STUDENT HAND BOOK

Bachelor of Technology

Semester- 4th

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 401 Strength of Materials-II

Unit –I
Strain energy: Introduction to strain energy, energy of dilation and distortion. Resilience, stress due to suddenly applied loads. Castigliano's and Maxwell's theorem of reciprocal deflection.

Unit –II
Theories of failure: Maximum principal stress theory, maximum shear stress theory, maximum principal strain theory, total strain energy theory, shear strain energy theory. Graphical representation and derivation of equation for these theories and their application to problems related to two dimensional stress systems.

Unit –III
Springs: Open and closed coiled helical springs under the action of axial load and/or couple. Flat spiral springs- derivation of formula for strain energy, maximum stress and rotation. Leaf springdeflection and bending stresses

Unit –IV
Thin cylinders and spheres: Calculation of Hoop stress, longitudinal stress in a cylinder, effects of joints, change in diameter, length and internal volume. Principal stresses in sphere, change in diameter and internal volume.

Unit –V
Thick cylinders: Derivation of Lame's equations, calculation of radial, longitudinal and hoop stresses and strains due to internal pressure in thick cylinders, compound cylinders, hub shrunk on solid shafts, shrinkage allowance and shrinkage stress.

Unit –VI
Bending of curved beams: Calculation of stresses in cranes or chain hooks, rings of circular and trapezoidal section, and chain links with straight sides.

Unit –VII
Shear stresses in beams: Shear stress distribution in rectangular, circular, I, T and channel section; built up beams. Shear centre and its importance.

Unit –VIII
Rotational discs: Stresses in rotating discs and rims of uniform thickness; disc of uniform strength.

BTME 402 Theory of Machines – II

Unit-I
Static force analysis:, Concept of force and couple, free body diagram, condition of equilibrium, static equilibrium of mechanism, methods of static force analysis of simple mechanisms. Power transmission elements, considerations of frictional forces

Unit –II

Dynamic force analysis Determination of forces and couples for a crank, inertia of reciprocating parts, dynamically equivalent system, analytical and graphical method, inertia force analysis of basic engine mechanism, torque required to overcome inertia and gravitational force of a four bar linkage.

Unit –III

Balancing: Necessity of balancing, static and dynamic balancing, balancing of single and multiple rotating masses, partial unbalanced primary force in an engine, balancing of reciprocating masses, and condition of balance in multi cylinder in line V-engines , concept of direct and reverse crank, balancing of machines, rotors, reversible rotors.

Unit –IV

Gears: Toothed gears, types of toothed gears and its terminology. Path of contact, arc of contact, conditions for correct gearing, forms of teeth, involutes and its variants, interference and methods of its removal. Calculation of minimum number of teeth on pinion/wheel for involute rack, helical, spiral, bevel and worm gears. Center distance for spiral gears and efficiency of spiral gears

Unit –V

Gear Trains: Types of gear trains, simple, compound and epicyclic gear trains, problems involving their applications, estimation of velocity ratio of worm and worm wheel.

Unit –VI

Gyroscopic motion and couples: Effect on supporting and holding structures of machines. stabilization of ships and planes, Gyroscopic effect on two and four wheeled vehicles and stone crusher.

Unit –VII

Kinematic synthesis of Mechanism: Freudenstien equation, Function generation errors in synthesis, two and three point synthesis, Transmission angles, least square techniques.

BTME 403 Fluid Mechanics

Unit –I

Fundamentals of Fluid Mechanics: Introduction; Applications; Concept of fluid; Difference between solids, liquids and gases; Concept of continuum; Ideal and real fluids; Fluid properties: density, specific volume, specific weight, specific gravity, viscosity (dynamic and kinematic), vapour pressure, compressibility, bulk modulus, Mach number, surface tension and capillarity; Newtonian and non-Newtonian fluids.

Unit –II

Fluid Statics: Concept of static fluid pressure; Pascal’s law and its engineering applications; Hydrostatic paradox; Action of fluid pressure on a plane submerged surface (horizontal, vertical and inclined): resultant force and centre of pressure; Force on a curved surface due to hydrostatic pressure; Buoyancy and flotation; Stability of floating and submerged bodies; Metacentric height and its determination; Periodic time of oscillation; Pressure distribution in a liquid subjected to : (i) constant acceleration along horizontal, vertical and inclined direction (linear motion), (ii) constant rotation.

Unit –III
Fluid Kinematics: Classification of fluid flows; Lagrangian and Euler flow descriptions; Velocity and acceleration of fluid particle; Local and convective acceleration; Normal and tangential acceleration; Path line, streak line, streamline and timelines; Flow rate and discharge mean velocity; One dimensional continuity equation; Continuity equation in Cartesian (x,y,z), polar (r,θ) and cylindrical (r,θ,z) coordinates; Derivation of continuity equation using the Lagrangian method in Cartesian coordinates; Rotational flows: rotation, vorticity and circulation; Stream function and velocity potential function, and relationship between them; Flow net.

Unit –IV
Fluid Dynamics: Derivation of Euler's equation of motion in Cartesian coordinates, and along a streamline; Derivation of Bernoulli's equation (using principle of conservation of energy and equation of motion) and its applications to steady state ideal and real fluid flows; Representation of energy changes in fluid system (hydraulic and energy gradient lines); Impulse momentum equation; Kinetic energy and momentum correction factors; Flow along a curved streamline; Free and forced vortex motions.

Unit –V
Dimensional Analysis and Similitude: Need of dimensional analysis; Fundamental and derived units; Dimensions and dimensional homogeneity; Rayleigh's and Buckingham's π - method for dimensional analysis; Dimensionless numbers (Reynolds, Froudes, Euler, Mach, and Weber) and their significance; Need of similitude; Geometric, kinematic and dynamic similarity; Model and prototype studies; Similarity model laws.

Unit –VI
Internal Flows: Laminar and Turbulent Flows: Reynolds number, critical velocity, critical Reynolds number, hydraulic diameter, flow regimes; Hagen – Poiseuille equation; Darcy equation; Head losses in pipes and pipe fittings; Flow through pipes in series and parallel; Concept of equivalent pipe; Roughness in pipes, Moody's chart.

Unit –VII
Pressure and Flow Measurement: Manometers; Pitot tubes; Various hydraulic coefficients; Orifice meters; Venturi meters; Borda mouthpieces; Notches (rectangular, V and Trapezoidal) and weirs; Rotameters.

BTME 404 Applied Thermodynamics-II

Unit –I
Air Compressors- Introduction: Classification of Air Compressors; Application of compressors and use of compressed air in industry and other places; Complete representation of compression process on P-v and T-s coordinates with detailed description of areas representing total work done andpolytropic work done; Areas representing energy lost in internal friction, energy carried away by cooling water and additional flow work being done for un-cooled and cooled compression on T-S coordinates; Best value of index of compression; Isentropic, polytropic and isothermal efficiencies and their representation in terms of ratio of areas representing various energy transfers on T-s

coordinates.

Unit –II

Reciprocating Air Compressors

Single stage single acting reciprocating compressor (with and without clearance volume): construction, operation, work input and best value of index of compression, heat rejected to cooling medium, isothermal, overall thermal, isentropic, polytropic, mechanical efficiency, Clearance Volumetric efficiency, Overall volumetric efficiency, effect of various parameters on volumetric efficiency, free air delivery; Multistage compressors: purpose and advantages, construction and operation, work input, heat rejected in intercoolers, minimum work input, optimum pressure ratio; isothermal, overall thermal, isentropic, polytropic and mechanical efficiencies; Performance curves.

Unit –III

Positive Displacement Rotary Compressors Introduction: Comparison of rotary positive displacement compressors with reciprocating compressors; Classification of rotary compressors; Construction, operation, work input and efficiency of positive displacement type of rotary compressors like Roots blower, Lysholm compressor and Vane type Blower.

Unit –IV

Thermodynamics of Dynamic Rotary Compressors: Applications of Steady Flow Energy Equation and thermodynamics of dynamic(i.e., centrifugal and axial flow m/cs) compressors; Stagnation and static values of pressure, Temperature and enthalpy etc. for flow through dynamic rotary machines; Complete representation of compression process on T-S coordinates with detailed description of areas representing total work done, polytropic work done; ideal work required for compression process, areas representing energy lost in internal friction, energy carried away by cooling water on TS coordinates for an uncooled and cooled compression; isentropic, polytropic, and isothermal efficiencies as ratios of the areas representing various energy transfers on T-S coordinates.

Unit –V

Centrifugal Compressors:- Complete thermodynamic analysis of centrifugal compressor stage; Polytropic, isentropic and isothermal efficiencies; Complete representation of compression process in the centrifugal compressor starting from ambient air flow through the suction pipe, Impeller, Diffuser and finally to delivery pipe on T-S coordinates; Pre-guide vanes and pre-whirl; Slip factor; Power input factor; Various modes of energy transfer in the impeller and diffuser; Degree of Reaction and its derivation; Energy transfer in backward, forward and radial vanes; Pressure coefficient as a function of slip factor; Efficiency and out-coming velocity profile from the impeller; Derivation of non-dimensional parameters for plotting compressor characteristics; Centrifugal compressor characteristic curves; Surging and choking in centrifugal compressors.

Unit –VI

Axial Flow Compressors

Different components of axial flow compressor and their arrangement; Discussion on flow passages and simple theory of aerofoil blading; Angle of attack; coefficients of lift and drag; Turbine versus compressor blades; Velocity vector; Vector diagrams; Thermodynamic analysis; Work done on the compressor and power calculations; Modes of energy transfer in rotor and stator blade flow passages; Detailed discussion on work done factor, degree of reaction, blade efficiency and their derivations; Isentropic, polytropic and isothermal efficiencies; Surging, Choking and Stalling in axial flow compressors; Characteristic curves for axial flow compressor; flow parameters of axial flow compressor like Pressure Coefficient, Flow Coefficient, Work Coefficient, Temperature-rise Coefficient and Specific Speed; Comparison of axial flow compressor with centrifugal compressor and reaction turbine; Field of application of axial flow compressors.

Unit –VII

Gas Turbines Classification and comparison of the Open and Closed cycles; Classification on the basis of combustion (at constant volume or constant pressure); Comparison of gas turbine with a steam turbine and IC engine; Fields of application of gas turbines; Position of gas turbine in power industry; Thermodynamics of constant pressure gas turbine cycle (Brayton cycle); Calculation of net output, work ratio and thermal efficiency of ideal and actual cycles; Cycle air rate, temperature ratio; Effect of changes in specific heat and that of mass of fuel on power and efficiency; Operating variables and their effects on thermal efficiency and work ratio; Thermal refinements like regeneration, inter-cooling and re-heating and their different combinations in the gas turbine cycle and their effects on gas turbine cycle i.e. gas turbine cycle. Multistage compression and expansion; Dual Turbine system; Series and parallel arrangements; Closed and Semi-closed gas turbine cycle; Requirements of a gas turbine combustion chamber; Blade materials and selection criteria for these materials and requirements of blade materials; Gas turbine fuels.

Unit –VIII

Jet Propulsion Principle of jet propulsion; Description of different types of jet propulsion systems like rockets and thermal jet engines, like (i) Athodyds(ramjet and pulsejet), (ii) Turbojet engine, and (iii) Turboprop engine. Thermodynamics of turbojet engine components; Development of thrust and methods for its boosting/augmentation; Thrust work and thrust power; Propulsion energy, Propulsion and thermal (internal) efficiencies; Overall thermal efficiency; Specific fuel c onsumption; Rocket propulsion, its thrust and thrust power; Propulsion and overall thermal efficiency; Types of rocket motors (e.g. solid propellant and liquid propellant systems); Various common propellant combinations (i.e. fuels) used in rocket motors; Cooling of rockets; Advantages and disadvantages of jet propulsion over other propulsion systems; Brief introduction to performance characteristics of different propulsion systems; Fields of application of various propulsion units.

BTME 405 Manufacturing Processes-II

Unit –I

Metal Forming: Introduction and classification. Rolling process: introduction, classification, rolling mills, products of rolling, rolling defects and remedies. Forging: open and closed die forging, forging operations, hammer forging, press forging and drop forging, forging defects, their causes and remedies. Extrusion: classification, equipment, defects and remedies. Drawing: drawing of rods, wires and tubes, draw benches, drawing defects and remedies. Sheet metal forming operations: piercing, blanking, embossing, squeezing, coining, bending, drawing and deep drawing, and spinning. Punch and die set up. Press working: press types, operations, press tools, progressive and combination dies. Process variables and numerical problems related to load calculation in Rolling, Forging, Extrusion, Drawing and Sheet metal forming. High velocity forming of metals: introduction, electro-hydraulic forming, mechanical high velocity forming, magnetic pulse forming and explosive forming. Powder Metallurgy: Introduction, advantages, limitations, and applications methods of producing metal powders, briquetting and sintering.

Unit –II

Metal Cutting: Introduction to machining processes, classification, Mechanics of chip formation process, concept of shear angle, chip contraction and cutting forces in metal cutting, Merchant theory, tool wear, tool life, machinability. Numerical problems based on above mentioned topics, Fundamentals of measurement of cutting forces and chip tool interface temperature. Cutting tools: types, geometry of single point cutting tool, twist drill and milling cutter, tool signature. Cutting tool materials: high carbon steels, alloy carbon steels, high speed steel, cast alloys, cemented carbides, ceramics and diamonds, and CBN. Selection of machining parameters. Coolants and lubricants: classification, purpose, function and properties.

Unit III

Machine Tools Lathe: classification, description and operations, kinematic scheme of lathe, and lathe attachments. Shaping and planing machine: classification, description and operations, drive mechanisms. Milling machine: classification, description and operations, indexing devices, up milling and down milling. Drilling machine: classification, description and operations. Boring machine: classification, description and operations. Grinding machines: classification, description and operations, wheel selection, grinding wheel composition and nomenclature of grinding wheels, dressing and truing of grinding wheels. Broaching machine: classification, description and operations. Speed, feed and machining time calculations of all the above machines.

BTME 406 Fluid Mechanics LAB

1. To determine the metacentric height of a floating vessel under loaded and unloaded conditions.
2. To study the flow through a variable area duct and verify Bernoulli's energy equation.
3. To determine the coefficient of discharge for an obstruction flow meter (venturi meter/ orifice meter)
4. To determine the discharge coefficient for a V- notch or rectangular notch.
5. To study the transition from laminar to turbulent flow and to ascertain the lower critical Reynolds number.
6. To determine the hydraulic coefficients for flow through an orifice.
7. To determine the friction coefficients for pipes of different diameters.
8. To determine the head loss in a pipe line due to sudden expansion/ sudden contraction/ bend.
9. To determine the velocity distribution for pipeline flow with a pitot static probe.
10. Experimental evaluation of free and forced vortex flow.

BTME 407 Manufacturing Processes Lab

Casting:
1. To determine clay content, moisture content, hardness of a moulding sand sample.
2. To determine shatter index of a moulding sand sample.
3. To test tensile, compressive, transverse strength of moulding sand in green condition.
4. To determine permeability and grain fineness number of a moulding sand sample.

Welding:
1. To make lap joint, butt joint and T- joints with oxy- acetylene gas welding and manual arc

welding processes
2. To study MIG, TIG and Spot welding equipment and make weld joints by these processes.
Machining and Forming
1. To study constructional features of following machines through drawings/ sketches:
a. Grinding machines (Surface, Cylindrical)
b. Hydraulic Press
c. Draw Bench
d. Drawing and Extrusion Dies
e. Rolling Mills
2. To grind single point and multipoint cutting tools
3. To prepare job on Lathe involving specified tolerances; cutting of V- threads and square threads.
4. To prepare job on shaper involving plane surface,
5. Use of milling machines for generation of plane surfaces, spur gears and helical gears; use of end mill cutters.
6. To determine cutting forces with dynamometer for turning, drilling and milling operations.

BTME 408 Theory of Machines Lab

1. To draw displacement, velocity & acceleration diagram of slider - crank and four bar mechanism.
2. To study the various inversions of kinematic chains.
3. Conduct experiments on various types of governors and draw graphs between height and equilibrium speed of a governor.
4. Determination of gyroscopic couple (graphical method).
5. Balancing of rotating masses (graphical method).
6. Cam profile analysis (graphical method)
7. Determination of gear- train value of compound gear trains and epicyclic gear trains.
8. To draw circumferential and axial pressure profile in a full journal bearing.
9. To determine coefficient of friction for a belt-pulley material combination.
10. Determination of moment of inertia of flywheel.

ASSIGNMENTS

BTME 401 Strength of Materials-II

Assignment 1 (Strain Energy & Theory of Failures)

1. An axial pull of 50 kN is suddenly applied to a steel rod 2m long and 10 cm2 in cross section. Calculate the strain energy that can be absorbed, if E=200 GPa.
2. A wrought iron bar 50 mm in diameter and 2.5 m long has to transmit a shock energy of 100 Nm. Calculate the maximum instantaneous stress and elongation produced. E= 200 GPa.
3. If 3 J of energy is to be absorbed by a 40 cm long shaft in torsion, find the suitable diameter of the shaft if shear stress is not exceed 40 MN/m2. Take G = 80x109 N/m2.
4. State and prove Castigliano's Theorem.
5. Explain the concept of Enerrgy of Distortion and Energy of Dilation.
6. Explain the following and represent them graphically:

(i) Maximum Principal Stress Theory
(ii) Maximum Principal Strain Theory
(iii) Maximum Shear Stress Theory
(iv) Total Strain Energy Theory
(v) Distortion Energy Theory

Assignment 2 (Springs and Thin cylinders & Spheres)

1. A close coiled helical spring, with the coil diameter as 100 mm and wire diameter as 12 mm consists of 16 coils. If it is subjected to an axial tension of 400 N, find the maximum stress induced in the coil, the extension suffered by the spring and the energy stored in it. C=84 GPa.
2. A laminated steel spring simply supported at the ends with a span of 75 cm is centrally loaded with a load of 7500 N. The central deflection under the above load is not to exceed 5 cm and the maximum stress is to be 400 MN/m2. Determine:

Width of plates or leaves
Thickness of leaves
Number of leaves.

3. A flat spiral spring is 6 mm wide and 0.25 mm thick, the length being 2.5m. Assuming the maximum stress of 800 MPa to occur at the point of greatest bending moment, calculate:

The torque
The work that can be stored in the spring
The number of turns to wind up the spring

4. An open coiled helical spring made from wire of circular cross-section is required to carry a load of 100N. The wire diameter is 8mm and the mean coil radius is 40mm. If the helix angle of the spring is 30° and number of turns is 12, calculate

Axial deflection
Angular rotation of free end with respect to the fixed end of the spring.

5. Calculate the bursting pressure for a cold drawn seamless steel tubing of 60 mm inside diameter with 2mm wall thickness. The ultimate strength of steel is 380 MPa.
6. A spherical shell of 1.5 m diameter has 1 cm thick wall. Determine the pressure that can increase its volume by 100 cm3. E= 200 GPa; 1/m= 0.3.

Assignment 3 (Thick Cylinders)

1. Calculate the thickness of metal necessary for a cylindrical shell of internal diameter 160 mm to withstand an internal pressure of 25 MN/m2, if the permissible tensile stress is 125 MN/m2.
2. A thick cylinder of 150 mm outside radius and 100 mm inside radius is subjected to an external pressure of 30 MN/m2 and internal pressure of 60 MN/m2. Calculate the maximum shear stress in the material of the cylinder at the inner radius.
3. Derive the Lame's equations.
4. A compound cylinder, formed by shrinking one tube to another is subjected to an internal pressure of 90 MPa. Before the fluid is admitted, the internal and external diameters of the compound cylinder are 180mm and 300 mm respectively and the diameter at the junction is 240 mm. If after shrinking on, the radial pressure at the common surface is 12 MPa, determine the final stresses developed in the compound cylinder.

Assignment 4 (Bending of Curved Beams)

1. A curved bar is formed of a tube 40 mm outside radius and 5 mm thickness. The center line of this beam is a circular arc of radius 150mm. a bending moment of 2kNm tending to increase curvature of the bar is applied. Calculate the maximum tensile and compressive stresses set up in the bar.
2. A chain link is made of round steel rod of 12 mm diameter, R=36mm, l=60mm and load applied is 1.2 kN. Determine the maximum compressive stress in the link and tensile stress at the same section.
3. Derive the expressions for stresses in curved beams. (Winkler-Bach Theory).

Assignment 5(Shear Stresses in Beams and Rotating Discs)

1. Explain the importance of shear center.
2. An I-section with rectangular ends, has the following dimensions:

Flange : 15 cm x 2 cm
Web : 30 cm x 1 cm
Find the maximum shearing stress developed in the beam for a shearing force of 10 kN.

3. Derive the expressions for stresses induced in rotating thin disc.
4. Derive an expression to calculate the thickness of disc of uniform strength.
5. A steel disc of uniform thickness and of diameter 400 mm is rotating about its axis at 2000 rpm. The density of the material is 7700 kg/m3 and Poisson's ratio is 0.3. Determine the variations of circumferential and radial stresses.

BTME-402 Theory of Machines-II

Assignment 1

Q.1 Differentiate between static and dynamic equilibrium.
Q.2 what is method of superposition in static forces analysis.
Q.3 Explain dynamically equivalent system.
Q.4 Derive an expression to find out inertia force in the reciprocating parts neglecting the weight of connecting rod.
Q.5 Define inertia force and inertia torque.

Assignment 2

Q.1 Define static and dynamic balancing.
Q.2 Explain the direct and reverse crank method for determine the unbalanced forces in radial engines.
Q.3 Derive an expression for variation in tractive forces .
Q.4 What is partial balancing?

Assignment 3

Q.1 With the neat sketch ,derive the minimum number of teeth on the pinion in order to avoid interference.
Q.2 What are the advantage of gear drive over the other drive?
Q.3 Define pitch circle, pitch point, module, circular pitch.
Q.4 Derive the expression for efficiency of worm gearing.

Assignment 4

Q.1 Explain how are the gear train classified.
Q.2 Draw neat sketch of a reverted gear train.
Q.3 Explain the effect of gyroscopic couple on a naval ship during steering and pitching.
Q.4 Explain the gyroscopic effect on sea going vessels.
Q.5 Analyze the stability of a two wheel vehicle turning left.

Assignment 5

Q.1 Derive the expression for freudenstien equation.
Q.2 Explain the term: 1)Types synthesis 2) Number synthesis.
Q.3 Explain function generation, path generation.
Q.4 Explain the coupler curve synthesis.
Q.5 Explain two-position synthesis for four bar mechanism.

BTME-403 Fluid Mechanics

Assignment 1

1. Differentiate between mass density and weight density.
2. Differentiate between ideal fluids and real fluids.
3. Explain surface tension and capillarity.
4. Define Newton's law of viscosity.
5. Differentiate between centre of gravity and centre of buoyancy.
6. Differentiate between centre of pressure and centre of buoyancy.
7. Explain pascals law and hydrostatic law.
8. What are the conditions of equilibrium for floating and submerged bodies?
9.

Assignment 2

1. Comparison

a. Local and convective acceleration
b. Path line and stream line
c. Rotational flow and irrotational flow
d. Stream function and velocity potential function

e. Laminar flow and turbulent flow
2. State Bernoulli equation and its applicatios.
3. Explain free and forced vortex.

Assignment 3

1. define dimensionally homogeneous equation.
2. Define reynold number, mach number, Froude number and weber number.
3. Differentiate distorted model and undistorted model.

Assignment 4

1. Define HGL and TEL.
2. List the various losses in pipe flow.
3. Explain moody's chart.
4. Derive Hagen poiseulle equation for laminar flow in circular pipes.

Assignment 5

1.Differentiate between orifice and mouthpiece.
2.Differentiate between notches and weirs.
3.Explain working of rotameter.
4.What are the advantages of triangular notch over rectangular notch.

Tutorial 1
Unit –I Fundamentals of Fluid Mechanics
D.S. Kumar, Fluid Mechanics and Fluid Power Engineering, S.K. Kataria and Sons Publishers.

1. If specific gravity of a liquid is 0.80, make calculations for its mass density, specific volume and specific weight . (p.n. 11)
2. An increase in pressure of a liquid from 7.5 MPa to 15 MPa results into 0.2 percent decrease in its volume . Determine the bulk modulus of elasticity and coefficient of compressibility of the liquid. (p.n. 15)
3. Determine the bulk modulus of elasticity of a fluid that has a density increase of 0.002 % for a pressure increase of 45 kN/m2 (p.n. 16)
4 A dash pot 10 cm diameter and 12.5 cm long slides vertically down in a 10.05 cm diameter cylinder. The oil filling the annular space has a viscosity of 0.80 poise . Find the speed with which the piston slides down if load on the piston is 10 N. (p.n. 23)

5. Air is introduced through a nozzle into a tank of water to form a stream of bubbles. If the bubbles are intended to have a diameter of 2 mm, calculate by how much the pressure of the air at the nozzle must exceed that of the surrounding water. Assume that surface tension of water is 0.073 N/m. what would be the absolute pressure inside the bubble if the surrounding water is at 100 kPa? (p.n. 42)

Tutorial 2
Unit –II Fluid Statics

1. Explain the terms intensity of pressure and pressure head. Convert a pressure of 1.5 bar to (i) meters of water (ii) cm of mercury sp. Gr. 13.6 (D.S. Kumar,p.n. 66)

2. A rectangular plate 3 m * 5 m is immersed vertically in water such that the 3 m side is parallel to the water surface . determine the hydrostatic force and the centre of pressure if the top edge of the surface is (i) flush with the water surface (ii) 2 m below the water surface (D.S. Kumar,p.n. 82)
3. An inclined rectangular sluice gate 4m wide * 1 m deep has been installed to control the discharge of water. The upper end is hinged and lies at a distance of 2 m from the free surface of water. What force normal to gate be applied at the lower end B to open it? (D.S. Kumar,p.n. 100)
4. Determine the total pressure on a circular plate of diameter 1.5 m which is placed vertically in water in such a way that the centre of the plate is 3 m below the free surface of water. Find the position of centre of pressure also.(Dr. R.K. Bansal , p.n. 73)
5. A rectangular block is 5 m long 3 m wide and 1.20 m high. The depth of immersion of the block is 0.80 m in the sea water. If the centre of gravity is 0.6 m above the bottom of the block , determine the meta centric height. The density for sea water 1025 kg/m3.(Dr. R.K. Bansal ,p.n.138)

Tutorial 3
Unit –III Fluid Kinematics

1. Define the normal and tangential components of acceleration. Calculate the normal component of acceleration when 8 m3/s of water passes over the bucket of a slipway of radius 4 m.consider thickness of sheet of water over the bucket as 0.5 m and take unit width.(D.S. Kumar,p.n. 199)
2. The centre line velocity of flow through a nozzle changes from 1.5 m/s to 12.5 m/s over a length of 40 cm. workout the change in the magnitude to convective tangential accelation.(D.S. Kumar,p.n. 199)
3. A pipe conveys 0.25 kg/s of air at 300 K and under an absolute pressure of 2.25 bar. Calculate the minimum diameter of pipe necessary if the flow velocity is limited to 7.5 m/s. (D.S. Kumar,p.n. 202)
4. The diameter of the pipe at the sections 1 and 2 are 10 cm and 15 cm resp. Find the discharge through the pipe if the velocity of water flowing through the pipe at section 1 is 5 m/s. Determine also the velocity at section 2. (Dr. R.K. Bansal , p.n. 166)
5. A 30 cm diameter pipe, conveying water,branches into two pipes of diameters 20 cm and 15 cm resp. If the average velocity in the 30 cm diameter pipe is 2.5 m/s,find the discharge in this pipe. Also determine the velocity in 15 cm pipe if the average velocity in 20 cm diameter pipe is 2 m/s. (Dr. R.K. Bansal , p.n. 166)
6. The velocity potential function is given by Ø = 5 (x2-y2). Calculate the velocity components at the point (4,5). (Dr. R.K. Bansal , p.n. 185)

Tutorial 4
Unit –IV Fluid Dynamics

1. Water is flowing through a pipe of 5 cm diameter under a pressure of 29.43 N/cm2 and with mean velocity of 2 m/s. Find the total head or total energy per unit weight of the water at a cross-section which is 5 m above the datum line. (Dr. R.K. Bansal , p.n. 261)
2. The water is flowing through a pipe having diameters 20 cm and 10 cm at section 1 and section 2 resp. The rate of flow through pipe is 35 lts/s. The section 1 is 6 m above the datum and section 2 is 4 m above datum. If the pressure at section 1 is 39.24 N/cm2, find the intensity of pressure at section 2.(Dr. R.K. Bansal , p.n. 263)

3. An open circular tank of 20 cm diameter and 100 cm long contains water upto a height of 60 cm .the tank is rotated about its vertical axis at 300 r.p.m. find the depth of parabola formed at the free surface of water. (Dr. R.K. Bansal , p.n. 197)
4. A pipe carrying oil of sp. Gr. 0.87, changes in diameter from 200 mm diameter at a position A to 500 mm diameter at a position B which is 4 m at a higher level. If the pressures at A and B are 9.81 N/cm2and 5.886 N/cm2 resp. And the discharge is 200lts/s. Determine the loss of head and direction of flow.(Dr. R.K. Bansal , p.n. 267)

Tutorial 5

Unit –V Dimensional Analysis and Similitude

1. Find the expression for the power P , derived by a pump when P depends upon the head H, the discharge Q and specific weight w of the fluid. (Dr. R.K. Bansal , p.n. 563)
2. The efficiency η of a fan depends on the density ρ, the dynamic viscosity μ of the fluid, the angular velocity ω, diameter D of the rotor and the discharge Q. Express η in terms of dimensionless parameters. (Dr. R.K. Bansal , p.n. 563)
3. The pressure difference Δp in a pipe of diameter D and the length l due to turbulent flow depends on the velocity V, viscosity μ, density ρ and roughness k. Using Buckingham π- theorem, obtain an expression for Δp. (Dr. R.K. Bansal , p.n. 571)

Tutorial 6

Unit –VI Internal Flows

1. A fluid of viscosity 0.7 Ns/m2 and specific gravity 1.3 is flowing through a circular pipe of diameter 100 mm. The maximum shear stress at the pipe wall is given as 196.2 N/m2.find (i)the pressure gradient (ii) the average velocity (iii) Reynolds number of the flow. (Dr. R.K. Bansal , p.n. 395)
2. Calculate the pressure gradient along flow, the average velocityand the discharge for an oil of viscosity 0.02 Ns/m2 flowing between two stationary parallel plates 1 m wide maintained 10 mm apart. The velocity midway between the plates is 2m/s.(p.n. 400)
3. Find the head lost due to friction in a pipe of diameter 300 mm and the length 50 m through which water is flowing at a velocity of 3 m/s using Darcy formula and Chezy’s formula for which C = 60. (Dr. R.K. Bansal , p.n. 467)
4. The rate of flow of water through a horizontal pipe is 0.25 m3/s.the diameter of the pipe which is 200 mm is suddenly enlarged to 400 mm. The pressure intensity in the smaller pipe is 11.772 N/cm2. Determine loss of head due to sudden enlargement, pressure intensity in the large pipe, power lost due to enlargement.(Dr. R.K. Bansal , p.n. 475)
5. Determine the difference in the elevations between the water surfaces in the two tanks which are connected by a horizontal pipe of diameter 300 mm and length 400 m.the rate of flow of water through the pipe is 300 lts/s. Consider all losses and take f = 0.008(Dr. R.K. Bansal , p.n. 487)
6. The difference in water surface levels in two tanks which are connected by three pipes in series of length 300 m, 170 m, 210 m and diameter 300 mm, 200 mm, and 400 mm resp. Is 12 m. Determine the rate of water if co-efficient of friction are 0.005, 0.0052 and 0.0048 resp. , considering minor losses also and neglecting minor losses.(Dr. R.K. Bansal , p.n. 503)

Tutorial 7

Unit –VII Pressure and Flow Measurement

1. A horizontal venturimeter with inlet diameter 20 cm and throat diameter 10 cm is used to measure the flow of water. The pressure at inlet is 17.658 N/cm2 and the vaccum pressure at the throat is 30 cm of mercury. Find the discharge of water through venturimeter. Take cd =0.98 (Dr. R.K. Bansal , p.n. 272)
2. An orificemeter with the orifice diameter 10 cm is inserted in a pipe of 20 cm diameter. The pressure gauges fitted upstream and downstream of the orifice meter gives readings of 19.62 N/cm2 and 9.81 N/cm2 resp. Co-efficicent of discharge for the orifice meter is given as 0.6. find the discharge of water through pipe. (Dr. R.K. Bansal , p.n. 283)
3. The head of water over a rectangular notch is 900 mm. The discharge is 300 lts/s. Find the length of the notch , when Cd = 0.62.(Dr. R.K. Bansal , p.n. 357)
4. Find the discharge over a triangular notch of angle 60 degree C when the head over the V- notch is 0.3 m. Assume Cd = 0.6. (Dr. R.K. Bansal , p.n. 359)
5. Find the discharge through a trapezoidal notch which is 1 m wide at the top and 0.40 m at the bottom and is 30 cm in height. The head of water on the notch is 20 cm . assume Cd for rectangular = 0.62 and for triangular = 0.60 (Dr. R.K. Bansal , p.n. 362)
6. An ogee weir 5 m long has a head of 40 cm of water. If Cd = 0.6 find the discharge over the weir. (Dr. R.K. Bansal , p.n. 381)

BTME 404 Applied Thermodynamics-II

Assignment 1

1.Classify air compressor.Describe the working of a single stage reciprocating air compressor?
2.Explain the effect of intercooling in a multi stage reciprocating compressor?
3.Define multistage compressor construction and advantages?
4.Discuss the working of root blower and vane types of blower with the help of neat sketch?
5.Listatleast five different application of rotary air compressor.

Assignment 2

1.How the compressors are classified?
2.Differentiate between reciprocating and rotary compressors?
3.Explain the root blower.
4.Explain vane type blower.
5.Explain rotary cycle input work and efficiencies

Assignment 3

1.What is centrifugal compressor? Derive an expression for pressure rise and work input.state its important feature?
2.What do u understand by the term slip factor?
3.What do u mean by surging and chocking?
4.Explain the construction and working of axial flow compressor?
5.Compare axial flow and centrifugal compressor?

Assignment 4

1.Write a short note on application of gas turbine
2.Write a short note on reheat and regenerative in gas turbine plant?

3.Describe with neat sketch the working of a simple constant pressure open cycle gas turbine?
4.Write short note on (1) blade material (2)fuel for gas turbine(3)cooling of turbine blade
5.Discuss the working of semi closed cycle with a neat sketch?

Assignment 5

1.Discuss the classification of jet propulsion device with examples?
2.State the difference between jet propulsion and rocket propulsion?
3.Discuss the working of rocket engine? explain its types?
4.Explain turbojet engine?
5.Write advantages or disadvantages of turbo jet engine?

BTME 405 Manufacturing Processes –II

Assignment 1

Q1.Define the process of mechanical working of metals.
Q2.What is the difference between plate, sheet, strip & foil?
Q3.Compare Extrusion and Rolling Processes.
Q4.What is Tubular Extrusion?
Q5.Describe a progressive, a combination and a compound die.

Assignment 2

Q1. Compare metal spinning with deep drawing.
Q2. What is electro hydraulic forming?
Q3. With the help of sketch, describe the working of cutting die.
Q4.Define powder metallurgy process.
Q5.Explain the advantages of PM.

Assignment 3

Q1.Define machining process.
Q2.What is the use of chip breaker?
Q3. What is orthogonal rake system?
Q4.Enumerate the essential requirements of a tool material
Q5.What is the significant characteristics of high speed steels.

Assignment 4

Q1. Explain the advantages of high speed steel produced by powder metallurgy.
Q2.Why are tools coated?
Q3. Discuss various types of cutting fluids.
Q4. Sketch and explain “change gear quadrant”.
Q5.What is the purpose of quick change gear box?

Assignment 5

Q1.What is difference between the live and dead center?
Q2.Sketch and explain the working of mandrel.
Q3.What are tracer and gap lathes?
Q4.Draw the block diagram of a horizontal shaper and its important parts.
Q5.Write the application of shapers.

LAB MANUALS

BTME 406 Fluid Mechanics LAB

Experiments No.1

To determine the metacentric height of a floating vessel under loaded and unloaded conditions.

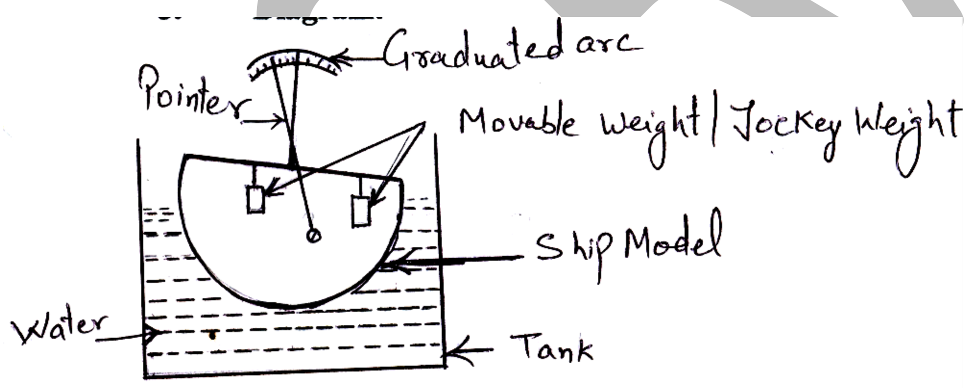
1. **Objective:**

To aware the students about stability of a ship.

2. Apparatus:

2.1 A Pontoon floating in tank
2.2 Removable strips.
2.3 Graduated arc with pointer.
2.4 Movable hangers set of weight.

3. **Diagram:**



METACENTRIC HEIGHT APPARATUS

4.

Theory:

A body floating in a fluid is subjected to the following system of forces:

a) The downward force of gravity acting on each particle that goes to make up the weight of body Wcacting through the center of gravity G.

b) The upward buoyant force of the fluid acting on the various elements of submerged surface of the floating object FB acting through the center of buoyancy.

For a body to be in equilibrium on the liquid surface, the two forces must be Wc& FB must lie in the same vertical line i.e. these two forces must be collinear and opposite.

When the pontoon has been tilted through an angle of Ɵ, the center of gravity of body G, is usually remained unchanged in its position, but B i.e. center of buoyancy will generally unchanged in its position, thus Wc and FB forms a couple. The line of action of FB in the new position at axis of the body at M, which is called the metacentre and the distance GM, is called metacentric height. The metacentric height is a measure of the static stability of the floating bodies.

The metacentric height can be obtained by equating righting couple and applied moment

$$= \frac{Wm \times d}{(Wc + Wm) \tan \theta}$$

Here Wc is weight of pontoon, Wm is weight of unbalanced mass causing moment on the body, d is the distance of the unbalanced mass from the centre of crossbar.

5. **Procedure:**

i) Note down the relevant dimensions as area of collecting tank, mass density of water etc.

ii) Note down the water level in the tank when pontoon is not in the tank.

iii) Pontoon is allowed to float in the tank. Note down the reading of water level in the tank. The help of Archimidie 's principle can obtain Mass of pontoon.

iv) Position of unbalanced mass, weight of unbalanced mass and the angle of heel can be noted down calculate the Metacentric height of the pontoon.

v) The procedure is repeated for other position and value of unbalanced mass. Also the procedure is repeated while changing the number of strips in the pontoon.

6. **Observations and Calculations:**

A) Loaded Condition:
Area of tank =
Rise in water level =
Weight of ship =

Sr. No	Unbalanced mass Wm	Distance of Unbalanced mass	Angle of heel Ɵ	Metacentric height $\frac{Wm \times d}{(Wc + Wm) \tan \Theta}$
1				
2				
3				

B. **Unloaded condition:**
Area of tank = 50 X 49 Cm2
Rise in water level =
Weight of ship =9810X.50X.49 X Rise in water level.

Sr. No	Unbalanced mass Wm (N)	Distance of Unbalanced Mass (m)	Angle of heel = l/r Ө	Metacentric height $\frac{W_m \times d}{(W_c + W_m) \tan \Theta}$
1				
2				
3				

7. **Result:**

i) In case of loaded,
Average Metacentric height = ---
ii) In case of unloaded,
Average Metacentric height = -----

8. **Precautions:**

i) Apparatus should be in leveled condition.
ii) Reading must be taken in steady condition of water. iii) Measure the angle of tilt accurately

9. **Question for viva:**

i) Can you compare the experimental result with those obtained analytically? If yes, list the formula used.
ii) How would the stability of the pontoon be affected if it were floated on a liquid with a density greater than that of water?
iii) Why care is taken to ensure that the metacentre is above the centre of gravity and center of buoyancy when the pontoon is in a tilted position?

<u>Experiments No.2</u>

To Study the Flow through Variable Area Duct And Verify Bernoulli's Energy Equation

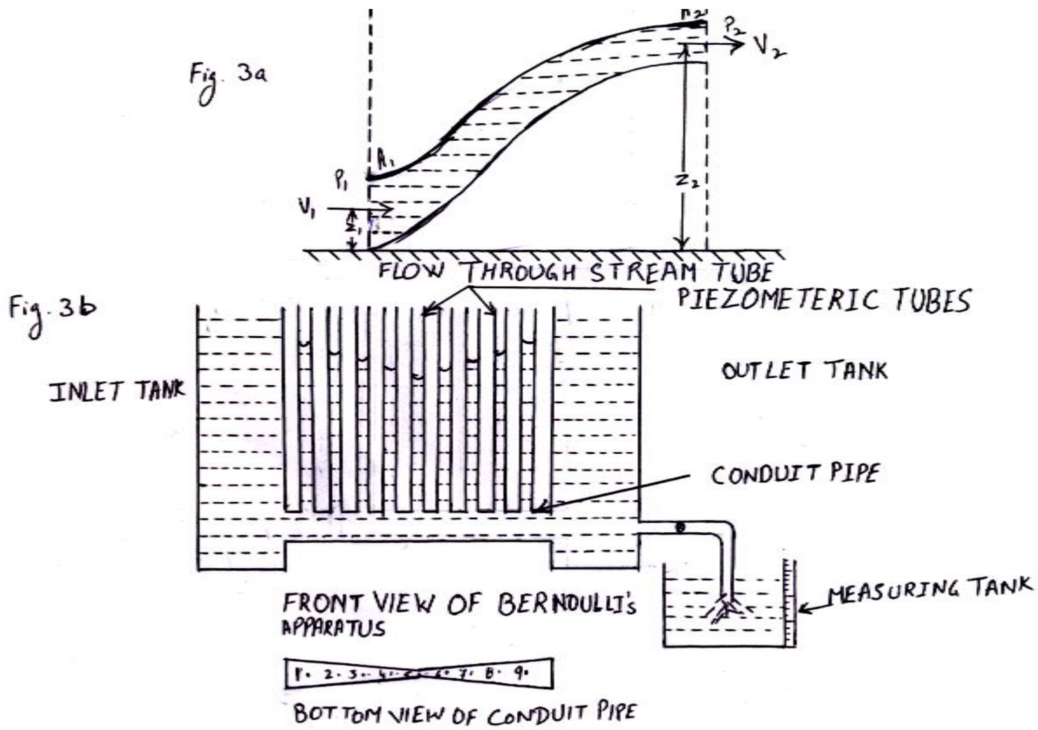
Objective:

To aware the students about energy principle and its experimental verification.

2. **Apparatus:**

It consists of conduit of varying cross- sectional area as shown in fig3b given below. Transparent acrylic metallic sheets are joined together to form first converging then diverging rectangular conduit of 50X25 on upstream side, 15 X25 in the middle and 50 X 25 downstream side . The length of the conduit pipe is 0.5m.Graduated piezometeric tubes are fitted on the conduit pipe to measure the Piezometric head at each gauge point.
This conduct is connected to an inlet tank. A Piezmetric tube is also connected to the collecting tank for recording the water level in tank. An outlet valve is fitted at
thedown stream end of the pipe.

3. **Diagram:**



4. **Theory:**

Daniel Bernoulli enunciated in 1738 that in any s1ream flowing steadily without friction the total energy contained in a given mass is same at every point in its path of flow. This statement is called Bernoulli's theorem.

With reference to section 1-1 and 2-2 along the length of steady flow in the stream tube shown in the figure 3a the total energy at section 1-1 is equal to the total energy at section 2-2 as stated in Bernoulli's theorem.

With usual notations, the expression for total energy contained in a unit weight of fluid at section 1-1 and 2-2 is given by

Total energy at section 1-1 = $P_1/w + V_1^2/2g + Z_1$

Total energy at section 2-2 = $P_2/w + V_2^2/2g + Z_2$

P_1/w= Pressure energy at section 1-1

$V_1^2/2g$ = Kinetic energy at section 1-1

Z_1 = Potential energy at section 1-1

P_2/w = Pressure energy at section 2-2

$V_2^2/2g$ = Kinetic energy at section 2-2

Z_2 = Potential energy at section 2-2

Thus applying Bernoulli's theorem between section 1-1 and 2-2

$$P_1/w + V_1^2/2g + Z_1 = P_2/w + V_2^2/2g + Z_2 \qquad \text{(i)}$$

In MKS system, the pressure energy, kinetic energy and potential energy
are measured fluid column per unit weight of fluid. Equation (i) is modified for taking into account the loss of friction between section 1-1 and 2-2 and is written as

$P1/w + V12/2g + Z1 = P2/w + V22/2g + Z2 + (\Delta H)1,2$

Where $(\Delta H)1,2$ represents the loss of energy between sections 1-1 and 2-2

5.**Procedure:**

i) Note down the area of the conduit at various gauge points.
ii) Ensure that the apparatus is horizontal with the help of spirit level.
iii) Open the supply valve and adjust the flow so that the water level in the inlet tank remains constant
iv) Measure the height of water-level (above an arbitrarily selected suitable plane) in different piezometric tubes.
v) Measure the discharge of the conduit with the help of measuring tank.
vi) Repeat steps (iii) to (v) for two more discharges.

6. **Observations & Calculations:**

Discharge

Run No.	Initial Vol. V1	Final vol. V2	Volume Collected V=V2 - V1	Time Taken t	Discharge Q =V/t
Units					
1					
2					
3					

Total head

Piezometric tube No.		1	2	3	4	5	6	7	8	9
Area of cross-section of conduit at each Gauge point, A										
Run No.1	V=Q/A V2/2g P/w + V2/2g +Z									
Run No.2	V=Q/A V2/2g P/w + V2/2g +Z									
Run No.3	V=Q/A V2/2g P/w + V2/2g +Z									

7. **Result:**
As the conduit is horizontal the total energy at any section with reference to the datum line of the conduit is the sum of P/w & V2/2g energy should be constant for each of the piezometric tube.

8. **Precautions:**

i) Before taking reading, take care that steady flow conditions are established in the conduit.

ii) Check that air is not entrapped in the piezometric tube.

iii) There should be no leakage between u/s and d/s end of the conduit.

9. **Questions for viva:**

i) Where is your datum plane?

ii) If piezometeric tubes are replaced by pressure gauges, then how will you calculate pressure energy and potential energy of plane?

What are units for P/w,V2/2g & Z?

What are the applications of Bernoulli's equations?

<u>Experiments No.3</u>

To determine the coefficient of discharge for an obstruction flow meter (venture meter/ orifice meter)

1. **Objective:**

To aware the students about coefficient of discharge measurement with the help of orifice-meter.

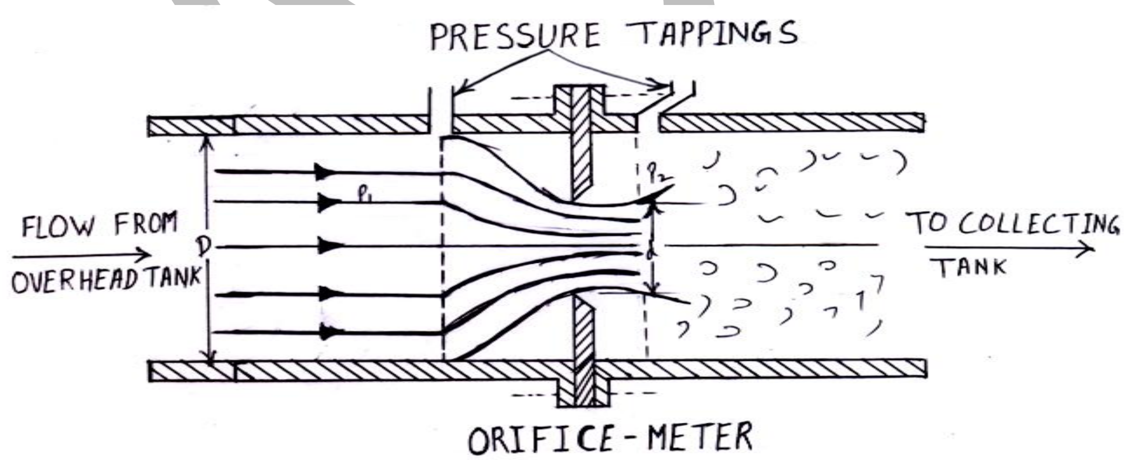
2. Apparatus:

2.1 An orifice meter with tapping at upstream and downstream 2.2 A 'u' tube manometer containingmercury .

2.3 A measuring tank to find actual discharge.

2.4 A stopwatch.

3. **Diagram:**



4. **Theory:**

Orifice-meter, also known as orifice plate meter, is a device used to measure the flow rate in any closed pipeline. It is different from the venturimeter in the sense that it provides sudden change in flow conditions instead of smooth transition provided by the venturimeter. As the liquid passes through the orifice-meter, a lot of eddies are formed and there is loss of energy due to which the measured value of discharge, Q is far less and is given by:

$$Q = C_d \left[\frac{a_1 a_2}{\sqrt{a_1^2 - a_2^2}} \sqrt{2g(h_1 - h_2)} \right]$$

In which C_d is the coefficient of discharge of orifice-meter, a_1 is the cross-sectional area of the pipe and a_2 the cross-sectional area of the orifice as shown in fig 3.a. The value of C_d varies from 0.6 to 0.62.

5. **Procedure:**

i) Open the regulating valve so that water starts flowing through the orifice meter. Wait for some time so that the flow gets stabilized.

ii) Remove air bubbles, if any entrapped in piezometeric tubes.
iii) Note differential manometer readings h_1 & h_2.
iv) Measure the discharge by collecting a certain volume of water in a predetermined time.
v) Repeat steps (iii) & (iv) for different flow rates & take at least three different sets of observations.
vi) Take another set of manometer readings for calculation of discharge of the pipeline for constant outflow.

6. **Observations and Calculations:**

Diameter of the main pipe, D = 25mm
Diameter of the orifice, d = 12.5mm
Area of cross-section of the pipeline, $a_1 = 0.4908 \times 10^{-3}$
Area of cross-section of the orifice, $a_2 = 0.1227 \times 10^{-3}$
Specific gravity of measuring liquid, $S_2 = 13.6$
Specific gravity ofliquid flowing in the Pipe, $S_1 = 1$

Sr. No	Discharge measurement			Manometer reading				$C_d = Q\sqrt{a_1^2 - a_2^2} / a_1 a_2 \sqrt{2gh}$
	Vo	t	Q=V0/t	h1	h 2	h'	h=(S2/S1 - l)h'	
units								
1								
2								
3								

7. **Result:**

Average Value of Cd =

8. **Precautions:**

i) There should be no air bubbles entrapped while taking reading of liquid level in piezometeric tubes.
ii) Check that the top level of measuring liquid is same in the two limbs of the differential manometer.

9. **Question for viva:**

i)What suggestions do you have for the improving the value of the coefficient of discharge?
ii) What happens to manometer if the pressure in the tapping is too more?

Which other liquids, we can use instead of mercury in manometer?

Experiment No. 4

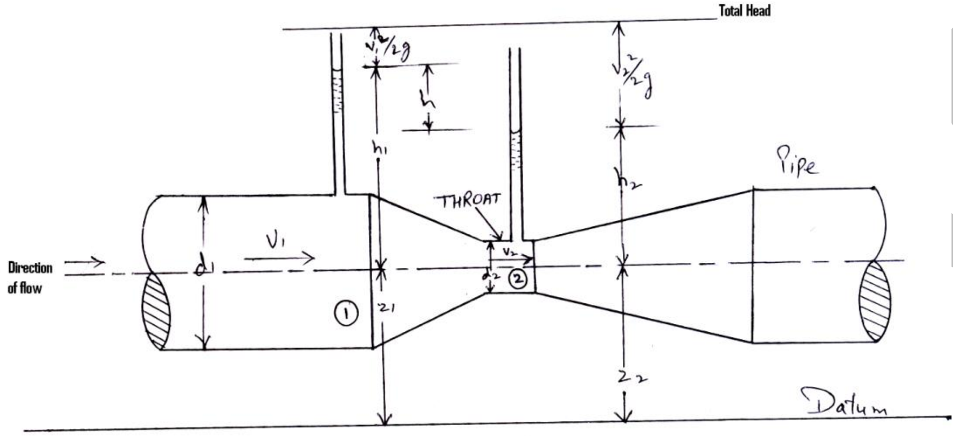
Objective:

To aware the students about coefficient of discharge measurement with the help of venturimeter.

Apparatus:

2.1 A venturimeter with tapping at the mouth and throat give connections to the manometer.
2.2 A 'U' tube manometer containing mercury.
2.3 A measuring tank to find actual discharge
2.4 A stopwatch.

Diagram:



VENTURIMETER

Theory:

The venturimeter is a device, which has been used over many years for measuring the discharge along the pipe. It consists of a convergent section which reduces in diameter to between one-half and one-fourth of pipe diameter. This is followed bya throat and then a divergent section. The convergent angle is usually 20°. For the divergent part the angle of divergence is usually 5° to 7°.

The fluid flowing in the pipe is led through a contraction section to a throat, which has a smaller cross-sectional area than the pipe. So that the velocity of fluid through the throat is higher in the pipe. This increase of velocity is accompanied bya fall in pressure, the magnitude of which depends on the rate of flow, so that by measuring the pressure drop, the discharge may be calculated.

Beyond the throat the fluid is decelerated in a pipe of slowly diverging section. The pressure increasing as the velocity falls.

With usual notations, the expression for discharge Q, through a venturimeter is given by

$$Q = \frac{a_1 a_2 \sqrt{2g(h_1-h_2)}}{\sqrt{a_1^2 - a_2^2}} \qquad \text{(i)}$$

Where

a_1	=	area of cross-section of an upstream section
a_2	=	area of cross-section at throat

h_1 = piezometric head at the upstream section
h_2 = piezometric head at the throat as shown in fig
g = acceleration due to gravity

In practice there is some loss of energy between section 1 & 2 & the velocity is not absolutely constant across either of these sections. As a result, measured value of Q usually falls a little sort of those calculated from Eq. (i) &It is customary to allow for this discrepancy by writing:

$$Q = K \frac{a_1 a_2 \sqrt{2g(h_1-h_2)}}{\sqrt{a_1^2 - a_2^2}}$$

$$= \left[K a_1 a_2 / \sqrt{a_1^2 - a_2^2}\right] \sqrt{2gh}, \text{ where } h = h_1 - h_2 \quad \text{(ii)}$$

In which K is known as the venturimeter coefficient & its value varies slightly from one venturimeter to another, and even for a given venturimeter it may vary with the discharge, but usually lies within the range of 0.92 to 0.99. In case the piezometric tapping are connected to a differential manometer, then:

$h = (S_2/S_1 - 1) h'$
h' = differential manometer reading
S_2 = sp. gr. of measuring liquid in differential manometer
S_1 = sp. gr. of liquid flowing in pipeline.

5. **Procedure:**

i) Open the regulating valve so that water starts flowing through the venturimeter.
ii)Wait for some time so that the flow gets stabilized.
iii)Remove air bubbles, if any, entrapped in piezometeric tubes.
iv)Note differential manometer readings hl& h2 .
v)Measure the discharge of the apparatus by collecting a certain volume of water in a predetermined time.
vi)Repeat steps (iii) & (iv) for different flow rates and take at least six different sets of observations.
vii) Take another set of manometer readings for calculation of discharge of the pipeline for constant outflow.

Observations and Calculations:

Sr. No	Discharge measurement		Manometer reading				$K = Q\, a_1 a_2/\sqrt{a_1^2 - a_2^2}\,]\sqrt{2gh}$
	Q=V0/t	t	h1	h2	h'	h=(S2/S1 - l)h'	
Unit							
1 2 3							

7. **Results:**

Average Value of k =

8. **Precautions:**

i) There should be no air bubble entrapped while taking reading of liquid

level in piezometeric tubes.
ii) Check that the top level of measuring liquid is same in the two limbs of the differential manometer.

9. **Question for discussion:**

i) What suggestions do you have for the improving the value of the coefficient of discharge?
ii) What happens to manometer if the pressure in the tapping is too more?
iii) What are other liquids (more sp. gr.) can be use?

<u>Experiments No.5</u>

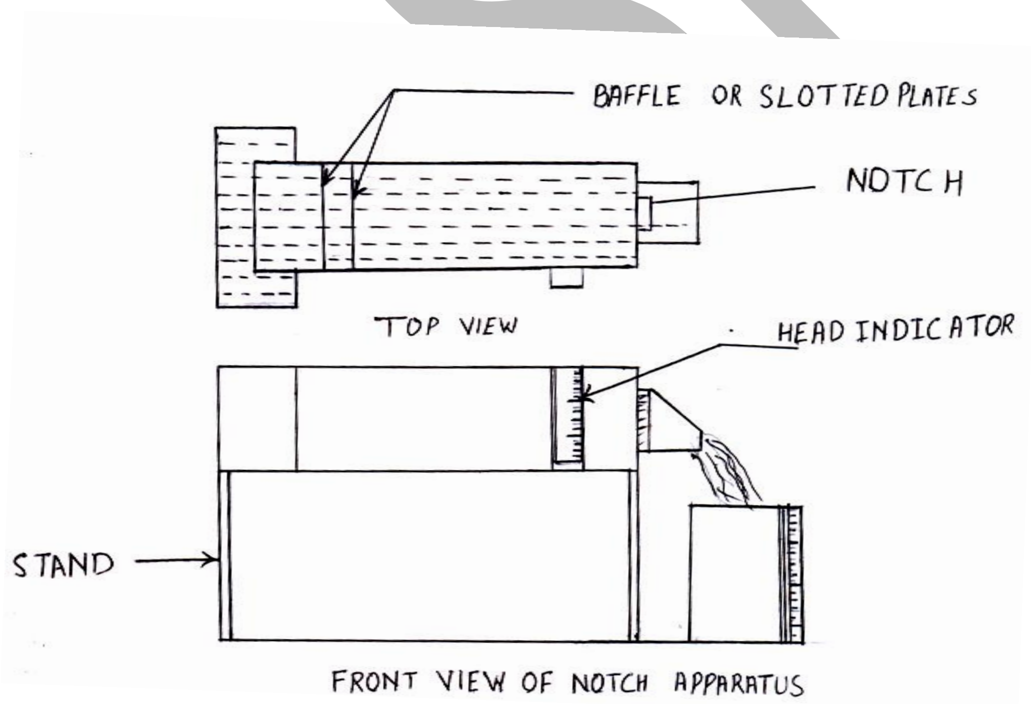
Objective:

To aware the students about Vee notch or rectangular notch and their use in measuring coefficient of discharge.

2. **Apparatus:**

2.1 A weir tank with baffle plates to reduce the velocity of approach
2.2 A Vee-notch or
2.3 A rectangular notch
2.4 A collecting tank

3. **Diagram:**



4. **Theory:**

Notches are commonly used to regulate flow in rivers and other open channels. The relationship between the water- level upstream of the notch and the discharge over it is, generally, known so that the discharge at any time may be found by observing the upstream water level. Notches usually have sharp edges so that the water springs clear of the plate as it passes through the notch.

With the usual notations, the equation for discharge past a sharp-edged notch can be derived in the following form:

For the rectangular notch:

$$Q = 2/3\sqrt{2g}\ bh^{3/2} \qquad \text{(i)}$$

For the triangular notch:

$$Q = 8/15\sqrt{2g}\ \tan \Theta/2\, h^{5/2} \qquad \text{(ii)}$$

Where h, b, Θ are as shown in fig.3a & 3b

The preceding equations are based upon the assumptions listed as follows: a) The height of the water level at the plane of the notch opening is h.

b) The velocity of flow is normal to the plane of the notch opening at all points.

c) The velocity in the approach channel is negligible.

d) There is no contraction of the stream as it passes through the notch.

In practice, however, none of these assumptions are satisfied. It is, therefore, customary to rewrite the equations in the form:

For the rectangular notch:

$$Q = 2/3\sqrt{2g}\ bh^{3/2} \qquad \text{(iii)}$$

For the triangular notch:

$$Q = 8/15\sqrt{2g}\ \tan \Theta/2\, h^{5/2} \qquad \text{(iv)}$$

Where Cd is coefficient of discharge of the notch. It is a non-dimensional number and the dependable way of its determination is by experimentation. A convenient way of finding Cd and the exponent of h in either of these expressions is as follows. Either of Eqs. (iii) & (iv) may be written in the form:

$$Q = K(h)^n \qquad \text{(v)}$$

$$\log Q = \log K + N \log h \qquad \text{(vi)}$$

If experimental results are plotted on a graph having log h as abscissa and log Q as ordinate, then provided that K and n are constant over the range of the results, they will lie on a straight line having slope n and intercept log K on the axis of log Q as indicated in fig 3c.

5. **Procedure:**

i) Record the width of the rectangular notch.
Or
The angle of V-notch.
Level the apparatus by using spirit level.
Take a series of measurements of discharge and head on the notch by regulating the flow. It is recommended that the rust reading be taken at maximum discharge and subsequent readings with roughly equal decrements in head.
Discontinue readings when the level falls to a point at which the stream ceases to spring clear of the notch plate. This is likely to occur when the head is reduced to about 1 cm for a rectangular notch and about 2.5 cm for a triangular notch.
About 3 different discharges for each notch should be noted.

6. **Observations and Calculations:**

Rectangular Notch

Width of notch, b =

Sr. No.	Gauge reading h	Quantity of water collected, Vo	Time t	Discharge Q		Calculation of Cd
				Actual = V0/t	Theoretical= $2/3\ \sqrt{2g}\ \ bh^{3/2}$	Qact./Qth

Sr. No	Gauge reading	Quantity of water	Time t	Discharge Q	Calculation of Cd =

Unit	(m)	(m3)	(s)	(m3/s)	(m3/s)	
1.						
2.						
3.						

From graph slope n =
Intercept on log Q axis i.e. log k =
The relationship between log Q and log h is thus, Log Q = log k + n log h = Comparing this with Q = $Cd 2/3\ \sqrt{2g}\ \ bh^{3/2}$
Cd = ---

7. Result:

	h	collected, Vo		Actual = V0/t	Theoretical = $2/3 \sqrt{2g}\ bh^{3/2}$	Qact./Qth
Units	(m)	(m^3)	(s)	(m^3/s)	(m^3/s)	
1. 2. 3.						

The graph between log Q and log h is a straight line.

8. **Precautions:**

i) As the correct discharge measurements are very important for this experiment, there should be no leakage at any of the regulating valves.

ii) The width of notch or the angle of the V - notch should be carefully recorded.

iii) The apparatus should be leveled.

9. **Questions for Viva:**

i) How would you interpret result which, when plotted logarithmically, fall on a line which is not straight, but slightly curved?

ii) What are changes in result when there is unleveled apparatus?

iii) Why plates are entrapped in the inlet tank?

<u>Experiments No.6</u>

To study the transition from laminar to turbulent flow and to ascertain the lower critical Reynolds number.

1. **Objective:**

To impart knowledge of laminarand turbulent flow in relation to Reynold’s Number.

2. **Apparatus:**

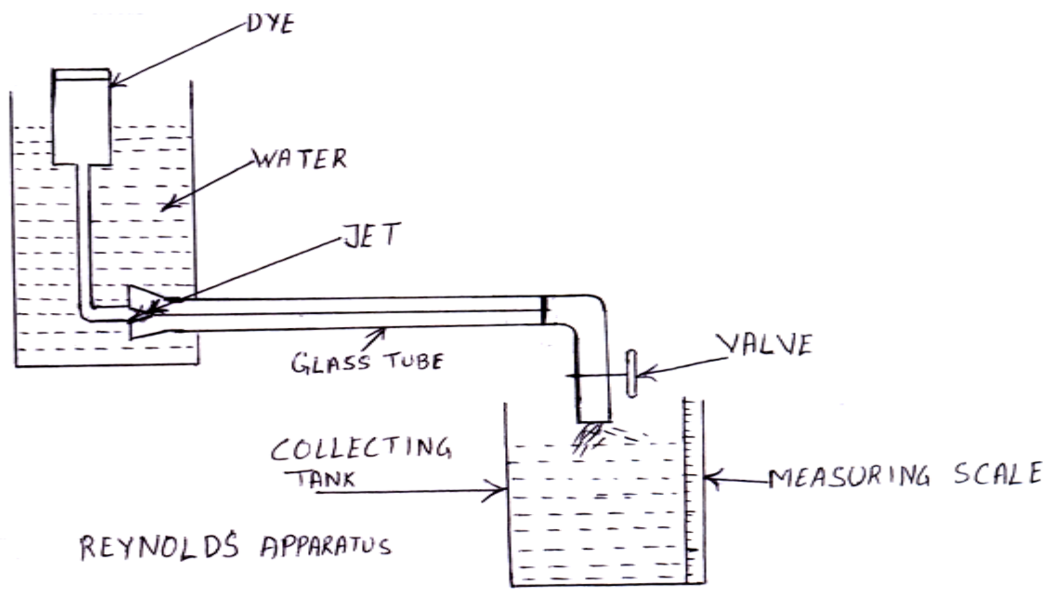
2.1 A glass tube with a bell mouthed inlet leads from a large tank.

2.2 A dye container is attached to the side- wall of the tank to inject a stream of dye into the glass tube.

2.3 A measuring tank to find actual discharge

2.4 A stopwatch.

3. **Diagram**:



4. **Theory:**

Osborne Reynolds, in 1883, conducted a number of experiments to determine the laws of resistance in pipes. By introducing a filament of dye into the flow of water along a glass pipe, he showed the existence of two different types of motion. At low velocities the filament appeared as a straight line, which passed down the whole length of the tube, indicating laminar flow. At higher velocities, the filament, after passing little way along the tube, suddenly mixed with the surrounding water, indicating that the motion had now become turbulent.

Experiments with pipes of different diameters & with water at different temperatures led Reynolds to conclude that the parameter, which determine whether the flow shall be laminar or turbulent in any particular case is:

$Re = \rho VD/\mu$

In which Re denotes the Reynolds Number of motion

ρ denotes the density of fluid

V denotes the velocity of flow

D denotes the diameter of pipe

μ denotes the coefficient of viscosity of the fluid

The motion is laminaror turbulent according as the value of Re is less than or greater than a certain value. If experiments are made with increasing rate of flow, the value of Re depends on the degree of care which is taken to eliminate disturbances in the supply or along the pipe. On the other hand, if experiments are made with decreasing flow, transition from turbulent to laminar flow takes place at a value of Re which is very much less dependent on initial disturbances. This value of Re is about 2000 for flow through circular tubes, and below this the flow is inherently laminar in nature. The velocity at which the flow in the pipe changes from one type of motion to the other is known as critical velocity and is given by:

$V= Re\ \mu / \rho\ D$

Also, the value of critical velocity corresponding to Re = 2000, also known as lower critical Reynolds Number, is called Lower Critical Velocity. The upper critical Reynolds Number (the maximum value of Re at which laminar flow is physically possible) depends largely upon the nature of disturbance present in the flow and may be as high as 40000.

5. **Procedure:**

i) Open the main supply valve & fill the tank of the apparatus with water, with outlet of glass tube partly open so that no air is entrapped in the glass tube.
ii) Close the outlet valve of the glass tube and the inlet valve of the tank when the tank is full.
iii) Leave the apparatus for some time so that water in the tank is at rest. No disturbance.
iv) Partially open the outlet valve of the glass tube & inlet of the tank so that velocity of flow is very small and the water level in the tank is fairly constant.
v) Open inlet of the dye-injector so that the dye stream moves as a straight line through the tube showing that the flow is laminar.
vi) Increase the velocity of flow & again measure the discharge.
vii) Take three readings till the dye filament wavers for the first time near the outlet end of glass tube.
viii) Note down the room temperature at least three times during the experiment
ix) Repeat the experiment with decreasing rate of flow & encircle the reading for which dye filament wavers for the last time near outlet end of glass tube; as the flow changes from turbulent to laminar.

6. **Observation & Calculations:**

Inner diameter of glass tube, D =
Cross-sectional area glass tube, A = (л/4)D2
Mass density of water, ρ =
Average room temperature, ϴ=
Dynamic viscosity of water at room temperature, μ =
Volume of water collected, Vo =

S.NO	Vo	t	Q	V=Q/A	Re= ρ VD/ μ	ϴ	Remarks
Units							
1							
2							
3							

7. **Result:**

Average Critical velocity = -------------
=
------

8. **Precautions:**

i) Don't forget remove any entrapped air in the apparatus before starting measurement.
ii) There should be no mechanical vibration near the apparatus.
iii) Don't forget to record the temperature of water at frequent intervals.

iv) Increase in velocity of flow should be in stages.

9. Question for viva:

i) Name the dye, which you have used?

ii) On which factor Reynolds apparatus depends.

What is basic difference between laminar and turbulent flow?

How we have calculated velocity in a pipe?

<u>Experiments No.7</u>

To determine the hydraulic coefficients for flow through an orifice.

1.**Objective:**

To visualizes the physical significance of Vena-Contracta& also hydraulic coefficient of the orifice.

2. **Apparatus:**

2.1 An orifice tank provided with:

a) A regulate supply.

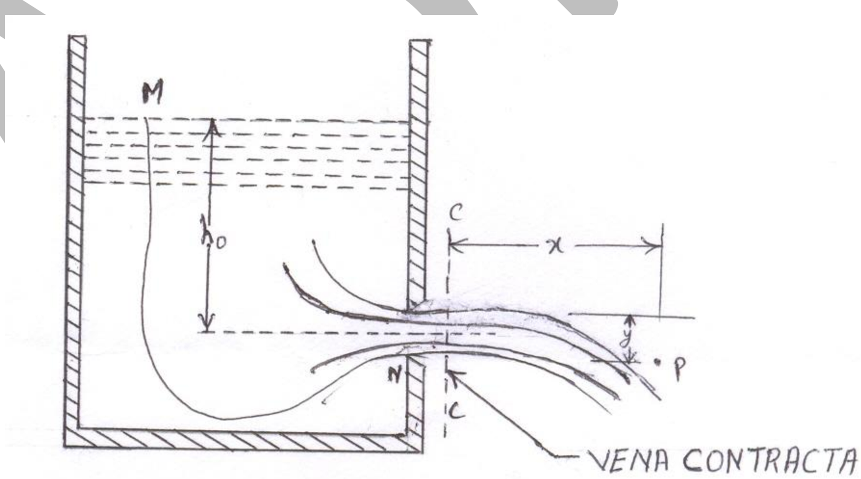
b) A piezometer tube to measure the head.

c) A horizontal graduated scale with a hook gauge at measure the coordinates of any point on the jet.

2.2 Micrometer contraction gauge.

2.3 Stopwatch.

2.4 Measuring tank.



FLOW THROUGH AN ORIFICE

3. **Diagram:**

4. **Theory:**

Fig.3a shows the essential features of flow through an orifice /mouthpiece. The tank is assumed to be sufficiently large for the velocity of flow in it to be negligibly small except close to the orifice. In the vicinity of the orifice the flow accelerates towards the center of the hole so that as the jet emerges, it suffers a reduction of area due to the curvature of the streamlines, as typified by the streamlines MN indicated in the fig3a. The reduction of area due to this local Curvature may be taken to be complete at about half an orifice diameter downstream of the plane of the orifice; the reduction is usually referred as the vena-contracta.

The coefficient of contraction Cc is defined as the ratio of the cross-section of the vena-contracta 3c to the cross- section of the orifice, ao i.e.

$CC = a_c/ a_o$ (i)

Because of the energy loss, which takes place as the water passes down the tank and through the orifice the actual velocity V c in the plane of the vena-contracta, will be less than the theoretical velocity Vo. The ratio of the actual velocity Vc and the ideal velocity Vo is often referred as the coefficient of velocity Cv of the orifice i.e.

$C_v = V_c/ V_o$ (ii)

The theoretical velocity in the plane of vena- contractaVo can be calculated from the equation.

$V_o/2g = h_o$ i.e.

$V_o = \sqrt{2g h_o}$ (iii)

The actual velocity in the plane of vena- contracta is given by the equation.

$V_c = \sqrt{(g x^2/2y)}$ (iv)

Where x, & y measured positive downward represents the horizontal & vertical coordinates of point P on the trajectory of the jet (origin being taken at the lowest point of the jet at vena- contracta).

Substituting he values of Vo&Vc in the equation (ii) we get

$C_v = \sqrt{(x^2/4y h_o)}$ (v)

Finally, the coefficient of discharge Cd is defined as the ratio of the actual discharge to that which would take place if the jet is discharged at the ideal velocity without reduction of area. The actual discharge Q is given by

$Q = V_c a_c$ (vi)

& Can be measured with the help of measuring tank and if the

Thus the coefficient of discharge Cd is given

$C_d = Q/Q_o = (V_c a_c)/(V_o a_o) = Q/(a_o\sqrt{2g h_o})$ (vii)

$= (a_c/ a_o) (V_c/V_o) = C_c C_v$ (viii)

5. **Procedure:**

i) Fix the orifice! Mouth piece of desired shape & size is connected to the opening in the sidewall of the intake tank, near its bottom.

ii) Allow the water to enter the intake tank through the regulating valve & wait till the water level in the tank becomes steady.

iii) Measure the head h using a piezometric tube fixed to the inlet tank.

iv) Measure the discharge corresponding to each value of h.

v) Measure x & y co-ordinates of the lower surface of the jet trajectory at four different points of the jet at vena- contracta.
vi) Plot graph for Q vs $\sqrt{h}$

6. **Observation & Calculations:**
Area of cross- section of orifice, ao =
Reading on the piezometric scale at the
Level of the center of the orifice, h1=

Determination of Cd

S. No	Quantity of water collected V	Time taken t	Q	$Cd=Q/(\sqrt{2gho})$ ao	ho
1 2 3					

Average value of Cd = --

Determination of Cv

S.No	x0	y0	x'	y'	x= x'- y'	y=y'-y0	$Cv= x/2\sqrt{yh0}$	Remarks
1 2 3								

Average value of Cv= --
Then Cc = Cd/ Cv = ---

7. **Result:**
The variations of $\sqrt{ho}$ with Q should be linear provided Cd remains constant over the range of the experiment.

8. **Precautions:**
i) When taking reading with the piezometric tube check that air is not trapped in this tube.
ii) Take care that water level in the inlet tank is fairly constant when taking a reading.

9. **Questions for viva:**

i) Supposing that it is not possible to measure the diameter of the jet at the vena contracta, but that the diameter some distance away from it would the results is affected?

ii) If, when you plot the graph of h against Q, you obtain a line, which does not appear to pass through the origin, what possible reasons are there for this? How will the value of Cd obtained from the graph be affected?

iii) In the vicinity of the orifice the flow accelerates towards the center of the hole why?

iv) Is there any provision to control the flow of intake when rpm of motor vary with electricity fluctuation?

Experiments No.8

To determine the friction coefficient for pipe of different diameters.

1. **Objective:**

To aware the students about variation of friction coefficient by changing the dia& length of the pipe.

2. **Apparatus:**

2.1 Darcy's apparatus consists of three pipes having the diameter 25 mm, 19 nun and 15mm. The pipes may be 100cm long.

2.2 One common inlet valve is provided in the main supply line for the whole apparatus.

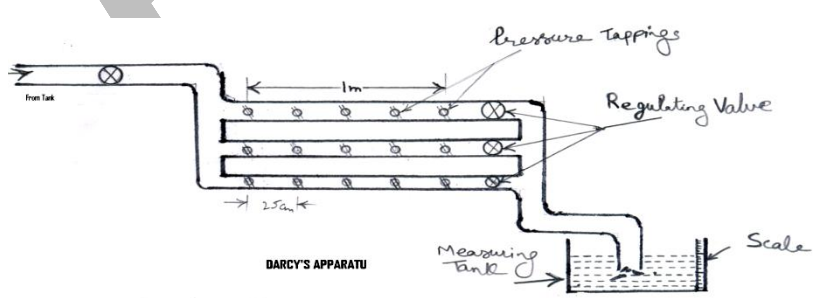
2.3 Five-pressure tapping is provided at a distance of25cm from the previous one on each the pipe.

2.4 Five Piezometric tubes.

2.5 A measuring tank.

2.6 A stopwatch

3. **Diagram:**



4. **Theory:**

While the nature of flow depends upon the Reynolds Number, the frictional resistance offered to the flow of fluids depends essentially on the roughness of the surface of the conduit carrying the flow. In laminar flow this frictional resistance is mostly due to viscous resistance of fluid to flow. In turbulent flow it is due to resistance offered by viscosity of fluid and surface roughness of the conduct This frictional resistance causes loss of head ~ which is given by Darcy and
Weisbach equation:

$hf = 4fLV2/2gD$

Where f is called Darcy's friction factor and given by $f = 64/Re$ for laminar flow and depends upon relative roughness of pipe in case of turbulent flow.

5. **Procedure:**

i) Connect the Piezometric rubber tubes to gauge points of one of the pipelines.
ii) Open the inlet valve, keeping the outlet valve closed.
iii) Check if there is any air bubbles in the Piezometric tube. Remove air bubbles if any.
iv) Open partially the outlet valve, keeping the common inlet valve fully open.
v) Allow the flow to get established and then take Piezometric reading.
vi) Measure the discharge.
vii)Repeat steps (iv) to (vii) for other pipes.

6.**Observations and Calculations:**

Diameter of pipes
D1= 25mm
D2= 19mm
D3 = 15mm
$f= 2gDhfA2/4LQ2$

Pipe	Run No	Discharge measurement			Piezometric reading			f= 2gDhfA2/4LQ2
		Volume Vo	Time t	Discharge Q=V/t	h1	h2	hf=h1- h2	
Units								
Length= Dia.=	1							
	2							
	3							
Length= Dia.=	1							
	2							
	3							
Length= Dia.=	1							
	2							
	3							

7. **Result:**

i) As the diameter of pipe is increased the value of Darcy's friction factor Increases.

ii) As the length of pipe increases the value of Darcy's friction factor decreases.

8. **Precaution:**

i) Take care that there is no air bubbles in the apparatus when taking piezometric readings.

ii) There should be no leakage.

9. **Question for viva:**

i) What happens to Darcy's friction factor by varying the length of pipe?

ii) What is drawback of air bubbles in the tubing?

iii) What are the other factors at which friction resistance depends?

<u>Experiments No.9</u>

To determine the head loss in a pipe line due to sudden expansion/ sudden contraction/ bend.

1. **Objective:**

To aware students about minor losses of the pipes.

2. **Apparatus:**

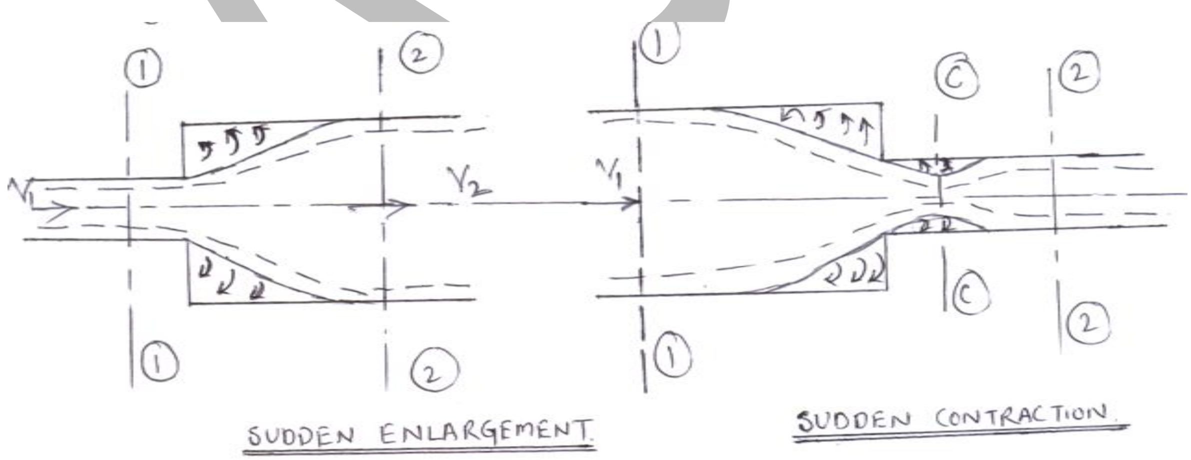
2.1 The apparatus consists of a bend, an elbow, a gate valve, a globe valve, a sudden contraction, and a sudden enlargement.

2.2 A "u" tube manometer.

2.3 A stopwatch

2.4 A measuring tank.

3. **Diagram:**



4. **Theory:**

The frictional resistance causes loss of head hf, which is given by Darcy & Weisbach Equation.

$hf = 4fLv2/2gD$

Where f is called Darcy's equation & is given by f = 64/Re for laminar flow & depends upon relative roughness of pipe in case of turbulent flow. But the head losses due to change of section, bend elbows; valves & fittings of all types are classified as minor losses in pipe lines.

Minor losses usually result from rather abrupt changes (in magnitude & direction) of velocity. In general, increase of velocity (acceleration) is associated with small head loss but decrease of velocity (deceleration) causes large head loss because of the production of large-scale turbulence. Early experiments with water (at high Reynolds Number) indicated that minor losses very approximately with the square of velocity & lead to the proposal of the basic equation.

$hL = kv2/2g$

In which k, the loss coefficient is practically constant Loss of head for

A bend = k v2/2g
An elbow = k v2/2g
Gate valve = k v2/2g
Globe valve = k v2/2g
Sudden contraction = 1/2v2/ 2g
Sudden enlargement = (v1-v2)2/ 2g

5. **Procedure:**

i) Open the inlet valve, keeping the outlet valve closed.
ii) Connect the manometer rubber tubing to one of the pipe/pipes fittings & check that there is no air bubbles entrapped.
iii) Open partially the outlet valve, keeping the common inlet valve fully open.
iv) Allow the flow to get constant & then take manometer reading.
v) Measure the discharge.
vi) Take at least three readings.
vii) Repeat steps (i) to (vi) for different fittings.

6. **Observation and Calculation:**

Diameter of main pipe, D =
Diameter of enlarge pipe, D1 =
Area of cross- section of main pipe,a =
Area of cross- section of enlarged pipe, al =
Length of main pipe between pressure tapping, L =

Pipe/s fittings	Run No.	Discharge measurement			Velocity of flow in		k	hf/ hL	
		Volume of water collected Vo	Time t	Discharge Q	V = Q/a	Enlarged Pipe Vl =Q/ al		Calculated	Measured

Bend Elbow Gate valve Globe valve Sudden Enlargement Sudden Contraction									

7. **Result:**

The friction resistance varies:

i) with the degree of roughness of surface with which fluid comes in contact

ii) with the extent of area of surface coming in contact with fluid

8. **Precautions:**

i) Take care that there is no air bubble entrapped in the apparatus when taking manometer reading.

ii) There should be no leakage from any of the pipe fittings.

9. **Question for viva:**

i) Name the manometer, which we have used in this equipment?

ii) In which tapping we have more losses?

iii) Why these losses are called minor losses?

<u>Experiments No.10</u>

To determine the velocity distribution for pipeline flow with a pitot static probe.

1. Objective:

To aware the students about velocity distributions due to friction & its practical measurement.

2. **Apparatus:**

2.1 A Pitot tube

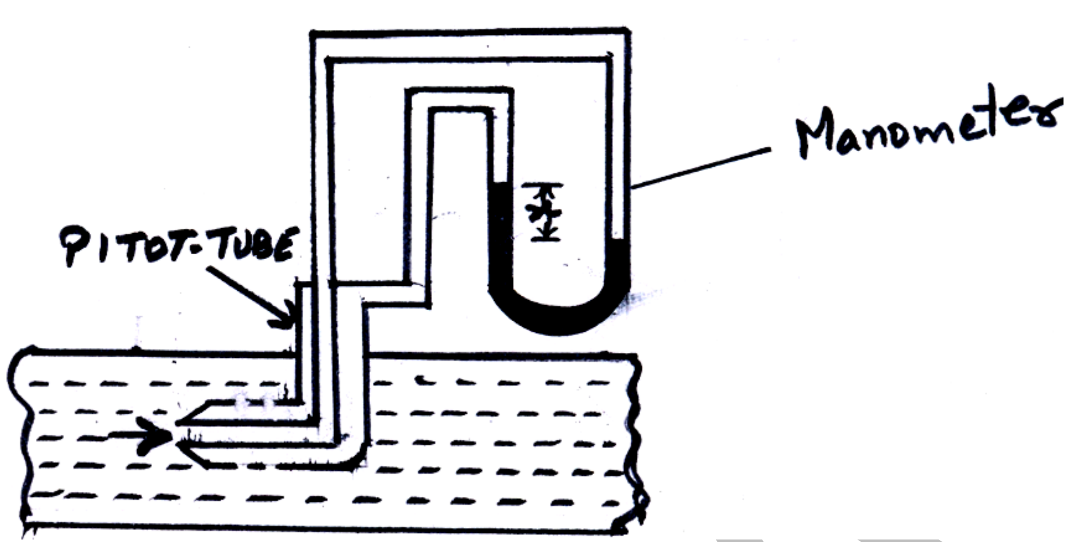
2.2 A channel having moving water

2.3 A "U" tube manometer

2.4 Measuring tank

2.5 A Stopwatch

3. **Diagram:**



Theory:

Velocity measurements in pipes as well as in open channels can be found by measuring the pressure corresponding to the kinetic energy of flow. The simplest method is to measure the pressure in an open-ended tube bent in such a way that the end is aligned opposite to the velocity vector measured; such tubes are called Pitot tubes. Invented by a French Scientist, Henry Pitot (1695 - 1771) in 1732, this tube was first used to measure the flow of river Seine in Paris. The kinetic energy at the center of this tube converts into pressure energy as the flow of fluid is halted at that point as shown in fig 1).

The inner end, which is bent through 90 o, is directed as shown in fig. 1). The liquid rises up in the tube due to the conversion of kinetic energy into pressure energy. The velocity is determined by measuring the rise of liquid in the tube.

Consider two points (1) & (2) at the same level in such a way that point (2) is just at the inlet of the Pitot tube & point (1) is far away from the tube.

Let

P_1 = Intensity of pressure at point (1)

V_1 = Velocity of flow at (1)

P_2 = Intensity of pressure at point (2)

V_2 = Velocity of flow at (2) which is zero.

h = Rise of liquid in the tube above the free surface.

Applying Bernoulli's equation at points (1) & (2)

We get

$$P_1/\rho g + V_1^2/2g + Z_1 = P_2/\rho g + V_2^2/2g + Z_2$$

But $Z_1 = Z_2$ aspts (1) & (2) are on the same line & $V_2 = 0$

$P_1/\rho g$ = Pressure head at (1) = H

$P_2/\rho g$ = Pressure head at (2) = h

substituting these values, we get

$$H + V_1^2/2g = h + H$$

$$h = V_1^2/2g \quad \text{or}$$

$$\overline{V_1} = \sqrt{2gh}$$

5**. Procedure:**

i) Connect the Pitot - tube to the manometer through rubber tubing.

ii) Start the motor & regulate the inlet valve.
iii) Open the outlet valve and allow the flow to take place for some time.
iv) Note down the manometer's reading.
v) Repeat by taking different discharges.

6. **Observation and Calculation:**

S. No	Manometer Reading		head h'	h0	$V = \sqrt{2gh}$
	h1	h2	h1- h2	h=(s2/s1-1) h'	
Units					
1 2 3					

7. **Result:**

Average Velocity = -----

8. **Precaution:**

Check that no air bubbles is entrapped in Pitot - tube or in the manometer while taking observations.

9. **Questions for viva:**

i) On which basic equation our Pitot - tube based?
ii) Is there coefficient of Pi tot?
iii) Why Pitot - tube is called Pitot Static tube?

<u>BTME407 Manufacturing Processes Lab</u>

<u>Experiment No.1</u>

Aim: -

To determine clay content in a molding sand sample.

Equipment: -

Clay washer
Glass jar
Siphon
Sodium hydroxide 30gm
Distilled water 1000cc.

Theory:

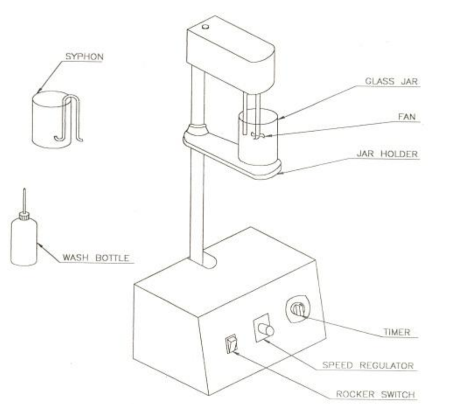
The main ingredients of molding sand sample are:

The silica grain (SiO_2)
The clay as binder
Moisture to activate the clay & provide plasticity.

Clays are the most generally used binding agents mixed with the molding sand to provide the strength, because of there low cost and wider utility. The most popular type clay used is Kaolinite or fire clay and Bentonite.Kaolinite has a melting point of 1750 to 1787 0C and bentonite has a melting temperature range of 1250 to 1300 0C.But, Bentonite can absorb more water which increase its bonding power.

The clay chosen for a molding sand should give it the requisite strength for the given application taking into account the metal being cast and the thickness of the casting. Normally the river sand contains a large amount of clay and therefore can be directly used.

CLAY WASHER - MODEL - VCW



Procedure: -

1. Weigh 30 g of sodium hydroxide, dissolve in 500cc of distilled water and make the volume to 1000cc by adding distilled water.
2. Take dried sand sample of 50gms into glass jar and fill halfway with water. Add 10cc alkaline solution (already made at 1st step) of the sodium hydroxide. Fill up the glass jar up to upper red mark.
3. Turn jar holder side & hold the jar as shown in the figure and take the jar holder under it. Keep the jar on holder. Let the solution stir for 8-10 minutes.
4. Remove the glass jar and rinse sand by means of wash bottle.
5. Allow sand to settle for 8-10 minutes then fill the siphon with fresh water and insert short leg into glass jar to siphon out the muddy water up to 25 mm mark.
6. Add 10cc of sodium hydroxide solution; refill the glass with water up to 150 mm. Stir for 5 minutes.
7. Remove the glass jar and rinse sand and fines adhering to stirrer into glass jar by means of wash bottle. Allow the sand to settle for 5minutes. Then again siphon out muddy water.
8. Continue the process till clear solution free from sand is obtained.
9. Transfer the washed sand with water into the sieve and dry completely under infrared lamp. Allow it to cool and weigh the same.

Observations and calculations: -

$$\text{Percentage clay} = \frac{(A-B) \times 100}{A}$$

A=weight of dry sand sample.

B= weight of the washed and dried sand sample.

Table 1:Percentage clay for different samples of sand

Serial number	Percentage clay
Sample 1	
Sample 2	
Sample 3	

Precautions: -

1. Alkaline solution should be made vary carefully & accurately.
2. After experiment the sand should be fully dry before weight.

Results: -The percentage clay for a given sand sample is…………………

Experiment No.2

Aim: -

To determine the moisture content in a molding sand.

Apparatus: -

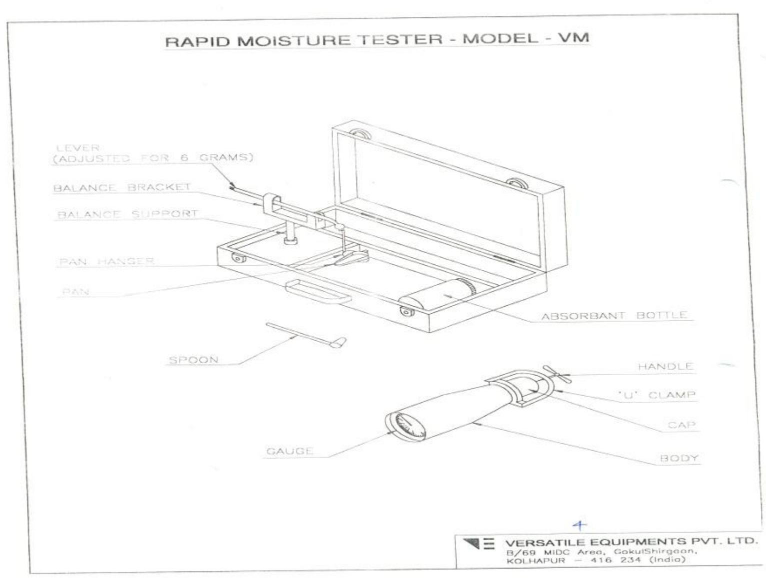
Molding sand, rapid moisture tester, and absorbent compound.

Theory: -

Moisture in requisite amount furnishes the bonding action of the clay. When water is added to clay, it penetrates the mixture. It forms a microfilm, which coats the surface of flake shaped clay particles. The bonding quality of clay depends upon maximum film of water it can maintain. The bonding action is considered best if water added is the exact quality and form the film on the other hand, the boundary is reduced and mould gets weakened if the water is in excess. The water should be between 7% to 8%.

Description of the equipment: -

The instrument operates on the principle of the gas pressure generated between the moisture in the sample and absorb ant compound. The instrument is portable and needs no power supply. It is accommodated in a handy wooden case with calibrated balance and ready to use absorb ant compound is provided with the instrument in an airtight bottle.



Presetting: -

Keep the case on the flat surface and open the case. Set the balance bracket into seat provided at the left side while tightening wing nuts sees the level. Place the balance lever, pan seat and pan in proper position in clamp. Clean body of tester from inside with brush.

Procedure: -

1. Weight the sample accurately by matching the red level marked on the bracket and lever. Transfer the sample in the cap. Take two spoon of an absorbent compound and transfer it into the body of tester.
2. Hold the body horizontally and place the cap into position. Bring the clamp in position and tighten the cap with screw. Shake the instrument vigraously. This ensures immediate mixing of sand sample to the absorbent compound. Immediately the pointer of the gauge moves.
3. Keep the instrument vertically. Observe the reading when pointer stops. This will gives the percentage of moisture in sample directly.
4. Unscrew the handle and take out the cap. Throw away the material and clean the bottle for reuse.

Observations and calculations: -

Table 1:Moisture content for different samples of sand

Serial number	Moisture content by weight
Sample 1	
Sample 2	
Sample 3	

Precautions: -

1. Clean the instrument before and after use.
2. Do not expose sand sample.
3. Do not keep the absorbent compound exposed to atmosphere.
4. Keep the entire bottle and other instruments in the box and clean them and then close the box after required tests.

Result: -

The moisture content in the mold sand sample is…………………by weight.

<u>Experiment No. 3</u>

Aim: -

To conduct hardness test for mould and core.

Equipment & material required: -

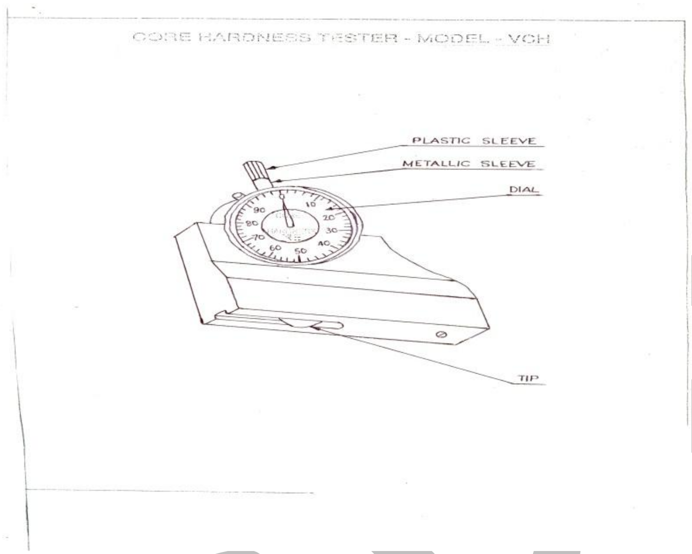
Hardness tester
Mould to be tested
Core to be tested

Theory: -

Insufficient strength may lead to a collapse in the mould or its partial destruction during conveying, turning over or closing. The mould may also be damaged during pouring by washing of the walls and core by the molten metal. The strength of molding sand must, therefore, be sufficient to permit the mould to be formed to the desired shape and to retain this shape even after the hot metal is poured in the mould.

Description of the equipment: -

It is a handy instrument with a special gauge to read the hardness number directly. The tip of the instrument is made of tungsten carbide. It is a scratch type tester supplied with the container. To check the correctness of the equipment, clean the tip and base of the instrument. Apply the instrument vertically placing tip on a hard smooth and plain glass surface and gently press on the surface until the surface of the base plate touches the surface of glass. The pointer of the gauge should show zero reading on dial after completion of one rotation of the pointer.



Procedure: -

1. Hold the instrument in right hand vertically with tipped plough facing the surface of the core and dial indicator facing conveniently for observation of reading.
2. Press the instrument against the surface of the core in such a way that the base of the instrument will just touch the surface of core and knife-edge will penetrate in the core.
3. Slowly pull the tester longitudinally and firmly on the surface of the dried or baked core (approx 1 inch)
4. Observe the reading on the dial, which indicates direct core hardness of the sand. This hardness indicates the firmness of the skin of the core, which is usually termed as core hardness.

Observations and calculations: -

Table 1:Hardness of core

Serial number	Hardness of core
Core 1	
Core 2	
Core 3	

Table 2:Hardness of mould

Serial number	Hardness of mould
Mould1	
Mould 2	
Mould 3	

Precautions: -

1. Check the zero reading of the instrument before use.
2. Do not penetrate too much of pointer tip in the core.
3. Do not touch the pointer.
4. Clean the instrument after use.

Result: -

The hardness of the given core is………………

The hardness of given mould is…………………….

Experiment No. 4

Aim: -

To test tensile, compressive, transverse strength of molding sand sample.

Equipment: -

Sand sample to be tested,
Universal strength machine (figure1)
Shear strength attachment (figure2)
Transverse strength attachment (figure3)
Tensile strength attachment (figure4)
Transverse core box (figure5)
Tensile core box (figure6)
Sand rammer (figure7)

Theory: -

Strength of the molding sand is the ability of the particles to stick together. Insufficient strength may lead to a collapse in the mold or its partial destruction during handling, conveying, turning over or closing. The mold may also be damaged during pouring by washing off the walls and core by the molten metal. The strength of the molding sand must, therefore, be sufficient to permit the mold to be the desired shape and to retain this shape even after the hot metal is poured in the mold. Measurement of the strength of the molding sands can be carried out on the universal sand strength-testing machine. The strength can be measured in compression, shear and tension. The sand that could be tested is green sand, dry sand or core sand.

Compression strength generally refers to the stress required to rupture the sand specimen under compressive loading. This strength is generally in the range of 30 to 160KPa.The stress required to shear the specimen along the axis is represented as shear strength. It may vary from 10 to 50KPa.If this stress is applied under tension, and then it represents tensile strength.

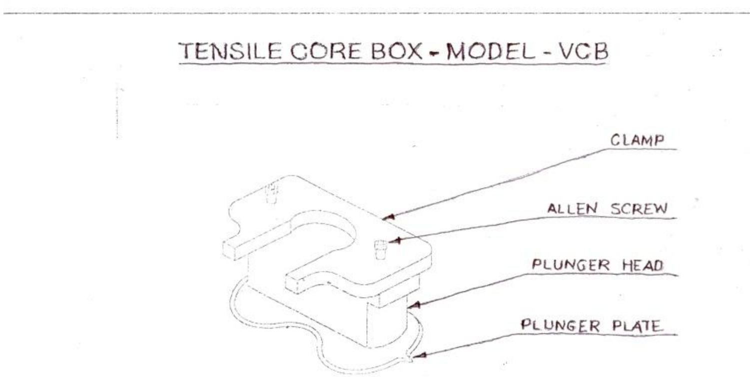
Description of equipments: -

Sand Rammer: Sand Rammer is used to prepare standard sand samples under identical condition for checking the important physical properties of foundry sand. The instrument consists of frame, ramming plunger, calibrated sliding weight, lifting cam and ramming cam. Ramming is done by lifting the ramming cam by giving the required strokes.

Universal Strength Machine: This machine is used to determine various strength, such as compression, shear, and tensile, transverse strength of foundry sand. The machine consist of oil reservoir, movable ram, plug-in coupling low and high pressure gauges to read 0 to 1600 gms/cm2 and 0 to 13 kg/cm2 compression strength respectively, loading piston connected to threaded shaft and wheel, funnel with special connections etc. Low pressure gauge (L) is used for green strength and high pressure gauge (h) is used for dry strength

Attachment with universal strength machine:
Shear strength attachment is used with the help of universal strength machine. It consists of a pair of shear pads. These stepped shear pads shear the specimen longitudinally.
Transverse strength attachment consists of holder with two knife-edges and supports and another knife-edge.
Tensile strength attachment consists of movable and stationary jaw with rollers, guide bracket, two rods and knurled screws.

Core Boxes: Transverse core box is used to prepare specimen to determine transverse strength. It consist of a hopper, split core box with base plate, scrapper, plunger head with clamping arrangement.
Tensile core box is used to prepare specimen to determine tensile strength. It consist of a hopper, split core box with bas plate, scrapper, plunger head with clamping arrangement.



SAND RAMMER - MODEL - VR

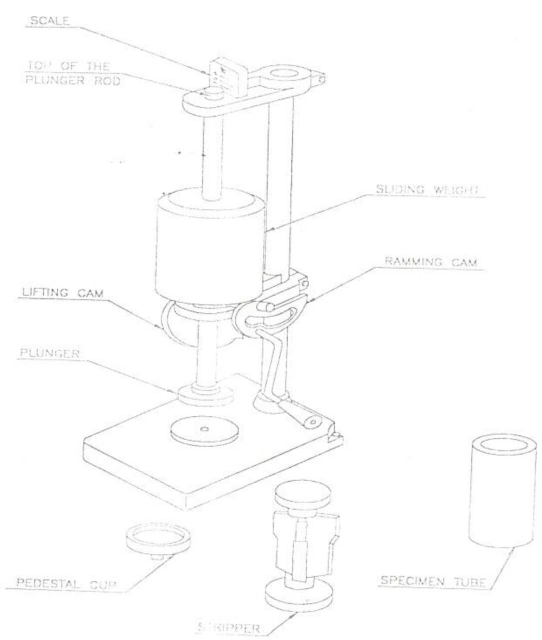


Fig - VIII

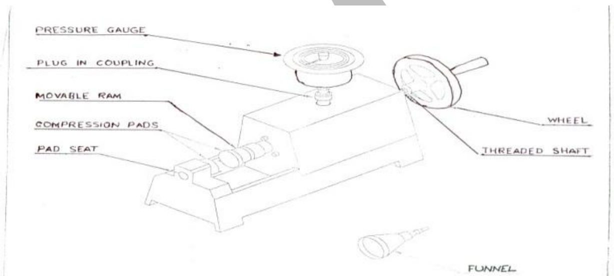
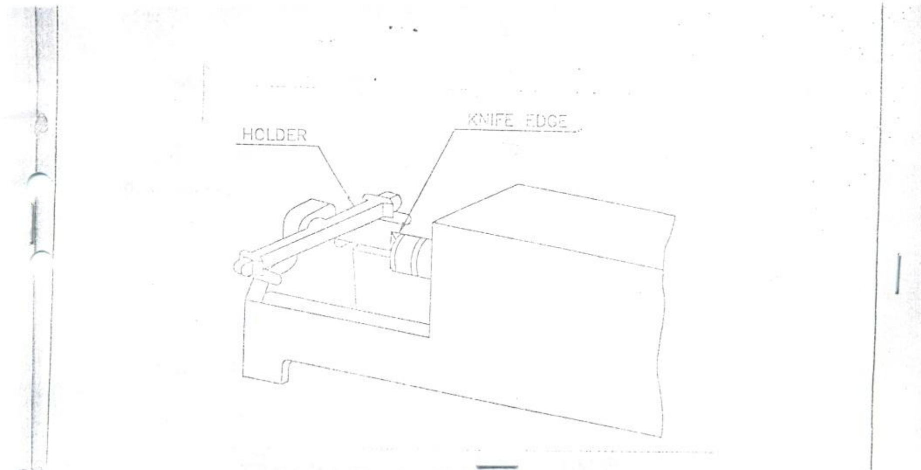
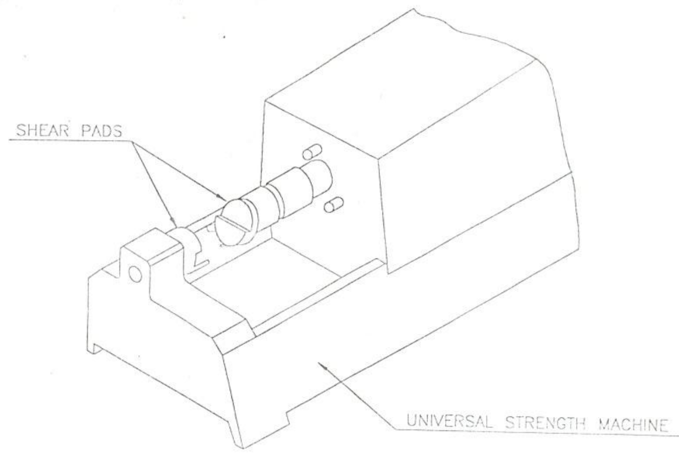


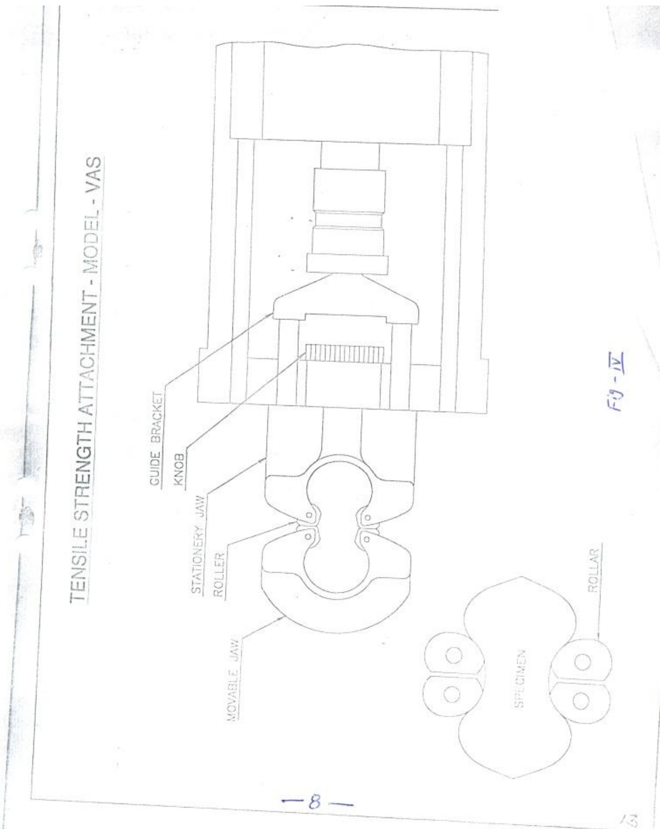
Fig - I

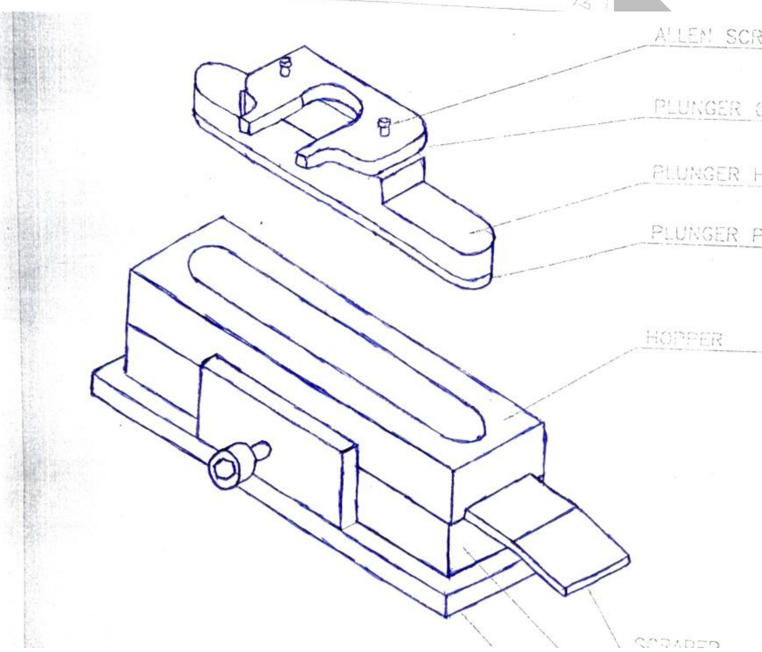


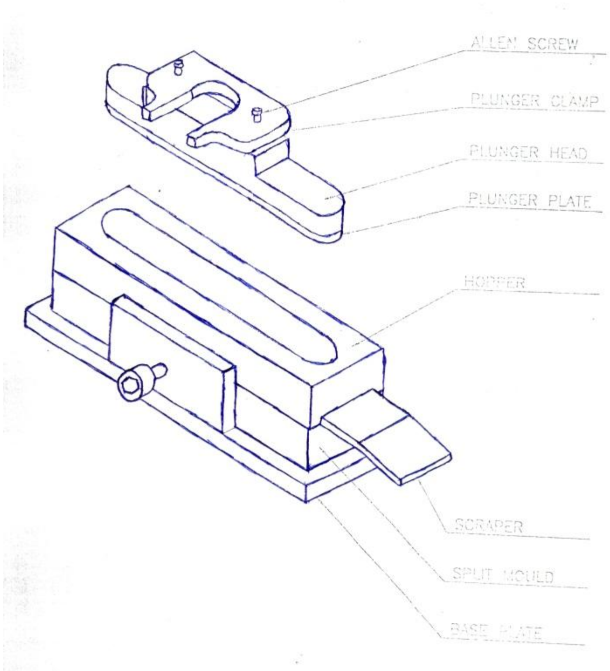
TRANSVERSE STRENGTH ATTACHMENT - Fig-III



SHER STRENGTH ATTACHMENT - Fig-II


TENSILE STRENGTH ATTACHMENT - MODEL - VAS
GUIDE BRACKET
KNOB
STATIONERY JAW
ROLLER
MOVABLE JAW
ROLLAR
SPECIMEN
Fig - IV
— 8 —


ALLEN SCR
PLUNGER
PLUNGER
PLUNGER
HOPPER



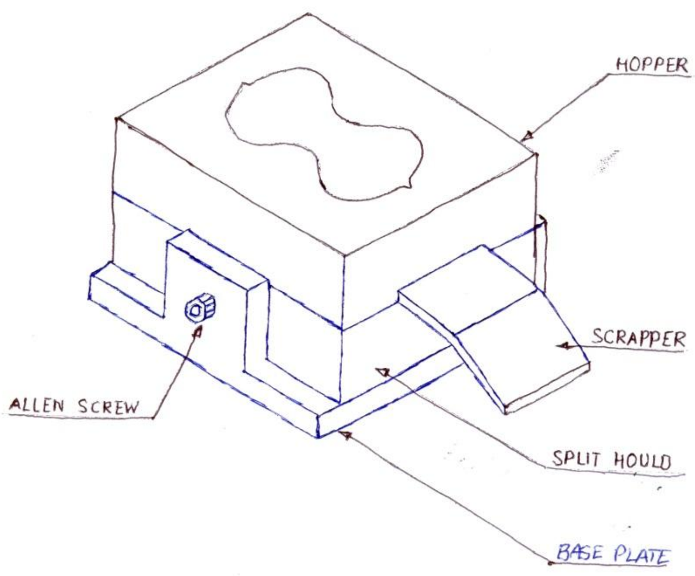


Fig-VII

Procedure: -

1. Insert the compression pads in the respective position as shown in diagram for compressive strength test.
2. Prepare the standard sand specimen of diameter 50x50 mm height.
3. Place the specimen between the compression pads so that the plane surfaces of the specimen touch against the pad.
4. Rotate the wheels clockwise until the load starts applying on specimen (this will be seen by movement of pressure gauge needle) and then uniformly at about 16 rpm till the specimen collapses. The red pointer also moves along with the needle.

5. As soon as the sample collapses the needle returns while the red pointer remains at the maximum reading before collapse of the specimen. Read compression strength on the scale (C.S scale), indicated by idle pointer.
6. To check the shear strength of sand sample, prepare sand sample with the help of sand rammer and separate above said procedure. To read the strength check the shear strength, (S.S scale)
7. To check the transverse strength of sand sample, prepare sand sample with the help of transverse core box and sand rammer. Place the transverse specimen on the support provided to the holder with two knife-edges. Apply the same procedure as above said. Read the inner scale and multiply by 10 to get transverse strength. (B.S scale) in kg/cm2.
8. To check the tensile strength of sand sample, prepare specimen with the help of tensile core box. Place the specimen carefully on the machine and follow the same loading procedure adopted for compression strength till sample breaks. Read the tensile strength (T.S) directly on the inner scale.

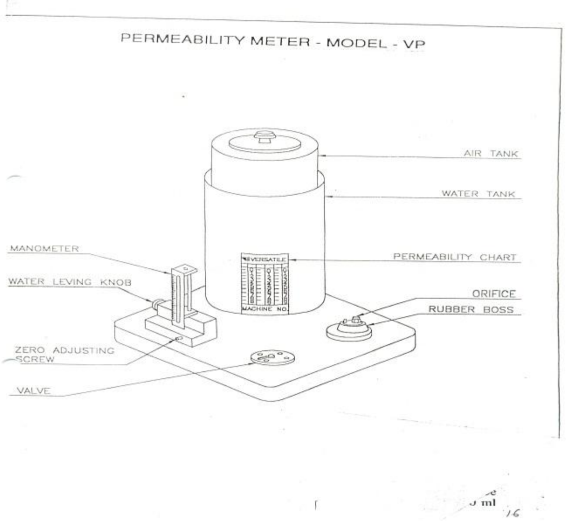
Results: -
Tensile strength of given sand sample is………………………
Compressive strength of given sand sample is………………………
Transverse strength of given sand sample is………………………

Precautions: -
1. Do not overload the gauge.
2. Remove the air completely from oil reservoir
3. Prepare the specimen very carefully.

<u>Experiment No.5</u>

Aim: -
Determination of permeability of a molding sand sample.
Equipment and material required: -
Water
Sand sample
Permeability meter

Theory: -
During the solidification of a casting, large amounts of gases are to be expelled from the mould. The gases are those which have been absorbed by the metal in the furnace, air absorbed from the atmosphere and



steam and other gases that are generated by the molding and care sands. If these gases are not allowed to escape from the mould, they would be trapped inside the casting and cause defects. The molding sand should be sufficiently porous so that the gases are allowed to escape from the mould. This gas evolution capability of the molding sand is termed as permeability.

Permeability number is defined as the volume of air in cc that will pass per minute under a pressure of 1 gm/cm2 through a specimen which is 1 cm2 in cross sectional area and 1 cm deep.

Equipment: -

The equipment consists of a water tank, precisely calibrated well balanced inverted air tank freely floating inside the water tank, water manometer, permeability chart, sealing boss with rubber sleeve, 'O-P-D' valve, siphoning attachment. One orifice of 1.5 mm diameter and one orifice of 0.5 diameters.

Presetting of the equipment: -

Place the instrument on leveled platform. Clean the air and water tank from inside, adjust 'O-P-D' valve at '0'.open the air tube inside water tank by thumb and pour water up to the level mark on the outside on the water tank. Insert air tank into water tank carefully. A cup with valve is provided at the left side of the manometer to fill the water in manometer. Fill water in manometer up to zero level or slightly above zero. Final zero is adjusted by opening 'zero adjust screw' provided in front of manometer tank. The manometer scale is calibrated for 0 to 10 and indicates pressure in gms/cm2 of water. It is recommended to use small orifice for permeability below 50 and large orifice for permeability above 50.

Procedure: -

1. Screw proper orifice with washer on the rubber-scaling boss. Tighten the orifice by fingers only.
2. Take the specimen tube with rammed specimen and place it inverted over the rubber-scaling boss.
3. Put the valve on 'P' position.
4. Read the height of the water column in the manometer tube. Find the corresponding permeability number from the chart fixed on the equipment.
5. Put the valve on 'O' position.
6. Whenever the air tank is flush with water tank, keep the valve on 'D' position and slowly lift the air tank to the top position. Lift the air tank drum slowly up keeping the valve 'D' position to avoid only water entering the air tube.

Precautions: -

It is advisable to remove water from water tank by using siphoning attachment provided with the instrument.

Instrument should be away from vibration.

Do not use metallic piece to clean the orifice. Always use blown air to clean orifices.

Results: -The permeability of given sand sample is……………………………

Experiment No. 6

Aim: -

Measurement of grain fineness number.

Equipment & material required: -

Sand sample

Sieves set

Cleaning brush

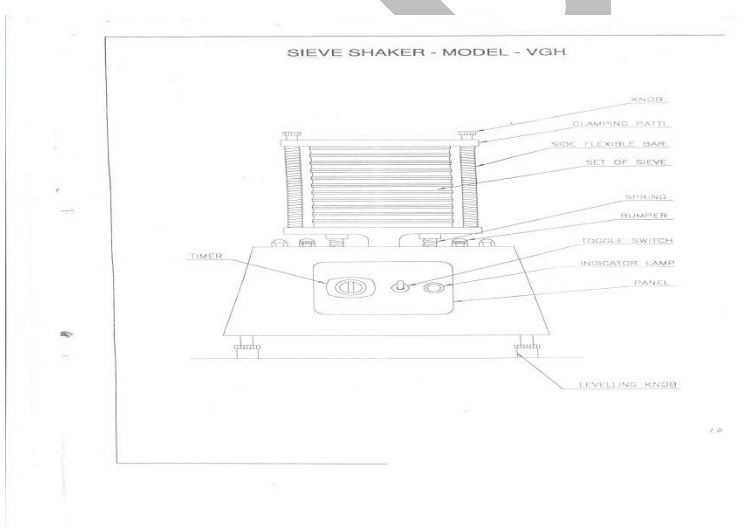
Weighing balance

Theory: -

The shape and size of sand grains has a substantial effect on the processing properties of molding sand and core sands. The shape of the grains and number of similar grains in the sand determine the possibility of its application in various types of foundry practice.

These are four distinct shapes of sand grains: rounded, sub angular, angular and compounded grains, with many degrees of roundness and angularity between two extremes. The sand may consist of either entirely one type of grain or a mixture of different shapes. Sharp angular grains cannot pack together closely and consequently give a higher permeability than rounded grains. But rounded grains. As a result, they are bounded together with a green strength than angular grains. Compound grains are cemented together such that fail to separate when screened. Compound grains are least desirable in sand mixture as they have tendency to disintegrate at high temperature. In actual practice, however, sharp, irregular shaped grains are usually preferred because of their ability to interlock and add strength to the mould

These are again three distinct sizes of sand grains: fine, medium & coarse. For small and intricate castings the use of fine sand is desirable. Medium sand is used in bench work and light floor work. As the size of the casting increases, the sand particles likewise would be coarser to permit the ready escape of gases that are generated in the mould. Grain size is determined by passing the sand through screens or measured in microns.



Procedure: -

1. Fix the instrument/equipment on a strong and sturdy base, which can with stand the vibrations of the instrument during shaking level.
2. Remove the clamping device by pulling the knobs of side flexible bar. Take OA the set of sieves.
3. Arrange set of sieves having pan at bottom and coarsest sieve on thetop.
4. Take 100gms of dried and washed sand sample on the top sieve. Put the lid. Keep entire sieve set on shaking mechanism & set the timer for desired sieving time. (10 minute average) PA “ON” the switch.
5. After stopping, disconnected the supply. Remove the clamping device.
6. Weigh the grains remaining on the individual sieves.
7. It is recommended to weigh each empty sieve before the test and again after test along with the sand. The difference between the two will give accurate weight of grains.

Observations & calculations: -

Sieve opening Number in mic (a)	Weight in gms on sieve (b)	Percentage retained (c)	Multiplying factor (d)	Product e=cxd
1700			05	
850			10	
600			20	
425			30	
300			40	
212			50	
150			70	
106			100	
75			140	
53			200	
Sieve pan			300	

Fineness Number = E/C= Total of e /total of c

The percentage of the retained grains on each sieve and the pan is to be multiplied with the multiplier and the results are to be added. This sum is divided by the total of percentage retained sand grains.

Precaution: -

1. Keep the instrument clean and tidy.
2. Remove sand grains from each sieve using soft brush.
3. Before tightening the knob ensure that sieves fit exactly into each other.
4. Do not rotate timer knob in anti clockwise direction.

Result: -The grain fineness number of given sand sample is………………………..

<u>Experiment No. 7</u>

AIM: - To make lap joint, butt joint & T joints with oxy-acetylene gas welding and manual metal arc welding processes.

THEORY:-

Arc welding process

Arc welding is a type of welding that uses a welding power supply to create an electric arc between an electrode and the base material to melt the metals at the welding point. They can use either direct (dc) or alternating (ac) current, and consumable or non-consumable electrodes. The welding region is usually protected by some type of shielding gas, vapour, and/or slag.

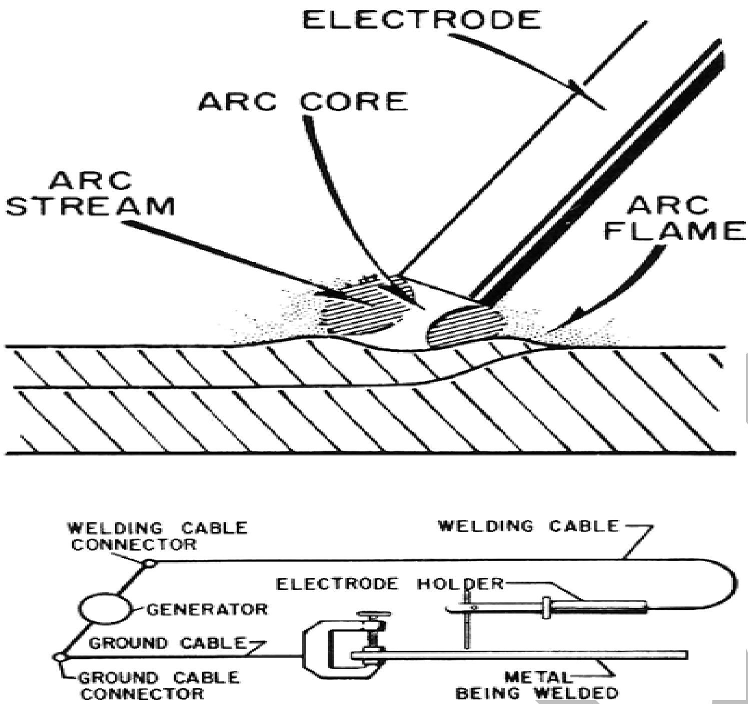


Figure :arc welding processes

Oxy-acetylene gas welding

In oxy-fuel welding, a welding torch is used to weld metals. Welding metal results when two pieces are heated to a temperature that produces a shared pool of molten metal. The molten pool is generally supplied with additional metal called filler. Filler material depends upon the metals to be welded.

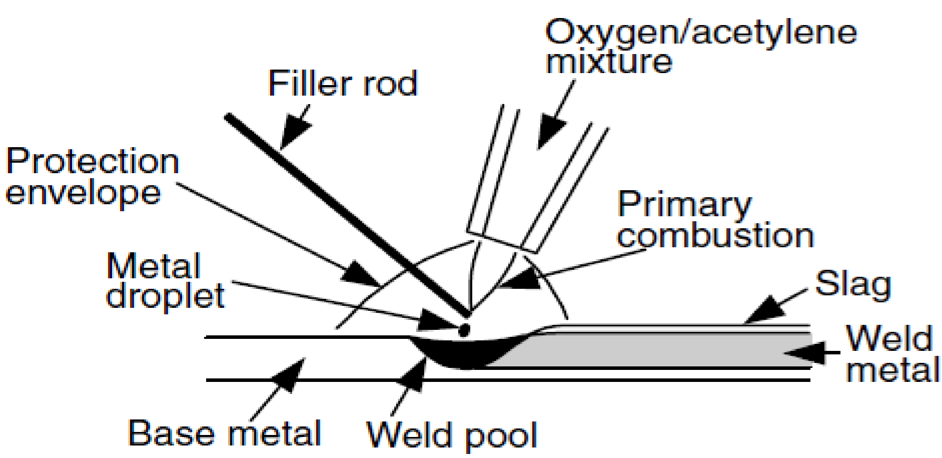
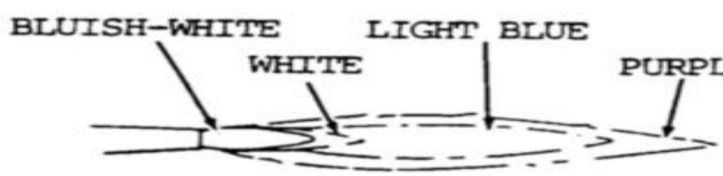
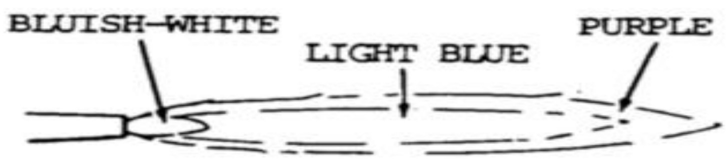


Figure: Oxy-acetylene gas welding

1. Cylinders:
Oxygen cylinder
Acetylene cylinder
2. Pressure Regulators
3. Check Valve
4. Torch (a) Cutting Torch (b) Welding Torch
5. Filler Rod & Hoses
Three types of flame used are:



REDUCING FLAME
5700 °F



NEUTRAL FLAME
5850 °F

OXIDIZING FLAME
6300 °F

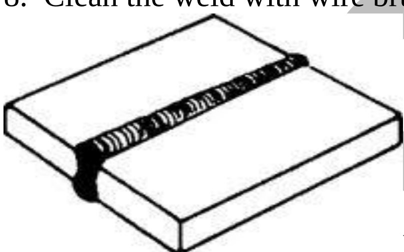
To make a BUTT-joint using Electric Arc welding & oxy-acetylene welding.

TOOLS &MATERIALS USED:
Electric Arc welding & oxy-acetylene welding set
Electrode
Electrode holder

Face shield & goggles
Earth clamp
Welding table
Chipping hammer
Wire brush
M.S two flat pieces 40 x 40 x 5mm
Steel rule
Try square
Marking gauge
Hand hack saw.

PROCEDURE:

1. Cut two pieces of size 40 x40 x 5mm from M.S flat.
2. Thoroughly clean & prepare the edges for proper deposition of metal.
3. Take the electrode of proper material. It should have composition that of base metal and size according to dimensions of the work piece.
4. Adjust the voltage to proper value.
5 Lay out the work pieces for Butt-Joint (edges are welded in the same plane with each other).
6. Strike the arc of proper position.
7. Take a proper run of the welding.
8. Clean the weld with wire brush and chipping the spatter with chipping hammer.



butt joint figure

Safety precautions:

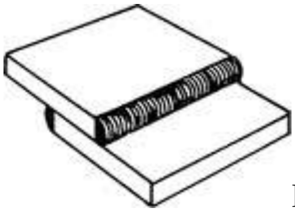
1. Use face shield with black glasses to protect eyes and face.
2. Use apron to protect skin the body and gloves to protect hands.
3. Never see the arc with naked eyes.
4. The work piece &the place of work should be completely dry.

To make a Lap-joint using Electric Arc welding & oxy-acetylene welding.

PROCEDURE:

1. cut two pieces of size 40 x40 x 5mm from M.S flat.
2. Thoroughly clean prepare the edges for proper deposition of metal.
3. Take the electrode of proper material. it should have composition that of base metal and size according to dimensions of the work piece.
4. Adjust the voltage to proper value.
5. Lay out the work pieces for lap-Joint.(edges are welded in the same plane with each other).
6. Strike the arc of proper position.

7. Take a proper run of the welding.
8. Clean the weld with wire brush and chipping the spatter with chipping hammer.

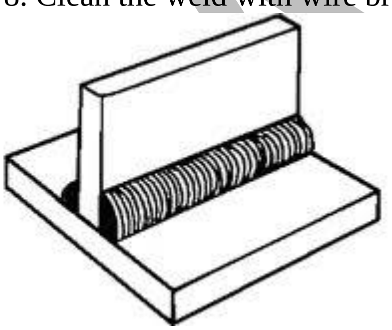

lap joint figure

Safety precautions:

1. Use face shield with black glasses to protect eyes and face.
2. Use apron to protect skin the body and gloves to protect hands.
3. Never see the arc with naked eyes.
4. The work piece & the place of work should be completely dry.

To make a T-joint using Electric Arc welding & oxy-acetylene welding.

PROCEDURE:
1. cut two pieces of size 40 x40 x 5mm from M.S flat.
2. Thoroughly clean prepare the edges for proper deposition of metal.
3. Take the electrode of proper material. it should have composition that of base metal and size according to dimensions of the work piece.
4. Adjust the voltage to proper value.
5. Lay out the work pieces for T-Joint (edges are welded in the opposite plane with each other).
6. Strike the arc of proper position.
7. Take a proper run of the welding.
8. Clean the weld with wire brush and chipping the spatter with chipping hammer.


T-joint figure

Safety precautions:

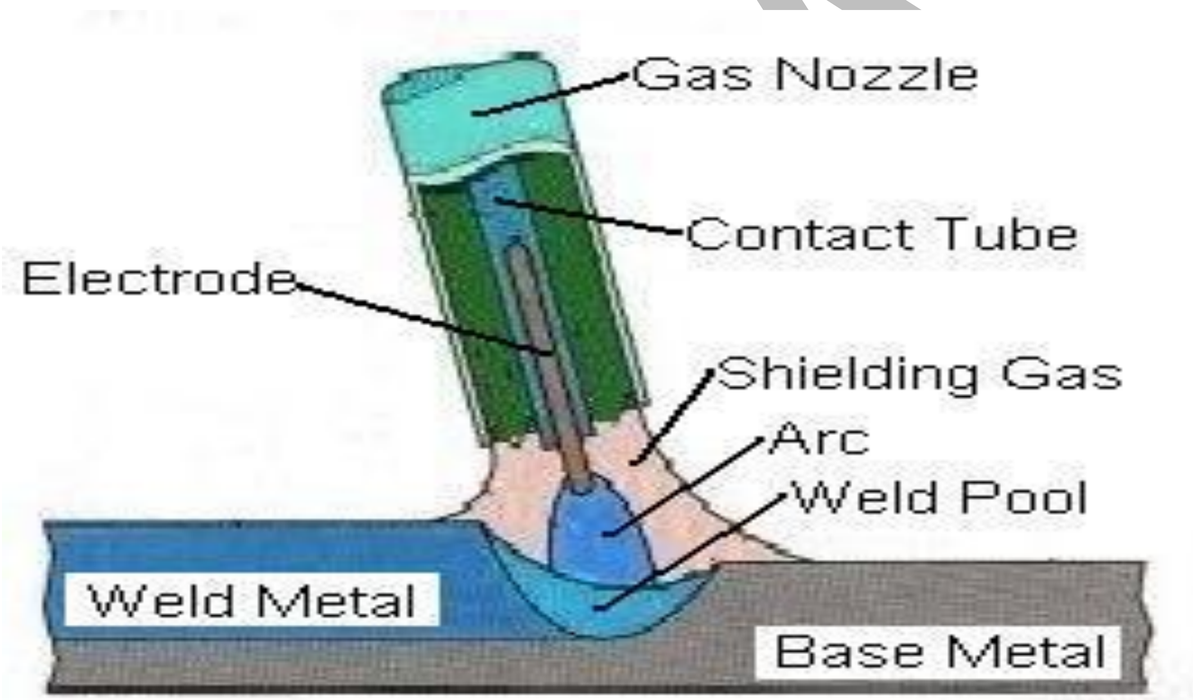
1. Use face shield with black glasses to protect eyes and face.
2. Use apron to protect skin the body and gloves to protect hands.
3. Never see the arc with naked eyes.
4. The work piece &the place of work should be completely dry.

EXPERIMENT NO.8

AIM : To study MIG, TIG & Spot welding equipment & make weld joints by these processes.

Theory:

MIG welding or Gas metal arc welding (GMAW): is a welding process in which an electric arc forms between a consumable wireelectrode and the workpiece metal(s), which heats the work piece metal (s), causing them to melt, and join. Along with the wire electrode, a shielding gas feeds through the welding gun, which shields the process from contaminants in the air. The process can be semi-automatic or automatic. A constant voltage, direct current power source is most commonly used with GMAW, but constant current systems, as well as alternating current, can be used



MIG Welding Figure

EQUIPMENTS :

Welding power source and cables.

Welding torch and wire electrode coiled on a spool.

Wire feed mechanism and controls consisting of a pair of driving rolls, electric motors etc.

Shielding gas cylinder, pressure regulator and flow meters.

Controls.

Advantages of MIG welding are:

1. High quality welds can be produced much faster
2. Since a flux is not used, there is no chance for the entrapment of slag in the weld metal resulting in high quality welds
3. The gas shield protects the arc so that there is very little loss of alloying elements. Only minor weld spatter is produced

4. MIG welding is versatile and can be used with a wide variety of metals and alloys
5. The MIG process can be operated several ways, including semi and fully automatic.

Disadvantages are:

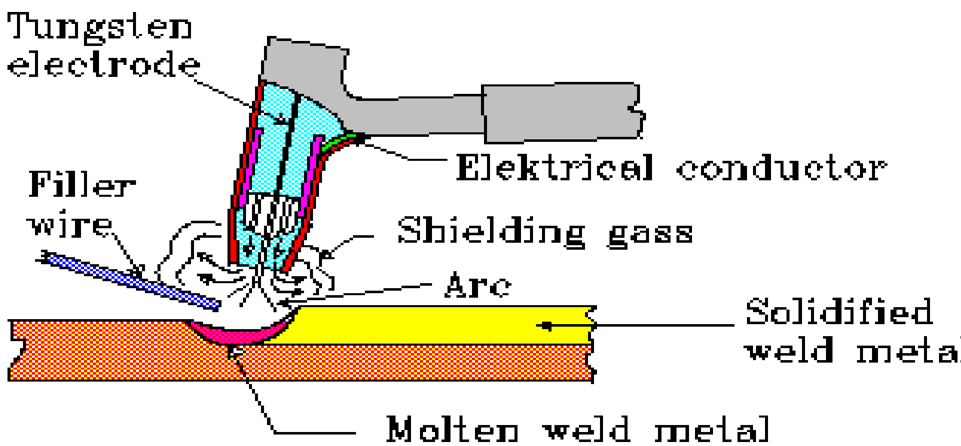
1. The MIG welding cannot be used in the vertical or overhead welding positions because of the high heat input and the fluidity of the weld puddle

The equipment is complex.

TIG WELDING

THEORY :

In this arc welding process, welding heat is produced from an electric arc established between ht tungsten electrode and the job. A shielding gas {argon, helium, nitrogen etc.} is used to avoid atmospheric contamination of the molten weld pool. Filler metal, If required is fed separately.



This process uses a non-consumable tungsten electrode, which is mounted in a special electrode holder. This holder is also designed to furnish a flow of inert gas around the electrode and around the arc. Welding operation is done by striking an arc between the work piece and tungsten electrode in an atmosphere of inert gas. The arc is struck either by touching the electrode with a scrap metal tungsten piece or using a high frequency unit. After striking the arc, it is allowed to impinge on the job and a molten weld pool is created. The welding torch and the filler metal are generally kept inclined at angles of 70-80 degree and 10-20 degree respectively with the flat work piece. Filler metal, if required should be added by dipping the filler rod in the weld pool. When doing so, the tungsten electrode should be taken a little away from weld pool. However the heated end of filler rod as well as the electrode should be within the inert gas shield. Both D.C. and A.C. power source can be used.

EQUIPMENT :

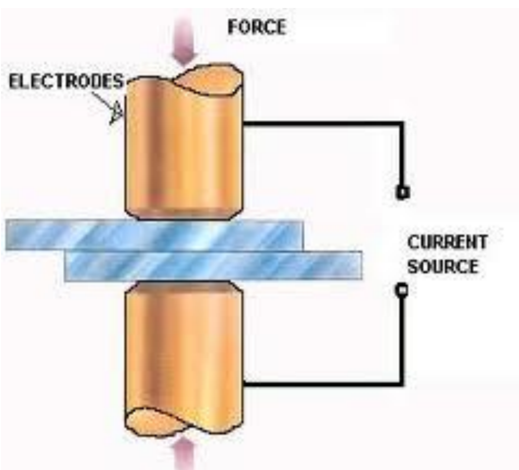
Welding torch, tungsten electrode and Filler metal.\
Welding power source, high frequency unit, D.C. suppressor unit and cable.
Inert gas cylinder, pressure regulator and flow meter.
Cooling water supply.
Water and gas solenoid valves.

SPOT WELDING

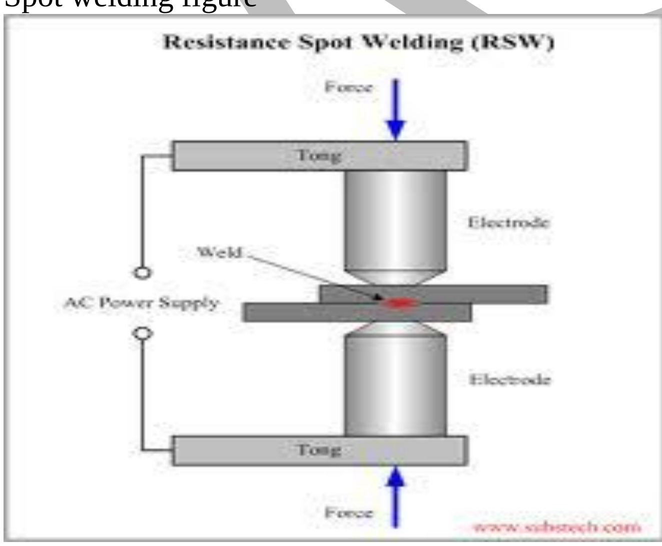
THEORY :

Spot welding is a process in which contacting metal surfaces are joined by the heat obtained from resistance to electric current. Work-pieces are held together under pressure exerted by electrodes. Typically the sheets are in the 0.5 to 3 mm (0.020 to 0.12 in) thickness range. The process uses two shaped copperalloyelectrodes to concentrate welding current into a small "spot" and to simultaneously clamp the sheets together. Forcing a large current through the spot will melt the metal and form the weld. The attractive feature of spot welding is a lot of energy can be delivered to the spot in a very short time (approximately ten milliseconds). That permits the welding to occur without excessive heating to the remainder of the sheet.

Projection welding is a modification of spot welding. In this process, the weld is localized by means of raised sections, or projections, on one or both of the work pieces to be joined. Heat is concentrated at the projections, which permits the welding of heavier sections or the closer spacing of welds. The projections can also serve as a means of positioning the work pieces



Spot welding figure



Precautions taken while performing different welding processes

1 Always wear safety goggles and full sleeve shirt.
2. Keep a fire extinguisher nearby.
3. Wear dry insulating gloves.
4. Do not put hands between tips.
5. Do not breathe the fumes.
6. Use proper ventilation.
7. Do not touch tongs and tips with bare hands.
8. Touch them only after it gets cooled.
9. Wear proper insulating gloves if handling hot work or parts is necessary.

Some safety tips are as follows:

1. Welding process requires heating, so remove all the inflammable materials near the vicinity.
2. Wear protective gear to avoid injury caused by fire or gas.
3. Fire extinguisher should be in operating condition
4. Proper ventilation can avoid accumulation of toxic materials
5. A welding operator should always wear woolen clothes instead of cotton as it can catch fire easily.
6. In extremely dangerous cases of welding, the person doing the welding process should wear flameproof jackets to avoid fire.

Definition of TIG Welding

Tungsten Inert Gas (TIG) welding joins reactive metals using a non-consumable Tungsten electrode. Inert gas, commonly Argon, is released at the same time as the electrodes to produce a weld without air contaminants. Tungsten is not the filler, it just creates the arc between the electrode and metal, but a filler may be used if needed.

Benefits of TIG Welding:

Cleaner - Using Tungsten to provide its electrical current, TIG welding decreases the amount of sparks, smoke and fumes produced.

Precision - TIG welding has less contamination in its weld, providing more precise and higher quality welds.

Autogenous Welds - These welds do not require a filler material to be used. TIG welding can create a weld by melting one part to the other. Autogenous welds are most commonly used when welding thinner materials.

Disadvantages of TIG Welding:

Setup - TIG welding requires more setup time and is not as user-friendly.

Price - These welds tend to be more expensive and take longer than MIG welding, especially in thicker metals.

Complexity - TIG welding is more complex and requires more skill than the MIG welding process.

Definition of MIG Welding

Metal Inert Gas (MIG) welding combines two metals by using a filler wire with a current to produce the electrode. Inert gas is also used simultaneously to protect the weld from any air contaminants.

Benefits of MIG Welding:

Quick - MIG welding is known for its quickness in producing welds.

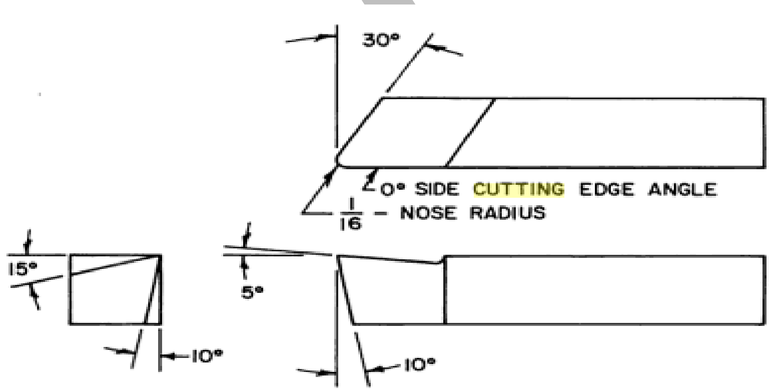
User-Friendly - These welds tend to be more forgiving and are easier to make. Setup takes less time and is easy to automate.
Price - Equipment is more accessible and costs less for MIG welding.
Disadvantages of MIG Welding:
Reliability - Less stable arc, some irregular wire feedback and burn back can occur with MIG welding.
Dirtier - More sparks, fumes and smoke are produced during this welding process.

EXPERIMENT NO.9

Aim: To grind a single point & multipoint cutting tools.
Apparatus: Grinder wheel, centre gauge.
Material used: H.S.S
Theory:A grinding wheel is an expendable wheel that is composed of an abrasive compound used for various grinding (abrasive cutting) and abrasive machining operations. They are used in grinding machines.
The wheels are generally made from a matrix of coarse particles pressed and bonded together to form a solid, circular shape, various profiles and cross sections are available depending on the intended usage for the wheel. They may also be made from a solid steel or aluminum disc with particles bonded to the surface.
The manufacture of these wheels is a precise and tightly controlled process, due not only to the inherent safety risks of a spinning disc, but also the composition and uniformity required to prevent that disc from exploding due to the high stresses produced on rotation.

Grinding wheel

NOMENCLATURE OF SINGLE POINT CUTTING TOOL



Cutting edge (300) and relief angle (100).
Side-relief angle (100) and side cutting edge angle (o0)
Side-rake (150) and back-rake angles. (50)
Nose radius (1/16'')

GRINDING OF SINGLE POINT CUTTING TOOL

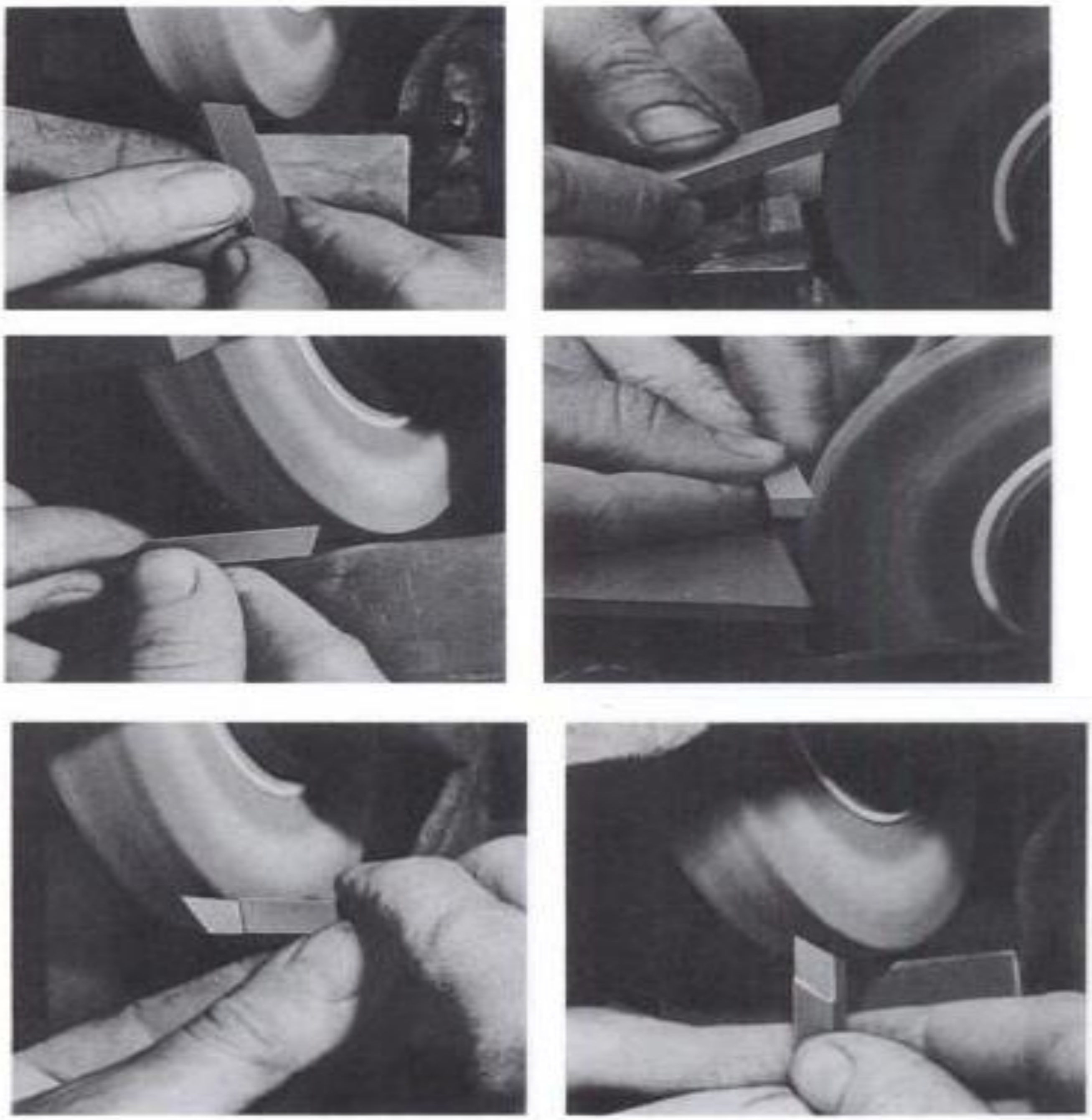


Fig.Sequence for grinding general purpose turning tool.

(Upper left) Top view of simultaneously grinding the end cutting edge and relief angle.
(Upper right) Side view of same operation.
(Center left) Top view of simultaneously grinding side-relief angle and side cutting edge angle(o0).
(Center right) Side view of same operation.
(Lower left) Simultaneously grinding the side-rake and back-rake angles.
(Lower right) Grinding the nose radius.

Terminology of single point cutting tool

Shank – It is main body of tool. The shank used to grippesd in tool holder.

Flank – The surface or surface below the adjacent of the cutting edge is called flank of the tool.

Face – It is top surface of the tool along which the chips slides.

Base – It is actually a bearing surface of the tool when it is held in tool holder or clamped directly in a tool post.

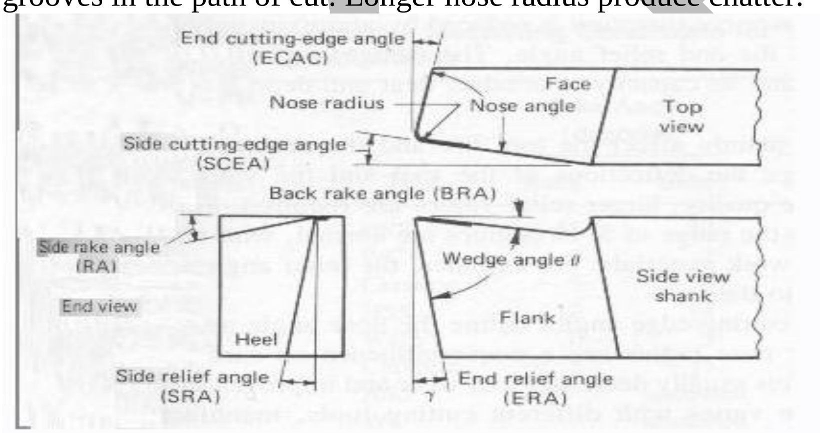
Heel – It is the intersection of the flank & base of the tool. It is curved portion at the bottom of the tool.

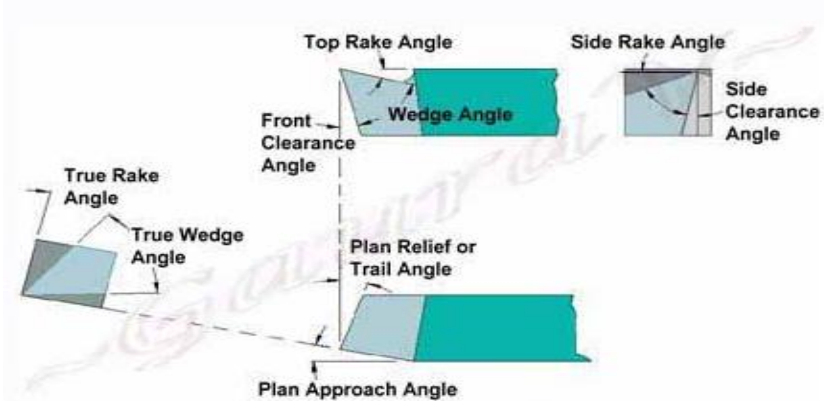
Nose – It is the point where side cutting edge & base cutting edge intersect.

Cutting edge – It is the edge on face of the tool which removes the material from work piece. The cutting edges are side cutting edge (major cutting edge) & end cutting edge (minor cutting edge)

Tool angles-Tool angles have great importance. The tool with proper angle, reduce breaking of tool, cut metal more efficiently, generate less heat.

Noise radius –It provide long life & good surface finish sharp point on nose is highly stressed, & leaves grooves in the path of cut. Longer nose radius produce chatter.





SAFETY PRECAUTIONS

1. Grinding machines are used daily in a machine shop. To avoid injuries follow the safety precautions listed below.

2. Wear goggles for all grinding machine operations.

3. Check grinding wheels for cracks (Ring Test Figure 5-11) before mounting.

4. Never operate grinding wheels at speeds in excess of the recommended speed.

5. Never adjust the work piece or work mounting devices when the machine is operating

6. Do not exceed recommended depth of cut for the grinding wheel or machine.

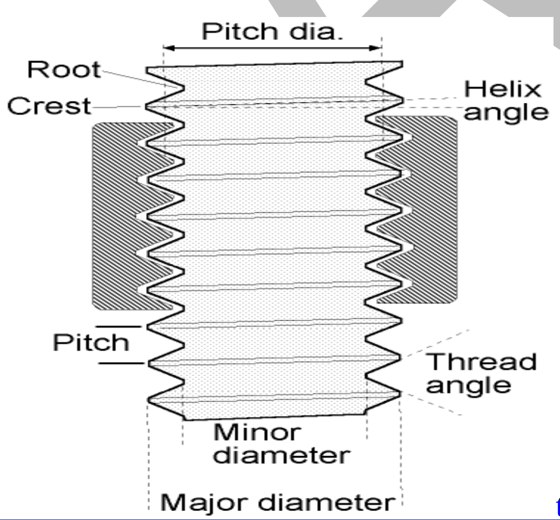
7. Remove work piece from grinding wheel before turning machine off.

8. Use proper wheel guards on all grinding machines.

9. On bench grinders, adjust tool rest 1/16 to 1/8 inch from the wheel.

EXPERIMENT NO.10

Aim: To prepare a job on lathe involving specified tolerances; cutting of v-threads & square threads.
Tool & Apparatus: lathe machine, vernier caliper, surface gauge.
Material used: Mild steel dia 36x105 mm length.
Theory: A screw thread, often shortened to thread, is a helical structure used to convert between rotational and linear movement or force. A screw thread is a ridge wrapped around a cylinder or cone in the form of a helix, with the former being called a straight thread and the latter called a tapered thread. A screw thread is the essential feature of the screw as a simple machine and also as a fastener.



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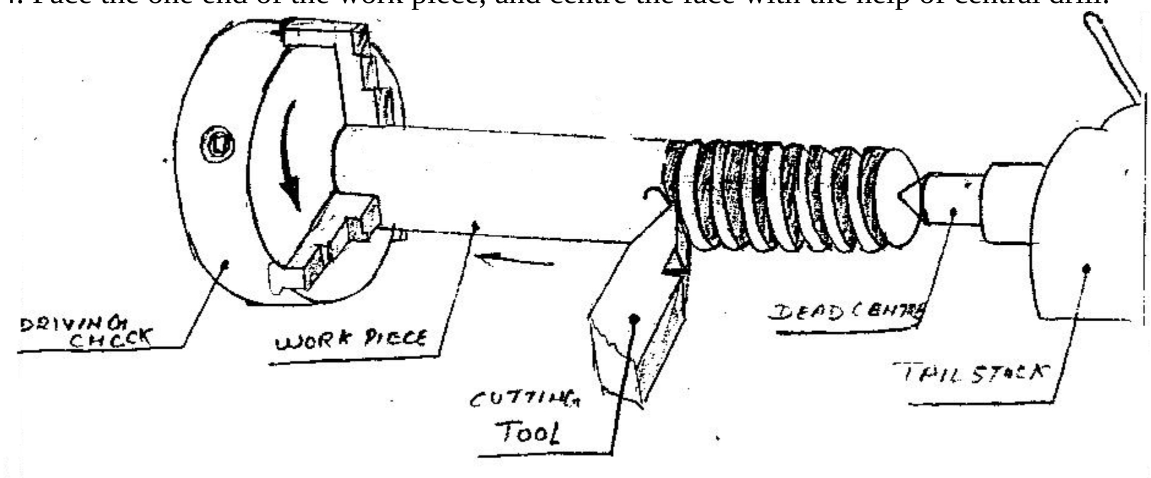
PROCEDURE FOR MAKING SQUARE AND V-THREADS:

1. Take the piece of M.S size diameter 36mmX105mm length.
2. Remove the burrs the help of files.
3. Hold the one end of the piece on the lathe chuck.
4. Face the one end of the work piece, and centre the face with the help of central drill.



5. Give the chamfering 1x450 to the work piece.
6. Open the piece from the chuck & reverse it.
7. Face the end & make the length 100mm.
8. Centre the end points with the help of centre drill.
9. Chamfering the end points by 1x450.
10. Remove the piece from chuck.
11. Load the piece between the centre with the help of dogtail.
12. Select the gear pitch .
13. Mount the tool.
14. Take the touching.
15. Take the tool on the side of job.
16. Give the depth of cut of .1mm & engage the gear.
17. Withdraw the tool.
18. Bring the carriage to the right hand side.
19. Give the depth of .3mm on the tool.
20. Give the final depth as calculated according to the thread to be cut.

21 Check the final dia of the work piece with the help of measuring tool.

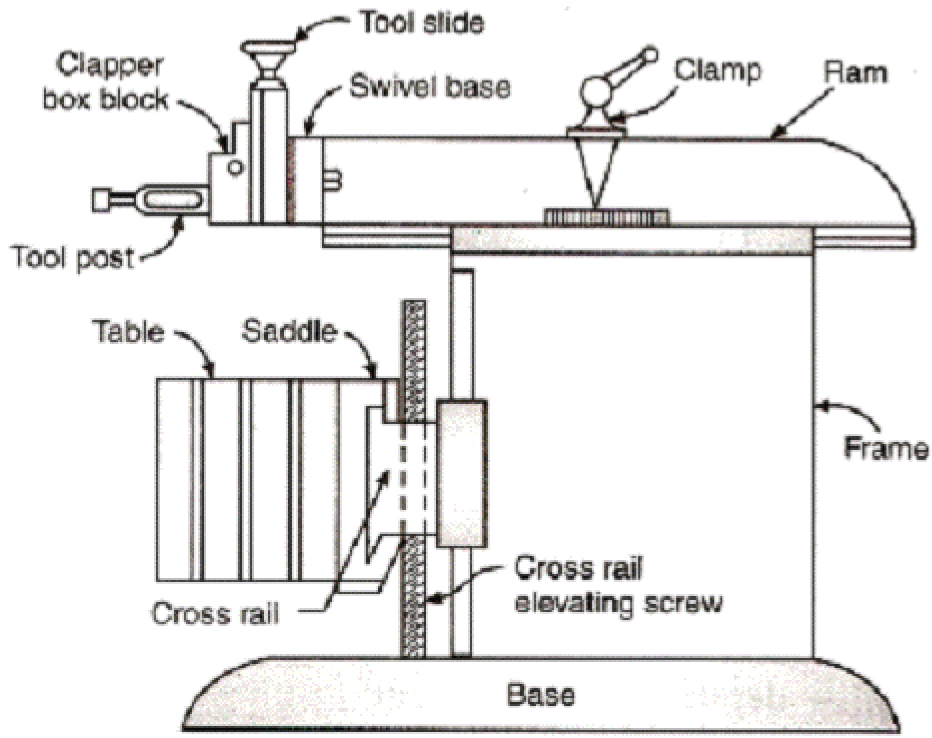
EXPERIMENT NO.11

Aim: To prepare a job on the shaper involving plane surfaces.

Tools & Apparatus: Shaper machine, vernier caliper, try square, single point cutting tool.

Material used: Mild steel.

Theory:A shaper is a type of machine tool that uses linear relative motion between the work piece and a single-point cutting tool to machine a linear tool path. The shaping machine is used to machine flat metal surfaces especially where a large amount of metal has to be removed. Other machines such as milling machines are much more expensive and are more suited to removing smaller amounts of metal, very accurately.



PROCEDURE FOR MAKING JOB ON SHAPER:

1. Select the suitable size raw material.
2. Remove the burrs.
3. Hold the job on the parallel packing in the vice.
4. Tighten the job carefully.
5. Work piece must be 1/3 outside the vice.
6. Hold the tool on the tool head.
7. Set the stroke length.
8. Now, first step is to take the tool qualification by touchining the tool with job.
9. Take the job on one side.
10. Give the depth of cut by raising the worktable.
11. Switch on the m/c and engage the lever to move the ram.
12. Give the feed to the job manually when the tool is away from the job.
13. Complete the surface.
14. Reverse the surface of the job to make the opposite side of the correct dimensions.
15. Hold the job in the vice on finish surface and make the third surface.
16. By reversing the job make the fourth surface of required size.
17. Finally check the dimensions of the job with the help of measuring tool.

Experiment no.12

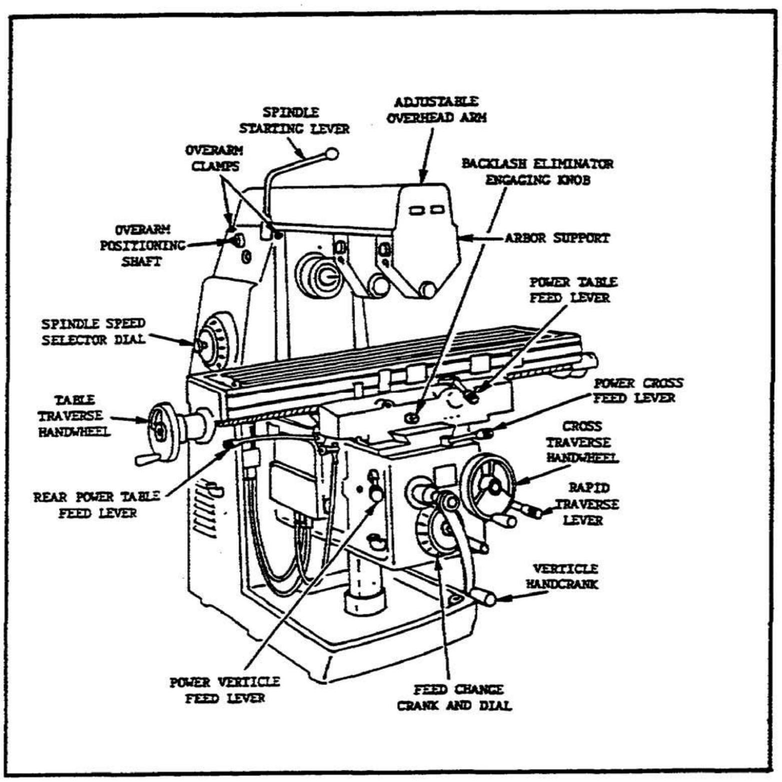
Aim: Use of milling machines for generation of plane surfaces, spur gears and helical gears; use of end mill cutters.

Material: M.S. blank ϕ 120, boreϕ 25 with thickness 5mm.

Machine: Milling Machine with indexing head, cutter 5 module.

Measuring Instrument: Vernier Caliper, Steel Rule

Theory:A milling machine is a machine tool used to machinesolidmaterials. Milling machines are often classed in two basic forms, horizontal and vertical, which refers to the orientation of the main spindle. Both types range in size from small, bench-mounted devices to room-sized machines. Unlike a press, which holds the work piece stationary while cutting as the drill moves axially to penetrate the material, milling machines also move the work piece radially against the rotating milling cutter, which cuts on its sides as well as its tip.

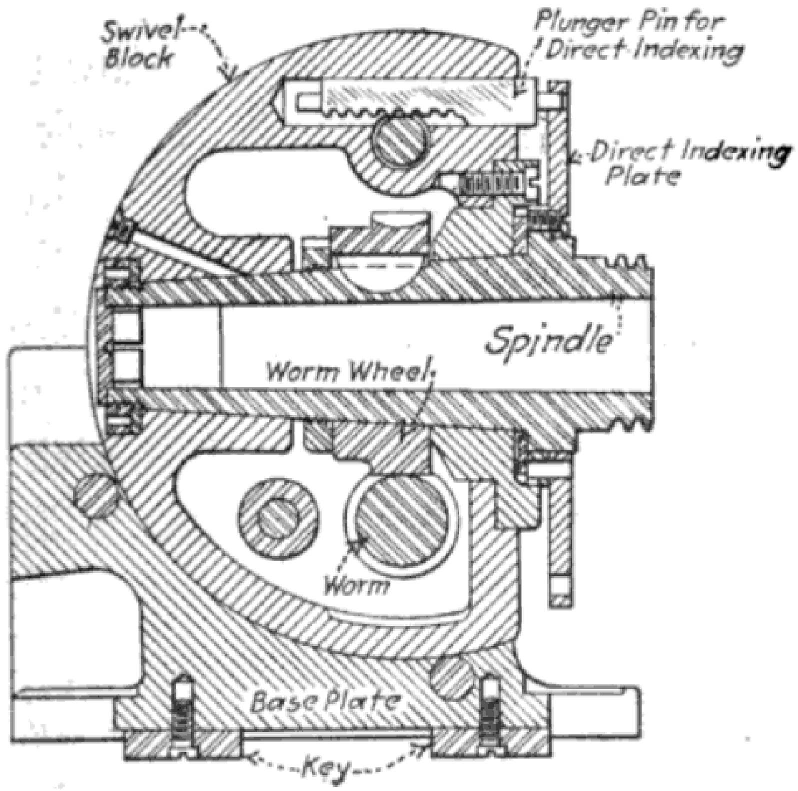


Universal dividing head:

An indexing head, also known as a dividing head or spiral head, is a specialized tool that allows a work piece to be circularly indexed; that is, easily and precisely rotated to preset angles or circular divisions. Indexing heads are usually used on the tables of milling machines, but may be used on many other machine tools including drill presses, grinders, and boring machines. Common jobs for a dividing head include machining the flutes of a milling cutter, cutting the teeth of a gear, milling curved slots, or drilling a bolt hole circle around the circumference of a part.

The tool is similar to a rotary table except that it is designed to be tilted as well as rotated. Most adjustable designs allow the head to be tilted from 10° below horizontal to 90° vertical, at which point the head is parallel with the machine table.

The work piece is held in the indexing head in the same manner as a metalworking lathe. This is most commonly a chuck but can include a collet fitted directly into the spindle on the indexing head, faceplate, or between centers. If the part is long then it may be supported with the help of an accompanying tailstock.



Calculation: To make a spur gear

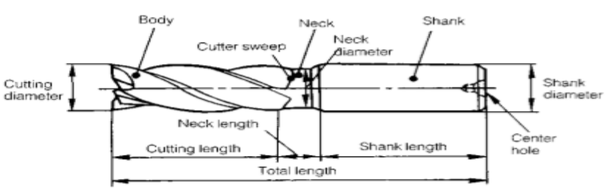
No. of teeth=22
Module (M) = 5mm
Outside diameter (O.D) = (N+2) M = (22+2)5 =120 mm
Pitch diameter (P.D) = NxM =110mm
Circular diameter (C.P) = πxM =15.714mm
Whole depth (Wh.D) =2.157xM =10.785mm
Working depth = 2xM = 10mm
Clearance = 0.157xM = 0.785mm
Addendum = Module = 5mm
Dedendum = 1.157xM = 5.785mm
Tooth thickness = 1.5708xM = 7.854mm
Indexing movement = 40/N = 40/22 =1 27/33

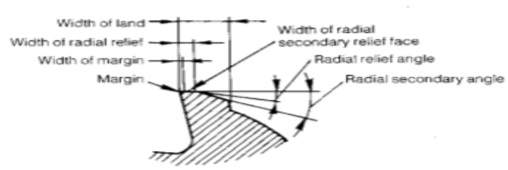
Procedure:

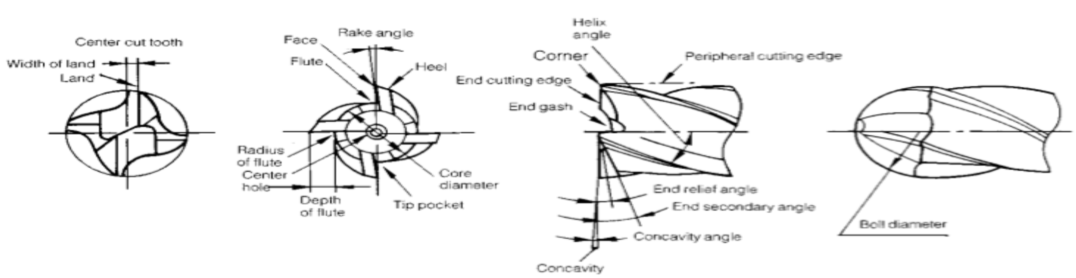
1. The one side of the job is held in the tail stock & second side is held in indexing head centre and an appropriate cutter (gear cutter) is held in the arbor..
2. Cutting speed & feed are adjusted depending upon whether it is a roughing or finishing cut.
3. The proper inclination of the cutter & the depth of cut is also set.
4. With the help of indexing head Crank Pin rotates & fixed in the 10th hole of 21 hole circular plate till the gear completed.
5. Cross feed to the table is given initially by hand till the cut starts & power feed is employed.
6. The teeth on the periphery do most of the actual cutting while those on the sides finish the sides of the cut to size.
7. After the cutter has cut the appropriate width of job, machine is stopped & job is inspected.

USE OF END MILL:

1. An End mill is a type of milling cutter, a cutting tool used in industrial milling applications. It is distinguished from the drill bit in its application, geometry, and manufacture. While a drill bit can only cut in the axial direction, a milling bit can generally cut in all directions, though some cannot cut axially.
2. End mills are used in milling applications such as profile milling, tracer milling, face milling, and plunging.
3. End mills are used for producing precision shapes and holes on a Milling or Turning machine. The correct selection and use of end milling cutters is paramount with either machining centers or lathes. End mills are available in a variety of design styles and materials.
4. Titanium coated end mills are available for extended tool life requirements. The successful application of end milling depends on how well the tool is held (supported) by the tool holder. To achieve best results an end mill must be mounted concentric in a tool holder.







The end mill can be selected for the following basic processes:
FACE MILLING - For small face areas, of relatively shallow depth of cut. The surface finish produced can be 'scratchy".
KEYWAY PRODUCTION - Normally two separate end mills are required to produce a quality keyway.

WOODRUFF KEYWAYS - Normally produced with a single cutter, in a straight plunge operation.
SPECIALTY CUTTING - Includes milling of tapered surfaces, ''T'' shaped slots & dovetail production.
FINISH PROFILING - To finish the inside/outside shape on a part with a parallel side wall.
CAVITY DIE WORK - Generally involves plunging and finish cutting of pockets in die steel. Cavity work requires the production of three dimensional shapes. A Ball type End mill is used for the finishing cutter with this application.

Precautions

When Operating Milling Machine, Precaution is meant by a measure taken in advance to avoid danger in order to secure good result. When we handling a machine, precautions have to be taken in order to secure good result of the work piece and personal safety. The precautions when operating milling machine as shown below:

1.) Avoid performing a machining operation on the milling machine until you are thoroughly familiar with how it should be done.

2.) Some materials that are machined produce chips, dust-, and fumes that are dangerous to your health. NEVER machine materials that contain asbestos, Fiberglass, beryllium, and beryllium copper unless you are fully aware of the precautions that must be taken.

3.) Maintain cutting fluids properly. Discard them when they become rancid or contaminated.

4.) Be sure the cutter rotates in the proper direction. Expensive cutters can be quickly ruined.

5.) Carefully store milling cutters, arbors, collets, adapters, etc., after each use. They can be damaged if not stored properly.

6.) Never start a cut unless you are sure there is adequate clearance on all moving parts!

7.) Exercise care when handling long sections of metal. Accidentally contacting a light fixture or bush bar can cause severe electrical burns and even electrocution!

8.) Carefully read instructions when using the new synthetic oils, solvents, and adhesives. Many of them dangerous if NOT handled correctly.

9.) Use adequate ventilation for jobs where dust and fumes are a hazard. Return oils and solvents to proper storage. Wipe up spilled fluids. Do NOT pour used coolants, oil, solvents, etc., down a drain.

EXPERIMENT NO.13

Aim:-To study the constructional details of rolling mills.

Equipment: - Rolling Machine

Theory:-Rolling is a fabricating process in which the metal, plastic, paper, glass, etc. is passed through a pair (or pairs) of rolls. There are two types of rolling process, flat and profile rolling. In flat rolling the final shape of the product is either classed as sheet (typically thickness less than 3 mm, also called "strip") or plate (typically thickness more than 3 mm). In profile rolling the final product may be a round rod or other shaped bar, such as a structural section (beam, channel, joist etc). Rolling is also classified according to the temperature of the metal rolled. If the temperature of the metal is above its recrystallization temperature, then the process is termed as hot rolling. If the temperature of the metal is below its recrystallization temperature, the process is termed as cold rolling. Another process also termed as 'hot bending' is induction bending, whereby the section is heated in small sections and dragged into a required radius.

Figure 1 Rolling

Hot Rolling:-Hot rolling is a hot workingmetalworking process where large pieces of metal, such as slabs or billets, are heated above their recrystallization temperature and then deformed between rollers to form thinner cross sections. Hot rolling produces thinner cross sections than cold rolling processes with the same number of stages. Hot rolling, due to recrystallization, will reduce the average grain size of a metal while maintaining an equiaxedmicrostructure where as cold rolling will produce a hardened microstructure.

Hot Rolling Process:- A slab or billet is passed or deformed between a set of work rolls and the temperature of the metal is generally above its recrystallizationtemperature, as opposed to cold rolling, which takes place below this temperature. Hot rolling permits large deformations of the metal to be achieved with a low number of rolling cycles. As the rolling process breaks up the grains, they recrystallize maintaining an equiaxed structure and preventing the metal from hardening. Hot rolled material typically does not require annealing and the high temperature will prevent residual stress from accumulating in the material resulting better dimensional stability than cold worked materials.
Hot rolling is primarily concerned with manipulating material shape and geometry rather than mechanical properties. This is achieved by heating a component or material to its upper critical temperature and then applying controlled load which forms the material to a desired specification or size.

Hot Rolling Applications:- Hot rolling is used mainly to produce sheet metal or simple cross sections such as rail road bars from billets.
Mechanical properties of the material in its final 'as-rolled' form are a function of:
materialchemistry,
reheattemperature,
rate of temperature decrease during deformation,
rate of deformation,
heat of deformation,
total reduction,
recovery time,
recrystallisation time, and
subsequent rate of cooling after deformation

Types of Hot Rolling Mills:-

Prior to continuous casting technology, ingots were rolled to approximately 200 millimetres (7.9 in) thick in a slab or bloom mill. Blooms have a nominal square cross section, whereas slabs are rectangular in cross section.

Slabs are the feed material for hot strip mills or plate mills and blooms are rolled to billets in a billet mill or large sections in a structural mill.

The output from a strip mill is coiled and, subsequently, used as the feed for a cold rolling mill or used directly by fabricators. Billets, for re-rolling, are subsequently rolled in either a merchant, bar or rod mill.

Merchant or bar mills produce a variety of shaped products such as angles, channels, beams, rounds (long or coiled) and hexagons. Rounds less than 16 millimetres (0.63 in) in diameter are more efficiently rolled from billet in a rod mill.

Cold rolling:-

Cold rolling is a metalworking process in which metal is deformed by passing it through rollers at a temperature below its recrystallization temperature. Cold rolling increases the yield strength and hardness of a metal by introducing defects into the metal's crystal structure. These defects prevent further slip and can reduce the grain size of the metal, resulting in Hall-Petch hardening.

Cold rolling is most often used to decreas the thickness of plate and sheet metal.

Physical metallurgy of cold rolling:-

Cold rolling is a method of cold working a metal. When a metal is cold worked, microscopic defects are nucleated throughout the deformed area. These defects can be either point defects (a vacancy on the crystal lattice) or a line defect (an extra half plane of atoms jammed in a crystal). As defects accumulate through deformation, it becomes increasingly more difficult for slip, or the movement of defects, to occur. This results in a hardening of the metal.

If enough grains split apart, a grain may split into two or more grains in order to minimize the strain energy of the system. When large grains split into smaller grains, the alloy hardens as a result of the Hall-Petch relationship. If cold work is continued, the hardened metal may fracture.

During cold rolling, metal absorbs a great deal of energy. Some of this energy is used to nucleate and move defects (and subsequently deform the metal). The remainder of the energy is released as heat.

While cold rolling increases the hardness and strength of a metal, it also results in a large decrease in ductility. Thus metals strengthened by cold rolling are more sensitive to the presence of cracks and are prone to brittle fracture.

A metal that has been hardened by cold rolling can be softened by annealing. Annealing will relieve stresses, allow grain growth, and restore the original properties of the alloy. Ductility is also restored by annealing. Thus, after annealing, the metal may be further cold rolled without fracturing.

Degree of cold work:-

Cold rolled metal is given a rating based on the degree it was cold worked. "Skin-rolled" metal undergoes the least rolling, being compressed only 0.5-1% to harden the surface of the metal and make it more easily workable for later processes. Higher ratings are "quarter hard," "half hard" and "full hard"; in the last of these, the thickness of the metal is reduced by 50%.

Cold rolling as a manufacturing process:-

Cold rolling is a common manufacturing process. It is often used to form sheet metal. Beverage cans are closed by rolling, and steel food cans are strengthened by rolling ribs into their sides. Rolling mills are commonly used to precisely reduce the thickness of strip and sheet metals.

EXPERIMENT NO.14

Aim:-To study the constructional details of a grinding machine.

Equipment: - Grinding Maching

Theory:-A grinding machine is a machine tool used for grinding, which is a type of machining using an abrasive wheel as the cutting tool. Each grain of abrasive on the wheel's surface cuts a small chip from the workpiece via shear deformation.

The grinding machine consists of a power driven grinding wheel spinning at the required speed (which is determined by the wheel's diameter and manufacturer's rating, usually by a formula) and a bed with a fixture to guide and hold the work-piece. The grinding head can be controlled to travel across a fixed work piece or the workpiece can be moved whilst the grind head stays in a fixed position. Very fine control of the grinding head or tables position is possible using a vernier calibrated hand wheel, or using the features of NC or CNC controls.

Grinding machines remove material from the workpiece by abrasion, which can generate substantial amounts of heat; they therefore incorporate a coolant to cool the workpiece so that it does not overheat and go outside its tolerance. The coolant also benefits the machinist as the heat generated may cause burns in some cases. In very high-precision grinding machines (most cylindrical and surface grinders) the final grinding stages are usually set up so that they remove about 2/10000mm (less than 1/100000 in) per pass - this generates so little heat that even with no coolant, the temperature rise is negligible.

Types of a Grinding Machine:-

These machines include the Belt grinder, which is usually used as a machining method to process metals and other materials, with the aid of coated abrasives. Sanding is the machining of wood; grinding is the common name for machining metals. Belt grinding is a versatile process suitable for all kind of applications like finishing, deburring, and stock removal Bench grinder, which usually has two wheels of different grain sizes for roughing and finishing operations and is secured to a workbench. It is used for shaping tool bits or various tools that need to be made or repaired. Bench grinders are manually operated.

Cylindrical grinder which includes the centerless grinder. A cylindrical grinder may have multiple grinding wheels. The workpiece is rotated and fed past the wheel/s to form a cylinder. It is used to make precision rods.

Surface grinder which includes the wash grinder. A surface grinder has a "head" which is lowered, and the workpiece is moved back and forth past the grinding wheel on a table that has a permanent magnet for use with magnetic stock. Surface grinders can be manually operated or have CNC controls.

Tool and Cutter grinder and the D-bit grinder. These usually can perform the minor function of the drill bit grinder, or other specialist toolroom grinding operations.

Jig grinder, which as the name implies, has a variety of uses when finishing jigs, dies, and fixtures. Its primary function is in the realm of grinding holes and pins. It can also be used for complex surface grinding to finish work started on a mill.

Surface Grinder:-

A surface grinder is a machine tool used to provide precision ground surfaces, either to a critical size or for the surface finish.

Figure 1 Surface grinder

The typical precision of a surface grinder depends on the type and usage, however +/- 0.002 mm (+/- 0.0001") should be achievable on most surface grinders.

The machine consists of a table that traverses both longitudinally and across the face of the wheel. The longitudinal feed is usually powered by hydraulics, as may the cross feed, however any mixture of hand, electrical or hydraulic may be used depending on the ultimate usage of the machine (ie: production, workshop, cost). The grinding wheel rotates in the spindle head and is also adjustable for height, by any of the methods described previously. Modern surface grinders are semi-automated, depth of cut and spark-out may be preset as to the number of passes and once setup the machining process requires very little operator intervention.

Spark out is a term used when precision values are sought and literally means "until the sparks are out (no more)". It involves passing the workpiece under the wheel, without resetting the depth of cut, more than once and generally multiple times. This ensures that any inconsistencies in the machine or workpiece are eliminated.

As with any grinding operation, the condition of the wheel is extremely important. Diamond dressers are used to maintain the condition of the wheel, these may be table mounted or as the first image shows, mounted in the wheel head where they can be readily applied.

Depending on the workpiece material, the work is generally held by the use of a magnetic chuck. This may be either an electromagnetic chuck, or a manually operated, permanent magnet type chuck; both types are shown in the first image.

Aluminum oxide, silicon carbide, diamond, and cubic boron nitride (CBN) are four commonly used abrasive materials for the surface of the grinding wheels. Of these materials, aluminum oxide is the most common. Because of cost, diamond and CBN grinding wheels are generally made with a core of less expensive material surrounded by a layer of diamond or CBN. Diamond and CBN wheels are very hard and are capable of economically grinding materials, such as ceramics and carbides, that cannot be ground by aluminum oxide or silicon carbide wheels.

Effects on work material properties:-

The mechanical properties of the work material can receive residual surface stresses, a thin martensitic layer may form on the part surface, and fatigue strength may be reduced. In the physical aspect, some of the magnetic properties may be lost on ferromagnetic materials. Chemically, the work material may become more susceptible to corrosion.

Lubrication and Cooling:-

The machine has provision for the application of coolant as well as the extraction of metal dust (metal and grinding particles).

Common lubricants include water-soluble chemical fluids, water soluble oils, synthetic oils, and petroleum-based oils. These lubricants must be applied directly to the cutting area to ensure that the fluid is not carried away by the rotating grinding wheel.

When grinding various materials, the use of different types of lubrication fluids should be used to fit the properties of a particular metal.

Work material	Cutting Fluid	Application
Aluminum	Light duty oil	Flood
Brass	Light duty oil	Flood

Cast Iron	Heavy duty emulsifiable oil, light duty chemical and synthetic oil	Flood
Mild steel	Heavy duty water-soluble oil	Flood
Stainless steel	Heavy duty emulsifiable oil, heavy duty chemical and synthetic oil	Flood
Plastics	Water-soluble oil, dry, heavy duty emulsifiable oil, light duty chemical and synthetic oil	Flood

Cylindrical grinders:-

Cylindrical grinders are a class of grinding machines used on the work pieces that are symmetrical about an axis of rotation (e.g. cylindrical

Types of Cylindrical grinders:-

OD grinder:-An OD grinder grinds the outer diameter (OD) of the work piece, held on one or both ends. Usually, the work piece is held between centers or chucked and rotated against a faster spinning grinding wheel,great care should be taken as the OD comes closer to finished size as its too easy to over grind the tool.

ID grinder:- An ID grinder grinds the inside diameter (ID) of a work piece but usually this tends to be a longer process than OD grinding as the ID grinding stone is smaller and requires the operator to make smaller cuts from the tool to ensure that the ID grind is perfect and to the correct size.

Center less grinder:-

A center less grinder is a type of OD grinder where the workpiece, rather than being supported on either end, is held against the grinding wheel by a second smaller wheel, turning at a slower RPM and known as a regulating wheel, while resting on a workblade.

Figure 2Centerless cylindrical grinder

Centerless grinding is much easier to combine with automatic loading procedures than centred grinding; throughfeed grinding, where the regulating wheel is held at a slight angle to the part so that there is a force feeding the part through the grinder, is particularly efficient. Plunge grinding involves feeding the part onto the support blade and then lowering the grinding wheel radially into it.

The workblade is angled slightly towards the regulating wheel, with the workpiece centerline above the centerlines of the regulating and grinding wheel; this means that high spots do not tend to generate corresponding opposite low spots, and hence the roundness of parts can be improved

EXPERIMENT NO. :- 1

OBJECTIVE: - Study of Various Links and Mechanisms.

KINEMATIC LINK OR ELEMENT:-

Kinematic links is a resistance body or an assembly of an resistant body which go to make a part of machine connecting other parts which have motion relative to it.

A kinematic link is assumed to be a completely rigidity such as springs usually have no effect on the kinematics of device but play role in supplying forces. Sometimes belt or chain a machine may posse's one way rigidity.

EXAMPLE:

In every machine there is one fixed link. This is essentially the frame of the mechanism. Schematically shown in fig. we can explain the use of term link.

Link one is the fixed link and includes the frame and all others stationary parts like cylinder, crank shafts bearing and cam shaft bearing etc. Link 2 may include crank shaft, flywheel etc. All having a motion of rotation about the fixed axis.

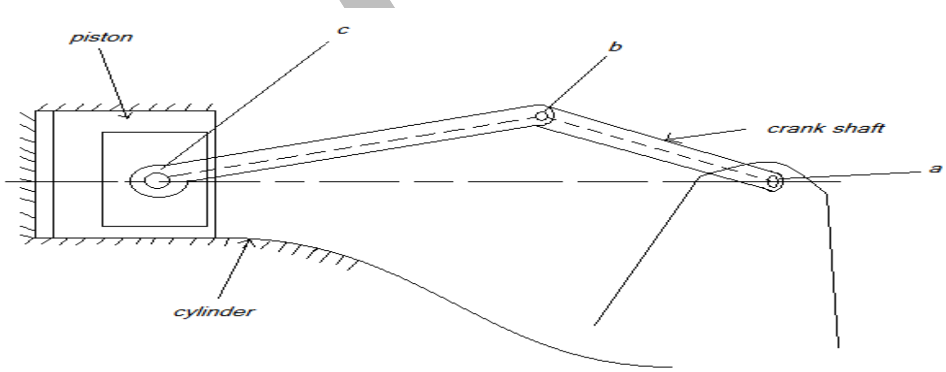
Link 3 is connecting rod. An intermediate b/w floating link 4 is the piston having reciprocating rectilinear translatory motion.

EXAMPLE:

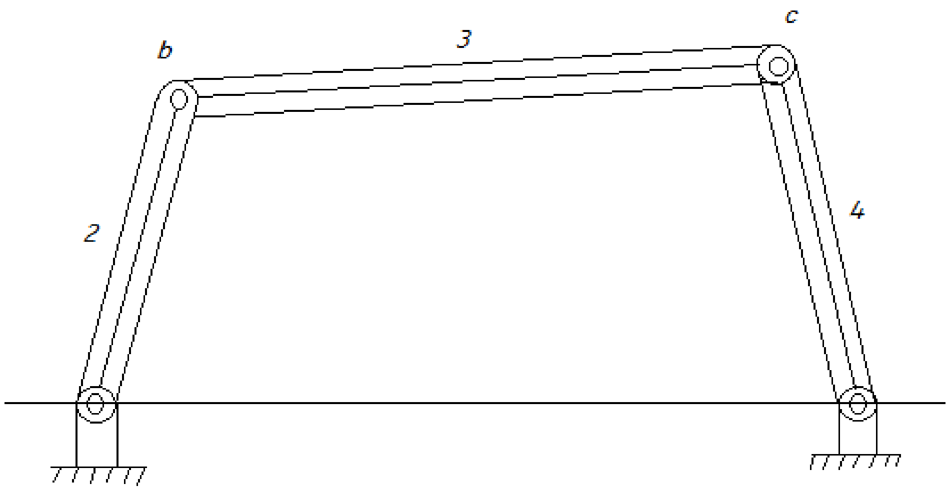
In flexible links like ropes, chains and belts acting in tension, deformation produced on working load can be neglected for analysis and so they are also created as kinetic links. Similarly fluid in compression transmitting motion as in hydraulic press will be created as a kinematic link.

MECHANISM:

If one of the links of a constrained kinematics chain is fixed the result in a mechanism.if a different link of same chain is made the fixed link the result in a different mechanism. mechanism is only a kinetic chain with one link fixed. Slider crank arrangement of fig is a mechanism.



Piston cylinder arrangement representing various links as well as a mechanism.



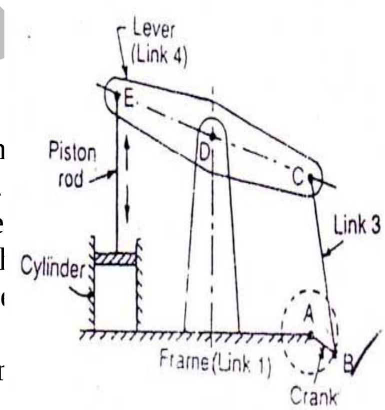
Four bar kinetic chain mechanism.

EXPERIMENT NO. :- 2

OBJECTIVE:- Study and Draw Various Inversions of 4-Bar Chain and Single Slider Crank Chain.

INVERSIONS OF FOUR BAR CHAIN

Though there are many inversions of the four bar chain, following are important from the subject point of view:



1. *Beam engine (crank and lever mechanism)* A part mechanism of a beam engine (also known as crank an mechanism) which consists of four links, is shown in Fig. this mechanism, when the crank rotates about the fixed ce The lever oscillates about a fixed centre D. The end E of tl CDE is connected to a piston rod which reciprocates du rotation of the crank. In other words, the purpose mechanism is to convert rotary motion into reciprocating r

2. *Coupling rod of a locomotive (Double crank mechanism*). The mechanism of coupling rod of a locomotive (also as double crank mechanism) which consists of four l shown in Fig. 5.20.
   In this mechanism, the links AD and BC (having equal act as cranks and are connected to the respective wheels. T CD act as a coupling rod and the link AB is fixed in c maintain a constant centre to centre distance between the mechanism is meant for transmitting rotary motion fro wheel to the other wheel.

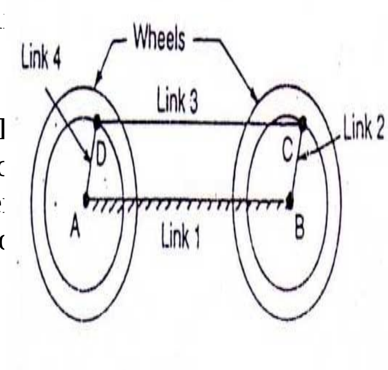


Fig. 5.20. Coupling rod of a locomotive.

3. *Watt's indicator mechanism (Double lever mechanism).*

A *Watt's indicator mechanism (also known as watt's line mechanism or double lever mechanism) which con four links, is shown link CE and link BFD. It may be no BF and FD motion between them. The links CE and BFI levers. The displacement of the link BFD is directly prop to the pressure of gas or steam which acts on the i plunger. On any small displacement of the mechani tracing point E at the end of the link CE traces out approx a straight line.

The initial position of the mechanism is shown in Fig. 5 full line where as the dotted lines shown the positior mechanism when the gas or steam pressure acts on the i plunger.

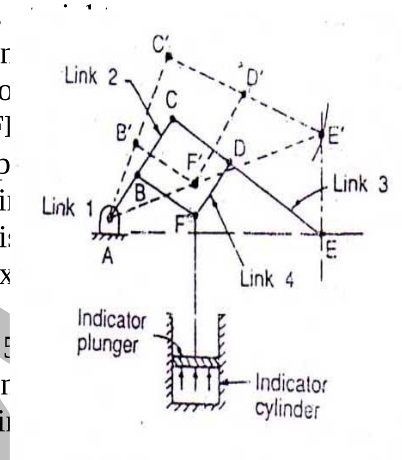
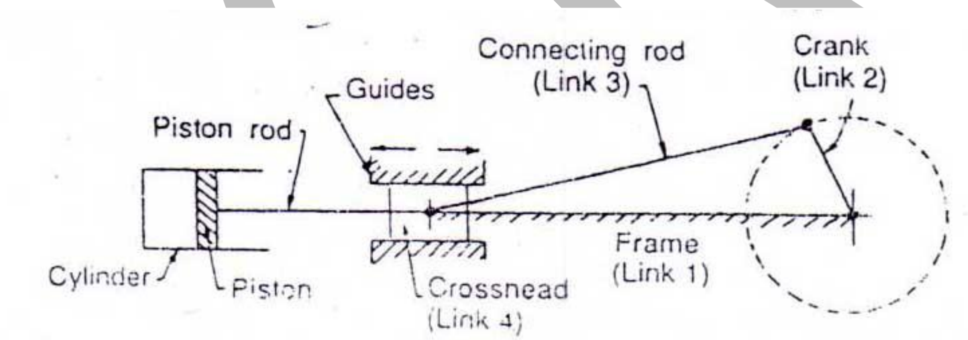


Fig. 5.21. Watt's indicator mechanism.

5.19 SINGLE SLIDER CRANK CHAIN

A single slider crank chain is a modification of the basic four bar chain. It consists of one sliding pair and three turning pairs. It is, usually, found in reciprocating steam engine mechanism. This type of mechanism converts rotary motion into reciprocating motion and vice versa. In a single slider crank chain, as shown in Fig. 5.22, the links 1 and 2 and 3, and links 3 and 4 from there taming pairs while the links 4 and 1 from a sliding pair.



5.20 INVERSION OF SINGLE SLIDER CRANK CHAIN

We have seen in the previous article that a single slider crank chain is a four-link mechanism. We know that by fixing, in turn, different links in a kinematics chain, an inversion is obtained and we can obtain as many mechanisms as the links in a kinematics chain. It is thus obvious, that four inversions of a single slider crank chain are possible. These inversions are found in the following mechanism.

1. *Pendulum pump or Bull engine*. In this mechanism, the inversion is obtained by fixing the cylinder or link 4 (i.e. sliding pair), as shown in Fig. 5.23. In this case, when the crank (link 2) rotates the connecting rod (link 3) oscillates about a pin pivoted to the fixed link 4 at A and the piston attached to the piston rod (link 1) reciprocates. The duplex pump which is used to supply feed water to boilers have two pistons attached to link 1, as shown in Fig. 5.23.

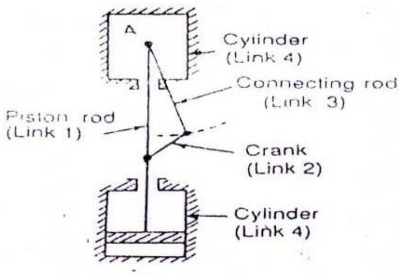


Fig. 5.23. Pendulum pump.

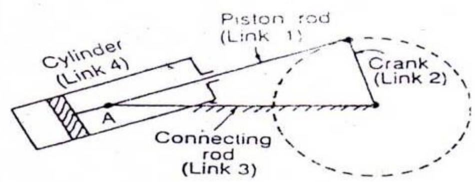


Fig. 5.24. Oscillating cylinder engine.

2. *Oscillating cylinder engine*. The arrangement of oscillating cylinder engine mechanism, as shown in Fig. 5.24, is used to convert reciprocating motion into rotary motion. In this mechanism, the link 3 forming the turning pair is fixed. The link 3 corresponds to the connection rod of a reciprocating steam engine mechanism. When the crank (link 2) rotates, the piston attached to piston rod (link 1) reciprocates and the cylinder (link 4) oscillates about a pin pivoted to the fixed link at A.
3. *Rotary internal combustion engine or Gnome engine*. Sometimes back, rotary internal combustion engines were used in aviation. But now-a-days gas turbines are used in its place. It consists of seven cylinders in one plane and all revolves about fixed centre D, as shown in Fig. 5.25. While the crank (link 2) is fixed. In this mechanism,

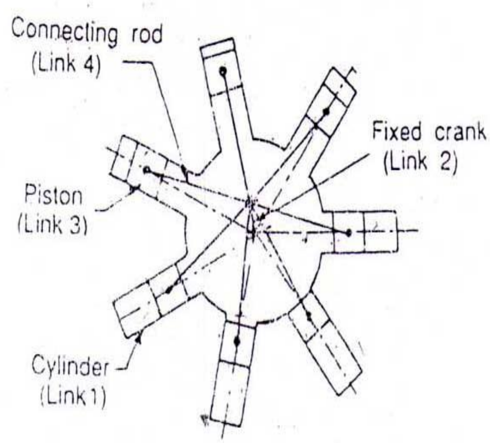


Fig. 5.25. Rotary internal combustion engine.

When the connecting rod (link 4) rotates, the piston (link 3) reciprocates inside the cylinders forming link 1.

EXPERIMENT NO. 3

1. **OBJECTIVE**:
   - 1.1 To study the working of a governor
   - 1.2 To compare the difference between different governors.

2. **APPARATUS:**

The apparatus consists of a main spindle driven by a variable speed D.C motor with variable speed control unit. The motor is connected through 'V' belt to drive shaft. Motor and main shaft are mounted on a rigid M.S base plate in vertical fashion. The spindle is supported in ball bearings.

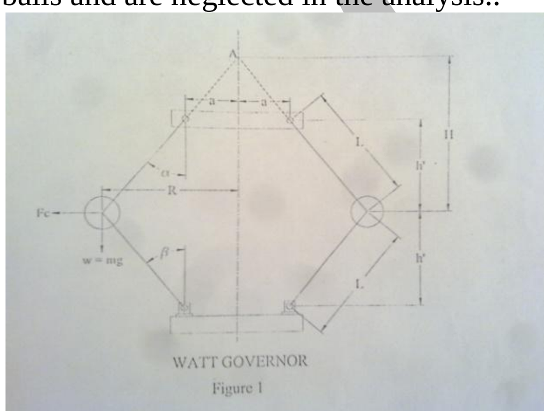
The optional governor mechanism can be mounted on spindle shaft allows the use of a hand tachometer to determine the speed. A graduated scale is fixed to the sleeve and guided in vertical direction, which measures the sleeve displacement.

The center sleeve of the porter and proell governors incorporates a weight sleeve to which weights may be added. The hartnell governor provides means of varying spring rate, initial compression level and mass of rotating weight. This enables the Hartnell governor, to be operated as a
stable or unstable governor.

3. DIAGRAM:

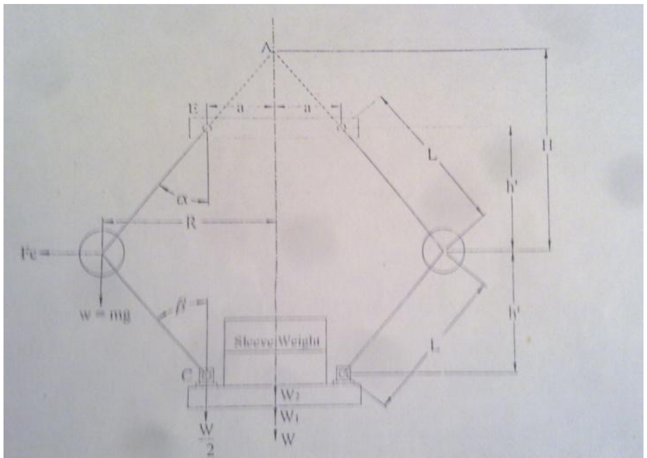
WATT GOVERNOR

It is assumed that mass of the arms, links and sleeve are negligible in comparison with the mass of the balls and are neglected in the analysis..



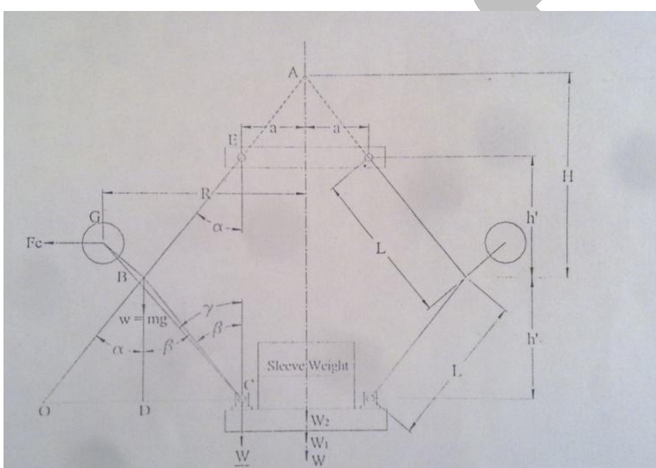
PORTER GOVERNOR

Porter governor differs from Watt's Governor only in extra sleeve weight,else is similar to watt governor..



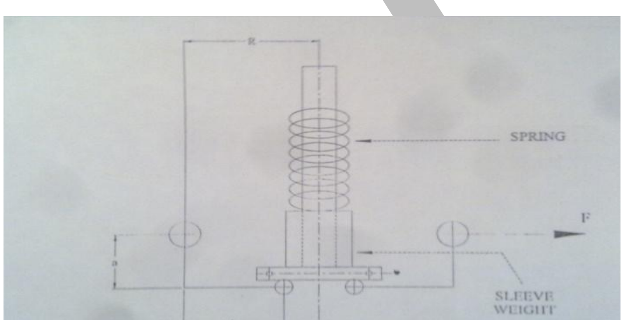
PORTER GOVERNOR
Figure 2

PROCELL GOVERNOR



PROELL GOVERNOR
Figure 3

HARTNELL GOVERNOR



HARTNELL GOVERNOR
Figure 4

4. THEORY:

The function of a governor is to regulate the mean speed of an engine, when there are variations in the load e.g when the load on an engine increases, its speed decreases, therefore it becomes necessary to increase the supply of working fluid. On the other hand when the load on the engine decreases, its speed increases and thus less working fluid is required. The governor automatically controls the supply of working fluid to the engine with the varying load conditions and keeps the mean speed within certain limits.

Terms used in governors:

4.1 Height of governor:

It is the vertical distance from the center of the ball to a point where the axis of the arms (arms produced) intersect on the spindle axis. It is usually denoted by h.

4.2 Equilibrium speed:

It is the speed at which the governor balls, arms etc are in complete equilibrium and the sleeve does not tend to move upwards or downwards.

4.3 Mean equilibrium speed:

It is the speed at the mean position of the balls or the sleeve.

4.4 Maximum and minimum equilibrium speeds:

The speed at the maximum and minimum radius of rotation of the balls, without tending to move either way are known as maximum and minimum equilibrium speeds respectively.

4.5 Sleeve lift:

It is the vertical distance which the sleeve travels due to change in equilibrium speed.

5. PROCEDURE:

5.1 Connect the motor to speed control unit using four way cable provided.

5.2 The control unit is switched ON and the speed control slowly rotated, increasing the governor speed until the center sleeve rises off the lower stop and aligns with the first division on the graduated scale.

5.3 The sleeve position and speed are then recorded. Speed may be determined using a hand tachometer on the spindle. The governor speed is then increased in step to give suitable sleeve movements, and readings repeated at each stage through out the range of sleeve movement possible.

6. OBSERVATIONS AND CALCULATIONS:

For Watt and porter governor

Radius of rotation 'r' can be calculated as follows:

Find height $h = (h_o - x/2)$

Find 'α' by using $\cos\alpha = h/L$

Then, $r = 50 + L \sin \alpha$

Force can be calculated as follows:

a) the angular velocity 'ω' of the arm and ball about the spindle axis.

$\omega = 2\pi N/60$ rad/sec

where N is the seed of the spindle.

b) The centrifugal force acting on the ball

Force, F = (W/g) ω^2 x r_o in kg
Where g is the acceleration due to gravity, g = 9.81 m/sec^2

WATT GOVERNOR

Length of each link, L = 125 mm
Initial height of governor, h_o = 94 mm
Initial radius of rotation ,r_o = 136 mm
Weight of each ball, W = 0.6 kg

Sr.No	Sleeve displacement "X" (mm)	Speed "N" (rmp)	Height "h" = h_o -X/2 (mm)	cosα = h/L	Radius of rotation, "r" r = 50 + L Sin α (cm)	Force "F" (kg)

PORTER GOVERNOR

Length of each link, L = 125 mm
Initial height of governor, h_o = 94 mm
Initial radius of rotation ,r_o = 136 mm
Weight of each ball, W = 0.6 kg
Weight of sleeve = 0.6 kg

Sr.No	Sleeve displacement "X" (mm)	Speed "N" (rmp)	Height "h" = h_o –X/2 (mm)	cosα = h/L	Radius of rotation, "r" r = 50 + L Sin α (cm)	Force "F" (kg)

PROELL GOVERNOR:

In the proell governor, with the use of flywheel (forming full ball) the governor becomes highly sensitive. Under this conditions large sleeve displacement is observed for very small change in speed. In order to make it stable, it is necessary to carry out the experiments by using half flyweight on each side.

Length of each link, L = 125 mm

Initial height of governor, h_o = 94 mm
Initial radius of rotation ,r_o = 141.5 mm
Weight of each ball, W = 0.6 kg
Weight of sleeve = 0.6 kg
Extension of length BG = 75 mm

Sr.No	Sleeve displacement "X" (mm)	Speed "N" (rmp)	Height "h" = h_o –X/2 (mm)	cosα = h/L	Radius of rotation, "r" r = 50 + L Sin α (cm)	Force "F" (kg)

HARTNELL GOVERNOR:

Length ,a = 77 mm
Length ,b = 122 mm
Initial radius of rotation ,r_o = 177.5 mm
Weight of each ball, W = 0.6 kg
Weight of sleeve = 0.6 kg
Free height of spring = 102 mm
Spring stiffness (P) = 10 & 5 kg/cm
Initial compression of the spring =

Sr.No	Sleeve displacement "X" (mm)	Speed "N" (rmp)	Radius of rotation, "r" r = r_0 + X a/b (cm)	Force "F" (kg)

7. PRECAUTIONS:
   7.1 Do not keep the mains " ON" when trail is complete.
   7.2 Increase the speed gradually.
   7.3 Take the sleeve displacement reading when the pointer remains steady.
   7.4 See that at higher speed the load on sleeve does not hit the upper sleeve of the governor.
   7.5 While closing the test bring the dimmer to zero position and then switch "OFF" the motor.

EXPERIMENT NO. 4

1. **OBJECTIVE:**

1.1 Observation of Gyroscopic behavior

1.2 Experimental justification of the equation $C = I\omega\omega_p$ for calculating the gyroscopic couple by observation and measurements of results for independent variation in applied couple C and precession $\omega_{p.}$

2. **APPARATUS:**

Schematic arrangement of the gyroscope is shown in fig. 3. The motorized gyroscope consists of a disc rotor mounted on a horizontal shaft rotates about XX axis in two ball bearings of one frame. This frame can swing about YY axis in bearings provided in the yoke type frame No. 2. the rotor shaft is coupled to a motor mounted on a trunion frame having bearings in a yoke frame , which is free to rotate about vertical axis ZZ. Thus freedom of rotation about three perpendicular axis is given to the rotor (or the disc can be rotated about three perpendicular axis). Angular scale and pointer fitted to frame helps to measure precession rate. In steady position, frame No.1 is balanced by providing a weight pan on the opposite side of the motor.

3. **DIAGRAM:**

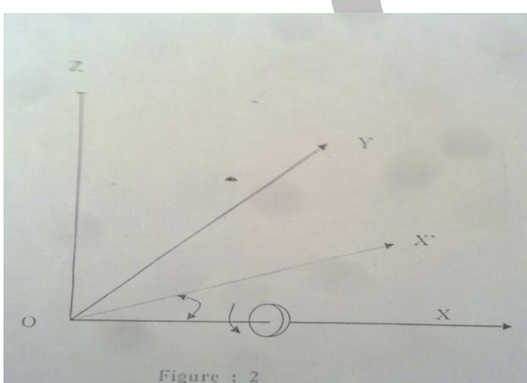
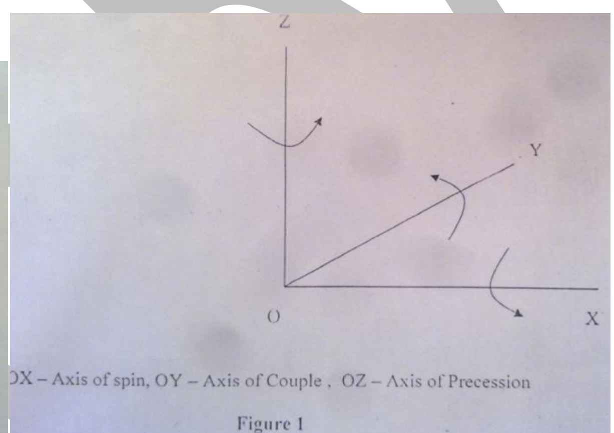


Figure : 2



OX – Axis of spin, OY – Axis of Couple , OZ – Axis of Precession

Figure 1

THEORY:

3.1 Definitions:

3.1.1 Axis of Spin:

If a body is revolving about an axis, the latter is known as axis of spin.

3.1.2 Gyroscopic Effect:

To a body revolving (or spinning) about an axis say OX, if a couple represented by a vector OY perpendicular to OX is applied, then the body tries to process about an axis OZ which is perpendicular both to OX and OY. Thus the plane of spin, plane of precession and plane of gyroscopic couple are mutually perpendicular. The above combined effect is known as processional or gyroscopic effect.

3.1.3 Precession:

Precession means the rotation about the third axis OZ, which is perpendicular to both the axis of spin OX and that of couple OY.

3.1.4 Axis of Precession:

The third axis OZ is perpendicular to both the axis of spin OX and that of couple OY is known as axis of precession.

3.1.5 Gyroscope:

Gyroscope is a body while spinning about an axis is free to rotate in other directions under the action of external forces. E.g locomotive, automobile and aeroplane making a turn. In certain cases the gyroscope forces are undesirable whereas in other cases the gyroscopic effect may be utilized in developing desirable forces. For minimizing rolling, yawing and pitching of ship or air-craft gyroscope is used. Balloons use gyroscope for controlling direction.

3.2 Gyroscopic couple of a plane disc:

Let a disc of weight W and having a moment of inertia I be spinning with an angular velocity ω about axis OX in an anti clockwise direction viewing from front. Therefore, the angular momentum of disc is I ω. Applying right hand screw rule, the sense of vector representing the angular momentum of disc which is also a vector quantity will be in the direction OX as shown in fig.

A couple, whose axis is OY perpendicular to OX and is in the plane XOZ, is now applied to process the axis OX.

Let axis OX turn through a small angular displacement θ about axis OZ and in the plane XOY, from OX to OX' in time t. The couple applied produces a change in the direction of angular velocity, the magnitude remaining constant. This change is due to the velocity of precession. Therefore, 'OX' represents the angular momentum after time t.

Change of angular momentum = OX' – OX = XX'

Or rate of change of angular momentum = $\frac{\text{Angular Displacement}}{\text{Time}}$

$$= \frac{XX'}{t}$$

But rate of change of angular momentum = Couple applied, C

Where, XX' = OX x θ in direction of XX'

$$= (I\,\omega)\,\theta$$

$$C = I\,\omega\,\frac{\theta}{t}$$

and in the limit, when t is very small,

$$C = I\,\omega\,\frac{\theta}{t}$$

let $\frac{\theta}{t} = \omega_p$, the angular velocity of precession of yoke, which is uniform and is about axis OZ.

Thus, we get $C = I \omega \omega_p$

The direction of the couple applied on the body is clockwise when looking in the direction XX' and in the limit this is perpendicular to axis of$\omega$and ω_p.

3. PROCEDURE:

"The spinning body exerts a torque or couple in such a direction which tends to make the axis of spin coincide with that of the precession."

4.1 Balance the initial horizontal position of the rotor.

4.2 Start the motor by increasing the voltage with the autotransformer and wait until it attains constant speed.

4.3 Precess the yoke frame no. 2 about vertical axis by applying necessary force by hand to the same (in clockwise sense seen from above).

4.4 It will be observed that the rotor frame swings about the horizontal axis YY. Motor side is seen coming upward and the weight pan side going downward.

4.5 Rotate the vertical yoke frame swing in opposite sense (as compared to that in previous case following the above rule.

"The spinning body precesses in such a way as to make the axis of spin coincide with that of the couple applied, through 90 turn".

4.1.a Balance the rotor position on the horizontal frame.

4.2.b Start the motor by increasing the voltage with the autotransformer and wait till the disc attains constant speed. Note down the speed.

4.3.c Put weight(0.5 kg, 1 kg or 2 kg) in the weight pan and start the stop watch to note the time in seconds required for precession, through 60 or 45 etc.

4.4.d The vertical yoke precesses about OZ axis as per the rule .

4.5.e Speed may be varied by the autotransformer provided on the control panel.

4. OBSERVATIONS AND CALCULATIONS:

Weight of rotor : 6.7 kg

Rotor diameter : 300mm

Rotor thickness : 10.5mm

Moment of inertia of the disc, coupling and motor rotor about central axis, $I = W/g \times D^2/g$

$= 6.7/981 \times (30)^2/8$

$= 0.768$ kg cm sec^2

Distance of bolt of weight pan from disc center, L = 17.6 cm

Motor : Fractional H.P single phase .6000 rpm AC/DC type.

S.No	Weight, W (kg)	Time required for Precession, dt (sec)	Speed, N (RPM)	Angle of precession Θ (degree)

Angular velocity of disc in rad/sec

$\omega = 2\pi N/ 60$ rad/sec

Angular velocity of precession of yoke ω_p in rad/sec

$$\omega_p = \frac{d\theta}{t}$$

where $d\theta$ is in radian =

6. **RESULT:**

$C = I\ \omega\ \omega_p$

$C_{actual} = W \times L$

7. **PRECAUTIONS:**

7.1 ω_p is to be calculated for short duration of time, as the balance of rotation of disc about the horizontal axis YY due to application of torque, because of which $\omega_p$goes on reducing gradually.

7.2 Avoid using the tachometer while taking reading of time as it will reduce the time taken for precession.
Autotransformer should be varied gradually.

EXPERIMENT NO. 5

OBJECTIVE:- Balancing of rotating masses (graphical method)

THEORY:

CONDITIONS FOR STATIC AND DYNAMIC BALANCING:

- ❖ If a shaft carries a number of unbalanced masses such that the center of mass of the system lies on the axis of rotation, the system is said to statistically balance..
- ❖ The result couple due to all the inertia forces during rotation must be zero.

These two conditions together will give complete dynamic balancing .It is obvious that a dynamically-balanced system is also statvally balanced, but the statically balanced system is not dynamically balanced.

BALANCING OF SEVERAL MASSES ROTATING IN DIFFERENT PLANES:

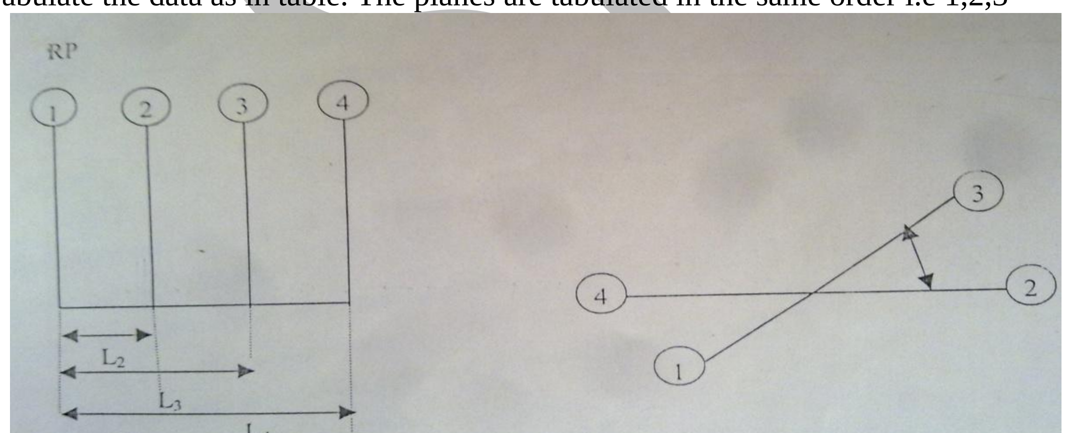
When several masses revolve in different planes, they may be transferred to a reference plane, which may be defined as the plane passing the A point on the axis of rotation and perpendicular to it. The effect of transferring a revolving mass to the referencing plane is to cause a force of magnitude equal to centrifugal force of the revolving mass to act in the reference plane, together with a couple of magnitude equal to the product of force and the distance between the plane of rotation and the reference plane. In order to have a complete balance of the several revolving masses in different planes.

THE FOLLOWING CONDITIONS MUST BE SATISFIED:

- the forces in the reference plane must balance, i.e. the resultant force must be zero..
- The couple about the reference plane must balance ie the resultant couple must be zero..

Let us consider four masses m1, m2, m3 and m4 revolving in plane 1,2,3,4 shown in fig. .The relative angular positions of these masses are shown in the end view Fig. The magnitude angular position and position of balancing masses m1 in plane 1 may be obtained as discussed below..

- Take one of the planes, say 1 as the reference plane(R.P.).The distance of all other planes to the left of the reference plane may be regarded as –ve, and those to the right as +ve.
- Tabulate the data as in table. The planes are tabulated in the same order i.e 1,2,3



Plane (1)	Mass (m) (2)	Radius(r) (3)	Mass moment mr(4)	Distance from plane 1 (L)(5)	Couple mrL (6)
1.(R.P)	M1	R1	M1 r1	0	0
2	M2	R2	M2 r2	L2	M2r2L2
3	M3	R3	M3r3	L3	M3r3L3
4.	M4	R4	M4r4	L4	M4r4l4

- The position of plane from position 2 may be obtained by drawing the couple polygon with the help of data given in column 6.
- The magnitude and angular position of mass m1 may be determined by drawing the force polygon by the given data of column (4) to some suitable scale. Since the masses are to be completely balanced, therefore the force polygon must be closed fig..The closing side of force polygon is proportional to the m1r1..

The angular position of mass m1 must be equal to the angle in anti clock wise direction measured from R.P. to the line drawn on the fig.(b)parallel to the closing side of force polygon..

DESCRIPTION:

The apparatus basically consist of a steel shaft mounted in ball bearings in a stiff rectangular main frame. A set of four blocks of different weights is provided and may be detached from the shaft.
A disc carrying a circular protractor scale is fitted to one side of the rectangular frame. A scale is provided to adjust the apparatus to adjust the longitudinal distance of the blocks on the shaft. The circular protractor scale is provided to determine the exact angular position of each adjustable block. The shaft is driven by a 230 volts, single phase,50 cycles electric motor mounted under the main frame.

For static balancing of weights the main frame is suspended to support frame by chains then rotate the shaft manually after fixing the blocks at their proper angles. It should be completely balanced. In this position the motor driving belt is removed..

For dynamic balancing of the rotating mass system the main frame is suspended from the support frame by two short links such that the main frame and the supporting frame are in the same plane. Rotatae the statically balanced weights with the help of motor. If they rotate smoothly and without vibrations, they are dynamically balanced..

EXPERIMENTAL PROCEDURE:

- Insert all the weights in sequence 1-2-3-4 from pulley side.
- Fix the pointer and pulley on shaft.
- Fix the pointer on 0 degree on the circular protractor scale.
- Fix the weight no. 2 in horizontal position.
- Rotate the shaft after loosening previous position of pointer and fix it on 25 degree..
- Fix the weight no. 3 in horizontal position..
- Loose the pointer and rotate the shaft to fixed pointer on 188 degree..
- Fix the weight no. 1 in horizontal position..
- Now the weights are mounted in fixed position.
- For the static balancing the system will remain steady in any angular position.
- Now put the belt on pulleys of shaft and motor.
- Supply the main power to the motor dimmer start.
- Gradually increase the speed of motor. If the system runs smoothly and without vibrations, it shows that the system is dynamically balanced.
- Gradually reduced the speed to minimum and then switch off the main supply to stop the system.

STANDARD DATA:

- Mass of 1 =232 gms
- Mass of 2 =244gms
- Mass of 3 =236gms
- Mass of 4 =241gms
- Radius of 1,2,3,4 =r cm.(Same radius)
- Angle between 2 and 3 =25 degree
- Angle between 2 and 4 =197 degree
- Angle between 2 and 1 =188 degree

OBSERVATIONS AND CALCULATIONS:

Plane (1)	Mass(m) (2)	Angle from reference line,θ	Radius(r) (cm)(3)	Mass moment mr (4)	Distance from plane 1(L)(cm)(5)	Couple mrL (6)
1(R.P)						
2.						
3.						
4.						

PRECAUTIONS:

- Do not run the motor at low voltage i.e. less than 180 volts.
- Increase the motor speed gradually.
- Experimental set up is proper tightly before starting experiment.
- Always keep the apparatus free from dust.
- Before starting the rotary switch check the needle of dimmer start at zero position.
-

EXPERIMENT NO. 6

OBJECTIVE: - To Plot the N-Θ Curves For Different Cam Following Pairs.

THEORY:

CAM MECHANISM AND ITS USES:

A cam may be defined as a rotating or a reciprocating element of a mechanism which imparts a rotating, reciprocating or oscillating motion to the another element termed as follower:

In most of the cases the cam is connected to a frame, forming a turning pair and the follower is connected to the frame to form a sliding pair. The cam and the follower form a three link mechanism of the higher pair type. The three links of the mechanism are:

- The cam, which is driving link and has a curved or a straight contact surface.
- The follower, which is the driven link and it gets motion by contact with the surface of the cam.

- The frame which is used to support the cam and guide the follower.

The cam mechanism is used in clocks, printing machines, automatic screw cutting machines, internal combustion engines for operating valves, shoe –making machinery etc.

DESCRIPTION:

Combustion engines for operating valves, shoe –making machinery etc. The shaft runs in a double ball bearing. At the end of the cam shaft a cam can be easily mounted. As the follower is properly guided in gun-metal bushes and the type of the follower can be changed to suit the cam under test.

A graduated circular protector is fitted coaxial with the shaft and a dial gauge can be fitted to note the follower displacement for the angle of cam rotation. A spring is used to provide controlling force to the system. Weights on the follower rod can be adjuster as per the requirement. An arrangement is provided to vary the speed of camshaft. The machine is particularly very useful for testing the cam performance for jump phenomenon during operation. It is used for testing various cam and following pairs, ie.

1. Circular arc cam with mushroom follower
2. Tangent cam with roller follower
3. An eccentric cam with knife edge follower

EXPERIMENTAL PROCEDURE:

- Fix the required cam and follower assembly on the apparatus.
- Fix the dial gauge at top of follower shaft to get the following displacement.
- To find out the angular displacement,rotate the cam manually.
- Note the angular displacement of cam and vertical displacement of the follower with the help of protractor and dial gauge respectively.
- Draw the n-θ curve.
- Now remove the dial gauge from the follower shaft.
- Repeat the procedure for other two cam and follower assemblies..

STANDARD DATA:

The cam and follower assemblies are;

- Circular arc cam with mushroom follower.
- Tangent cam with roller follower.
- An eccentric cam with knife edge follower.
- Weight of follower rod =.775kg
- Weight of mushroom follower =.134kg
- Weight of roller follower =.220kg
- Weight of knife edge follower =.111kg
- Radius of circular arc cam ,r =16mm =.016m
- Radius of eccentric cam,r =17.75mm =.01775m
- Radius of tangent cam,r =16mm =.016m

OBSERVATIONS AND CALCULATIONS:

S.NO	Cam’s angular displacement 0	Follower vertical displacement n(mm)

DESCRIPTION:

The apparatus consist of a M.S. bearing mounted freely on a steel journal shaft. This journal shaft is coupled to a DC motor. Speed regulator is provided with the set up to control the speed of journal shaft, RPM of the journal shaft can be measured using a hand tachometer.

The journal bearing has twelve equal spaced pressure tapping around its circumference and four No. A, B, C, D additional pressure tapping are positioned on the top of bearing..

Small balancing weights are provided with the set up to maintain the bearing in its normal position and avoiding the presentation during the experimentations. For this purpose a rod is attached to the housing and 2 no's weights are fixed on both ends. Distance of the both weight from the journal can be adjusted by sliding both the rods. Third weight is hanged on the center of rod.

Oil film pressures are indicated in a tall 16 tubes directly in head of oil. Clear flexible plastic tubes are clamped and are connected to the tapping spaced around bearing, and thus permit the bearing to turn freely. An oil reservoir accompanies the set up to store the sufficient oil for experiment. This reservoir supplies oli to the bearing.

UTILITIES REQUIRED:

1. Lubricating oil SAE-40 =4Ltrs.app.
2. Power supply =220V AC, Single phase 5amp socket

EXPERIMENTAL PROCEDURE:

- Fill the oil tank with lubricating oil SAE 40up to half of the level.
- Drain out the air from all the tubes on the manometer and check level balance with supply level.
- Check that some oil leakage is there. Some leakage of oil is necessary for cooling purpose.
- Check the direction of rotation and increase the speed of motor slowly.
- Set the speed and let the journal run for about 20 or 25 min. to achieve the steady state.
- Note the RPM of the journal shaft.
- Add the required loads and keep the balancing rod in horizontal position by moving balancing weight on the rod and observe the steady levels.
- When all the tubes free from air then take the pressure reading one by one.
- Repeat the experiment for the various speeds and loads.
- After the test is over set dimmer to zero position and switch off main supply.
- Let settle down the oil in manometer tubes.

OBSERVATION TABLE:

Total load on journal,W=
RPM, N=

S.NO	Tubes no.	Pressure head,p cm of oil
	1	
	2	
	3	
	4	
	5	
	6	
	7	
	8	
	9	
	10	
	11	
	12	
	A	
	B	
	C	

PRECAUTIONS:

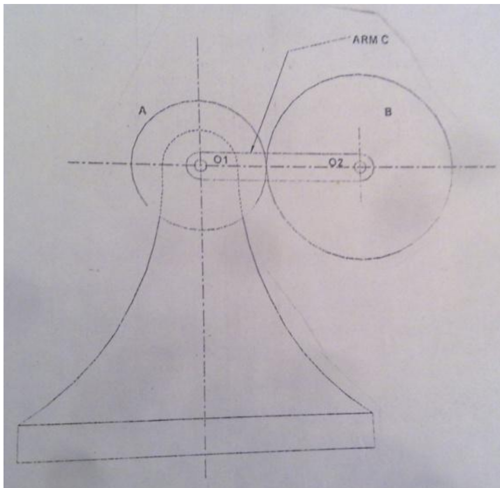
1. Always lubricate the cam before starting the apparatus.
2. Tighten all the nuts properly before starting the apparatus.
3. Always keep apparatus free from dust.

<u>EXPERIMENT NO. 7</u>

OBJECTIVE: - To Measure Epicyclic Gear Ratio between Input Shaft and Output Shaft.
THEORY:
EPICYCLIC GEAR TRAIN:
A simple gear train is the train in which the gear A and the arm C have a common axis at O1, about which they can rotate. The gear B mashes with the gear A and has its axis on the arm at O2.about which the gear B can rotate. If the arm is fixed the gear train is simple and gear A can drive gear B. But if gear A is fixed and arm is rotated about its axis of gear A, then the gear B is force to rotate upon and around gear A. Such the motion is called epicyclic and the gear train arrangement in such a way that one or more members of

their move upon and around another member are known as cyclic gear train. The epicyclic gear train is simple or compound.

The gear trains are useful for transmitting high velocity ratio with gears of moderate size in a comparatively lesser space. The epicyclic gear train are used in the back gear oh lathe, different gear automobiles, wristwatches etc..



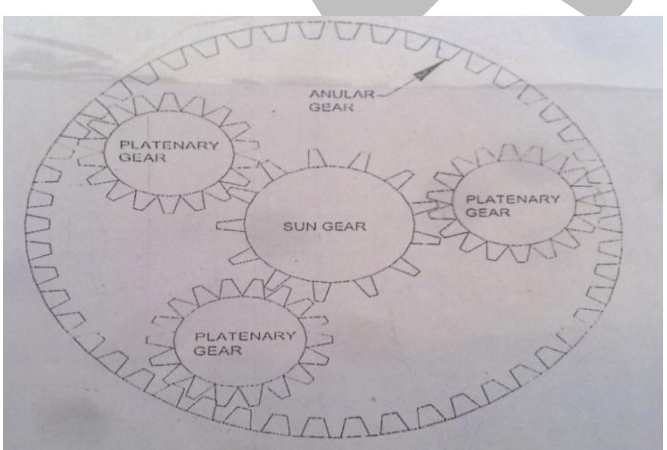
EPICYCLIC GEAR TRAIN

FIG. 1

DESCRIPTION:

Any combination of gear wheels by means of which motion is transmitted from one shaft is called a gear train. In case of epicyclic gear the axis of shaft on which the gears are mounted may move relatively to a fixed axis. In this apparatus internal type of Epicyclic Gear train is demonstrated.

It consists of aepicyclic gear train in which sun gear is mounted or input shaft. Three planet gear are mounted on the arm that rotate freely on the fixed pin and mesh with sun gear and internal teeth of the annular gear. A dc motor is provided for the DC power supply. To measure the holding torque and output torque, spring balance arrangement is given. Digital RPM indicator is provided to measure the speed of input and output shafts. Digital voltmeter and ammeter give the voltage of current.



EPICYCLIC GEAR TRAIN

VELOCITY RATIO OF EPICYCLIC GEAR TRAIN:

The following two methods may be used for finding out the velocity ratio of an epicyclic gear train..
1. Tabular method
2. Algebric method
A compound epicyclic gear train consist of two co-axial shaft S1 and S2.A sun gear(A) and arm (H) three planetary gears, B, C, E and an angular gear. Wheel A has 13 external teeth B,C and E have 18 external teeth. The angular gear has 50 internal teeth. The sun gear A is fixed on input shaft S1.Three planetary or compound gear B,C,E are mesh with sun gear A and angular gear D. The planetary gears are fixed to revolve on the pins of arm H.

Revolution of element

Step. no	Condition of element	Arm H	Gear A	Compound gear B,C,E	Gear D
1		0	+1	-Ta/TB	- TA/TB*TB?TD*_TA/TD
2		0	+X	-X Ta/Tb	_X Ta/Td
3		+Y			

Speed of gear A;
If we know that the speed of arm 271 r.p.m
Therefore Y=271 r.p.m
And the gear D is fixed due to holding
Therefore Y-X Ta/Td=0
271-13/50=0
X=271*50/13=1042.30rpm

Speed of A =X+Y=1042.30+271=1313.34 rpm
1313 rpm in the direction of arm
Speed ratio=Speed of driver/Speed of driven=Speed of sun gear A/speed of arm H
=1313/271=4.85

Let dA, dB and d be the pitch circular diameter of sun gear A, planet gear B, and internally toothed gear D. Assuming the pitch of all the to be same therefore from the fig..
dA+2dn=d
The numbers of teeth r proportional to their pitch circle diameters, therefore TA+2TB=TD
2TB+13=50
2TB=50-13=37
TB=37/2=18.5=18
The numbers of teeth of planetary gears B,C,E are
TB=TC=TE+18

EXPERIMENTAL PROCEDURE:

- Check the experiment set up.
- Give supply to motor from central panel.
- Adjust the RPM of input shaft to some fix value.
- Apply holding torque just to hold the drum. This must be done carefully.
- Take the readings of loads of the holding drum and output drum as well as take readings input and output RPM.
- Take the next reading to apply load on output drum. By applying the load on output drum holding start to rotate..
- Repeat the same procedure for next reading.

STANDARD DATA:

- Number of teeth of SUN gear =13 teeth
- Number of teeth of planet gear =18 teeth
- Number of teeth of annular gear =50 teeth
- Diameter of holding drum =186mm =.186m
- Radius of holding drum =93mm =.093m
- Diameter of output break drum ,R1 =186mm =.186m
- Radius of output brake drum,R2 =93mm =.093m

OBSERVATION TABLE:

s.no	Speed I/P Shaft N1	Speed O/p Shaft N2	G.R =N1/N2
1			
2			
3			
4			

PRECAUTIONS:

- Do not run the motor at low voltage i.e less than 180 volts.

Before starting the motor both the ropes

- Before starting the motor with rotary switch, the diameter state at zero position.
- Increase speed gradually.
- Always keep apparatus free from dust..

EXPERIMENT NO. 8

OBJECTIVE: - To Study the Pressure Profile of Lubricating Oil and Various Conditions of Load and Speed

THEORY:

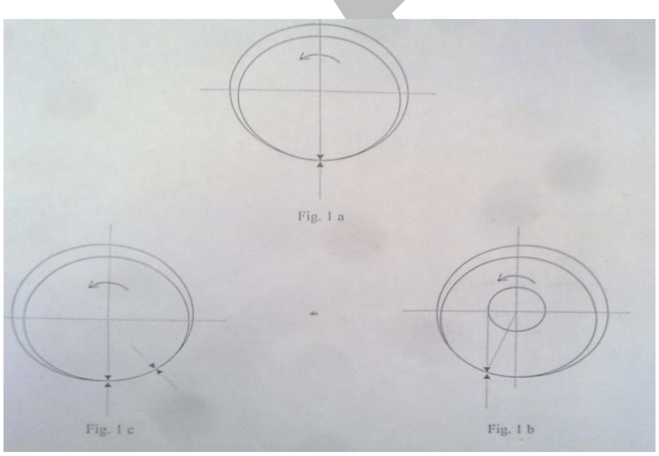
CONCEPT OF JOURNAL BEARING:

The portion of a shaft which revolves in the bearing and is subjected to load at right angle to the axis of shaft is known as journal. The whole unit consisting of journal and its supporting part is known as bearing. The whole process is known as journal bearing.

Journal bearing apparatus is designed on the basis of hydrodynamic bearing action used in practice. In a simple journal bearing the bearing surface is board out to a slightly larger diameter than that of the journal. Thus when a journal is at rest, it makes contact with bearing surface along a line the position of which is determined by the line of action of external load. If the load is vertical as fig 1.a the line of contact is parallel to axis of the journal and directly below that axis..The crescent shaped space between the journal and the bearing will be filled with lubricant…When the rotation begins the first tendency is for line of contact to move up the bearing surface in the opposite direction to that of rotation as shown once which jai 1 b..When the journal slides over the bearing the true reaction on the bearing on the journal is inclined to the normal to the two surfaces at the friction angle θ and this reaction must be in line with the load. The layer of lubricant immediately adjacent to the journal tends to be carried round with it, but is scaped off by the bearing so that a condition of boundary lubricants exists between the high spot on the journal and bearing surface which are actually in contact.

As the speed of rotation of journal increases the viscous force which tends to drag ooil between the surface also increases and more and more of the load is taken by the oil film in the convergent space between the journal and bearing. This gradually shifts the line of contact round the bearing in the direction of motion of the journal. Ultimately the film may break so that the two surfaces are completely separated and the load is transmitted frot the journal to the bearing by the oil. The film will only break if it is possible for the resultant oil pressure to be the equal to load and to have same line of action. the pressure of oil in the diir will vergent part of film may fall below that of atmosphere, in which case air will leak in from the ends of the bearing. Assuming that the necessary conditions are fulfilled and that the complete film is formed.the pt. of nearest approach of journal to the earing will by this time have moved to the position ai 1 c

To formulate the bearing action accurately in mathematical terms is a more complex job. However one can visualize the pateeren of bearing pressure distribution due to the hydrodynamic action with the help of experimental rig.this helps to understand the subject properly.
This apparatus helps to demonstrate and study the effect of important vRIABLES such as speed,viscosity and load,on the pressure distribution in a journal bearing..



PRECAUTIONS:

- Do not run the motor at low voltage ie less than 180 volts.
- Increase the speed gradually.
- Do not run the journal and bearing with out lubricant oil.
- Use clean lubricant oil.

Always keep the apparatus free from dust….

Objective:

To determine the moment of inertia of a flywheel.

Apparatus:

A flywheel, a timer, a meter stick, a hanger and weights.

Theory:

According to Newton's law, F = Ma, where F is the resultant of the external forces acting on the body, 'a' is the linear acceleration of the body and M is its mass. The analogous relation for rotational acceleration is

$$\Sigma\tau = I\,\alpha. \qquad (1)$$

Here $\Sigma\tau$ is the resultant of external torques acting on the body about the axis of rotation, α is the angular acceleration and I is the moment of inertia of the body about the axis of rotation. The kinetic energy of a mass M having a linear velocity v is given by

$$K = \frac{1}{2}mv^2. \qquad (2)$$

In an analogous manner, the kinetic energy of a body of moment of inertia I and having an angular acceleration ω is given by

$$K = \frac{1}{2}I\omega^2. \qquad (3)$$

Thus, in rotational motion, the moment of inertia plays a role which is analogous to the role of mass M in linear motion. The cgs unit of moment of inertia is $gm.cm^2$. The moment of inertia of a body depends on the axis of rotation and the distribution of mass about the axis of rotation.

Equation (3) indicates that a rotating body having a large moment of inertia, like a flywheel, can be used to store large amounts of kinetic energy.

Let a mass m be attached to the free end of a string wound around the axle of a flywheel as shown in Fig. 1. Further, let r be the radius of the axle and T, the tension in the string. If the linear acceleration of mass m is 'a' downward, then by Newton's second law of motion,

$$T - mg = - m a,$$

$$\text{or} \quad T = m(g - a). \qquad (4)$$

The torque acting on the flywheel due to tension T in the string is given by

$$\tau = r T \qquad (5)$$

Now if τ' is the torque due to the frictional forces acting on the flywheel and if α is the angular acceleration of the flywheel, then Eq. (1) yields

$$\tau - \tau' = I \alpha \qquad (6)$$

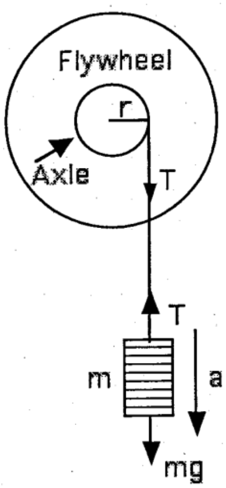


Fig. 1

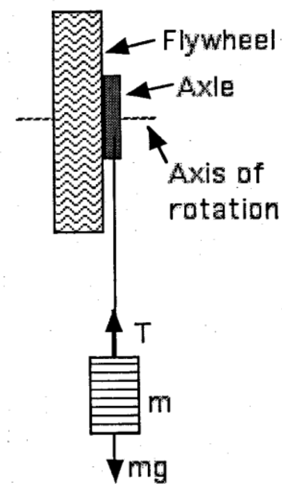


Fig. 2

The linear acceleration 'a' can be determined by measuring the time taken by the mass m to fall from rest through a distance d. In such case,

$d = \frac{1}{2} at^2$, because the initial velocity is zero.

$$\text{Thus} \quad a = \frac{2d}{t^2}. \qquad (7)$$

The torque τ can be determined by using Eqs. (4) and (5), and α can be calculated by $a = r\,\alpha$.

By determining a number of pairs of values of τ and α (for different values of m), and by plotting a graph between τ and α, we shall get a straight line graph according to Eq. (6). Here τ' is assumed to be constant. If (τ_1, α_1) and (τ_2, α_2) are the coordinates of two points on this graph, then

$\tau_1 - \tau' = I\,\alpha_1$ and $\tau_2 - \tau' = I\,\alpha_2$.

By subtracting, we get $\tau_2 - \tau_1 = I(\alpha_2 - \alpha_1)$.

$$\text{Or} \quad I = \frac{\tau_2 - \tau_1}{\alpha_2 - \alpha_1}. \qquad (8)$$

If the flywheel is a circular disk of mass M and radius R_1, the theoretical value of its moment of inertia is given by

$$I = \frac{1}{2} M R_1^2. \qquad (9)$$

The radius of gyration (k) of a body of moment of inertia I and mass M is defined by the relation $I = Mk^2$.

$$\text{Thus} \quad k = \sqrt{\frac{I}{M}}. \qquad (10)$$

A particle of mass M placed at a distance k from the axis of rotation will have the same moment of inertia as that of the flywheel.

Procedure:

1. Determine d, the distance of fall of mass m by measuring the length of the string (including the height of the hanger). Record the mass of the hanger.
2. Place a suitable mass on the hanger, wind the string around the axle (the black disk attached to the side of the flywheel) and place the hanger on the small circular platform under the flywheel. Trip the platform and simultaneously start the timer. Stop the timer as soon as the string gets detached from the small peg on the axle.
3. Repeat step 2 by changing the mass on the hanger 4 or 5 times.
4. Measure the diameter of the axle. Record the radius and mass of the flywheel.