¾ with clean water and ensure that no foreign particles are there.
3. Fill manometer fluid i.e. Hg. in manometer by opening the valves V5 & V6 of manometer and one PU pipe from pressure measurement point of pipe.
4. Connect the PU pipe is back to its position and close the valves V5 & V6 of manometer.
5. Connect Inlet water supply to the dynamometer & outlet from dynamometer to drain.
6. Supply water to the dynamometer for cooling purposes & maintain the pressure with the help of valve V8.

   (NOTE:- Maintain the pressure of water at 1kgcm^2)

7. Ensure that there is no load on the dynamometer.
8. Fully open the By pass valve V9& control valve V10.
9. Switches ON the MCB.
10. Switch ON the pump with the help of starter.
11. Open the air release valve V5, V6 and valves V3, V4 for venture provided on the manometer, slowly to release the air from manometer. This should be done very carefully.
12. When there is no air in the manometer, close the air release valves V5 &V6.
13. Now turbine is in operation.
14. Maintain the flow rate of water with the help of by pass valve V9 & control valve V10.
15. Apply load on dynamometer with the help of knob provided on the control panel.
16. Maintain the maximum RPM of turbine by regulating the guide vanes arrangement.
17. Note the manometer reading, pressure gauge reading and vacuum gauge reading.
18. Note the RPM of the turbine.
19. Note the load with the help of digital load indicator load.
20. Repeat the same experiment for different load.
21. Repeat the experiment for different discharge.

CLOSING PROCEDURE:

1. When the experiment is over, first remove load from dynamometer.
2. Close the valves V3& V4 provided on manometer.
3. Switch OFF Pump with the help of starter.
4. Switch OFF main power supply.
5. Shut the water supply to the dynamometer.
6. Drain water from sump tank by drain valve V9.

OBSERVATION AND CALCULATION:

DATA:	
Co-efficient of venture C_d= .97	Diameter of pipe D= 0.052m
Acceleration due to gravity g= 9.81m/s^2	Diameter of throat at venture D_t= 0.035m
Density of water ρ_w= 1000kg/m^3	Effective radius of dynamometer R_e= 0.145m
Density of manometer fluid (Hg) ρ_m= 13600kg/m^3	

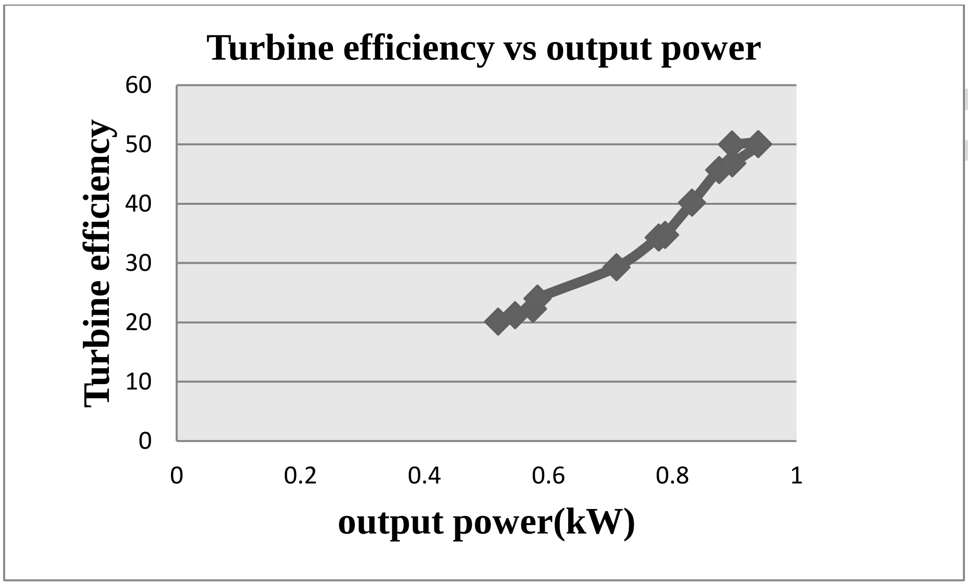
OBSERVATION TABLE:

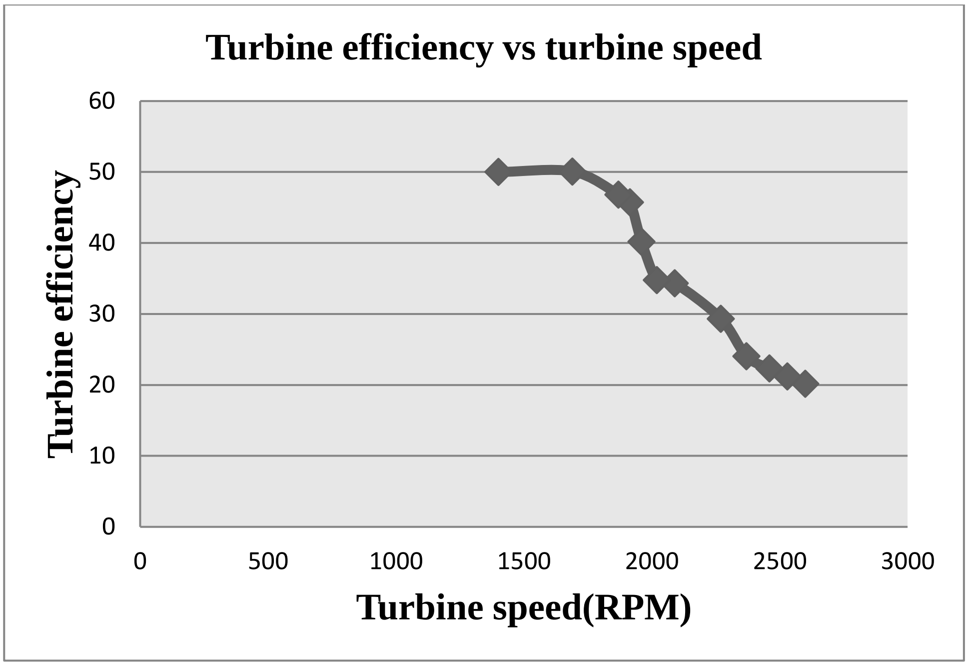
S.No.	N(RPM)	h_1(cm)	h_2(cm)	W(kg)	P_d(kg/cm^2)	P_s(mmHg)
1	2600	5.5	29	1.34	1.4	200
2	2530	5.5	29	1.45	1.4	200
3	2460	5.5	29	1.57	1.4	200
4	2370	5.5	29	1.65	1.3	200
5	2270	5.5	29	2.10	1.3	200
6	2090	5.5	29	2.50	1.2	200
7	2020	5.5	29	2.62	1.2	200
8	1960	5.5	29	2.85	1.1	180
9	1915	5.5	29	3.07	1	180
10	1870	5.5	29	3.22	1	180
11	1690	5.5	29	3.73	1	160
12	1400	5.5	29	4.30	1	120

Cross section of area of pipe, A_p= 0.005024 m^2
Cross section of area of throat of venture, A_t= 0.0019625 m^2
Constant differential pressure of manometer, h= 2.961 m

CALCULATION TABLE:						
S.No.	**H(m)**	**Q(m^3/s)**	**E_i(kw)**	**T(N-m)**	**E_o(kw)**	**η(%)**
1	16.6315789	0.01577977	2.57456149	1.90608	0.5187087	20.147459
2	16.6315789	0.01577977	2.57456149	2.06255	0.5461777	21.2143953
3	16.6315789	0.01577977	2.57456149	2.23325	0.5750163	22.3345339
4	15.6315789	0.01577977	2.41976191	2.34704	0.5822074	24.0605227
5	15.6315789	0.01577977	2.41976191	2.98715	0.7097257	29.3303955
6	14.6315789	0.01577977	2.26496232	3.55613	0.7779142	34.345569
7	14.6315789	0.01577977	2.26496232	3.72682	0.7879489	34.7886104
8	13.3684211	0.01577977	2.06942601	4.05398	0.831661	40.1880035
9	12.3684211	0.01577977	1.91462643	4.36692	0.8752912	45.7160299
10	12.3684211	0.01577977	1.91462643	4.58029	0.8964847	46.8229565
11	12.1052632	0.01577977	1.87388969	5.30574	0.9385144	50.083759
12	11.5789474	0.01577977	1.79241623	6.11654	0.8962763	50.003802

OPERATING CHARACTERISTICS CURVE:





PRECAUTION AND MAINTENANCE INSTRUCTION:

1. Never run the apparatus if power supply is less than 200V and more than 230V.
2. Never fully close the delivery line valve V_1.
3. To prevent clogging of moving parts, run pump at least once in a fortnight.

EXPERIMENT NO. 8

OBJECTIVE:

Study of hydraulic force.

AIM:

To study the effect of force on following type of vanes:

1. Hemispherical Vane.
2. Flat Plate Vane.

INTRODUCTION:

When a plate is placed in the path of a jet, the jet exerts a force on the plate. This force can be calculated from the impulse-momentum equation. Momentum equation is based on Newton's Second law of motion, which states that "The algebraic sum of external forces applied to control volume of fluid in any direction is equal to the rate of change of momentum in that direction." The external forces include the components of the weight of the fluid and of the forces exerted externally upon the boundary surface of the control volume.

THEORY:

If a vertical water jet moving with velocity 'V' is made to strike a target, which is free to move in the vertical direction, then a force will be exerted on the target by the impact of jet. According to momentum equation, this force (which is also equal to the force required to bring back the target in its original position) must be equal to the rate of change of momentum of the jet flow in the same direction.

Due to impact of the jet on the flat stationary plate, the entire velocity of the jet is destroyed and due to the rate of change of momentum, force acts on the plate. The jet after striking will move along the plate. But the plate is at right angles to the jet. Hence the components of the velocity of the jet in the direction of the jet after striking it will be zero.

F_x = Rate of change of momentum in the direction of force

$F_x = \rho A V^2$ (For flat plate vane)

For hemispherical vane

$F_x = 2\rho A V^2$

DESCRIPTION:

The setup consists of sump tank with centrifugal pump to circulating water. A chamber with side glass is provided for visualization of impact of jet on vanes. Water from sump tank flows through a nozzle and strikes vertically to vane positioned above the nozzle. Two types of vanes (hemispherical/flat) are provided that can be fixed one at a time. Arrangement is made for the movement of the plate of the under the action of the jet and also because of the weight placed on the loading pan. Measuring tank and stop watch is provided for flow measurement.

EXPERIMENTAL PROCEDURE:

STARTING PROCEDURE:

1. Close all valves provided V_1 to V_4.
2. Fill sump tank ¾ with water and ensure that no foreign particles are there.
3. Fix desired vane (Hemispherical/Flat).
4. Ensure that all On/Off switches given on the panel are at OFF position.
5. Open by pass valve V_2.
6. Switch on the pump.
7. Put weight on the pan.
8. Operate by pass valve V_2 and flow control valve V_1 to regulate the flow of water through channel.
9. Now control the flow of water so that the applied weight on the top is counter balanced by the impact of jet (Pan leaves its rest position on the spring).
10. Measure flow rate using measuring tank and stop watch.
11. Repeat the experiment for different weights.
12. Repeat the experiment for other vane.

CLOSING PROCEDURE:

1. When the experiment is over, switch OFF the pump.

2. Switch OFF power supply to panel.
3. Drain water from all tanks with the help of drain valves V_4 & V_3.

OBSERVATION AND CALCULATION:

DATA:	
Diameter of nozzle, d= 0.01m	Weight of Flat plate vane W_F=0.022kg
Acceleration due to gravity g= 9.81m/s^2	Weight of aluminium disc with rod W_{D+R}=0.213kg
Density of water ρ_w= 1000kg/m^3	Weight of Hemispherical vane W_H=0.045kg
Area of measuring tank A=0.077m^2	

OBSERVATION TABLE:									
For Flat Plate Vane					**For Hemispherical Vane**				
S.No.	**W_A (kg)**	**R_1(cm)**	**R_2(cm)**	**t(sec)**	**S.No.**	**W_A (kg)**	**R_1(cm)**	**R_2(cm)**	**t(sec)**
1	0.205	7.5	13.5	10	1	0.205	15.5	19.5	10
2	0.305	13.5	21.8	10	2	0.305	8	13.4	10
3	0.605	8.5	17.6	10	3	0.605	13.4	20	10
4	0.705	11	17.7	10	4	0.705	14.3	20.5	10

Cross section area of nozzle, a =0.0000785 m^2

CALCULATION TABLE:							
For Flat Plate Vane							
S.No.	**W (kg)**	**R (cm)**	**Q (m^3/sec)**	**V (m/sec)**	**F_X (N)**	**F_{th} (N)**	**Error (%)**
1	0.439	0.06	0.00046	5.88535	2.719032	4.309533	36.90658
2	0.539	0.083	0.00064	8.141401	5.20317	5.290533	1.651317
3	0.839	0.091	0.0007	8.926115	6.254529	8.233533	24.03591
4	0.939	0.067	0.00052	6.571975	3.390482	9.214533	63.20506

CALCULATION TABLE:							
For Hemispherical Vane							
S.No.	**W (kg)**	**R (cm)**	**Q (m^3/sec)**	**V (m/sec)**	**F_X (N)**	**F_{th} (N)**	**Error (%)**
1	0.439	0.04	0.00031	3.923567	1.208459	4.309533	71.95848
2	0.539	0.054	0.00042	5.296815	2.202416	5.290533	58.37063
3	0.839	0.066	0.00051	6.473885	3.290029	8.233533	60.04111
4	0.939	0.062	0.00048	6.081529	2.903322	9.214533	68.49193

PRECAUTION AND MAINTENANCE INSTRUCTION:

1. Never run the apparatus if power supply is less than 200V and more than 230V.
2. Never fully close the delivery line valve V_1.
3. To prevent clogging of moving parts, run pump at least once in a fortnight.

IMPACT OF JET ON VANES

Flat Vane

Data :

A, m2	p, kg/m3	WD+R, kg	d, m	WH, kg	WF, kg
0.079	1000	0.205	0.01	0.043	0.022

Observation Table :

Run No.	WA, kg	R1, m	R2, m	t, sec
1	0.1	15	8	10.38
2	0.2	16.3	8	10.28
3	0.4	17.5	8	10.31
4	0.5	18	8	10.44

Calculation Table :

Run No.	R, m	Q, m3/sec	V, m/sec	Fx, N	W, kg	Fth, N	Error, %
1	0.07	5.33E-04	6.78E+00	3.614	3.27E-01	3.208	11.2
2	0.083	6.38E-04	8.12E+00	5.18	4.27E-01	4.189	19.1
3	0.095	7.28E-04	9.27E+00	6.747	6.27E-01	6.151	8.8
4	0.1	7.57E-04	9.64E+00	7.291	7.27E-01	7.132	2.2

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