Asra Group Of Institutions

STUDENT HAND BOOK

Bachelor of Technology

Semester- 6th

Study Scheme- 2011 onwards

DEPARMENT OF MECHANICAL ENGINEERING

ASRA COLLEGE OF ENGINEERING & TECHNOLOGY

BHAWANIGARH (SANGRUR)

Department of Mechanical Engineering

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SYLLABUS

BTME 601 DESIGN OF MACHINE ELEMENTS –II

1. **Transmission Drives**
Belt and rope drives: Basics, Characteristics of belt drives, selection of flat belt, Design of Flat belt, V-belt and rope (steel wire), Design of the pulley for the same
Chain Drives: Basics, Roller chains, polygonal effect, power rating, selection of chain
Gear drives: Standard system of gear tooth and gear module, gear tooth failure, strength of gear tooth, terminology of spur, helical, bevel, worm and worm wheel, Design of spur, helical, straight bevel gears, worm and worm wheel

2. **Bearings**
Slider: Principle of hydrodynamic lubrication, modes of lubrication, Reynolds equation, bearing performance parameters, slider bearing design
Roller: Types, selection guidelines, static and dynamic load carrying capacity, Stribeck's equation, equivalent bearing load, load life relationship, selection of bearing, comparison of roller and slider bearing

3. **Design of Flywheel**
Introduction, Energy stored in a flywheel, stresses in a rim, design considerations

4. **Springs**
Types; end styles of helical compression spring; stress and deflection equation; surge in spring; nipping of leaf spring; Design of close-coil helical spring and multi leaf spring

5. **Clutches**
Design of contact clutches i.e. plate, multi-disc, cone and centrifugal clutches.

6**. Brakes**
Design of band, disc, block with shoe and internal expanding brakes.

BTME-602 HEAT TRANSFER

1. Introduction:
Concept of heat transfer, Difference between the subject of "Heat Transfer" and its parent subject "Thermodynamics". Different modes of heat transfer - conditions, convection, and radiation.

2. Conduction:
Fouier's law of heat conduction, coefficient of thermal conductivity, effect of temperature and pressure on thermal conductivity of solids, liquids and gases and its measurement. Threedimensional general conduction equation in rectangular, cylindrical and spherical coordinates involving internal heat generation and unsteady state conditions. Derivation of equations for simple one dimensional steady state heat conduction from three dimensional equations for heat conduction though walls, cylinders and spherical shells (simple and composite), electrical

analogy of the heat transfer phenomenon in the cases discussed above. Influence of variable thermal conductivity on conduction through simple cases of walls / cylinders and spheres. Equivalent areas, shape factor, conduction through edges and corners of walls and critical thickness of insulation layers on electric wires and pipes carrying hot fluids. Internal generation cases along with some practical cases of heat conduction like heat transfer through piston crown, through under-ground electrical cables/Hot fluid pipes etc and case of nuclear fuel rod with and without cladding. Introduction to unsteady heat transfer, Newtonian heating and cooling of solids; definition and explanation of the term thermal diffusivity. Numerical.

3. Theory of Fins:

Concept of fin, classification of fins and their applications. Straight fins of uniform cross-section; e.g. of circular, rectangular or any other cross-section). Straight fins with varying cross-sectional area and having triangular or trapezoidal profile area. Circumferential fins of rectangular crosssection provided on the circumference of a cylinder. Fin performance: fin effectiveness and fin efficiency, total fin effectiveness, total fin efficiency. Optimum design of straight fin of rectangular and triangular profile area. Application of fins in temperature measurement of flow through pipes and determination of error in its measurement. Numerical.

4. Convection:

Free and forced convection. Derivation of three-dimensional mass, momentum and energy conservation equations (with introduction to Tensor notations).

Boundary layer formation, laminar and turbulent boundary layers (simple explanation only and no derivation). Theory of dimensional analysis and its application to free and forced convective heat transfer. Analytical formulae for heat transfer in laminar and turbulent flow over vertical and horizontal tubes and plates. Numerical.

Newton's law of cooling. Overall coefficient of heat transfer. Different design criterion for heat exchangers. Log mean temperature difference for evaporator and condenser tubes, and parallel and counter flow heat exchangers, Calculation of number and length of tubes in a heat exchanger effectiveness and number of transfer units(NTU); Numerical.

5. Convection with Phase Change (Boiling and Condensation):

Pool boiling, forced convection boiling, heat transfer during pool boiling of a liquid. Nucleation and different theories of nucleation, different theories accounting for the increased values of h.t.c. during nucleate phase of boiling of liquids; different phases of flow boiling (theory only), Condensation, types of condensation, film wise condensation on a vertical and inclined surface, Numerical.

6. Radiation:

Process of heat flow due to radiation, definition of emissivity, absorptivity, reflectivity and transmissivity. Concept of black and grey bodies, Plank's law of nonchromatic radiation. Kirchoff's law and Stefan Boltzman's law. Interchange factor. Lambert's Cosine law and the geometric factor. Intensity of Radiation (Definition only), radiation density, irradiation, radiosity and radiation shields. Derivation formula for radiation exchange between two bodies using the definition of radiosity and irradiation and its application to cases of radiation exchange between three or four bodies (e.g. boiler or other furnaces), simplification of the formula for its application to simple bodies like two parallel surfaces, concentric cylinders and a body enveloped by another body etc. Error in Temperature measurement by a thermocouple probe due to radiation losses.

BTME 603 FLUID MACHINERY

1. General Concepts:
Impulse momentum principle; jet impingement on stationary and moving flat plates, and on stationary or moving vanes with jet striking at the centre and tangentially at one end of the vane; calculations for force exerted, work done and efficiency of jet.
Basic components of a turbo machine and its classification on the basis of purpose, fluid dynamic action, operating principle, geometrical features, path followed by the fluid and the type of fluid etc. Euler's equation for energy transfer in a turbo machine and specifying the energy transfer in terms of fluid and rotor kinetic energy changes.

2. Pelton Turbine:
Component parts and operation; velocity triangles for different runners, work output; Effective head, available power and efficiency; design aspects such as mean diameter of wheel, jet ratio, number of jets, number of buckets with working proportions

3. Francis and Kaplan Turbines:
Component parts and operation velocity triangles and work output; working proportions and design parameters for the runner; Degree of reaction; Draft tubes - its function and types. Function and brief description of commonly used surge tanks, Electro- Mechanical governing of turbines

4. Centrifugal Pumps:
Layout and installation; Main elements and their functions; Various types and classification; Pressure changes in a pump - suction, delivery and manometric heads; vane shape and its effect on head-capacity relationships; Departure from Euler's theory and losses; pump output and efficiency; Minimum starting speed and impeller diameters at the inner and outer periphery; Priming and priming devices, Multistage pumps - series and parallel arrangement; submersible pumps. Construction and operation; Axial and mixed flow pumps; Trouble shooting - field problems, causes and remedies.

5. Similarity Relations and Performance Characteristics:
Unit quantities, specific speed and model relationships, scale effect; cavitation and Thoma's cavitation number; Concept of Net Positive Suction Head (NPSH) and its application in determining turbine / pump setting

6. Reciprocating Pumps:
Components parts and working; pressure variations due to piston acceleration; acceleration effects in suction and delivery pipes; work done against friction; maximum permissible vacuum during suction stroke; Air vessels

7. Hydraulic Devices and Systems:
Const., operation and utility of simple and differential accumulator, intensifier, fluid coupling and torque converter, Air lift and jet pumps; gear, vane and piston pumps, Hydraulic Rams

BTME-604 STATISTICAL AND NUMERICAL METHODS\

1. Data, its Arrangements and Measures:
Introduction: Data, Data Array; Frequency Distribution Construction and Graphic representation. Mean, median, mode and standard deviation.

2. Probability and Probability Distributions:
Introduction: Definition probability and Probability Distribution; Conditional probability; Random variables, Poisson, Normal and Binomial distributions.

3. Sampling and Sampling Distributions:
Introduction: Fundamentals of Sampling, Large samples, small samples; Normal sampling distributions; Sampling distribution of the means, t-Distribution, F-Distribution, Chi-square Distribution.

4. Errors in Numerical Calculations:
Errors and their analysis, general error formula, errors in a series approximation

5. Solution of Algebraic and Transcendental Equations:
Bisection method, iteration method, Method of false position,, Newton -Raphson method, solution of systems of non linear equations.

6. Interpolation Method:
Finite difference, forward, backward and central difference, Difference of polynomial, Newton's formulae for interpolation, central difference interpolation formulae, Interpolation with unevenly spaced points, Newton's general interpolation formula, interpolation by iteration.

7. Numerical Differentiation and Integration:
Numerical differentiation, maximum and minimum values of a tabulated function; Numerical Integrationtrapezoidal
rule, Simpson1/3 rule, Simpsons 3/8 rule, Newton-cots integration formulae; Euler-Meclaurin formula, Gaussian integration(One dimensional only)

8. Solution of Linear Systems of Equations:
Gauss Elimination method (fall and banded symmetric and unsymmetric systems), Gauss Jordon method. Eigen value problems (Power method only).

9. Numerical solution of ordinary and partial differential equations:
Solution by Taylor's series, Prediction -correction method, Boundary value problems, Prediction corrector method, Euler's and modified Euler's method, Runge-Kutta method, finite difference methods. Finite difference approximation to derivatives, Solution to Laplaces equation- Jacobi's method, Gauss -Siedel method.

DE/ME-2.4 NON-DESTRUCTIVE TESTING

1. Introduction:
Classification of techniques of material testing, Need and Significance of Non Destructive

Testing methods, type of Non Destructive testing methods.

2. Radiographic Examination:
Radiant energy and radiography, practical applications, X-ray and Gamma –ray equipment, effect of variables on radiographs, requirement of a good radiograph, interpretation of radiograph, safety precautions, Xeroradiography.

3. Magnaflux methods:
Basic principles, scope and applications, magnetic analysis of steel bars and tubing magnetization methods, equipment, inspection medium, preparation of surfaces Fluorescent Penetration inspection, Demagnetization.

4. Electrical and ultrasonic Methods:
Basic principles, flaw detection in rails and tubes (Sperry Detector), Ultrasonic testing surface roughness, moisture in wood, Detection of defects in ferrous and non ferrous metals, plastics, ceramics, measurement of thickness, hardness, stiffness, sonic material analyzer, proof tests, concrete test hammer.

5. Photoelasticity:
Concept and applications of Plane and circular polarization, Photo stress, models.

BTME 605 HEAT TRANSFER LAB

A. Two to three students in a group are required to do one or two practicals in the form of Lab. Project in the topic/s related to the subject matter and in consultation with teacher. The complete theoretical and experimental analysis of the concerned topic is required to be performed (including design and fabrication of new experimental set up, if required, or modifications/retrofitting in the existing experimental set ups). The following topics can be taken as reference:-
1. Determination of thermal conductivity of:
- a solid insulating material by slab method
- powder materials by concentric spheres method / or by some transient heat transfer technique
- a metal by comparison with another metal by employing two bars when kept in series and / or in parallel under different boundary conditions
- Liquids by employing thin layer

2. Determination of coefficient of heat transfer for free/forced convection from the surface of a cylinder / plate when kept:
a) along the direction of flow
b) perpendicular to the direction of flow
c) inclined at an angle to the direction of flow

3. To plot the pool boiling curves for water and to determine its critical point

4. Determination of heat transfer coefficient for

i) film condensation ii) drop-wise condensation

5. Determination heat transfer coefficient by radiation and hence find the Stefan Boltzman's constant using two plates/two cylinders of same size by making one of the plates/cylinders as a black body.

6. Determination of shape factor of a complex body by an analog technique.

7. To plot the temperature profile and to determine fin effectiveness and fin efficiency for
i) A rod fin when its tip surface is superimposed by different boundary condition like.
a) Insulated tip
b) Cooled tip
c) Temperature controlled tip
ii) Straight triangular fins of various sizes and optimization of fin proportions
iii) Circumferential fins of rectangular/triangular section

B. Each student is required to use Finite Difference Method for analysis of steady state one dimensional and two dimensional conduction problems (Minimum two problems one may be from the Lab. Project) such as conduction through plane/cylindrical/spherical wall with or without internal heat generation, heat transfer through fins, bodies with irregular boundaries subjected to different boundary conditions.

BTME 606 FLUID MACHINERY LAB

1. Determination of various efficiencies of Hydraulic Ram
2. To draw characteristics of Francis turbine/Kaplan Turbine
3. To study the constructional features of reciprocating pump and to perform test on it for determination of pump performance
4. To draw the characteristics of Pelton Turbine
5. To draw the various characteristics of Centrifugal pump
6. Determine the effect of vane shape and vane angle on the performance of centrifugal fan/Blower
7. A visit to any Hydroelectric Power Station

ASSIGNMENTS

BTME 601 DESIGN OF MACHINE ELEMENTS –II

Assignment No.1

Q.1 Design of flat belt
Q.2 How many 38mm ropes are necessary for a rope drive that is to transmit 195kw at a rope speed of 17.5m/s
Q.3Design a bevel gear drive between two shafts whose axes are at angle. Speed of pinion shaft is 240 rev/min. pinion is to have 21 teeth of involute profile with module of 20mm and a pressure angle of 20^0 and is to be of suitable material. Gear is of cast iron. Power at gear shaft=75kw
Q.4 Explain the design of spur gear

Assignment No.2

Q.1 Explain Hydrodynamic lubrication
Q.2 Explain the selection of Rolling contact Bearing on the Basis of load rating
Q.3 A bearing is required to carry 4500N stationary radial load. The shaft rotates at 1000rev/min and the life desired is 30000hours. The running condition are steady, no shock loading select a suitable bearing
Q.4 Explain the comparison of roller and slider bearing

Assignment No.3

Q.1 Explain energy stored in a flywheel
Q.2 Explain stresses in flywheel rim
Q.3 A single cylinder double acting steam engine deliver 187.5kw at 100rev./min the maximum fluctuation of energy/revolution is 15 percent. The speed variation is limited to 1percent either way from the mean The mean diameter of the rim is 2.4m Design a cast iron from flywheel for the engine

Assignment No.4

Q.1 Explain stress and defection equation
Q.2 Explain leaf spring and nipping of leaf spring
Q.3 A semi elliptical, laminated, automobile spring to carry a load of 2850N is to consist of seven leaves extending the full of spring The spring is to be 1075mm in length and is to be attached to axle by u bolts 75mm apart These bolts clamp the central portion of spring so rigidly that they may be considered equivalent to band having width equal to the distance between the bolts The leaves are to be made of silica Assuming an allowable stress of $350N/mm^2$, determine thickness for leaves and deflection
Q.4 Explain design of close coil helical spring

Assignment No. 5

Q.1Explain clutches and types
Q.2 A small multiple disc clutch is to be made up of 6 steel and 5 bronze disk, with an inner radius of 25mm Determine the outer dia. And axial pressure to torsional moment of 17.5Nm

Q.3 Explain design of plate clutches
Q.4 Explain design of centrifugal clutches

Assignment No. 6

Q.1 Explain design of band brakes
Q.2 Explain block brakes
Q.3 Explain internal expanding shoe brakes
Q.4 Explain Band and Block Brakes

BTME-602 HEAT TRANSFER

ASSIGNMENT NO. 1

Q. 1 Define Critical Radius of Insulation.
Q. 2 What is Heat Transfer? How it occurs? Define about Conduction and Convection.
Q. 3 What is Thermal Conductivity? Explain about Thermal Conductivity of Liquids and Solids.
Q.4 Explain about 3-D General Differential Equation of Heat Conduction.

ASSIGNMENT NO. 2

Q. 1 Explain about Heat Conduction through Plane Wall.
Q. 2 Explain about Shape Factor.
Q. 3 What is Convection? Write the difference between Free and Forced Convection.
Q. 4 What is the difference between Plain and Laminar Flow? Explain with diagram.

ASSIGNMENT NO. 3

Q. 1 Explain about Boundary Layer Concept.
Q. 2 Explain about Nusselt Number and Fourier Number.
Q. 3 A hot plate 1 m X 1.5 m is maintained at 300°C. Air at 25°C blows over the plate. If the heat transfer coefficient is $20W/m^{2o}C$, calculate the rate of heat transfer.
Q. 4 What is Emissive Power?

ASSIGNMENT NO. 4

Q. 1 Give the classification of Heat Exchanger with neat sketch.
Q. 2 What is the heat transfer mechanism in Heat Exchangers?
Q. 3 What is the geometry of the construction of Heat Exchanger? Explain with suitable sketch.
Q. 4 Explain about Effectiveness-NTU method of Heat Exchanger Analysis.

ASSIGNMENT NO. 5

Q. 1 Explain about Boiling Heat Transfer.
Q. 2 What is the difference between Free Convection and Nucleate Boiling?
Q. 3 What is the difference between Filmwise Condensation and Dropwise Condensation?
Q. 4 Explain about Bubble Growth and Collapse with neat sketch.

BTME 603 FLUID MACHINERY

ASSIGNMENT NO:-1

Q1 Drive the Expression for the Force, W/done & Efficiency of the jet on the moving plate held normal to the jet?
Q2 Drive the Expression for the Force, W/done & Efficiency of the jet on the Stationary flat plate held inclined to the jet?
Q3 Drive the Expression for the Force, W/done & Efficiency of the jet on the moving plate held inclined to the direction of the jet?
Q4 Define turbo machine and state its classification?
Q5 A jet of water of diameter 4. Mm moving with a velocity of 30m/s, strikes a curved fixed symmetrical plate at the center. Find if the jet is deflected through an angle of 120° at the outlet of the curved plate?

ASSIGNMENT NO:-2

Q1 Explain the components and operation of Pelton wheel turbine?
Q2 Define the followings:-
a. Gross Head b.Net effective head c.Hydraulic Efficiency d.Mechanical Efficiency
e.Volumetric Efficiency f.Overall Efficiency
Q3 Write the function of draft tube & surge tank also write its types?
Q4 Explain the components and Operation of Kaplan Turbine?
Q5 A Pelton Wheel Turbine is to be designed for the following specification: Power (brake or Shaft) =9560 KW, Head=350Mtrs, Speed=750RPM, Overall Efficiency =85%, Jet Diameter = not to exceed 1/6 thof the wheel diameter. Determine the followings
1. The wheel diameter 2.Diameter of the jet 3.The no. of jets required
Take C_v=0.985, Speed ratio =0.45

ASSIGNMENT NO:-3

Q1 Define Pump & writes its classifications?
Q2 Drive the expression for the work done by the Centrifugal pump?
Q3 Explain the multistage centrifugal pump & also states its types?
Q4 Explain cavitation and its harmful effects?
Q5 The centrifugal pump is to discharge 0.118 m^3/sec at a speed of 1450 rpm against a head of 25m. The impeller diameter is 250mm. its width at outlet is 50mmand monomeric efficiency is 75 percent. Determine the vane angle at the outer periphery of the impeller.

ASSIGNMENT NO:-4

Q1 Explain the components and working of Reciprocating pump in Detail along with diagram?
Q2 Explain Air vessel & drive the expression for the w/done with air vessel?
Q3 A Single acting reciprocating pump, running at 50rpm delivers 0.00736m3/sec of water. The diameter of piston is 200mm and stroke length 300mm. The suction and delivery heads are 3.5m and 11.5m respectively. Determine
Theoretical discharge.

Co-efficient of discharge.
Percentage slip of the pump and
Power required to run the pump

Q4 A single acting reciprocating pump has a stroke length of 150mm. suction pipe is 7m long and ratio of suction pipe diameter to the piston diameter is 3/4. The water level in the sump is 2.5m below the axis of the pump cylinder and pipe connecting the sump and pump cylinder is 75 mm in diameter. If the crank is running at 75 rpm. Determine the pressure head on the piston at the beginning, middle and end of the suction stroke. Take friction co-efficient, f=0.01

ASSIGNMENT NO:-5

Q1 Explain the components and operation of simple accumulator?
Q2 Explain the components and operation of Torque convertor?
Q3 Explain the components and operation of vane pump?
Q4 Explain the components and operation of Hydraulics pump?
Q5 Explain the components and operation of Intensifier?

BTME-604 STATISTICAL AND NUMERICAL METHODS

Assignment-1

TOPIC: Solutions of Algebraic and Transcendental Equation & Interpolation

1. Find the real root of equation x^3-2x– 5=0 by **Regular False method.**
2. f(x) =x^3- 4x– 9=0, Find real root by **Bisection Method**.
3. F (x) = x^4-x - 10 = 0 Find real root of the equation **Bisection Method**.
4. Solve F (x) =$xlog\,{}^{x}_{10}$-1.2 = 0 by **Regular False method.**
5. Solve 3x^3 - 9^2 + 8 = 0 by **Newton Raphson method**.
6. Find the polynomial f(x) by using Lagrange’s Formula. Hence find f(3) for:

X:	0	1	2	5
F(x):	2	3	12	147

7. Find y(8) using gauss backward difference formula from the following table:

x	0	5	10	15	20	25
y	7	11	14	18	24	32

8. Using Newton’s Divided differences formula,evaluate f(8) and f(15) given:

x	4	5	7	10	11	13
y	48	100	294	900	1210	2028

Assignment-2

TOPIC: Eigen Values and Eigen Vectors &

1) Define Inversion Method :-$3x$ + y + $2Z$ = 3 , $2x$ - $3y$ - z = - 3

   x + $2y$ + z = 4

2) Find the Eigen values :-

   $2x_1$ + $4x_2$ + $2x_3$ = 15

   $2x_1$ + x_2 + $2x_3$ = - 5

   $4x_1$ + x_2 - $2x_3$ = 0

3) Explain Power Method as Initial Eigen.

   $\begin{bmatrix} 2 & -1 & 0 \\ -1 & 2 & -1 \\ 0 & -1 & 2 \end{bmatrix}$ Take [1, 0, 0]

4) Explain the Properties of Eigen Value.
5) Solve by Gauss elimination method:

$$\begin{aligned} 2x + y + 4z &= 12 \\ 8x - 3y + 2z &= 20 \\ 4x + 11y - z &= 33 \end{aligned}$$

6) Solve the above system of equation by Gauss Jordan method.
7) Solve by Jacobi method

$$\begin{aligned} 5x + 2y + z &= 12 \\ X + 4y + 2z &= 15 \\ X + 2y + 5z &= 20 \end{aligned}$$

8) Solve the following system by Gauss Seidel method:

$$\begin{aligned} 83x + 11y - 4z &= 95 \\ 7x + 52y + 13z &= 104 \\ 3x + 8y + 29z &= 71 \end{aligned}$$

9) Solve the above system of equation by Jacobi method.

Assignment-3

Numerical Integration & Errors in Numerical Methods & Numerical Solutions Of ODE

1. Prove **Simpson's** 1/3rd rule.
2. Evaluate $\int_0^5 \frac{dx}{4x+5}$by using Simpson 1/3 rule. taking n=10.
3. Evaluate $\int_0^1 \frac{dx}{1+x}$using **Simpson 3/8th Rule**.

4. Evaluate $\int_{-2}^{3} \frac{t}{5+2t}$ dt using **Trapezoidal Rule.**
5. Using three point **Gaussian Quadrature** formula, Evaluate$\int_0^1 \frac{dx}{1+x}$.
6. Define **Rounding Off Error**.
7. Explain **Absolute, Relative** and **Percentage Error**.
8. Explain **Euler- Maclaurin** formula and solve one example related to this.
9. Use **Runge-Kutta** method to find the value of y when x=0.5 Given that y=1, When x=0 and that $\frac{dy}{dx}=\frac{y-x}{y+x}$, take h=0.25.
10. Apply **Modified Euler Method** to find the value of y at x=1.4 given $\frac{dy}{dx}$=xy, y (1) = 2, having h = 0.2.
11. Find the value of y for x=0.1by picard's method.$given\ that\ \frac{dy}{dx} = \frac{y-x}{y+x}$ y(0)=1
12. Determine the value of y(0.1) given that y(0) =1, $\frac{dy}{dx} = x^2+y$ by **Modified Euler's Method** taking h = 0.25.
13. Apply **Milin's**method, to find the solution of differential equation $y'=x-y^2$ in the range 0<x<1,given that y(0)=0.

Assignment-4

TOPIC: Numerical Solutions Of PDE& Statistics and Probability

1) Solve the elliptic equation by **Jacobi**'s method.
2) Apply **Adams-Bashforth** method to solve $y'=x-y^2$,y(0)=1.
3) The final grade card of 80 students in a selection test. Calculate the median.

Marks	Below 10	Below 20	Below 30	Below 40	Below 50	Below 60
No. of students	3	12	27	57	75	80

4) Estimate the mode for the following frequency distribution

Age in years	20-25	25-30	30-35	35-40	40-45	45-50	50-55	55-60
Frequency	50	70	100	180	150	120	70	59

5) From the following data , find the missing frequency when mean is 15.38.

Size	10	12	14	16	18	20
Frequency	3	7	x	20	8	5

6) From the following data, find the standard deviation and co-efficient of variation.

Marks	0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80
No. of students	5	10	20	40	30	20	10	4

7) A student obtained the mean and standard deviation of 100 observations as 40 and 5 resp. It was later
8) Discovered that he had wrongly copied down an observation as 50 instead of 40 . Calculate the Correct mean and standard deviation from a group of 8 children, 5 boys and 3 girls .three children are selected at random. the probabilities that the selected group contains No girls ,Only one girl, At least one girl, More girls than boys.

Assignment-5

TOPIC : Sampling & Sampling Distribution

1) A machine produced 16 defective articles in a batch of 500. After overhauling it produced 3 defectives in a batch of 100. Has the machine improved?
2) A sample of 20 items has mean 42 units and S.D. 5 units. Test the hypothesis that it is a random sample from a normal population with mean 45 units.
3) A coin was tossed 400 times and the head turned up to 216 times. Test the hypothesis that the coin is unbiased.
4) Define random variable, discrete random variable and continuous variable.
5) What is error in sampling? Explain acceptance and rejection region.
6) What do you understand by testing of a hypothesis? Explain null and alternative hypothesis.
7) Write down some properties and conditions of Poisson distribution.
8) Prove that Poisson distribution as the limiting case of binomial distribution.
9) If the sum of mean and variance of binomial distribution for 18 trials is 10.find the value of p.
10) Explain student's t-distribution test.

DE/ME-2.4 NON-DESTRUCTIVE TESTING

Assignment No.1

1. Classify the various types of mechanical testing methods.
2. What is non destructive testing? Explain its need and significance.
3. Classify various non destructive testing methods.

Assignment No.2

1. What is radiography? What are the practical applications of radiography?
2. Explain the Xeroradiography testing process in detail.
3. What are the requirements of a good radiograph?

Assignment 3

1. Explain the magnetization methods.
2. Explain the process of Fluorescent Penetration inspection.
3. Explain the process of magnetic analysis of steel bars and tubing.

Assignment 4

1. What is ultrasonic testing? Explain its process.
2. Explain the process of flaw detection in rails and tubes by Sperry Detector.
3. Explain the process of measurement of thickness, hardness & stiffness?

Assignment 5

1. Explain the concept and applications of Plane and circular polarization?
2. What is Photo stress?

LAB MANUALS

BTME 605 HEAT TRANSFER LAB

EXPERIMENT NO: -1

AIM: TO FIND TE THERMAL CONDUCTIVITY OF METAL ROD.

INTRODUCTION: THERMAL CONDUCTIVITY IS THE PHYSICAL PROPERTY OF THE MATERIAL DENTING THE EASE WITH WHICH A PARTCULAR SUBSTANCE CAN ACCOMPLISH THE TRANSMISION OF THERMAL ENERGY BY MOLECULAR MOTION.

THERMAL CONDUCTIVITYOF A MATERIAL IS FOUND TO DEPEND ON THE CHEMICAL COMPOSITION OF THE SUBSTANCE OR SUBSTANCES OF WHICH IT IS A COMPOSED ,THE PHASE(I.E. GAS ,LIQUID OR SOLID) IN WHICH IT EXISTS, ITS CRYSTALLINE STRUCTURE IF A SOLID, THE TEMPERATURE AND PRESSURE TO WHICH IT IS SUBJECTED, AND WEATHER OR NOT IT IS A HOMOGENEOUS MATERIAL.

TABLE 1 LISTS THE VALUES OF THERMAL CONDUCTIVITY FOR SOME COMMON MEATALS:-

SOLIDS(METAL)	THERMAL CONDUCTIVITY W/MOC	STATE
PURE COPPER	380	20 OC
BRASS	110	--DO--
STEEL (O.5%)	54	--DO--

STAINLESS STEEL	17	--DO--

MECHANISM OF THERMAL ENERGY CONDUCTION IN METALS

THEMAL ENERGY CAN BE CONDUCTED IN SOLIDS BY FREE ELECTRONS AND BY LATTICE VIBRATIONS.LARGE NUMBER OF ELECTRONS MOVE ABOUT IN LATTICE STRUCTURE OF THE MATERIAL, IN GOOD CONDUCTORS.THESE ELECTRONS CARRY THERMAL ENERGY FROM HIGHER TEMPERTURE REGION TO LOWER TEMPERTURE REGION, IN A SIMILAR WAY THEY TRANSPORT ELECTRIC CHARGE. IN FACT, THESE ELECTRONS ARE FREQUENTLY REFFERED AS ELECTRON GAS.ENERGY MAY ALSO BE TRANSFERRED AS VIBRATIONAL ENERGY IN THE LATTICE STRUCTURE OF THE MATERIAL.IN GENERAL, HOWEVER, THIS MODE OF ENERGY TRANSFER IS NOT AS LARGE AS ELECTRON TRANSPORT AND HENCE,GOOD ELECTRICAL CONDUCTORS ARE ALWAYS GOOD HEAT CONDUCTORS,E.G. COPPER, SILVER ETC.

HOWEVER, WITH INCREASE IN TEMERATURE,LATTICE VIBRATIONS COME IN THE WAY OF TRANSPORT BY FREE ELECTRONS AND FOR MOST THE METALS THERMAL CONDUCTIVITY DECREASES WITH INCREASE IN TEMPERATURE.

APPARATUS: THE “DYNAMIC” APPARTUS CONSISTS OF A COPPER BAR,ONE END OF WHICH IS HEATED BY AN ELECTRIC HEATER AND THE OTHER END IS COOLED BY A WATER CIRCULATED HEAT SINK.THE MIDDLE PORTION , I.E. TEST SECTION OF THE BAR IS COVERED BY A SHELL CONTAINING INSULATION.THE BAR TEMPERATURE IS MEASURED AT 8 DIFFERENT SECTIONS, WHILE 2 THERMOCOUPLES MEASURE THE TEMPERATURE AT SHELL.TYWO THERMOMETERS ARE PROVIDEDTO MEASURE WATER INLET AND OUTLET TEMPERATURES.

A DIMMER IS PROVIDED FOR THE HEATER TO CONTROL ITS INPUT.CONSTANT WATER FLOW IS CIRCULATED THROUGH THE HEAT SINK.A GATE VALVE PROVIDED, CONTROLS THE WATER FLOW.

SPECIFICATIONS:

1. METAL BAR-COPPER, 25 MM O.D., APPROX. 430 MM LONG WITH INSULATION SHELL ALONG THE TEST LENGTH AND WATER COOLED HEAT SINK AT THE OTHER END.
2. TEST LENGTH OF THE BAR-240 MM.
3. THERMOCOUPLES-CHROMEL/ALUMEL, 10 NOS.
4. BAND NICHROME HEATER TO HEAT THE BAR.
5. DIMMERSTAT TO CONTROL THE HEATER INPUT-2A, 230V.
6. VOLTMETER AND AMMETER TO MEASURE HEATER INPUT.
7. MULTICHANNEL DIGITAL TEMPERATURE INDICATOR, 0.1OC LEAST COUNT, 0-200OC WITH CHANNEL SELECT OR SWITCH.
8. MEASURING FLASK TO MEASURE WATER FLOW.

EXPERIMENTAL PROCEDURE:

1. START THE ELECTRIC SUPPLY.
2. START HEATING THE BAR BY ADJUSTING THE HEATER INPUT TO, SAY, 80V OR 100V.

3. START COLING WATER SUPPLY THROUGH THE HEAT SINK AND ADJUST IT AROUND 350-400 CC PER MINUTE.
4. BAR TEMPERATURE WILL START RISING.GO ON CHECKING THE TEMPERATURES AT TIME INTERVALS OF 5 MINUTES.
5. WHEN ALL THE TEMPERATURES REMAIN STEDY, NOTE DOWN ALL THE OBSERVATIONS AND COMPLETE THE OBSERVATION TABLE.

OBSERVATION TABLE:

S.NO	TEST BAR TEMPERATURE OC								SHELL		WATER TEMP.		
	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	INLET T11	OUTLET T12	FLOW LIT/SEC

USING THE TEMPERATURES OF THE BAR AT VARIOUS POINTS, PLOT THE TEMP DISTRIBUTION ALONG THE LENGTH OF THE BAR AND DETERMINE THE SLOPES OF THE GRAPH (I.E. TEMP RISE PER UNIT LENGTH) DT/DX AT THE SECTIONS AA, BB, CC AS SHOWN IN FIGURE.

CALCULATIONS:

HEAT IS FLOWING THROUGH THE BAR FROM HEATER END TO WATER HEAT SINK.WHEN STEADY STATE IS REACHED , HEAT PASSING THROUGH THE SECTION CC OF THE BAR IS HEAT TAKEN BY THE WATER.

1.HEAT PASSING THROUGH SECTION CC

$Q_{CC} = M.C_P.\Delta T$ WATTS

WHERE,

M = MASS FLOW RATE OF COOLING WATER, KG/S

C_P = SPECIFIC HEAT OF WATER = 4180 J/KG^{O}C

ΔT = (WATER OUTLET TEMP)-(WATER INLET TEMP) ^{O}C

NOW, $Q_{CC} = -K_{CC}[DT/DX]_{CC}.A$

A = CROSS SECTIONAL AREA OF THE BAR = 0.00049 M^2

K_{CC} = W/M^{O}C

2.HEAT PASSING THROUGH SECTION BB

$Q_{BB}=Q_{CC}$ + RADIAL HEAT LOSS BETWEEN CC AND BB.

$=Q_{CC} + [2.(3.14).L_1 (T_6-T_{10})/\log_E (R_O/R_I)]$

WHERE,

K = THERMAL CONDUCTIVITY OF INSULATION = 0.35 W/M^{O}C

L_1= LENGTH OF INSULATION CYLINDER = 0.060 M

R_O = OUTER RADIUS = 0.105 M
R_I = INNER RADIUS = 0.0125 M
$Q_{BB} = -K_{BB}.[dT/dx]_{BB}.A$
$K_{BB} = W/m\,^{o}C$

3.SIMILARLY, HEAT PASSING THROUGH SECTION AA

$Q_{AA}=Q_{BB}$ + RADIAL HEAT LOSS BETWEEN BB AND AA.
$=Q_{BB} + [2.(3.14).L_2\,(T_3-T_9)/\log_e(R_O/R_I)]$
WHERE,
$L_2 = 0.090$ M
$Q_{AA} = -K_{AA}.[dT/dx]_{AA}.A$
$K_{AA} = W/m^{o}C$

RESULTS:

1.TEMPERATURE OF THE BAR DECREASES FROM HOT END TO COOL END, WHICH SATISFIES THE FOURIER LAW O HEAT CONDUCTION.
2.THERMAL CONDUCTIVITY OF BAR AT THREE DIFFERENT SECTIONS
K_{CC} =
K_{BB} =
K_{AA} =

REFERENCES:

1.ENGINEERING HEAT TRANSFER BY GUPTA AND PRAKASH
2.EXPERIMENTAL METHODS FOR ENGINEERS-Mc GRAW HILL BOOK COMPANY, JP HOLMAN

EXPERIMENT NO: -2

AIM –

To find the thermal conductivity of an insulating plate by slab method.

APPARATUS –

The apparatus is designed& fabricated according to the Guarded Hot Plate principle. The Guarded Hot Plate method has been recognized by scientists & engineers in U.S.A., West Germany, Scandinavian Countries, USSR & India as most dependable & reproducible for the measurement of thermal conductivity of insulating materials. It is a steady state absolute method suitable for materials which can be laid flat between two parallel plates & can be adopted for loose fill materials which can be filled between these two plates.

PRINCIPLES OF GUARDED HOT PLATE METHOD -

A sketch of the apparatus is shown in fig. (1). The essential parts are – Hot plate, cold plates, the heater assembly, thermocouples & the specimens in position are shown in the same figure.

For the measurement of thermal conductivity (k) what is required is to have a one dimensional heat flow through the flat specimen, an arrangement for maintaining its faces at constant temp. & some metering method to measure the heat flow through the known area. To eliminate the distortion caused by the edge losses in unidirectional heat flow, the central plate is surrounded by a guard which is separately heated.

Temperatures are measured by calibrated thermocouples either attached to the specimen at the hot & cold faces. Two specimens are used to ensure that all the heat comes out through the specimen only. Knowing the heat input to the central plate heater, the temp. difference across the specimen, its thickness & the metering area, one can calculate K of the specimen by using the following formula: --

$$K = \frac{q}{2A} * \frac{L}{T_h - T_c} \quad W/m^oC \qquad \underline{\hspace{3cm}}(1)$$

Where,

K = Thermal Conductivity of Sample, W/m ^{0}C
Q = Heat Floe Rate in the specimen, Watts
A = Metering area of the specimen, m^2
T_h= Hot plate temperature, ^{0}C
T_c= Cold plate temperature, ^{0}C
L = Thickness of the specimen, m.

If the specimen thickness are different & the respective hot & cold temperatures are different then,

$$K = \frac{q}{A} * (a + b) \quad W/m\ ^0C$$

Where,

$$a = \frac{1}{(Th1 - Tc_1) / L_1}$$

$$b = \frac{1}{(Th_2 - Tc_2) / L_2}$$

Where Suffix 1 is for upper specimen & 2 is for lower specimen.

APPARATUS:- This apparatus is designed & fabricated with IS 3336 as a guide line, having the following specifications :-

Diameter of the heating plate - 100mm
Width of the heating ring - 37mm
Inner dia. Of the heating ring -110mm
Outside dia. Of the heating ring - 180mm
Max. thickness of the specimen - 25mm
min. thickness of the specimen - 6mm
Dia of the specimen - 180mm
Mean temp. range - 40 ^{0}C – 100 ^{0}C
Max. temp. of the hot plate - 170 ^{0}C
Dia. of the cooling plate - 180mm
Central Heater- Nichrome strip type wire sandwiched between mica sheets

Guarded Heater Rig - Nichrome strip type wire sandwiched between mica sheets
dimmerstat - (0-2 Amp, 0-240 V) – 2 Nos
Voltmeter - 0-200V
Ammeter - 0-2 A
Thermocouple - (ChromelAlmel) - 6 Nos
Glass wool insulation around assembly
Temperatre Indicator - 0 – 200^0C
Specimen supplied – Hylam 2 mm thick

DESCRIPTION:-

The heater plate is surrounded by a heating ring for stabilizing the temperature of the primary heater and prevent heat loss radically around its edges. The primary and guard heater are made up of mica sheets in which is wound closely spaced Nicrome wire and packed with upper and lower mica sheets. These heaters together form a flat which together with upper and lower copper plates and rings form the heater plate assembly.

Two thermocouple are used to measure the hot face temperature at the upper and lower central heater assembly copper plates. Two more thermocouples are used to check balance in both the heater. (See Fig 1)

Specimens are held between the heater and cooling unit o each side of the apparatus. Thermocouple No.5 and 6 measure the temperature of the upper cooling plate and lower cooling plate respectively (Fig 1).

The heater plate assembly together with cooling plates and specimen held in position by 3 vertical studs and nuts on a base plate are as shown in the assembly drawing (Fig – 3).

The cooling chamber is a composite assembly of Aluminium casting and Aluminium cover with entry and exit adapter for water inlet and outlet.

TEST PROCEDURE:-

The specimen is placed on either side of the plate assembly, uniformly touching the cooling plate. Then the outer container containing glass wool insulation is fixed over the test assembly carefully. The cooling circuit is started. Then input is given to central and guard heaters through separate single phase supply lines with a dimmerstat for each line and it is adjusted to maintain the desired temperatures. The guard heater input is adjusted in such a way that there is no radial heat flow which is checked form thermocouple readings and is adjusted accordingly. The input to the central heater (current and voltage) the thermocouple readings are recorded every 10 minutes till a reasonably steady state condition is reached. The readings are recorded in the observation table. The final steady state values are taken for calculation.

PRECAUTIONS:-

Keep dimmerstat to zero voltage position before start.

Increase the voltage gradually.

Start the cooling circuit before switching ON the heaters and adjust the flow rate so that particularly there is no temperature rise in the circulation.

Keep the heater plate undisturbed and adjust the cooling plates after keeping the samples with the help of nuts gently.

While fixing the insulation cover, be careful that heater and thermocouple connections as well as water connections are not disturbed.

OPERATIONAL INSTRUCTIONS:-

For ensuring that no radial heat transfer is there, generally outer heater input is babout 1.5 to 3 times than central heating output.

Observation Table:- [T.C. by Guarded hot plate]

Sr. No.	Main Heater				Ring Heater				Cooling Plate	
	V	I	T1	T2	V	I	T3	T4	T5	T6

CALCULATIONS:-

1) Main Heater Input (Inner Heater) = V1 x I1 = W1
2) Ring Heater Input (Outer Heater) = V2 x I2 = W2
3) Specimen Used =
4) Specimen Thickness =
5) Diameter of specimen =
6) Metering area

$$A = \frac{\Pi}{4}(0.10 + X)^2 \quad m^2$$

Where, X = Width of gap between the plates = 0.005m

7) $$K = \left[\frac{W_1}{\frac{2A\ (T_h - T_c)}{L}}\right] \quad W/m^0C$$

Referred at,

$$= \frac{T_h + T_c}{2} \quad {}^0C$$

Where, $$T_h = \frac{T_1 + T_2}{2} \quad {}^0C$$

$$T_c = \frac{T_5 + T_6}{2} \quad {}^0C$$

EXPERIMENT NO: -3

AIM-To finds the thermal conductivity of the powder material by co-centric spheres method.

THE APPARATUS-The apparatus consists of a smaller sphere,inside which is fitted a mica electric heater.Smaller sphere is fitted at the centre of outer sphere.The insulating powder whose thermal conductivity is to be determined,is filled in the gap between the two spheres.The heat generated by heater flows through the powder to the outer sphere.The outer sphere loses heat to atmosphere.The input to the heater is controlled by a dimmerstat and is measured on voltmeter and ammeter.Four thermocouples are provided on the outer surface of inner sphere and six thermocouples are on the inner surface of outer sohere,which are connected to a multichannel digital temperature indicator.Average of outer and inner sphere temperatures gives the temperature difference across the layer of powder.

THERMAL CONDUCTIVITY OF INSULATING POWDER-Conduction of heat is flow of heat which occurs due to exchange of energy from one molecule to another without appreciable motion of molecules.In any heating process heat is flowing outwards from heat generation point.In order to reduce losses of heat,various types of insulations are used for heat insulartion.In order to determine the appropriate thickness of insulation,knowledge of thermal conductivity of insulating material is issential.The DYNAMIC unit enables to determine the thermal conductivity of insulating powders,using 'sphere in sphere' method.

SPECIFICATIONS-

1.INNER SPHERE-100mmO.D.,halved construction.
2.OUTER SPHERE-200mmI.D.,halved construction.
3.HEATER-Mica flat heater,fitted inside inner sphere.
4.CONTROLS- a)Main switch-30 A, DPDT Switch.
    b)Dimmerstat -0-230 volts, 2 A capscity.
5.MEASUREMENTS- a)Voltmeter 0-200 volts.
    b)Ammeter 0-1 Amp.
    c)Multichannel digital temperature indicator,calibrated for cr/A1 thermocouples.

EXPERIMENTAL PROCEDURE-

1.Keep the dimmerstat knob at ZERO position and switch ON the equipment.
2.Slowly rotate the dimmerstatknob,so that voltage is applied across the heater, let the temperature rise.
3.Wait until steady state is reached.
4.Note down all the temperatures and input of heater in terms of volts and current.
5.Repeat the procedure for different heat inputs.

OBSERVATIONS-

Sr. No.	TEMPERATURE °C										HEATER INPUT	
	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9	T_{10}	Volts	Amps.
1												

THEORY- Consider the transfer of heat by heat conduction through the wall of a hollow sphere formed of insulating powder(Ref.fig.)

let, r_i =radius of inner sphere,m.
r_o =radius of outer sphere,m.
Ti =average inner sphere surface temp.°C

To =average outer sphere surface.°C

Consider a thin spherical layer of thickness dr at radius r & temp. difference of dT across the layer.Applyingfourier law of heat conduction,heat transfer rate,

$$q = -k \;.\; 4\pi \;.\; r^2 \;.\; [\, dT/dr \,]$$

where, k =thermal conductivity of insulating powder.

$$\frac{q}{4\pi . k} * \frac{dr}{r} = -dT$$

Integrating between ,r_i to r_o and Ti to To , we get

$$\frac{q}{\;} \int_{r_i}^{r_o} \frac{dr}{r^2} = -\int_{Ti}^{T_\circ} dT$$

$$\text{or } q = \frac{4\pi\, k\, ri\, r_0 (Ti - T_0)}{(r_o - ri)}$$

From the measured values of q, Ti and To thermal coductivity of the insulating powder can be determined as,

$$k = \frac{q \quad (r_o - ri)}{4\pi\, k\, ri\, r_0 (Ti - T_0)}$$

CALCULATIONS-

1. Heater input = q = V x I watts.

2.Average inner sphere surface temperature

$$Ti = \frac{T_1 + T_2 + T_3 + T_4}{4} \, ^\circ C$$

3.Average outer sphere surface temp.

$$T_O = \frac{T_5 + T_6 + T_7 + T_8 + T_9 + T_{10}}{6} \, ^\circ C$$

4.Inner sphere radius = 50mm = 0.05 m.

5.Outer sphere radius = 100mm = 0.1 m.

now,

$$k = \frac{q \quad (r_o - ri)}{4\pi \; ri\, r_0 (Ti - T_0)}$$

$Ti + T_O$

at -------------------° C
2

PRECAUTIONS-

1.Operate all the switches and controls gently.
2.If thermal conductivity of the powder other than supplied is to be determined, then gently dismantle the outer sphere and remove the powder, taking care that te heater connections and thermocouples are not disturbed.
3.Earthing is essential for the unit.

OBSERVATION TABLE

S.No.	MAIN HEATER				RING HEATER				COOLING PLA	
	V	I	T1	T2	V	I	T3	T4	T5	
1	65	0.325	91.3	91.3	70	0.75	89.2	89.7	28.7	2

CALCULATIONS:--

Main heater input W1 = 65 x 0.325
Inner heater = 21.125 Watts.
2. Ring heater input W2 = 70 x 0.75
Outer heater = 52.5 Watts
3. Specimen used = Bakelite
4. Specimen thickness ‘L’ = 0.01m
5. Diameter of the specimen= 0.180m
6. Metering area ‘A’ = 0.0086m^2

7. Therefore,

$$K = \frac{21.125 * 0.01}{2 * 0.0086 (91.3 – 28.05)}$$

$$= 0.19 \text{ W/m}^{20}\text{k}$$

EXPERIMENT NO: -4

AIM- Determination of thermal conductivity of composite wall kept in series

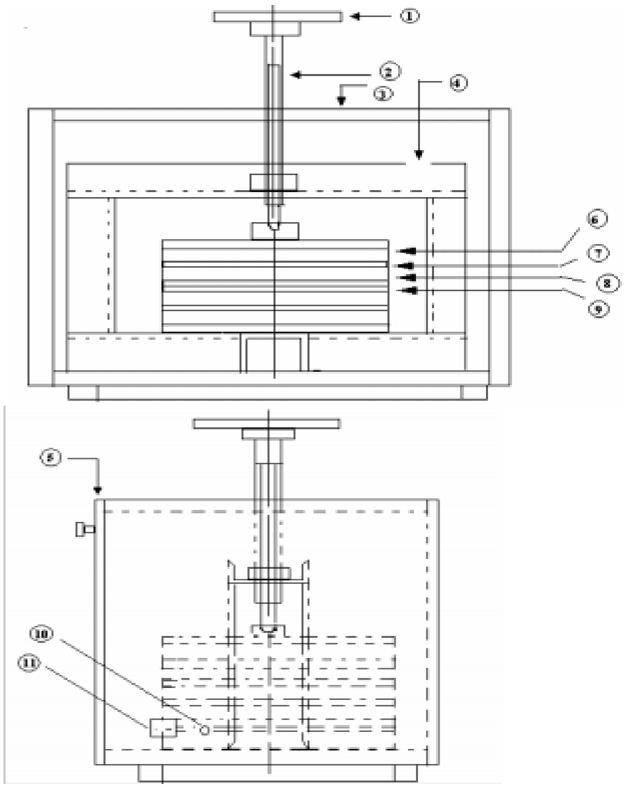
Description: The apparatus consists of a central heater sandwiched between two sheets. Three types of slabs are provided both sides of heater, which forms a composite structure. A small hand press frame is provided to ensure the perfect contact between the slabs. A dimmerstat is provided for varying the input to the heater and measurement of input is carried out by a voltmeter, ammeter. Thermocouples are embedded between interfaces of the slabs, to read the temperature at the surface. The experiments can be conducted at various values of input and calculation can be made accordingly.

Specifications:

1. Slab assembly arranged symmetrically on both sides of heater.
2. Heater: Nochrome heater wound on mica former and insulation with control unit capacity 300 watt maximum.
3. Heater Control Unit: 0-230V. Ammeter 0-2Amps. Single phase dimmerstat (1No.).
4. Voltmeter 0-100-200V. Ammeter 0-2Amps.
5. Temperature Indicator (digital type): 0-200oC. Service required – A.

C. single phase 230 V. earthed electric supply.

Schematic Diagram:



(1) Hand Wheel **(2)** Screw **(3)** Cabinet **(4)** Fabricated Frame
(5) Acrylic Sheet **(6)** Press Wood Plate **(7)** Bakelite Plate **(8)** C.I. Plate
(9) Heater **(10)** Heater Cable **(11)** Thermocouple Socket 12 Way
T1 To T6 Thermocouple Positions

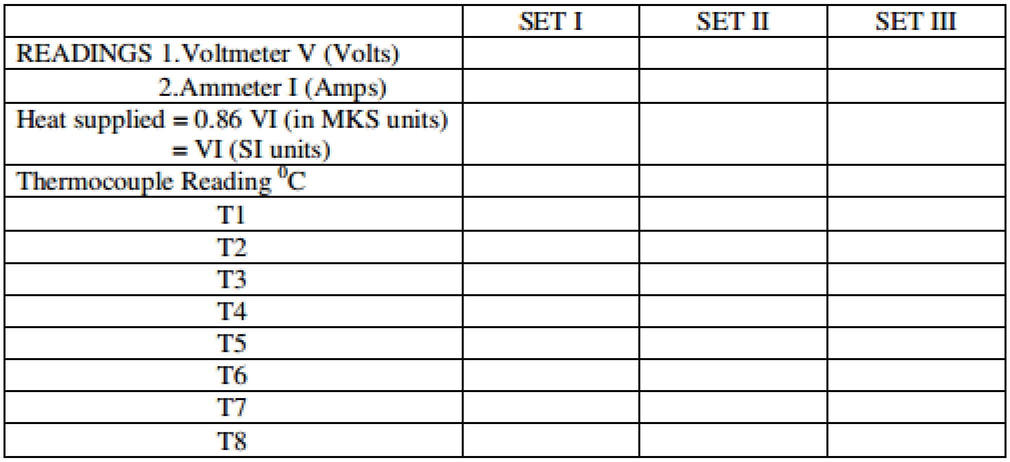
Procedure: Arrange the plates in proper fashion (symmetrical) on both sides of the Heater plates.

1. See that plates are symmetrically arranged on both sides of the heater plates.

2. Operate the hand press properly to ensure perfect contact between the plates.
3. Close the box by cover sheet to achieve steady environmental conditions.
4. Start the supply of heater by varying the dimmerstat; adjust the input at the desired value.
5. Take readings of all the thermocouples at an interval of 10 minutes until fairly steady temperatures are achieved and rate of rise is negligible.
6. Note down the reading in observation table.

Observations and observations table:

Composite slabs: 1. Wall thickness:
a. Cast iron =
b. Hylam =
c. Wood =
2. Slab diameter = 300mm.

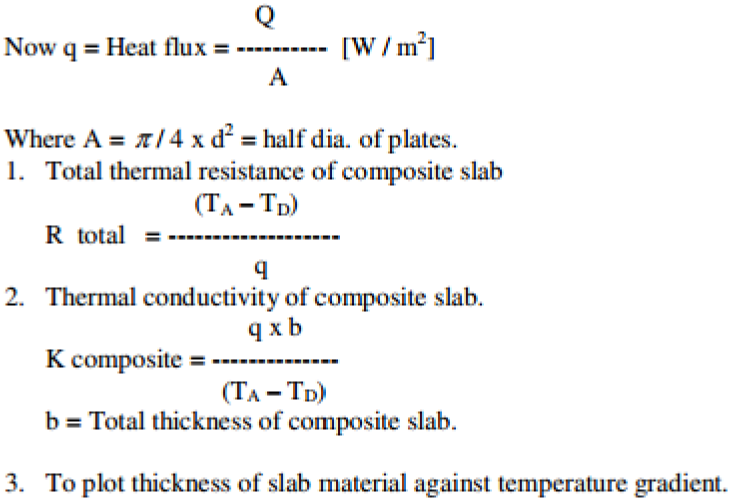


	SET I	SET II	SET III
READINGS 1.Voltmeter V (Volts)			
2.Ammeter I (Amps)			
Heat supplied = 0.86 VI (in MKS units) = VI (SI units)			
Thermocouple Reading ^{0}C			
T1			
T2			
T3			
T4			
T5			
T6			
T7			
T8			

Mean Readings: TA = --(T1 + T2)/2
TB = (T3 + T4)/2
TC = (T5 + T6)/2
TD = (T7 + T8)/2

Calculations:

Read the Heat supplied Q = V x I Watts (In S. I. Units) For calculating the thermal conductivity of composite walls, it is assumed that due to large diameter of the plates, heat flowing through central portion is unidirectional i. e. axial flow. Thus for calculation, central half diameter area where unidirectional flow is assumed is considered. Accordingly, thermocouples are fixed at close to center of the plates.



Now q = Heat flux = $\dfrac{Q}{A}$ $[W / m^2]$

Where $A = \pi / 4 \times d^2$ = half dia. of plates.

1. Total thermal resistance of composite slab

   $R \text{ total} = \dfrac{(T_A - T_D)}{q}$

2. Thermal conductivity of composite slab.

   $K \text{ composite} = \dfrac{q \times b}{(T_A - T_D)}$

   b = Total thickness of composite slab.

3. To plot thickness of slab material against temperature gradient.

Conclusion:

1) Total Thermal resistance to found out to be --------------------

EXPERIMENT NO: -5

AIM- To find the convective heat transfer coefficient for a vertical tube in natural convection
Introduction- In contrast to the forced convection, natural convection phenomenon is due to the temperature difference between the surface and the fluid and is not created by any external agency. Natural convection flow patterns for some commonly observed situations are shown in fig. 1**..**The present experimental setup is designed and fabricated to study the natural convection phenomenon from a vertical cylinder in terms of the variation of local heat transfer coefficient along the length and also the average heat transfer coefficient and its comparison with the value obtained by using an appropriate correlation.

Apparatus
The apparatus consists of a brass tube fitted in a rectangular vertical duct . the duct is open at the top and bottom and forms an enclosure and serves the purpose of undisturbed surrounding. One side of the duct is made up of Perspex for visualization. An electric heating element is kept in the vertical tube which in turn heats the tube surface. The heat is lost from the tube to the surrounding air by natural convection. The temperature of the vertical tube is measured by seven thermocouples. The heat input to the heater measured by an ammeter and a voltmeter and is varied by a dimmerstat. The vertical cylinder with the thermocouple positions is shown in fig.2 while the possible flow pattern and also the expected variation of local heat transfer coefficient are shown in fig.3. The tube surface is polished to minimize the radiation losses

SPECIFICATIONS
Diameter of the tube (d) = 38mm
Length of the tube (l) = 500mm
Duct size 200mm × 200mm × 800mm .length
Multichannel digital temperature indicator 0-3000c using chromel/ alumel thermocouple
Ammeter 0-2 amp. And voltmeter 0-200 volts.
Dimmerstat 2 amp. 240 volts

THEORY

When a hot body is kept in still atmosphere, heat is transferred to the surrounding fluid by natural convection. The fluid layer in contact with the hot body gets heated, rises due to the decrease in its density and the cold fluid rushes in to take place. The process is continuous and the heat transfer takes place due to the relative motion of hot and cold fluid particles.

The heat transfer is given by

$$h = \frac{q}{As \times (T_s - T_a)}$$

Where, h=Average surface heat transfer coefficient ($w/m^2\,{}^0C$)

Q= heat transfer rate (watts)

A_s=area of the heat transferring surface= π dl (m^2)

T_s = Average surface temperature

$$= \frac{(T_1 + T_2 + T_3 + T_4 + T_5 + T_6 + T_7)}{7} \quad ({}^0 C)$$

T_a = Ambient temperature in the duct= T_8 (^{0} C)

The surface heat transfer coefficient, of a system transferring heat by natural convection depends on the shape, dimensions and orientation of the fluid and the temperature difference between heat transferring surface and the fluid. The dependence of ‘h’ on all the above mentioned parameters is generally expressed in terms of non dimensional group as follow:

$$\frac{h\times L}{k} = A\times\left[\frac{g.L^3.\beta.\Delta T}{\nu^2} \times \frac{C_p.\,\mu}{k}\right]^n \text{ ------------------------------------ (2)}$$

Where $\frac{h\times L}{k}$---------------------- is called Nusselt number,

$\frac{g.L^3.\beta.\Delta T}{\nu^2}$ ----------------------- is called Grashof number and

$\frac{C_p.\,\mu}{k}$ -----------------------is called Prandtl number

A and n are constants depending on the shape and orientation of the heat transferring surface.

Where, L=A characteristic dimension of the surface.

K= Thermal conductivity of fluid

ν= Kinematic viscosity of fluid

μ=Dynamic viscosity of fluid

C_p= Specific heat of fluid.

β =coefficient of volumetric expansion for the fluid.

g= Acceleration due to gravity.

$\Delta T = T_s — T_a$

For gases, $\beta = \frac{1}{(T_f + 273)} / {}^o k$

$T_f = \frac{T_s + T_a}{2}$

For a vertical cylinder losing heat by natural convection, the constants A and n of equation (2) have been determined and the following empirical correlations obtained.

$\underline{h\times L} = 0.59\ (Gr.\ Pr.)^{0.25}$ for $10^4 < Gr.\ Pr. < 10^8$ ---------------------------------------(3)

k

$$\frac{h\times L}{k} = 0.13\ (Gr.\ Pr.)^{1/3} \quad \text{for } 10^{8} < Gr.\ Pr. < 10^{12} \text{ -- } (4)$$

L= Length of cylinder.

All the properties of the fluid are determined at the mean film temperature (T_f)

PROCEDURE-

Put on the supply and adjust the dimmerstat to obtain the required heat input (say 40 w, 60w, 70w etc.)

Wait till the steady state is reached, which is confirmed from temperature readings (T1 to T7).

Measure surface temperature at the various points T1 to T7.

Note the ambient temperature T8.

Repeat the experiment at different heat inputs (Do not exceed 80 w).

OBSERVATIONS-

O.D.cylinder = 38mm

Length of cylinder= 500mm

Input to heater= V×I watts

S.no	Volt	Amp	TEMPERATURE, ^{0} C							
			1	2	3	4	5	6	7	8(T_a)

CALCULATIONS-

Calculate the value of average surface heat transfer coefficient, neglecting end losses using equation (1)

Calculate and plot (fig. 4) the variation of local heat transfer coefficient along the length of tube using T= T1 to T7 and $h = \frac{q}{A_s.\,(T - T_a)}$

Compare the experimentally obtained value with the predictions of the correlation equations (3) or (4).

PRECAUTIONS

Proper earthing is necessary for the equipment.

Keep dimmerstat to ZERO volt position before putting on main switch and increase it slowly.

Keep at least 200 mm. space behind the equipment.

Operate the change over switch of temperature indicator gently from one position to other, i.e. from 1 to 8 positions.

Never exceed 80 watts.

Results and discussions

Some typical results are shown in figure 4 & 2 different heater inputs.

The heat transfer coefficient is having a maximum value at the beginning as expected because of the just starting of the building of the boundary layer & it decreases as expected in the upward direction due to thickening of layer & which is laminar one. The trend is maintained up to half of the lengths (approx.) & beyond that there is little variation in the value of local heat transfer coefficient because of the transition

&turbulent boundary layers. The last point shows somewhat increase the value of heat transfer coefficient which is attributed to end loss causing a temperature drop.

The comparison of average heat transfer coefficient is also made with predicted values are somewhat less than experiment values due to the heat loss by radiation.

Heat loss by radiation $=\sigma.A.\varepsilon(T_s^4-T_a^4)$

σ= Stefan Boltzmann constant= 5.667 × 10-8 w/m^2K^4

A= Surface area of pipe=0.59 m^2

ε= Emissivity of pipe material = 0.6

T_s& T_a= surface& ambient temperatures respectively.

EXPERIMENT NO: -6

AIM: - To find the heat transfer coefficient for heat transfer in forced convection.

Theory Whenever a fluid is being forced over the heated surface, forced convection heat transfer occurs . The apparatus consists of a circular pipe through which cold fluid, i.e. air is being forced. Pipe is heated by a band heater outside the pipe. Temperature of pipe is measured with thermocouples attached to pipe surface. Heater input is measured by a Voltmeter and Ammeter. Thus, heat transfer rate and heat transfer coefficient can be Calculated.

Specifications:

Test pipe -33 mm I.D. 500 mm Long.
Band heater for pipe.
Multichannel Digital Temperature indicator 0-300 ^{0}C using Chromel / alumel thermocouples.
Dimmerstat 2 amps . 240 Volts for heater input control.
Voltmeter 0-200 volts
Ammeter 0-2 Amps.
Blower to force the air through test pipe.
Orificemeter with water manometer.

EXPERIMENTAL PROCEDURE

Put 'ON' mains supply.
Adjust the heater input with the help of dimmer stat.
Start the blower and adjust the air flow with valve.
Wait till steady state is reached and note down the reading in the observation table.

Observations

Sr. No	Volt	Amp	Temperatures							Manometer Difference
			T1	T2	T3	T4	T5	T6	T7	

Calculations

Air inlet temp $T_1 =$ ^0C

Air outlet temp $T_7 =$ ^0C

Density Of Air ,

$$p_a = \frac{1.293 * 273}{273 + 21}$$

Diameter of orifice =22mm

Manometer difference = Water head = $h_w$mtrs.

Air head, $h_a = h_w\ (p_w / p_a)$

Where, p_w = Density of water = 1000 Kg / m3

Therefore, air volume flow rate,

$$Q = C_d * a_o * \ 2\,g\,h_a \qquad m^3 /sec.$$

Where, $c_d = 0.64$

a_o= C. S. area of orifice.

5. Mass flow rate of air,

$$m_a = Q \times \rho_a \quad Kg/sec$$

Velocity of air,

Q

V = —— m/sec

a_p

Where,

a_p = Cross sectional area of pipe

$= 8.33 \times 10^{-4}$ m²

6. Heat gained by air, $q = m_a \times c_{pa} \times (T_7 - T_1)$

Where, Cpa = Specific heat of air = 1 kJ/ Kg K.

= 10^3 J/ Kg K.

7. Average inside surface temperature

$T_2 + T_3 + T_4 + T_5 + T_6 T_s$ = ———————— $^\circ c$

5

8. Bulkmeantemp. of air,

$T_1 + T_7$

T_m = ——— $^\circ c$

2

9. Average surface heat transfer coefficient :-

Actual Heat Loss Due To Forced Convection = q – Heat Loss Due To Radiation

► Heat Loss Due To Radiation (q 1):-

$q_1 = 0.4 \times A \times (Ts^4 - Ta^4) \times \sigma$ (σ – Stefan Boltzman Constant)

► Actual Heat Loss = $q - q_1$

$$h\ \text{expt} = \frac{q - q_1}{A \times (Ts - Tm)} \qquad W/ m^2k$$

Where,

A = Inside surface area of the pipe $= \pi \times di \times 1$

$= \pi \times 0.33 \times 0.5$

$= 0.0518\ m^2$

10. Reynoulds number–

$$R_{eD} = \frac{V \text{ x } D}{v}$$

v = Kinematic viscosity at Tm.

D = 0.33 m.

If $R_{eD} < 2000$, flow is laminar.

For laminar flow $\dfrac{h \bullet D}{K_{air}} = 4.36$

If Reynoulds number exceeds 2000, flow is turbulent.

For turbulent. Flow,

$$N_{uD} = \frac{h \bullet D}{K_{air}}$$

$$= 0.023\,(R_{eD})^{0.8}\,(Pr.)^{n}$$

Where, n = 0.4 when fluid is being heated.

N = 0.3 when fluid is being cooled.

Determine htheo from Nu.

NOTE:- The calculated values and actuals may differ appreciable because of heat losses. The heat loss through natural natural convection , conduction and heat loss through insulation over the heater is not considered , but they are present. Also the heat flux is not uniform practically , as assumed in theory , which gives difference between the actual and theoretical value.

PRECAUTIONS:-

1. While putting "ON" the supply , keep dimmerstat at zero position and blower switch "OFF".
2. Operate all the switches and controls gently.
3. Do not obstruct the flow of air while experiment is going on.

EXPERIMENT NO: -7

AIM: - The objective of this experiment is to observe the regimes of nucleate, transition, and film boiling in a pool of saturated liquid, to determine the rate of boiling, and to construct the boiling curve

Concepts Emphasized

1. Energy balance and conditions justifying the lumped capacitance method;
2. variation of the boiling heat flux with excess temperature - peculiar features of the boiling curve;
3. magnitude of the overall heat transfer coefficient;
4. definition and physical significance of the critical heat flux and Leidenfrost point; and
5. transient nature of the problem and time variation of the surface temperature.

EXPERIMENTAL PROCEDURE

The experiment is designed to illustrate the characteristics of the boiling phase-change phenomenon. It involves observing the rate of boiling of a saturated liquid on the surface of a submerged hot object and measuring the variation of the object temperature with time. The object is initially at a temperature (Troom ≈ 273K) far above the boiling point of the liquid (in this case, liquid nitrogen: Tbp≈77K). By measuring the time variation of the object's temperature, the rate of boiling, and the boiling curve can be constructed based upon the application of the lumped capacitance method. A sample boiling curve is given in Figure 1. To prepare for the experiment, which could be performed prior to when the topic has been discussed in the Heat Transfer course, the student should complete the following items:

1. Review sections 10.2, 10.3, and 10.4 of the text by Incropera et al., 4th ed., 5th ed., or 6th edition.
2. Consider a hot metal sphere, initially at a temperature of Ti , that is suddenly quenched in a large pool of
saturated liquid at Tbp<Ti (see Fig. 2). If the excess temperature, (Ti−Tbp) is between about 5 and 30□ C, what is this boiling regime called? Describe the boiling phenomena in this regime.

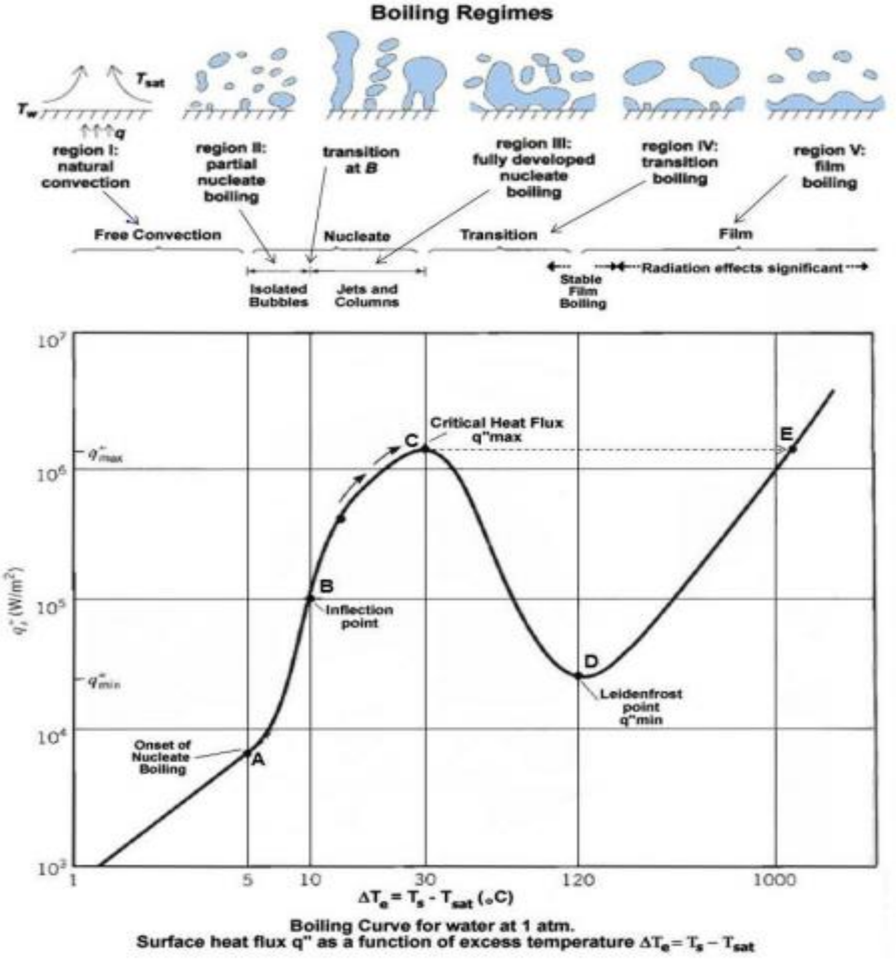


Figure 1. Boiling curve for water including regime illustrations and labeling of key points.

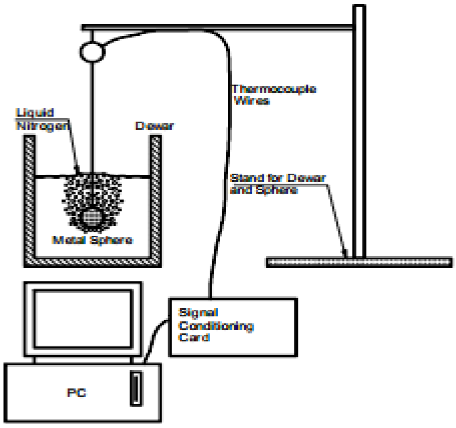


Figure 2. Experimental setup for measuring transient temperature of a metal sphere cooled in liquid nitrogen (not to scale).

3. If the excess temperature, (Ti−Tbp) is beyond the Leidenfrost point, will there be direct contact between the liquid phase and the surface of the sphere? What do we call this regime of pool boiling?
4. Using the lumped capacitance method, derive a differential equation for the transient temperature response of the sphere. The boiling heat flux takes an unusual form, so leave the heat flux as a variable for now.
5. If the metal sphere in item 2 above is copper, has a diameter of 2.54* 10-2 m , an initial temperature of Ti = 773K, and the liquid is saturated water at 373K and 1 atm, estimate the time for the sphere to become partially wetted by the liquid phase (i.e., the time for the sphere to reach the Leidenfrost point at 493K).

DAQView Setup Parameters
Thermocouple Type: T
Units: K
Number of Thermocouples: 2 (+CJC)
Start Condition: Manual Start
Stop Condition: Manual Stop
Scan Rate: 4 scans/secs
Averaging: Enabled: 100
Suggested Monitoring Method: Digital Meters

EXPERIMENT NO: -8

AIM-To finds the Stefan Boltzmann constant.

STEFAN BOLTZMANN APPARATUS- All the substances emit thermal radiation.When heat radiation is incident over a body; part of radiation is absorbed, transmitted through and reflected by the body. A surface which absorbs all thermal radiation incidents over it is called black surface. For black surface, transmissivity and reflectivity are zero and absorptivity is unity. Stefan Boltzmann Law states that emissivity of a surface is proportional to fourth power of absolute surface temp. i.e.

$$e \quad \alpha T^4$$

$$\text{or} \quad e = \alpha.\varepsilon.T^4$$

Where, e = emissive power of surface.
T = absolute temp.
σ= Stefan Boltazmann Constant.
& ε = Emissivity of the surface.
Value of Stefan Boltazmann constant is taken as

$$= 5.667 \times 10^{-8} \ \mathrm{W/m^2\,K^4}$$

For black surface, $\varepsilon = 1$, hence above equation reduces to

$$e = \sigma . T^4$$

THE APPARATUS-

The apparatus consists of a water heated jacket of hemispherical shape.A copper test disc is fitted at the centre of jacket.The hot water is obtained from a hot water tank, fitted to the pannel, in which water is heated by an electric imersionheater.The hot water is taken around the hemisphere, so that hemisphere temp. rises.The test disc is then inserted in the centre.Thermocouples are fitted inside hemisphere to average out hemisphere temp. Another thermocouple fitted at the centre of test disc mearures the temp of test disc.

A timer with a small buzzer is provided to note down the disc temp at the time intervals of 3 seconds.

EXPERIMENTAL PROCEDURE-

1.See that water inlet cock of water jacket is closed and fill up sufficent water in the heater tank.
2.Put 'ON' the heater.
3.Blaken the test disc with the help of lamp black & let it cool.
4.Put the thermometer and check the temp.
5.Boil the water ans switch 'OFF' the heater.
6.See that the drain cock of water jacket is closed and open water inlet cock.
7.See that there is sufficent water above the top of hemisphere(A piezometer tube is fitted to indicate water level)
8.Note down the hemisphere temp.(i.e, upto channel 1 to 4)
9.Note down the test disc temp. (i.e, channel no. 5)
10.Start the timer.Buzzer will start ringing.At the start of timer cycle, insert test disc into the hole at the bottom of hemisphere.
11.Note down the temp of disc, every time the buzzer rings.Takeatleast 3-4 readings.

OBSERVATIONS-

Hemisphere Temperature (°C)	Time interval (Sec)	The disc temperature (°C) T5
T1 =	03	
T2 =	06	
T3 =	09	
T4 =	12	

CALCULATIONS-

1) Area of test disc, A = 3.14 x 10-4 m2 (d = 20 mm)

2) Weight of test disc, m = 5.0 gms. = 5.0 x 10-3 kg.

3) Plot a graph of temp. rise of test disc with time as base and find out its slope at origin.

i.e. dT

[-----------------------] at t =0   k/sec

dt

4) Hemisphere temp.

T1+T2+T3+T4

T_H = [-------------------------- + 273.15] K

4

5) Initial test disc temp.

T_D =[T_5 +273.15] K

as area of hemisphere is very large as compared to that of test disc, we can put

q =σ.ε.A (TH^4 -TD^4)

where, q = heat gained by disc/sec.

dT

= m.ρ. (-------)

dt

σ = Stefan Boltazmann constant.

m = Mass of test disc = 5.0 x 10^{-3} kg.

p = Specific heat of copper = 381 J/kg °C

Theoretical value of   is 5.667 x 10^{-8} W/m^2 k^4

In the experiment, this value may deviate due to reasons like convection, temp. drop of hemisphere, heat losses, etc.

PRECAUTIONS-

1) Never put 'ON' the heater before putting water in the tank.

2) Put 'OFF' the heater before draining the water from heater tank.

3) Drain the water after completion of experiment.

4) Operate all the switches and controls gently.

EXPERIMENT NO: -9

Heat Transfer from a Pin-Fin Apparatus

Aim: -To calculate the value of fin efficiency for natural & forced convection

Introduction:

Extended surfaces of fins are used to increase the heat transfer rate from a surface to a fluid wherever it is not possible to increase the value of the surface heat transfer coefficient or the temperature difference between the surface and the fluid. The use of this is variety of shapes (refer fig. 1). Circumferential fins around the cylinder of a motor cycle engine and fins attached to condenser tubes of a refrigerator are a few familiar examples.

It is obvious that a fin surface sticks out from the primary heat transfer surface. The temperature difference with surrounding fluid will steadily diminish as one moves out along the fin. The design of the fins therefore required a knowledge of the temperature distribution in the fin. The main objective of this experimental set up is to study temperature distribution in a simple pin fin.

Apparatus:

A brass fin of circular cross section in fitted across a long rectangular duct. The other end of the duct is connected to the suction side of a blower and the air flows past the fin perpendicular to the axis. One end of the fin projects outside the duct and is heated by a heater. Temperature at five points along the length of the fin. The air flow rate is measured by an orifice meter fitted on the delivery side of the blower. Schematic diagram of the set up is shown in fig. 2, while the details of the pin fin are as per fig. 3.

Theory:

Consider the fin connected at its bast to a heated wall and transferring heat to the surroundings. (Refer fig. 4)

Let, A = Cross section area of the fin.
C = Circumference of the fin.
L = Length of the fin.
T_1 = Temp. of the fin at the beginning.
T_f = Duct fluid temperatures.
$\varnothing = (T - T_f)$ = Rise in temperature.

The heat is conducted along the rod and also lost to the surrounding fluid by convection.

Let, h = Heat Transfer coefficient.
K = Thermal conductivity of the fin material.

Applying the first law of thermodynamics to a controlled volume along the length of the fin at X, the resulting equation of heat balance appears as:

$$\frac{d^2\varnothing}{d\,x^2} - \frac{h.\,c}{K.\,A}\,\varnothing = 0 \qquad \ldots\ldots\ldots\ldots\ldots..(1)$$

and the general solution of equation (1) is

$$\varnothing = C_1 . e^{mx} + C^2 . e^{-mx} \qquad \text{…………………………..(2)}$$

$$\text{Where, } m = \sqrt{\frac{h.\,c}{K.\,A}}$$

With the boundary conditions of $\varnothing = \varnothing_1$ at $x = 0$

Where, $\varnothing_1 = T_1 - T_F$ and assuming the fin tip to be insulated.

$\frac{d\varnothing}{dx} = 0$ at $x = L$ results in obtaining eq^n (2) in the form:

$$\frac{\varnothing}{\varnothing_1} \text{ x } \frac{T - T_F}{T_1 - T_F} = \frac{\text{Cosh } m\,(L - x)}{\text{Cosh } mL} \qquad \text{……………(3)}$$

This is the equation for the temperature distribution along the length of the fin. It is seen from the equation that for a fin of given geometry with uniform cross section, the temperature at any point can be calculated by knowing the values of T_1, T_F and X. Temperature T_1 and T_F will be known for a given situation and the value of h depends on whether the heat is lost to the surrounding by free convection or forced convection and can be obtained by using the correlation as given below:

1. For free convection condition,

$Nu = 1.1 \ (Gr. Pr)^{1/6}$ . . $\qquad 10^{-1} < Gr. Pr. < 10^4$ }
$Nu = 0.53 \ (Gr. Pr)^{1/4}$ . . $\qquad 10^4 < Gr. Pr. < 10^9$ } 4
$Nu = 0.13 \ (Gr. Pr)^{1/4}$ . . $\qquad 10^9 < Gr. Pr. < 10^{12}$ }

2. For forced convection,

$Nu = 0.615 \ (R_e)^{0.466}$ . . $\qquad 40 < R_e < 4000$
$Nu = 0.174 \ (R_e)^{0.618}$ . . $\qquad 4000 < R_e < 40000$

Where, $\quad Nu = \frac{h.\,D}{A_{Air}}$

$\quad R_e = \frac{\rho\, VD}{\nu}$ = Reynold's Number.

$$G_r = \frac{g.\ \beta.\ D^3\ \Delta T}{\nu^2} = \text{Grashoff Number.}$$

$$P_r = \frac{Cp\ .\ \mu}{K_{Air}} = \text{Prandt 1 Number}$$

All the properties are to be evaluated at the mean film temperature. The mean film temperature is to arithmetic average of the fin temperature and air temperature.

Nomenclature:

ρ = Density of air, Kg / m^3
D = Diameter of pin-fin, m
μ = Dynamic viscosity, N.sec/m^2
C_p = Specific heat, KJ/Kg.k
= Kinematic viscosity, m2/Sec
K = Thermal conductivity of air, W/m ^{0}C
g = Acceleration due to gravity, 9.81m/sec^2
Tm = Average fin temperature

$$= \frac{(T1 + T2 + T4 + T5)}{5}$$

$\Delta T = T_m - T_F$

$$T_{mF} = \frac{T_m + T_F}{2}$$

= Coefficient of thermal expansion

$$= \frac{1}{T_{mF} + 273}$$

= Velocity of air in the duct.
The velocity of air can be obtained by calculating the volume flow rate through the duct.

$$Q = Cd\ \frac{\pi}{4} \times d^2 \times \sqrt{2g\left(H.\ \frac{\rho W}{\rho_a}\right)}\ \ \frac{m^3}{Sec}$$

Where, H = Difference of levels in manometer, M

ρW = Density of water 1000 Kg/m^3
ρ_a = Density of air at T_f
Cd = 0.64

d = Diameter of the orifice = 18mm.

$$\text{Velocity of air at } T_f = \frac{Q}{\text{Duct c/s Area}} = \text{m/sec}$$

Use this velocity in the calculation of R_e.

The rate of heat transfer from the fin can be calculated as,

$$Q = \sqrt{h.\ c.\ k.\ A}\ \ x\ (T1 - Tf)\ \tanh mL \quad \text{………………(6)}$$

And the effectiveness of the fin can also be calculated as,

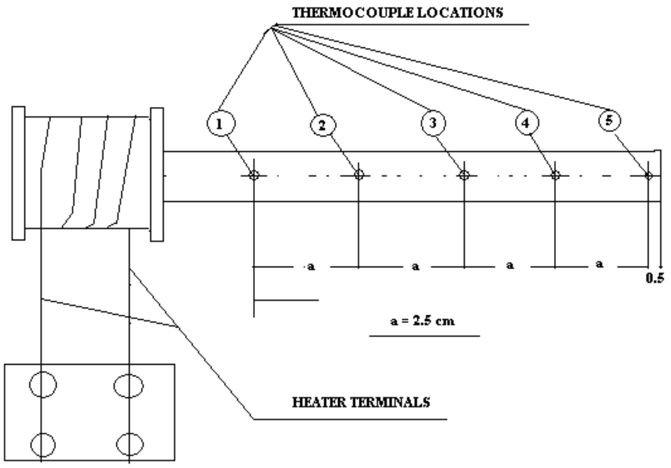
tanh mL

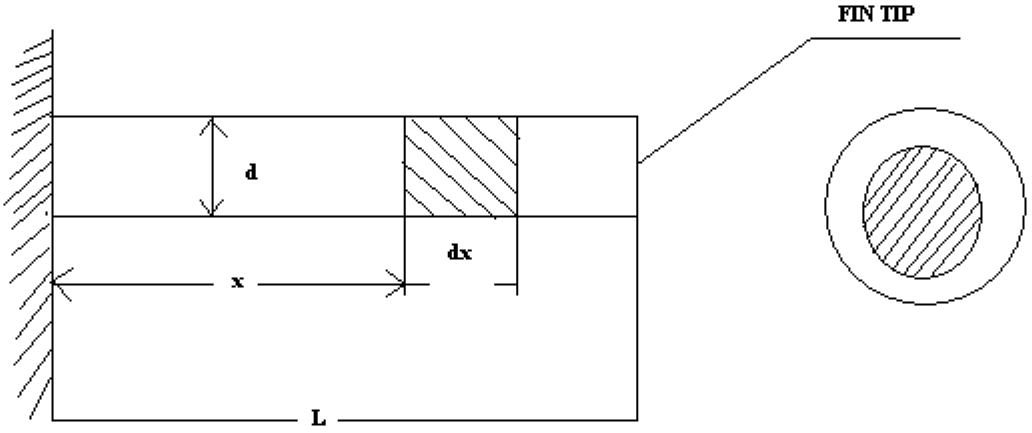
η = -------------- …………………..(7)

Specifications:

Duct size = 150mm x 100mm.
Diameter of the fin = 12.7mm.
Diameter of the orifice = 18mm.
Diameter of the delivery pipe = 42mm.
Coefficient of discharge (or orifice meter) Cd = 0.64.
Centrifugal Blower 1 HP single-phase motor.
No. of thermocouples on fin = 5.
(1) to (5) as shown in fig. 3 and indicated on temperature indicator.
Thermocouple (6) reads ambient temperature inside of the duct.
Thermal conductivity of fin material (Brass) = 110w/m ^{0}C.
Temperature indicator = 0 – 300 ^{0}C with compensation of ambient temperature up to 50^{0}C.
Dimmerstat for heat input control 230V, 2 Amps.
Heater suitable for mounting at the fin end outside the duct = 400 watts (Band type).
Voltmeter = 0 – 100/200 V.
Ammeter = 0 – 2 Amps.

Schematic Diagram





Experimental Procedure:

To study the temperature distribution along the length of a pin fin natural and forced convection, the procedure is as under

Natural Convection:

Start heating the fin by switching ON the heater element and adjust the voltage on dimmerstat to say 80 volt (Increase slowly from 0 to onwards)

Note down the thermocouple reading 1 to 5.

When steady state is reached, record the final readings 1 to 5 and also record the ambient temperature reading 6.

Repeat the same experiment with voltage 100 volts and 120 volts.

(2) Forced Convection:

Start heating the fin by switching ON the heater and adjust dimmerstat voltage equal to 100 volts.

Start the blower and adjust the difference of level in the manometer with the help of gate valve.

Note down the thermocouple readings (1) to (5) at a time interval of 5 minutes.

When the steady state is reached, record the final reading (1) to (5) and also record the ambient temperature reading (6).

Repeat the same experiment with different manometer readings.

Precautions:

See that the dimmerstat is at zero position before switching ON the heater.

Operate the changeover switch of temperature indicator, gently.

Be sure that the steady state is reached before taking the final reading.

4. See that throughout the experiment, the blower is OFF

Observation Table:

Natural Convection:

Sr. No.	V Volts	I Amps	Fin Temperatures					Ambient Temp.
			T_1 (^{0}C)	T_2 (^{0}C)	T_2 (^{0}C)	T_4 (^{0}C)	T_5 (^{0}C)	$T_6 = T_f$ (^{0}C)

FORCED CONVECTION:

Sr. No	V Volts	I Amps	Manometer reading (Cm.)	Fin Temperatures					Ambient Temp
				T_1 (^{0}C)	T_2 (^{0}C)	T_2 (^{0}C)	T_4 (^{0}C)	T_5 (^{0}C)	$T_6 = T_f$ (^{0}C)

Results from Experiments:

I) Natural Convection:

Plot the temperature distribution along the length of the fin from readings (refer fig. 5)

Calculate Gr and Pr and obtain Nu form equation (4) and finally get the value of ‘h’ in natural convection.

Calculate the value of ‘m’ and obtain the temperature at various locations along the length of the fin by using equation (3) and plot them (refer fig. 5)

Calculate the value of heat transfer rate from the fin effectiveness by using equation (6) and equation (7).

Repeat the same procedure for all other sets.

II) Forced Convection:

plot the temperature distribution along the length of the fin from observed readings (refer fig. 6)

Calculate the value of ‘m’ and obtain the temperature at various locations along the length of fin by using equation (3) and plot them. (Refer fig. 6)

Calculate Re and Pr and obtain Nu from equation (5).

Calculate the value of heat transfer rate from the fin and fin effectiveness by using equation (6) and equation (7).

Repeat the same procedure for all other sets of observations.

Conclusion:

Heat transfer coefficient form the fin for natural & forced convection is found out to be -----------

BTME 606 FLUID MACHINERY LAB

EXPERIMENT NO. 1

Objective: determination of various EFFICIENCIES of hydraulic RAM.

THEORY :

A hydraulic ram is a device which raises small quantity of water q to a greater height H, if large quantity of water Q is available at a lower height h as shown in fig. 1. It does not use any external power. It works on the principle of water hammer.

In this sketch of hydraulic ram
h = Height of water in the supply tank above the chamber.
H= Height of water raised above the chamber
Q = Discharge of water into the chamber per second
q = Quantity of water raised per second

APPARATUS SPECIFICATIONS
Supply tank capacity = 500 Ltrs (Approx.)
Measuring flask capacity = 1 Ltr
Internal diameter of delivery pipe = 15mm
External diameter of supply pipe = 25mm

PROCEDURE:

Measure the discharge head with the help of meter tape
Start the water supply to the tank by opening supply valve.
Start the ram by pressing waste valve.
Adjust supply valve so that water level in the tank is at constant highest level.
Measure the supply head.
When the sufficient pressure is built in the air vessel by waste valve the water will start flowing through delivery pipe at higher head.
Measure discharge to delivery pipe by collecting water in 1 liter measuring flask and noting down the time taken (T_2).
Also note down the time taken (T_1) for a specific number of rotation of the flow meter needle.
Change the supply head and take more readings. (Say 10)

OBSERVATIONS:

Discharge head (H) =

Sr. No.	Supply head (h) (m)	Q			q		
		Time (T_1) Sec.	Vol. Collected (Litre)	$Q = \frac{Vol\ \text{collected}}{T_1 \times 1000}$ m^3/sec.	Time (T_2) Sec.	Vol. Collected (Litre)	$q = \frac{Vol.\ \text{collected}}{T_2 \times 1000}$ m^3/sec.
1.							
2.							
3.							
4.							
5.							
6.							
7.							
8.							
9.							
10.							

CALCULATIONS:

D' Aubission efficiency $\eta_a = \frac{qH}{Qh}$

Rankine efficiency $\eta_R = \frac{q(H-h)}{(Q-q)h}$

Sr. no.	Supply head (h)	supply water (Q) m^3/sec.	Delivery water (q) m^3/sec.	D'aubission efficiency	Rankine efficiency
1.					
2.					
3.					
4.					
5.					
6.					
7.					
8.					
9.					
10.					

PRECAUTIONS:

Water level in supply tank should be constant before taking observations.
Do not interrupt the operation of waste valve.
Empty the tank after completion of the experiment.

EXPERIMENT NO.2

OBJECTIVE: TO DRAW THE CHARACTERISTICS OF FRANCIS TURBINE.

THEORY:

Francis turbine is a mixed flow reaction turbine which is used to utilized head (H) and discharge (Q) of water to develop power (P_{in}).

Head over the turbine (H):-

h_1 = Pressure gauge reading (p_1)(Kg/cm^2) $\times 10$ m
h_2 = Vaccum gauge reading (p_2) (Kg/cm^2) $\times 10$ m
Since 10 mtrs. of water head corresponds to 1 Kg/cm^2
H = h_1+$h_2$mtr.

Water flow rate :-

$$Q = \mathrm{Cd} \times \frac{\mathrm{a}_1 \times \mathrm{a}_2}{\sqrt{\mathrm{a}_1^{\ 2} - \mathrm{a}_2^{\ 2}}} \times \sqrt{2gh_w} \quad \mathrm{m}^3/\mathrm{sec}$$

Where,

a_1 = Inlet area of venturi at dia. = 0.1m = 7.854 x 10^{-3} m^2
a_2 = Throat area of venturi at dia = 0.75m = 4.417 x 10^{-3} m^2
C_d = Co – efficient of discharge = 0.98
h_w = Manometric Differential head across venturimeter (h) × 13.6 m of water.
Manometer difference (h) = h_1-h_2 m.

Power supplied to turbine :-

P_{in} = (wQH)/1000 KW.
Where,
w = Specific weight of water = 9810 Kg./m^3

Bake Power

T = (T_1-T_2) x 9.81 x (0.135+0.003) N-m

Brake Power(P_B) = $\frac{2\pi N}{60} \times \frac{\mathrm{T}}{1000}$ KW.

where T(Torque) = (T_1-T_2) x 9.81 x $(\frac{D_m + t_m}{2})Nm$

where T_1 and T_2 is the reading on spring balance which are tension in spring on tight side and slack side (Kg)

D_m = Mean diameter of brake drum (m)
t_m = Mean thickness of belt (m)

Overall efficiency of turbine : -

$$\eta_0 = \frac{P_B}{P_{in}} \times 100\%$$

PROCEDURE:

(A) For operating characteristics at constant sped curves.

Note down the brake diameter and belt thickness.
Fill up sufficient water in the sump tank.
Prime the pump.
Keep the venturimeter cocks closed.
Ensure that there should not be any load on the turbine. Close gate valve (top of the turbine) & guide vane pointer should be in zero position (Full open position).
Press ‘Green’ button of starter, hold it for 1-2 seconds and release so that pump starts running.
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.
Slowly open the venturimeter cocks and remove the air bubble. Then slowly open the gate valve.
Keep gate valve in the pipe in full open position and close guide vanes till speed reduces to 1500 rpm.
Take reading in observation table.
Open the clock for the cooling water to the brake drum.
Put load in a small steps & open guide vanes gradually till the speed is constant at 1500 rpm again.
Repeat step 10 by increasing load in small steps for about 10 readings of the table.
Repeat the experiment for 1300, 1400, 1600, rpm.

(B) For drawing main characteristics

Repeat the procedure with constant guide vane position for full $\frac{3}{4},\frac{1}{2},\frac{1}{4}$ opening positions and allow the head and speed to vary continuously.

OBSERVATIONS:
(A) For operating characteristics
Constant Speed (1500 rpm say)
(BY CHANGING GUIDE VANE POSITION - AT FULL OPENING OF GATE VALVE)

Sr. No.	Spring balance readings, Kg			Manometer reading mm of Hg		Manometric differential head (h_w) m of water	Pressure gauge (kg/cm^2)	H_1 Inlet head (m)	Vaccum gauge mm of Hg	Outlet head (m)
	T_1	T_2	(T_2 - T_1)	H_1	h_2	$h_w = h_1 - h_2$	p_1	H_1	p_2	
1										
2										
3										
4										
5										
6										
7										
8										

9										

RESULT TABLE :

Constant Speed =

(BY CHANGING GUIDE VANE POSITON – AT FULL OPENING OF GATE VALVE)

Sr. No.	T Torque (Nm)	H Head over Turbine (mtr)	Discharge ‘Q’ (m^3/sec.)	Input power, ‘P_{in}’ (kw)	Brake power ‘P_B’ (kw)	% Load $P_B / 3.75 \times 100$	Overall efficiency ‘η_o’ (%)
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							

Graph : Plot the graph between

$$\left.\begin{array}{l}\eta_o \text{ Vs. \% load}\\ \eta_o \text{ Vs. Head}\\ \eta_o \text{ Vs. Discharge}\end{array}\right\} N = \text{Constant}$$

(B) For main Characteristics

OBSERVATIONS:

Constant Guide vanes position:-

(AT FULL OPENING OF GATE VALVE)

Sr. No.	Spring balance reading			Manometer reading mm of Hg		Manometric differential head M of water	Speed (N) RPM	Pressure gauge (kg/cm^2)	Vaccum gauge mm of Hg
1	T_1	T_2	(T_2-T_1)	h_1	h_2	$h_w = h_1-h_2$			
2									
3									
4									
5									
6									
7									
8									
9									

10									

RESULT TABLE
(AT FULL OPENING OF GATE VALVE AND AT CONSTANT GUIDE VANES POSITION)

Sr. No.	H Head over turbine (m)	T Torque (Nm)	N (rpm)	Discharge 'Q' (m^3/sec.)	Input power, 'P_{in}' (kw)	Brake power 'P_B' (kw)	Overall efficiency 'η_o' (%)
1							
2							
3							
4							
5							
6							
7							
8							
9							

Plot the graph between

$$\left.\begin{array}{l} \eta_o \ \& \ N \\ Q \ \& \ N \\ T \ \& \ N \end{array}\right\} \quad \text{Guide vane opening constant.}$$

PRECAUTIONS:-

Before switching off the supply pump set., first remove all the load.
Close the cooling inlet water gate valve.
Slowly close the guide vanes to its full closed position. Then close the gate valve just above the turbine.
Switch off the supply of pump set. Never switch off the supply of pump set when the turbine is working under load.

EXPERIMENT NO.3

OBJECTIVE: TO STUDY THE CONSTRUCTIONAL FEATURES OF RECIPROCATING PUMP AND TO PERFORM TEST ON IT FOR DETERMINE OF PUMP PERFORMANCE.

THEORY:
A reciprocating pump is a device, driven by Power (P_i) for transferring the liquid of small volume (Q) from a pressure (p_1) to higher pressure (p_2)
Here

Suction pressure = p_1 (mm of Hg)
Suction head $p_{1'}$ = $p_1 \times 13.6$ Kg/cm^2
H_1 = $p_1' \times 10$ meter of water
Discharge pressure = p_2 (Kg/cm^2)
Discharge head H_2 = $p_2 \times 10$ meter of water

Total Head H = H_1+H_2 meter

Flow rate = Q m^3/sec.

$$Q = \frac{\text{Volume of water collected (v)}}{\textit{time}\text{ taken (T)}}$$

$V = (h_2-h_1) \times A$

h_1 = Initial level of water in tank

h_2 = Final level of water in tank

Input power $P_i = P \times 76\%$ watts

Where P = Input power reading directly from watt meter

Water power $P_o = \rho g HQ$ watts

Where $g = 9.81$ m/sec^2

$\rho = 1000$ kg/m^3

Efficiency $\eta = \frac{P_o}{P_i} \times 100\,\%$

PROCEDURE

Note down the area of collection tank.
Prime the pump set and check that pump is free to rotate.
Start the motor and pump will start working.
Adjust the flow control valve for maximum possible discharge.
Note the pressure gauge reading at inlet and outlet of the pump and note the rise in level of water in the tank.
Note down the input power reading directly from wattmeter.
Flow rate is reduced in steps and the above procedure is repeated.
Note the speed (N) of crank.
See that delivery valve is not completely closed till last reading.

OBSERVATIONS:

Area of collecting tank, a = ……..m^2

Efficiency of motor = 76%

Sr. No.	Speed of crank (N)	Discharge measurement				Suction pressure p_1' (mm of Hg)	Suction head H_1' (m of water)	Delivery pressure p_2 (Kg/cm^2)	Delivery Head H_2 (m of water)
		Initial level h_1 (m)	Final level h_2 (m)	Time 'T' (sec)	Discharge Q (m^3/sec)				
1									
2									

3									
4									
5									

RESULT TABLE:

Sr. No.	Total head H (m)	Input power of the pump P_i (watt)	Water power P_o (Watt)	Efficiency η(%)
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				

Plot the graph

$$\left.\begin{array}{lll} \eta & \text{Vs} & Q \\ P_i & \text{Vs} & Q \\ H & \text{Vs} & Q \end{array}\right\} \text{At constant speed of crank}$$

EXPERIMENT NO.4

OBJECTIVE: TO DRAW THE VARIOUS CHARACTERISTICS OF PELTON TURBINE.

THEORY: Pelton turbine is an impulse turbine which is used to utilize high head (H) for generation of power (P_{in}) by converting it into kinetic energy by means of a spear and nozzle arrangement. The water flow rate (Q) is measured with the help of venturimeter fitted in the supply pipe. The rope brake arrangement with spring balance is provided to measure the brake power (P_B) The rpm of the turbine (N) is measured with a tachometer.

Head over the turbine (H) :

H = Pressure Gauge Reading Kg/cm^2 x 10 m

Since 10 Mtr. of water head corresponds to 1 Kg/cm^2

Water flow rate :

$$Q = C_d \times \frac{a_1 \times a_2}{\sqrt{a_1^2 - a_2^2}} \times \sqrt{2gh_w} \ \ \text{m}^3/\text{sec}$$

Where,

a_1 = Inlet area of Venturimeter at dia. = 0.05m = 1.963x10^{-3} m^2

a_2 = Throat area of Venturimeter at dia = 0.038m = 1.13×10^{-3} m^2
C_d = Co-efficient of discharge = 0.98
h_w = Water head across venturimeter (h) × 13.6 m of water.
= Manometer difference $h = h_1 - h_2$ m

Power supplied to turbine :
P_{in} = wQH x 9.81 watts
Where,
w = Density of water = 1000 Kg/m^3

Brake Power

Brake Power (P_B) = $\frac{2\pi NT}{60}$ watts

Where $T_{(Torque)} = (T_1 - T_2) \times 9.81 \times \left(\frac{D_m + t_m}{2}\right)$ Nm

T_1 and T_2 are tight side and slack side tension readings of spring balances.

D_m = Mean diameter of brake drum (m)
t_m = Mean thickness of belt (m)

Specific speed

$$N_s = \frac{N\sqrt{P}}{H^{5/4}} (where\ \text{P in h.p.})$$

$$= \frac{N\sqrt{P_{in}/0.735}}{H^{5/4}}$$

$$= \frac{N \times 1.166 \times \sqrt{P_{in}}}{H^{5/4}}$$

Overall efficiency of turbine

$$\eta = \frac{P_B}{P_{in}} \times 100\%$$

PROCEDURE:

Measure the mean diameter (D_m) of the rope pulley and note down the belt thickness (t_m).
Check that the belt should be loose for free movement of pulley and nozzle should be closed by spear.
Prime the pump then start the motor, the rotation of the motor should be in clockwise direction seen from fan end side.

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.
Put the load using loading stud. Open the nozzle, so that turbine is again rotating at 1000 rpm.
Note down the readings in observation table, for 10 different loads.
Repeat the experiment for different speeds, say 800 rpm., 600rpm., 500rpm by loading the turbine.
Now, release all the load. Keep the spear at ¼ opening position with the help of spear adjustment wheel.
Load the rope brake with 0.5 Kg Load. Note down the speed.
Go on adding the load, without disturbing spear position. Note down head, speed, discharge and load each time.
Repeat the procedure for ½ , ¾ and full spear opening. This is a constant head test.

OBSERVATION TABLE:

(A) Constant speed test : Turbine speed, N = (1500 rpm) say

Sr. No.	Spring balance difference (Kg)			Manometer difference (Mtr)			Pressure gauge reading (Kg/cm^2)
	T_1	T_2	$(T_2 - T_1)$ Kg	H_1	h_2	$h = h_1 - h_2$	

RESULT TABLE:

Sr. No.	Manometeric head (m) h_w	$Q = 0.0210 \times \sqrt{h_w}$ $m^3/\sec$	P_B. = $\frac{2\pi NT}{60000} Kw$	Torque (T) Nm	H= $Pr \times 10m$	P_{in} = Whq Kw	$\eta\%$
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							

Graph : Plot the graph between

$$\left.\begin{array}{l}\eta_o \text{ Vs. \% load}\\ \eta_o \text{ Vs. Head}\end{array}\right\} N = \text{Constant}$$

η_o Vs. Discharge

OBSERVATION TABLE:

(B) Constant gate opening : Spear opening – ¼ , ½ , ¾ , Full.

Manometer difference :________ m.

Pressure gauge reading :_______ Kg/cm^2

Sr. No.	Spring balance difference (Kg)			Manometer difference (m)			Pressure gauge reading (Kg/cm^2)	Speed (N) rpm
	T_1	T_2	$(T_2 - T_1)$ Kg	h_1	h_2	$h = h_1 - h_2$		

RESULT TABLE :

Sr. No.	Spring Balance Difference (Kg)			Speed rpm	Discharge Q m^3/Sec.	Power in = wQH Kw	B.P. Kw	η%
	T_1	T_2	$(T_2 - T_1)$					

Plot the graph between

η_o & N

Q & N Constant spear opening.

T & N

CONSTANT HEAD TEST : ½ SPEAR OPENING

Pressure in Kg/cm^2 =

Manometer reading in ‘m’ of Hg =

Sr. No.	Spring Balance Difference (Kg)			Speed (N) rpm	Discharge Q m^3/Sec.	Power in = wQH Kw	B.P. Kw	Over all efficiency η%
	T_1	T_2	$(T_2 - T_1)$					

PRECAUTIONS :

Speed should be constant before taking observations
Before starting experiment check that nozzle is closed by spear and load on the brake drum released.
Operate the controls and switches gently

EXPERIMENT NO. 5

OBJECTIVE: TO DRAW THE VARIOUS CHARACTERISTICS OF CENTRIFUGAL PUMP.
THEORY: Centrifugal pump is a rotodynamic machine which develops dynamic pressure (P_d) of liquid by virtue of rotation (N) for pumping liquid (Q) to a higher height (h).

Discharge Pressure,P_d = Kg/cm^2
For water, 10m height corresponds to 1 kg/cm^2
$\therefore$ Discharge head $h_d = P_d \times 10$ m of water.

Suction Head
Suction vaccum, P_s = mm of Hg.
$\therefore$ suction head, $H_S = \frac{P_S}{1000} \times \frac{13.6}{1}$ of water
Where, sp. gravity of hg = 13.6
sp. gravity of water = 1

Total Head, $H_t = H_d + H_S + H_f$of water
H_f = head loss due to friction which is to be calculated for each reading.

Discharge
Let time for 10 lits. water collection be t_w sec.
$Q = \frac{Vol \text{ collected}}{\text{time}} m^3 / \text{sec}$

Since Vol. = Area of tank x rise in water level(m^3).

Output power (or water power)

P_o (W.P.) = $\frac{wQ.H_t}{1000} kw$

Where,

w = Specific weight of water = 9810 N/m^3

Q = discharge m^3/sec.

H_t = total head, mtrs.

Electrical Input

Let time required for 10 rev. of energy meter disc be T_e – Sec.

(Electrical input power) $P_{ie} = \frac{10}{T_e} \times \frac{3600}{120} Kw.$

Taking motor efficiency as 75% we have input shaft power (P_i)

$P_i = P_{ie} \times 0.75$

Overall efficiency of the pump

$$\therefore \eta_o = \frac{P_o}{P_i} \times 100 \ \%$$

APPARATUS:

Centrifugal pump, Measuring tank, Gate valve to control the head, pressure gauge, vaccum gauge, Energy meter

EXPERIMENTAL PROCEDURE:

Fill up sufficient water in the sump tank.

Open the priming nipple plug (At the top of pump) and fill up water upto the nipple. Replace the plug and tighten it properly.

Close the discharge valve.

Start the pump. As discharge valve is closed, no discharge will be observed, but discharge pressure will be indicated. This is called ‘Shut off head’ of the pump.

Slowly open the discharge valve, so that small discharge is observed.

Note down discharge head, suction vaccum, time required for 10 ltr. water.

Collection in measuring tank and 10 revolutions of energy meter disc. rpm of motor

Note down the readings at different valve openings, set by uniform intervals.

Repeat the steps 3 to 7 for different speeds. Different speeds can be obtained by changing the position of motor and belt for different pulley configuration

OBSERVATIONS:

Pump speed N = _________rpm

Sr. No.	Discharge Pr. (P_d) (Kg/cm^2)	Suction Vacuum (P_s) mm of Hg	Time for 10 lit. water collection, (T_w) sec.	Time for 10 rev. of Energymeter (T_e) sec.
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				

RESULT TABLE:
Pump speed N = ____________rpm

S. No.	Discharge head (H_d) meter of water	Suction head (H_s) meter of water	Total head H_t= $H_d + H_s + H_f$ m of water	Discharge (Q) m^3/sec	Output Power (P_o)	Power Input (P_i)	Over all efficiency (η_o) %
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							

Plot the following graphs

$$\left.\begin{array}{lll} H & \text{Vs.} & Q \\ P_i & \text{Vs.} & Q \\ \eta_o & \text{Vs.} & Q \end{array}\right\} \text{At constant rpm.}$$

PRECAUTIONS:

Priming is must before starting the pump. Pump should never be run empty.
Use all the controls and switches carefully.
Do not disturb the pressure gauge connections.

EXPERIMENT NO. 6

OBJECTIVE: TO DETERMINE THE EFFECT OF VANE SHAPE AND VANE ANGLE ON THE PERFORMANCE OF CENTRIFUGAL FAN.

THEORY:
Blowers are used to discharge higher volume (Q) of air at low pressure by rotation (N) of impeller. Motor rotates the impeller and impeller sucks the air through the center and delivers the air through its periphery.

Power input to blower(P_i)

$$P_i = \frac{P}{t} \times \frac{3600}{E.M.C.} \times 0.8 \text{ K.W.}$$

Head (H)

$$H = \Delta h \left(\frac{\rho_w}{\rho_a} - 1 \right) \text{ m of water}$$

$\Delta h = h_1 - h_2$

Velocity of Air

$$v = C_{\text{Pitot}} \sqrt{2gh} \quad \text{m/sec.}$$

Discharge (Q)

$$Q = A \times v \text{ m}^3\text{/sec}$$

Power imparted to air

$$P_o = \frac{\rho_a Q H}{1000} \text{ KW}$$

Overall Efficiency

$$\eta_o \% = \frac{P_o}{P_i} \times 100$$

Where :

P = No. of pulses of energy meter

t = Time taken for r (s)

E.M.C. = Energy meter constant

h_1’ = Static pressure gauge reading – cm of water

h_2’ = Dynamic pressure gauge reading – cm of water

h_1 = Static head = $\frac{h_1'}{100}$ m of water

h_2 = Dynamic head = $\frac{h_2'}{100}$ m of water

R’ = Manometer reading cm of water

R = Manometer head = $\frac{R}{100}$ m of water

h = $R\left(\frac{\rho_w}{\rho_a} - 1\right)$ m of air

STANDARD DATA:

d = ID of pipe at outlet = 69mm = (0.069m)

A = $\frac{\pi d^2}{4}$ = Cross-sectional area of outlet line = 0.00373m^2

g = Acceleration due to gravity = 9.81 m/s^2

ρ_a = Density of air = 1.19kg/m^3

ρ_w = Density of water = 1000kg/m^3

C_{Pitot} = Co-efficient of discharge for ‘Pitot’ tube = 0.98

E.M.C. = 3200 Pulses /kW

Motor Efficiency = 0.8

EXPERIMENTAL PROCEDURE:

Starting Procedure :

Check and fill water in manometer tube.
Fix the impeller on the desired blower (say radial vane).
Ensure that all On/Off switches given on the Panel are at OFF position. Now switch on the Main Power Supply (220 V AC, 50 Hz).
Switch on the Blower. Adjust the speed of the Impeller with the help of DC Drive and RPM indicator, provided on the panel, to the speed at which experiment is to be performed.
Measure the pressure difference, static head & dynamic head with the help of manometer. By this procedure, outlet readings can be found. Record the power consumption by means of Energy meter, provided in panel.
Change flow by rotating the control valve by one step, again regulate the RPM of impeller, using DC drive and RPM indicator and take all the readings. Take 10 readings.
When experiment on first particular impeller is over, follow closing procedure and fix second desired impeller on blower. Repeat the experiment for second and third Impeller.

Closing Procedure :
When experiment is over, switch off the blower first.
Adjust DC drive knob at ZERO.
Switch off power supply to Panel.

OBSERVATION TABLE:

Rotational speed of Impeller	Flow rate opening	Static Pressure h_1' (cm)	Dynamic Pressure h_2' (cm)	Differential pressure R'	Time Taken for power input to blower (10 pulses) sec.
(N) rpm					(t)
	Full Open				
	9/10 Open				
	8/10 Open				
	7/10 Open				
	6/10 Open				
	5/10 open				
	4/10 Open				
	3/10 Open				

	2/10 Open				
	1/10 Open				

RESULT TABLE:

Opening	Static Head $h_1 = \frac{h_1'}{100}$ (m)	Dynamic Head $h_2 = \frac{h_2'}{100}$ (m)	Diff. Head $R = \frac{R'}{100}$ (m)	(P_i) H.P.	(P_o) H.P.	Head H (m)	Discharge Q m^3/sec	Overall Efficiency η_o%
Full open								
9/10 Open								
8/10 Open								
7/10 Open								
6/10 Open								
5/10 open								
4/10 Open								
3/10 Open								
2/10 Open								
1/10 Open								

Plot graph between

$$\left.\begin{array}{lll} H & \text{Vs} & Q \\ \eta_o & \text{Vs} & Q \\ P & \text{Vs} & Q \end{array}\right\} \text{At constant RPM}$$

PRECAUTIONS & TROUBLE SHOOTING:

Always keep apparatus free from dust.
Keep the butterfly valve provided at suction and delivery closed when apparatus is not in use.
Increase the speed of the motor gradually.
If blower is not blowing the air, revolution of the DC motor may be reverse. Change the electric connection of motor to change the direction?
If panel is not showing input, check the fuse and main supply.
If field failure (FF) indicates on the control panel and the motor is not moving, check the fuses, if burnt change it.
If overload (OL) indicates on the panel and motor stops moving, reduce the load.
If rpm indicator is not displaying the rpm, check the distance of proximity switch and adjust it to 3mm.