ARUNAI ENGINEERING COLLEGE

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DEPARTMENT OF MECHANICAL ENGINEERING

CE 8381- FLUID MECHANICS & MACHINERY AND

STRENGTH OF MATERIALS LABORATORY

LABORATORY MANUAL

CE 8381 FLUID MECHANICS AND MACHINERY LABORATORY **L T P C**
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OBJECTIVES:

Upon Completion of this subject, the students can able to have hands on experience in flow measurements using different devices and also perform calculation related to losses in pipes and also perform characteristic study of pumps, turbines etc.,

LIST OF EXPERIMENTS

1. Determination of the Coefficient of discharge of given Orifice meter.
2. Determination of the Coefficient of discharge of given Venturi meter.
3. Calculation of the rate of flow using Rota meter.
4. Determination of friction factor for a given set of pipes.
5. Conducting experiments and drawing the characteristic curves of centrifugal pump/ submergible pump
6. Conducting experiments and drawing the characteristic curves of reciprocating pump.
7. Conducting experiments and drawing the characteristic curves of Gear pump.
8. Conducting experiments and drawing the characteristic curves of Pelton wheel.
9. Conducting experiments and drawing the characteristics curves of Francis turbine.
10. Conducting experiments and drawing the characteristic curves of Kaplan turbine.

OUTCOMES:

- Ability to use the measurement equipments for flow measurement
- Ability to do performance trust on different fluid machinery

LIST OF EQUIPMENT FOR A BATCH OF 30 STUDENTS

S. NO.	NAME OF THE EQUIPMENT	Qty.
1	Orifice meter setup	1
2	Venturi meter setup	1
3	Rotameter setup	1
4	Pipe Flow analysis setup	1
5	Centrifugal pump/submergible pump setup	1
6	Reciprocating pump setup	1
7	Gear pump setup	1
8	Pelton wheel setup	1
9	Francis turbine setup	1
10	Kaplan turbine setup	1

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DETERMINATION OF THE CO-EFFICIENT OF DISCHARGE OF GIVEN ORIFICE METER

Exp No: 1

Date :

AIM:

To determine the co-efficient discharge through orifice meter

APPARATUS REQUIRED:

1. Orifice meter
2. Differential U tube
3. Collecting tank
4. Stop watch
5. Scale

FORMULAE:

1. **ACTUAL DISCHARGE**:

$$Q_{act} = A \times h / t \ (m^3 / s)$$

2. **THEORTICAL DISCHARGE**:

$$Q_{th} = a_1 \times a_2 \times \sqrt{2gh} / \sqrt{a_1^2 - a_2^2} \ (m^3 / s)$$

Where:

A = Area of collecting tank in m^2

h = Height of collected water in tank = 10 cm

a_1 = Area of inlet pipe in, m^2

a_2 = Area of the throat in m^2

g = Specify gravity in m / s^2

t = Time taken for h cm rise of water

H = Orifice head in terms of flowing liquid

$= (H_1 \sim H_2)(s_m / s_1 - 1)$

Where:

H1 = Manometric head in first limb

H2 = Manometric head in second limb

s_m = Specific gravity of Manometric liquid

(i.e.) Liquid mercury Hg = 13.6

s_1 = Specific gravity of flowing liquid water = 1

3. **CO EFFICENT OF DISCHARGE:**

Co- efficient of discharge = Q act / Q th (no units)

DESCRIPTION:

Orifice meter has two sections. First one is of area a_1, and second one of area a_2, it does not have throat like venturimeter but a small holes on a plate fixed along the diameter of pipe. The mercury level should not fluctuate because it would come out of manometer.

PROCEDURE:

1. The pipe is selected for doing experiments
2. The motor is switched on, as a result water will flow
3. According to the flow, the mercury level fluctuates in the U-tube manometer
4. The reading of H_1 and H_2 are noted
5. The time taken for 10 cm rise of water in the collecting tank is noted
6. The experiment is repeated for various flow in the same pipe
7. The co-efficient of discharge is calculated

RESULT:

The co efficient of discharge through orifice meter is ……… (No unit)

S.no	Diameter in mm	Manometric reading		Manometric head H=(H1~H2) x 12.6 x 10^{-2}	Time taken for h cm rise of water t Sec	Actual discharge Q act x 10^{-3} m^3 / s	Theoretical discharge Qth x 10^{-3} m^3 / s	Co-efficient of discharge Cd (no unit)
		H1 cm of Hg	H2 cm of Hg					
							Mean Cd =	

DETERMINATION OF THE CO EFFICIENT OF DISCHARGE OF GIVEN VENTURIMETER

Exp No: 2

Date:

AIM:

To determine the coefficient of discharge for liquid flowing through venturimeter.

APPARATUS REQUIRED:

1. Venturimeter
2. Stop watch
3. Collecting tank
4. Differential U-tube
5. Manometer
6. Scale

FORMULAE:

1. **ACTUAL DISCHARGE:**

$$Q_{act} = A \times h / t \ (m^3 / s)$$

2. **THEORTICAL DISCHARGE:**

$$Q_{th} = a_1 \times a_2 \times \sqrt{2gh} / \sqrt{a_1^2 - a_2^2} \ (m^3 / s)$$

Where:

A = Area of collecting tank in m^2

h = Height of collected water in tank = 10 cm

a_1 = Area of inlet pipe in m^2

a_2 = Area of the throat in m^2

g = Specify gravity in m / s^2

t = Time taken for h cm rise of water

H = Orifice head in terms of flowing liquid $(H_1 \sim H_2)(s_m / s_1 - 1)$

Where:

$H1$ = Manometric head in first limb

$H2$ = Manometric head in second limb

s_m = Specific gravity of Manometric liquid

(i.e.) Liquid mercury Hg = 13.6

s_1 = Specific gravity of flowing liquid water = 1

3. **CO EFFICENT OF DISCHARGE:**

Co- efficient of discharge = Q act / Q th (no units)

DESCRIPTION:

Venturi meter has two sections. One divergent area and the other throat area. The former is represented as a_1 and the later is a_2 water or any other liquid flows through the Venturi meter and it passes to the throat area the value of discharge is same at a_1 and a_2 .

PROCEDURE:

1. The pipe is selected for doing experiments
2. The motor is switched on, as a result water will flow
3. According to the flow, the mercury level fluctuates in the U-tube manometer
4. The reading of H_1 and H_2 are noted
5. The time taken for 10 cm rise of water in the collecting tank is noted
6. The experiment is repeated for various flow in the same pipe
7. The co-efficient of discharge is calculated

RESULT:

The co efficient of discharge through Venturimeter is ……… (No unit)

S.no	Diameter in mm	Manometric reading		Manometric head H=(H1~H2) x 12.6 x 10^{-2}	Time taken for h cm rise of water t sec	Actual discharge Q act x 10^{-3} m^3 / s	Theoretical discharge Qth x 10^{-3} m^3 / s	Co-efficient of discharge Cd (no unit)
		H1 cm of Hg	H2 cm of Hg					
							Mean Cd =	

CALCULATION OF THE RATE OF FLOW USING ROTOMETER

Exp No: 3

Date:

AIM:

To determine the percentage error in Rotometer with the actual flow rate.

APPARATUS REQUIRED:

1. Rotometer setup
2. Measuring scale
3. Stopwatch.

FORMULAE:

1. **ACTUAL DISCHARGE:**

$$Q_{act} = A \times h / t \ (m^3 / s)$$

Where:

A = Area of the collecting tank (m^2)

h= 10 cm rise of water level in the collecting tank (10^{-2} m).

t = Time taken for 10 cm rise of water level in collecting tank.

CONVERSION:

Actual flow rate (lit / min), Q_{act} = Qact x 1000 x 60 lit /min

$$\text{Percentage error of Rotometer} = \frac{\text{Rotometer reading} \sim \text{Actual} \times 100\ \%}{\text{Rotometer reading}}$$

$$= R \sim Qact / R \times 100\ \%$$

PROCEDURE:

1. Switch on the motor and the delivery valve is opened
2. Adjust the delivery valve to control the rate in the pipe
3. Set the flow rate in the Rotometer, for example say 50 litres per minute
4. Note down the time taken for 10 cm rise in collecting tank
5. Repeat the experiment for different set of Rotometer readings
6. Tabular column is drawn and readings are noted
7. Graph is drawn by ploting Rotometer reading Vs percentage error of the Rotometer

RESULT:

The percentage error of the Rotometer was found to be……. %

S.no	Rotometer Reading (lpm)	Actual Discharge Q_{act} (m^3/sec)	Time taken for 10cm rise of water In tank (t sec)	Actual discharge Q_{act} (lpm)	Percentage Error of Rotometer (%)

DETERMINATION OF FRICTION FACTOR OF GIVEN SET OF PIPES

Exp No: 4

Date:

AIM:

To find the friction 'f' for the given pipe.

APPARATUS REQUIRED:

1. A pipe provided with inlet and outlet and pressure tapping
2. Differential u-tube manometer
3. Collecting tank with piezometer
4. Stopwatch
5. Scale

FORMULAE:

1. FRICTION FACTOR (F):

$$f = 2 \times g \times d \times h_f / l \times v^2 \quad \text{(no unit)}$$

Where,

g = Acceleration due to gravity (m / sec^2)
d = Diameter of the pipe (m)
l = Length of the pipe (m)
v = Velocity of liquid following in the pipe (m / s)
h_f = Loss of head due to friction (m)
= $h1 \sim h_2$

Where

h_1 = Manometric head in the first limbs

h_2 = Manometric head in the second limbs

2. ACTUAL DISCHARGE:

$Q = A \times h / t$ (m^3 / sec)

Where

A = Area of the collecting tank (m^2)

h = Rise of water for 5 cm (m)

t = Time taken for 5 cm rise (sec)

3. VELOCITY:

$V = Q / a$ (m / sec)

Where

Q = Actual discharge (m^3/ sec)

A = Area of the pipe (m^2)

DESCRIPTION:

When liquid flows through a pipeline it is subjected to frictional resistance. The frictional resistance depends upon the roughness of the pipe. More the roughness of the pipe will be more the frictional resistance. The loss of head between selected lengths of the pipe is observed.

PROCEDURE:

1. The diameter of the pipe is measured and the internal dimensions of the collecting tank and the length of the pipe line is measured
2. Keeping the outlet valve closed and the inlet valve opened
3. The outlet valve is slightly opened and the manometer head on the limbs h_1 and h_2 are noted
4. The above procedure is repeated by gradually increasing the flow rate and then the corresponding readings are noted.

RESULT:

1. The frictional factor 'f' for given pipe = $\times 10^{-2}$ (no unit)
2. The friction factor for given pipe by graphical method = …… $\times 10^{-2}$ (no unit)

S.no	Diameter of pipe mm	Manometer readings			Time for 5cm rise of water t sec	Actual discharge Qact x 10^{-3} m^3 / s	Velocity V m/s	V^2 m^2 / s^2	Friction factor f x 10^{-2}
		h1 x 10^{-2}	h2 x 10^{-2}	hf = (h1-h2) x 10^{-2}					
								Mean f =	

CHARACTERISTICS TEST ON CENTRIFUGAL PUMP

Exp No: 5

Date:

AIM:

To study the performance characteristics of a centrifugal pump and to determine the characteristic with maximum efficiency.

APPARATUS REQUIRED:

1. Centrifugal pump setup
2. Meter scale
3. Stop watch

FORMULAE :

1.ACTUAL DISCHARGE:

$$Q_{act} = A \times y / t \ (m^3 / s)$$

Where:

A = Area of the collecting tank (m^2)

y = 10 cm rise of water level in the collecting tank

t = Time taken for 10 cm rise of water level in collecting tank.

2. TOTAL HEAD:

$$H = H_d + H_s + Z$$

Where:

H_d = Discharge head, meter

H_s = Suction head, meter

Z = Datum head, meter

3. INPUT POWER:

$$I/P = (3600 \times N \times 1000) / (E \times T) \quad \text{(watts)}$$

Where,

N = Number of revolutions of energy meter disc

E = Energy meter constant (rev / Kw hr)

T = time taken for 'Nr' revolutions (seconds)

4. OUTPUT POWER:

$$Po = \rho \times g \times Q \times H / 1000 \quad \text{(watts)}$$

Where,

ρ = Density of water (kg / m^3)

g = Acceleration due to gravity (m / s^2)

H = Total head of water (m)

5. EFFICIENCY:

$$\eta_o = (\text{Output power o/p / input power I/p}) \times 100 \%$$

Where,

O/p = Output power kW

I/ p = Input power kW

DESCRIPTION:

PRIMING:

The operation of filling water in the suction pipe casing and a portion delivery pipe for the removal of air before starting is called priming.

After priming the impeller is rotated by a prime mover. The rotating vane gives a centrifugal head to the pump. When the pump attains a constant speed, the delivery valve is gradually opened. The water flows in a radially outward direction. Then, it leaves the vanes at the outer circumference with a high velocity and pressure. Now kinetic energy is gradually converted in to pressure energy. The high-pressure water is through the delivery pipe to the required height.

PROCEDURE:

1. Prime the pump close the delivery valve and switch on the unit
2. Open the delivery valve and maintain the required delivery head

3. Note down the reading and note the corresponding suction head reading
4. Close the drain valve and note down the time taken for 10 cm rise of water level in collecting tank
5. Measure the area of collecting tank
6. For different delivery tubes, repeat the experiment
7. For every set reading note down the time taken for 5 revolutions of energy meter disc.

GRAPHS:

1. Actual discharge Vs Total head
2. Actual discharge Vs Efficiency
3. Actual discharge Vs Input power
4. Actual discharge Vs Output power

RESULT:

Thus the performance characteristics of centrifugal pump was studied and the maximum efficiency was found to be _____________

S.no	Suction gauge Hs m of water	Suction head Hs m of water	Delivery Gauge Reading (hd) m of water	Delivery Head (Hd) m of water	Total Head (H) m of water	Time taken for 'h' rise of water (t) S	Time taken for Nr revolution t S	Actual Discharge (Qact) x10^{-3} m^3\sec	Input Power (Pi) watt	Output Power (Po) watt	% η

CHARACTERISTICS CURVES OF SUBMERSIBLE PUMP

Exp No: 6

Date:

AIM:

To study the performance characteristics of a submersible pump.

APPARATUS REQUIRED:

1. Submersible pump
2. Meter scale
3. Stop watch

FORMULAE:

1. ACTUAL DISCHARGE:

$$Q_{act} = A \times h / t \qquad (m^3 / sec)$$

Where,

A = Area of the collecting tank (m²)

h = Height of the water level collected (cm)

t = Time taken for 'h' rise of water (seconds)

x = Distance between the suction and delivery gauge

2. INPUT POWER:

$$P_i = (3600 \times N_r \times 1000) / (N_e \times t_e) \quad (watts)$$

Where,

N_r = number of revolutions of energy meter disc

N_e = energy meter constant (rev / Kw hr)

t_e = time taken for 'Nr' revolutions (seconds)

3. OUTPUT POWER:

$$P_o = W \times Q_{act} \times H \qquad (watts)$$

Where,

W = specific weight of water (N / m^3)

Qact = actual discharge (m^3 / s)

H = total head of water (m)

4. EFFICIENCY:

$\%\eta$ = (Output power Po / input power Pi) × 100

DESCRIPTION:

In submergible pump electric motor and pump are coupled together and both are submerged in the water. The electric current is conducted through a waterproof cable. This is multi stage centrifugal pump with radial or mixed flow impellers.

The suction housing of the pump is fitted between the pump and motors are provided with a perforated strainer. The windings of the motor are insulated well and cooled by water. A gate valve, which is a non-return valve, is provided at the top of the pump to discharge water.

PROCEDURE:

1. The submersible pump is started
2. The delivery gauge reading is set to the required value by means of Adjusting the gate-valve
3. The time taken for Nr revolutions in the energy meter disc is Noted with the help of stop watch
4. The time taken for 'h' rise in water level in the collecting tank is Found carefully. If the water flow is heavy reduce the 'h' value
5. The experiment is repeated for different delivery gauge readings
6. Finally the readings are tabulated and calculated

GRAPHS:

1. Actual discharge Vs Total head
2. Actual discharge Vs Input power
3. Actual discharge Vs Efficiency

RESULT:

The performance characteristic of the submersible pump is studied and the efficiency is calculated …………… %

S.no	Delivery Gauge Reading [Hd] Kg/cm^2	Delivery Head [Hd]x10 m of water	Total Head [Hd +2] m of water	Time taken for 'h' rise Of water [t] Sec	Time taken for Nr revolution Sec	Actual Discharge [Qact] m^3/sec	Input Power [Pi] Watts	Output Power [Po] watts	Efficiency η %
								Mean =	

CHARACTERISTICS CURVES OF RECIPROCATING PUMP

Exp No: 7

Date:

AIM:

To study the performance characteristics of a reciprocating pump and to determine the characteristic with maximum efficiency.

APPARATUS REQUIRED:

1. Reciprocating pump
2. Meter scale
3. Stop watch

FORMULAE:

1. **ACTUAL DISCHARGE:**

$$Q_{act} = A \times y / t \qquad (m^3 / s)$$

Where:

A = Area of the collecting tank (m^2)

y = 10 cm rise of water level in the collecting tank

t = Time taken for 10 cm rise of water level in collecting tank

2. TOTAL HEAD:

$$H = Hd + Hs + Z$$

Where:

H_d = Discharge head; Hd = Pd x 10, m

H_s = Suction head; Pd = Ps x 0.0136, m

Z = Datum head, m

P_d = Pressure gauge reading, kg / cm^2

P_s = Suction pressure gauge reading, mm of Hg

3. INPUT POWER:

$$P_i = (3600 \times N) / (E \times T) \qquad (Kw)$$

Where,

N = Number of revolutions of energy meter disc

E = Energy meter constant (rev / Kw hr)

T = time taken for 'N' revolutions (seconds)

4. OUTPUT POWER:

$$P_o = \rho \times g \times Q \times H / 1000 \quad \text{(Kw)}$$

Where,

ρ = Density of water (kg / m³)

g = Acceleration due to gravity (m / s2)

H = Total head of water (m)

Q = Discharge (m3 / sec)

5. EFFICIENCY:

$$\eta_o = (\text{Output power po / input power pi}) \times 100\ \%$$

Where,

Po = Output power KW

Pi = Input power KW

PROCEDURE:

1. Close the delivery valve and switch on the unit
2. Open the delivery valve and maintain the required delivery head
3. Note down the reading and note the corresponding suction head reading
4. Close the drain valve and note down the time taken for 10 cm rise of water level in collecting tank
5. Measure the area of collecting tank
6. For different delivery tubes, repeat the experiment
7. For every set reading note down the time taken for 5 revolutions of energy meter disc.

GRAPHS:

1. Actual discharge Vs Total head
2. Actual discharge Vs Efficiency
3. Actual discharge Vs Input power
4. Actual discharge Vs Output power

RESULT:

The performance characteristic of the reciprocating pump is studied and the efficiency is calculated …………… %

S.no	Delivery pressure reading Pd kg / cm^2	Suction pressure reading Ps mm of Hg	Delivery head Hd=Pdx10.0	Suction head Hs = Ps x 0.0136	Datum head Z m	Total head H	Time taken for 10 cm of rise of water in tank t sec	Actual discharge Q_{act} m^3/s	Time taken for N rev of energy meter disc t sec	Input power Pi kw	Output power Po kw	η %
											Mean =	

CHARACTERISTICS CURVES OF GEAR OIL PUMP

Exp No: 8

Date:

AIM:

To draw the characteristics curves of gear oil pump and also to determine efficiency of given gear oil pump.

APPARATUS REQUIRED:

1. Gear oil pump setup
2. Meter scale
3. Stop watch

FORMULAE:

1. ACTUAL DISCHARGE:

Qact = A x y / t (m³ / sec)

Where,

A = Area of the collecting tank (m²)

y = Rise of oil level in collecting tank (cm)

t = Time taken for ‘h’ rise of oil in collecting tank (s)

2. TOTAL HEAD:

H = Hd + Hs + Z

Where

Hd = Discharge head; Hd = Pd x 12.5, m

Hs = Suction head; Pd = Ps x 0.0136, m

Z = Datum head, m

Pd = Pressure gauge reading, kg / cm^2

Ps = Suction pressure gauge reading, mm of Hg

3. INPUT POWER:

Pi = (3600 × N) / (E× T) (kw)

Where,

Nr = Number of revolutions of energy meter disc

Ne = Energy meter constant (rev / Kw hr)

te = Time taken for ‘Nr’ revolutions (seconds)

4. OUTPUT POWER:

$$P_o = W \times Q_{act} \times H / 1000 \quad \text{(watts)}$$

Where,

W = Specific weight of oil (N / m^3)

Qact = Actual discharge h = (m^3 / s)

Total head of oil (m)

5. EFFICIENCY:

$$\%\eta = (\text{Output power } P_o / \text{input power } P_i) \times 100$$

DESCRIPTION:

The gear oil pump consists of two identical intermeshing spur wheels working with a fine clearance inside the casing. The wheels are so designed that they form a fluid tight joint at the point of contact. One of the wheels is keyed to driving shaft and the other revolves as the driven wheel.

The pump is first filled with the oil before it starts. As the gear rotates, the oil is trapped in between their teeth and is flown to the discharge end round the casing. The rotating gears build-up sufficient pressure to force the oil in to the delivery pipe.

PROCEDURE:

1. The gear oil pump is stated.
2. The delivery gauge reading is adjusted for the required value.
3. The corresponding suction gauge reading is noted.
4. The time taken for ‘N’ revolutions in the energy meter is noted with the help of a stopwatch.
5. The time taken for ‘h’ rise in oil level is also noted down after closing the gate valve.
6. With the help of the meter scale the distance between the suction and delivery gauge is noted.
7. For calculating the area of the collecting tank its dimensions are noted down.
8. The experiment is repeated for different delivery gauge readings.
9. Finally the readings are tabulated.

GRAPH:

1. Actual discharge Vs Total head
2. Actual discharge Vs Efficiency
3. Actual discharge Vs Input power
4. Actual discharge Vs Output power

RESULT:

Thus the performance characteristics of gear oil pump were studied and maximum efficiency was found to be. ………%.

S.no	Delivery pressure reading Pd	Suction pressure reading Ps mm of Hg	Delivery head Hd=Pdx 12.5 m	Suction head Hs = Ps x 0.0136 m	Datum head Z m	Total head H m	Time taken for 10 cm of rise of water in tank t sec	Actual discharge Q_{act} m^3/s	Time taken for N rev of energy meter disc t sec	Input power Pi kw	Output power Po kw	η %
											Mean =	

CHARACTERISTICS CURVES OF PELTON WHEEL

Exp No: 9

Date:

AIM:

To conduct load test on pelton wheel turbine and to study the characteristics of pelton wheel turbine.

APPARATUS REQUIRED:

1. Venturimeter
2. Stopwatch
3. Tachometer
4. Dead weight

FORMULAE:

1. **VENTURIMETER READING:**

$h = (P1 \sim P2) \times 10$ (m of water)

Where,

P1, P2 - venturimeter reading in Kg/cm^2

2. DISCHARGE:

$Q = 0.0055 \times \sqrt{h}$ (m^3 / s)

3. BRAKE HORSE POWER:

$BHP = (\pi \times D \times N \times T) / (60 \times 75)$ (hp)

Where,

N = Speed of the turbine in (rpm)

D = Effective diameter of brake drum = 0.315 m

T = Torsion in To + T1 – T2 (Kg)

4. INDICATED HORSE POWER:

$IHP = (1000 \times Q \times H) / 75$ (hp)

Where,

H = Total head (m)

5. PERCENTAGE EFFICIENCY:

$$\%\eta = (B.H.P / I.H.P \times 100) \quad (\%)$$

DESCRIPTION:

Pelton wheel turbine is an impulse turbine, which is used to act on high loads and for generating electricity. All the available heads are classified in to velocity energy by means of spear and nozzle arrangement. Position of the jet strikes the knife-edge of the buckets with least relative resistances and shocks. While passing along the buckets the velocity of the water is reduced and hence an impulse force is supplied to the cups which in turn are moved and hence shaft is rotated.

PROCEDURE:

1. The Pelton wheel turbine is started.
2. All the weight in the hanger is removed.
3. The pressure gauge reading is noted down and it is to be maintained constant for different loads.
4. The venturimeter readings are noted down.
5. The spring balance reading and speed of the turbine are also noted down.
6. A 5Kg load is put on the hanger, similarly all the corresponding readings are noted down.
7. The experiment is repeated for different loads and the readings are tabulated.

GRAPHS:

The following graphs are drawn.

1. BHP Vs IHP
2. BHP Vs speed
3. BHP Vs Efficiency

RESULT:

Thus the performance characteristics of the Pelton Wheel Turbine are done and the maximum efficiency of the turbine is ………. %

S.no	Pressure Gauge Reading [Hp] Kg\cm^2	Total Head [H] m of water	Venturimeter reading Kg\cm^2		H= (P1-P2) x 10 m of water	Weight of hanger To Kg	Speed of turbine N Rpm	Weigh of hanger [T1] kg	Spring Balance T2 Kg	Tension [T] Kg	Discharge Q x10^{-3} m^3\sec	B.H.P hp	I.H.P hp	η %
			P1	P2										
											Mean =			

CHARACTERISTICS CURVES OF FRANCIS TURBINE

Exp No: 10

Date:

AIM:

To conduct load test on franchis turbine and to study the characteristics of francis turbine.

APPARATUS REQUIRED:

1. Stop watch
2. Tachometer

FORMULAE:

1. VENTURIMETER READING:

h = (p1 - p2) x 10 (m)

Where

P1, p2- venturimeter readings in kg / cm^2

2. DISCHARGE:

Q = 0.011 x $\sqrt{h}$ (m^3 / s)

3. BRAKE HORSEPOWER:

BHP = π x D x N x T / 60 x 75 (h p)

Where

N = Speed of turbine in (rpm)

D = Effective diameter of brake drum = 0.315m

T = torsion in [kg]

4. INDICATED HORSEPOWER:

HP = 1000 x Q x H / 75 (hp)

Where

H – Total head in (m)

5. PERCENTAGE EFFICIENCY:

%η = B.H.P x 100 / I.H.P (%)

DESCRIPTION:

Modern Francis turbine in an inward mixed flow reaction turbine it is a medium head turbine. Hence it required medium quantity of water. The water under pressure from the penstock enters the squirrel casing. The casing completely surrounds the series of fixed vanes. The guides' vanes direct the water on to the runner. The water enters the runner of the turbine in the dial direction at outlet and leaves in the axial direction at the inlet of the runner. Thus it is a mixed flow turbine.

PROCEDURE:

1. The Francis turbine is started
2. All the weights in the hanger are removed
3. The pressure gauge reading is noted down and this is to be maintained constant for different loads
4. Pressure gauge reading is assended down
5. The venturimeter reading and speed of turbine are noted down
6. The experiment is repeated for different loads and the reading are tabulated.

GRAPHS:

The following graphs are drawn

1. BHP (vs.) IHP
2. BHP (vs.) speed
3. BHP (vs.) % efficiency

RESULT:

Thus the performance charactertics of the Francis wheel turbine are done and the maximum efficiency of the turbine is …………. %

S.no	Pressure Gauge Reading [Hp] Kg\cm^2		Total Head [H] m of water	Venturimeter reading Kg\cm^2		H= (P1-P2) x 10 m of water	Weight of hanger To Kg	Speed of turbine N Rpm	Weigh of hanger [T1] kg	Spring Balance T2 Kg	Tension [T] Kg	Discharge Q x10^{-3} m^3\sec	B.H.P hp	I.H.P hp	η %
	H1	H2		P1	P2										
														Mean	

CHARACTERISTICS CURVES OF TRIANGULAR NOTCH

Exp No: 11

Date:

AIM:

To determine the co-efficient of discharge of flow through triangular notch.

APPARATUS REQUIRED:

1. Notch tank
2. Triangular notch
3. Hook gauge
4. Collecting tank
5. Stop watch
6. Piezo meter
7. Meter scale

FORMULAE:

1. ACTUAL DISCHARGE:

$Q_{act} = A \times h / t$ (m^3 / sec)

Where,

A = Area of the collecting tank (m^2)

h = Rise of water level in collecting tank (cm)

t = Time taken for 'h' rise of oil in collecting tank (s)

2. THEORETICAL DISCHARGE:

$Q_{the} = (8 / 15) \times (\tan \theta / 2) \sqrt{2 \times g} \times H^{5/2}$ (m^3 / s)

Where

H = Manometer height in m

g = Gravity in m / s

3. CO-EFFICIENT OF DISCHARGE:

$Cd = Q_{act} / Q_{the}$ (no unit)

DESCRIPTION:

1. The inlet valve is opened and water is allowed to rise up to the level of the triangular notch
2. The pointer of the manometer gauge is adjusted so that it coincides the water surface and note down reading
3. The inlet valve is opened so that the water flows over the notch at the same rate
4. The water level is noted by means of point gauge
5. The readings for H2 is noted
6. The time required for10 cm rise of water level is noted
7. The above procedure is repeated for different discharge

RESULT:

The co-efficient of discharge of triangular notch is Cd = …… (No unit)

S.no	Manometric reading			Time taken for 10 cm of rise of water t sec	Actual discharge Q_{act} $x10^{-3}$ $m^3\backslash sec$	Theoretical discharge Q_{the} $x10^{-3}$ $m^3 \backslash sec$	Co efficient of discharge Cd (no unit)
	H1 cm	H2 cm	H= H1~ H2 cm				
						Mean =	

KAPLAN TURBINE TEST RIG

Exp No: 12

Date:

AIM:

To study the characteristics of a Kaplan turbine

DESCRIPTION:

Kaplan turbine is an axial flow reaction turbine used in dams and reservoirs of low height to convert hydraulic energy into mechanical and electrical energy. They are best suited for low heads say from 10m to 5 m. the specific speed ranges from 200 to 1000

The turbine test rig consists of a 3.72 KW (5 Hp) turbine supplied with water from a suitable 20 Hp mixed flow pump through pipelines, sluice valve, and a flow measuring orifice meter. The turbine consists of a cast-iron body with a volute casing, and axial flow gunmetal runner with adjustable pitch vanes, a ring of adjustable guide vanes and draft tube. The runner consists of four numbers of adjustable vanes of aerofoil section. These vanes can be adjusted by means of a regulator, which changes the inlet and outlet angles of the runner vanes to suit the operating conditions. The marking at the outer end of the shaft indicates the amount of opening the vanes. The guide van can be rotated about their axis by means of hand wheel and the position indicated by a pair of dummy guide vanes fixed outside the turbine casing. A rope brake drum is mounted on the turbine shaft to absorb the power developed. Suitable dead weights and a hanger arrangement, a spring balance and cooling water arrangement is provided for the brake drum.

Water under pressure from pump enters through the volute casing and the guiding vanes into the runner while passing through the spiral casing and guide vanes a part of the pressure energy(potential energy) is converted into velocity energy(kinetic energy). Water thus enters the runner at a high velocity and as it passes through the runner vanes, the remaining potential energy is converted into kinetic energy due to curvature of the vanes the kinetic energy is transformed in to mechanical energy, i.e., the water head is converted into mechanical energy and hence the number rotates. The water from the runner is then discharged into the tailrace. Operating guide vane also can regulate the discharge through the runner.

The flow through the pipelines into the turbine is measured with the office meter fitted in the pipeline. A mercury manometer is used to measure the pressure difference across the orifice meter. The net pressure difference across the turbine output torque is measured with a pressure gauge and vacum gauge. The turbine output torque is determined with the rope brake drum. A tachometer is used to measure the rpm.

EXPERIMENTAL PROCEDURE:

1. Keep the runner vane at require opening
2. Keep the guide vanes at required opening
3. Prime the pump if necessary
4. Close the main sluice valve and they start the pump.
5. Open the sluice valve for the required discharge when the pump motor switches from star to delta mode.
6. Load the turbine by adding weights in the weight hanger. Open the brake drum cooling water gate valve for cooling the brake drum.
7. Measure the turbine rpm with tachometer
8. Note the pressure gauge and vacum gauge readings
9. Note the orifice meter pressure readings.

Repeat the experiments for other loads

CE8381 **STRENGTH OF MATERIALS LABORATORY**

L	T	P	C
0	0	4	2

OBJECTIVES:

- To study the mechanical properties of materials when subjected to different types of loading.
- To verify the principles studied in Fluid Mechanics theory by performing experiments in lab.

STRENGTH OF MATERIALS **30**

LIST OF EXPERIMENTS

1. Tension test on a mild steel rod
2. Double shear test on Mild steel and Aluminum rods
3. Torsion test on mild steel rod
4. Impact test on metal specimen
5. Hardness test on metals - Brinnell and Rockwell Hardness Number
6. Deflection test on beams
7. Compression test on helical springs
8. Strain Measurement using Rosette strain gauge
9. Effect of hardening- Improvement in hardness and impact resistance of steels.
10. Tempering- Improvement Mechanical properties Comparison

(i) Unhardened specimen (ii) Quenched Specimen and (iii) Quenched and tempered specimen.

11. Microscopic Examination of

(i) Hardened samples (ii) Hardened and tempered samples

LIST OF EQUIPMENT FOR BATCH OF 30 STUDENTS

S.No.	NAME OF THE EQUIPMENT	Qty.
1	Universal Tensile Testing machine with double 1 shear attachment – 40 Ton Capacity	1
2	Torsion Testing Machine (60 NM Capacity)	1
3	Impact Testing Machine (300 J Capacity)	1
4	Brinell Hardness Testing Machine	1
5	Rockwell Hardness Testing Machine	1
6	Spring Testing Machine for tensile and compressive loads (2500 N)	1
7	Metallurgical Microscopes	3
8	Muffle Furnace (800 C)	1

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INTRODUCTION

Materials which we come across may be classified into elastic, plastic and rigid materials. An elastic material undergoes a deformation when subjected to an external loading such that the deformation disappears on the removal of loading. A plastic material undergoes a continuous deformation during the period of loading and the deformation is permanent and the material does not regain its original dimensions on the removal of the loading. A rigid material does not undergo any deformation when subjected to an external loading.

In practice no material is absolutely elastic or plastic or rigid. We attribute these properties when the deformations are within certain limits. Generally we handle a member in its elastic range. Structural members are all generally designed so as to remain in the elastic condition under the action of the working loads.

A material when subjected to an external load system undergoes a deformation. It becomes necessary to study the deformations in order to determine the conditions under which failure may occur. The ability of a part or element of a structure to resist failure by virtue of its strength.

The ability to resist deformation is called stiffness. The material will have the ability to offer the necessary resistance when the deformation is with in a certain limit. A loaded member remains in equilibrium when the resistance offered by the member against the deformation and the applied load are in equilibrium. When the member is incapable of offering the necessary resistance against the external forces, the deformation will continue leading to the failure of the member.

Because of the complexity involved certain simplifying assumptions are made in strength calculations:

1. The material of the body has a solid continuous structure.
2. Within the limits of the part of the body the material is homogeneous and isotropic i.e., it has identical properties in all directions at all points
3. There are no internal forces in a body prior to loading
4. The effect of the system of forces acting on a body is equal to the sum of the effects of these same forces applied in succession and in any order. This is the principle of super imposition.
5. At points in a body sufficiently away from the points of application of loads, internal forces are independent of the manner in which the loads are applied. This is known as Saint Venant Principle. Theoretical investigations show that points more than 1.5-2 times the greatest linear dimension of the area of load transmission from the region of loading a distributed load can be replaced by a concentrated load. Thus the principle enables a distributed load replaced by a point load over a small area.

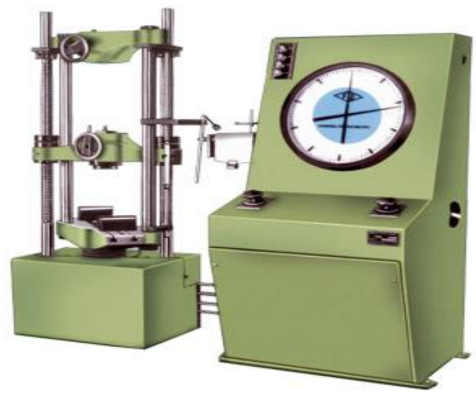
EXPERIMENTAL STUDY

AIM: - Study of Universal Testing Machine (U.T.M.)

OBJECT: - To Study the various component parts of the Universal Testing Machine (U.T.M.) & test procedures of various practical's to be performed.

APPARATUS: - Universal Testing Machine with all attachment i.e. shears test attachment, bending attachment, tension grips, compression test attachment etc.

DIAGRAM – UNIVERSAL TESTING MACHINE:-



THEORY: - The Universal Testing Machine consists of two units.

1) Loading unit, 2) Control panel.

LOADING UNIT:-

It consists of main hydraulic cylinder with robust base inside. The piston which moves up and down. The chain driven by electric motor which is fitted on left hand side. The screw column maintained in the base can be rotated using above arrangement of chain. Each column passes through the main nut which is fitted in the lower cross head. The lower table connected to main piston through a ball & the ball seat is joined to ensure axial loading. There is a connection between lower table and upper head assembly that moves up and down with main piston. The measurement of this assembly is carried out by number of bearings which slides over the columns. The test specimen each fixed in the job is known as 'Jack Job'. To fix up the specimen tightly, the movement of jack job is achieved helically by handle.

CONTROL PANEL:-

It consists of oil tank having a hydraulic oil level sight glass for checking the oil level. The pump is displacement type piston pump having free plungers those ensure for continuation of high pressure. The pump is fixed to the tank from bottom. The suction & delivery valve are fitted to the pump near tank

Electric motor driven the pump is mounted on four studs which is fitted on the right side of the tank. There is an arrangement for loosing or tightening of the valve. The four valves on control panel control the oil stroke in the hydraulic system. The loading system works as described below.

The return valve is close, oil delivered by the pump through the flow control valves to the cylinder & the piston goes up. Pressure starts developing & either the specimen breaks or the load having maximum value is controlled with the base dynameters consisting in a cylinder in which the piston reciprocates. The switches have upper and lower push at the control panel for the downward & upward movement of the movable head. The on & off switch provided on the control panel & the pilot lamp shows the transmission of main supply.

METHOD OF TESTING:-

Initial Adjustment: - before testing adjust the pendulum with respect to capacity of the test i.e. 8 Tones; 10 Tones; 20 Tones; 40 Tones etc. For ex: - A specimen of 6 tones capacity gives more accurate result of 10 Tones capacity range instead of 20 Tones capacity range. These ranges of capacity are adjusted on the dial with the help of range selector knob. Engineering control weights of the pendulum are adjusted correctly. The ink should be inserted in pen holder of recording paper around the drum & the testing process is started depending upon the types of test as mentioned below.

TENSION TEST:-

Select the proper job and complete upper and lower check adjustment. Apply some Greece to the tapered surface of specimen or groove. Then operate the upper cross head grip operation handle & grip the upper end of test specimen fully in to the groove. Keep the lower left valve in fully close position. Open the right valve & close it after lower table is slightly lifted. Adjust the lower points to zero with the help of adjusting knob. This is necessary to remove the dead weight of the lower table. Then lock the jobs in this position by operating job working handle. Then open the left control valve. The printer on dial gauge at which the specimen breaks slightly return back & corresponding load is known as breaking load & maximum load is known as the ultimate load.

COMPRESSION TEST:-

Fix upper and lower pressure plates to the upper stationary head & lower table respectively. Place the specimen on the lower plate in order to grip. Then adjust zero by lifting the lower table. Then perform the test in the same manner as described in tension test.

FLEXURAL OR BENDING TEST:-

Keep the bending table on the lower table in such a way that the central position of the bending table is fixed in the central location value of the lower table. The bending supports are adjusted to required distance.

Stuffers at the back of the bending table at different positions. Then place the specimen on bending table & apply the load by bending attachment at the upper stationary head. Then perform the test in the same manner as described in tension test.

BRINELL HARDNESS TEST:-

Place the specimen on the lower table & lift it up slightly. Adjust the zero fixed value at the bottom side of the lower cross head. Increase the load slowly ultimate load value is obtained. Then release the load slowly with left control valve. Get the impression of a suitable value of five to ten millimeter on the specimen & measure the diameter of the impression correctly by microscope & calculate Brinell hardness.

SHEAR TEST:-

Place the shear test attachment on the lower table, this attachment consists of cutter. The specimen is inserted in roles of shear test attachment & lift the lower table so that the zero is adjusted, then applies the load such that the specimen breaks in two or three pieces. If the specimen breaks in two pieces then it will be in angle shear, & if it breaks in three pieces then it will be in double shear.

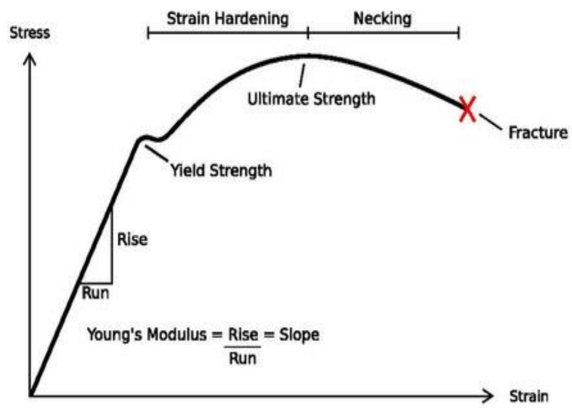
STUDY OF EXTENSOMETER:-

This instrument is an attachment to Universal / Tensile Testing Machines. This measures the elongation of a test place on load for the set gauge length. The least count of measurement being 0.01 mm, and maximum elongation measurement up to 3 mm. This elongation measurement helps in finding out the proof stress at the required percentage elongation.

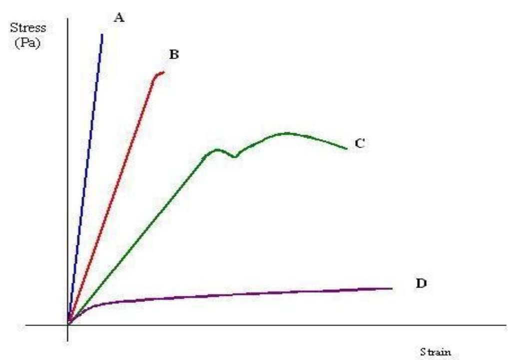
WORKING OF THE INSTRUMENT:-

The required gauge length (between 30to 120) is set by adjusting the upper knife edges (3) A scale (2) is provided for this purpose. Hold the specimen in the upper and lower jaws of Tensile / Universal Testing Machine. Position the extensometer on the specimen, Position upper clamp (4) to press upper knife edges on the specimen. The extensometer will be now fixed to the specimen by spring pressure. Set zero on both the dial gauges by zero adjusts screws (7). Start loading the specimen and take the reading of load on the machine at required elongation or the elongation at required load. Force setter accuracies mean of both the dial gauge (8) readings should be taken as elongation. It is very important to note & follow the practice of removing the extensometer from the specimen before the specimen breaks otherwise the instrument will be totally damaged. As a safety, while testing the instrument may be kept hanging from a fixed support by a slightly loose thread.

1. Stress-strain graph Ductile Material



2. Stress-Strain Graphs of Different Materials.



- Curve **A** shows a **brittle** material. This material is also strong because there is little strain for a high stress. The fracture of a brittle material is sudden and catastrophic, with little or no plastic deformation. Brittle materials crack under tension and the stress increases around the cracks. Cracks propagate less under compression.
- Curve **B** is a **strong** material which is not ductile. Steel wires stretch very little, and break suddenly. There can be a lot of elastic strain energy in a steel wire under tension and it will "whiplash" if it breaks. The ends are razor sharp and such a failure is very dangerous indeed.
- Curve **C** is a **ductile** material
- Curve **D** is a **plastic** material. Notice a very large strain for a small stress. The material will not go back to its original length

TENSION TEST ON A MILD STEEL ROD

Ex.No : 1

Date :

AIM:

To determine tensile strength on a required material (Mild Steel)

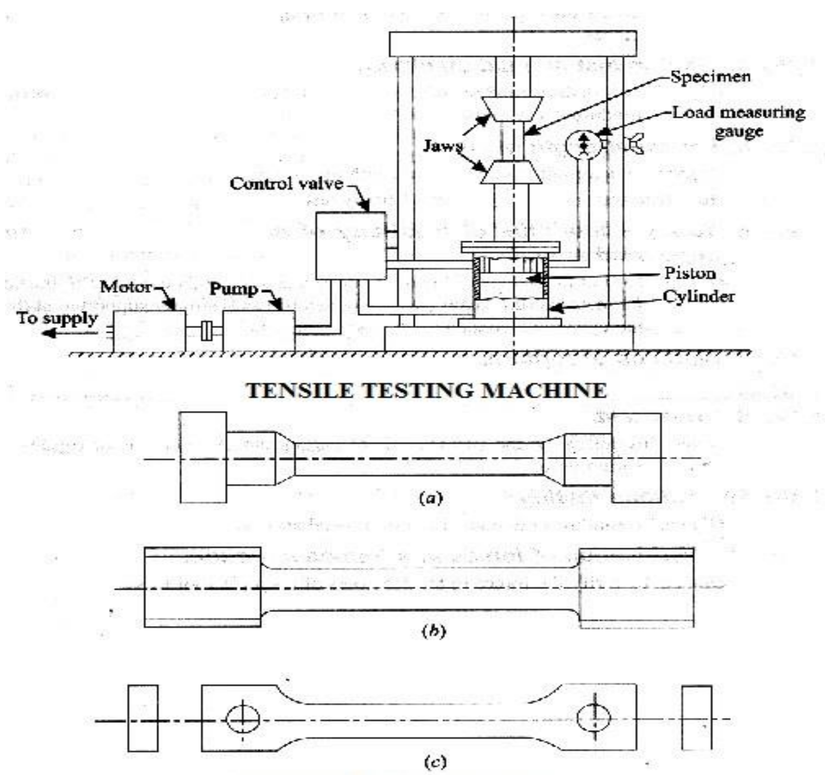
OBJECT: To conduct tensile test on a mild steel specimen and determine the following

1. Limit of proportionality 2. Upper yield point 3.Ultimate strength 4. Lower yield point 5.Ultimate strength 6.Fracture Strength 7.Young's modulus 8.Percentage elongation 9.Percentage reduction in area 10.Duetility 11.Toughness 12.Malleability 13. True-Stress & true-strain values

APPARATUS:

(i) Universal Testing Machine (UTM)
(ii) Mild steel specimens
(iii) Graph paper
(iv) Scale
(v) Vernier Caliper

GRAPHICAL REPRESENTATION



MILD STEEL SPECIMEN

PROCEDURE:

1. Measure the original length and diameter of the specimen. The length may either be length of gauge section which is marked on the specimen with a preset punch or the total length of the specimen.

2. Insert the specimen into grips of the test machine and attach strain-measuring device to it.

3. Begin the load application and record load versus elongation data.

4. Take readings more frequently as yield point is approached.

5. Measure elongation values with the help of dividers and a ruler.

6. Continue the test till Fracture occurs.

7. By joining the two broken halves of the specimen together, measure the final length and diameter of specimen.

FORMULA USED:

Percentage of elongation in length=CL/L

Percentage of reduction in area=CA/A

CL = Final Length

CA = Final Area

OBESERVATION:

A) Material: Initial Dimension

1. Length = ---------------
2. Diameter = ----------------
3. Area = ----------------

B) Final Dimensions:

1. Length = ---------------

2. Diameter = ----------------

S.No	Load(N)	Original Gauge length	Extension (mm)	Load Stress = Area (N/mm^2)	Increase in length Strain = --------- Original length
1					
2					
3					
4					
5					

3. Area = ----------------

TABLE:

PRECAUTIONS:

1. The specimen should be prepared in proper dimensions.
2. The specimen should be properly to get between the jaws.
3. Take reading carefully.
4. After breaking specimen stop to m/c.

RESULT:

1.Percentage of elongation in Length =

2. Percentage of reduction in Area =

DOUBLE SHEAR TEST ON MILD STEEL AND ALUMINUM RODS

Ex.No : 2

Date :

AIM:

To Determine Shear Strength on given specimen under double shear.

OBJECTIVE

To conduct and Investigate shear test on given Mild Steel and Aluminum Rod under double shear.

THEORY

In actual practice when a beam is loaded the shear force at a section always comes to play along with bending moment. It has been observed that the effect of shearing stress as compared to bending stress is quite negligible. But sometimes, the shearing stress at a section assumes much importance in design calculations. Universal testing machine is used for performing shear, compression and tension. There are two types of UTM. (i)Screw type, (ii) Hydraulic type. Hydraulic machines are easier to operate. They have a testing unit and control unit connected to each other with hydraulic pipes. It has a reservoir of oil, which is pumped into a cylinder, which has a piston. By this arrangement, the piston is made to move up. Same oil is taken in a tube to measure the pressure. This causes movement of the pointer, which gives reading for the load applied.

APPARATUS:

(i) Universal Testing Machine (UTM)
(ii) Mild steel & Aluminum specimens
(iii) Load capacity = 0-40000 kgf.
(iv) Least count = 8kgf.
(v) Power supply = 440V

DIAGRAM

PROCEDURE:

1. Insert the specimen in position and grip one end of the attachment in the upper portion and one end in the lower portion.

2. Switch on the main switch of universal testing machine.

3. The drag indicator in contact with the main indicator.

4. Select the suitable range of loads and space the corresponding weight in the pendulum and balance it if necessary with the help of small balancing weights.

5. Operate (push) buttons for driving the motor to drive the pump.

6. Gradually move the head control level in left-hand direction till the specimen shears.

7. Down the load at which the specimen shears.

8. Stop the machine and remove the specimen

FORMULA USED & OBESERVATION

Diameter of the Rod, D =-------mm

Cross-section area of the Rod (in double shear) = $2x\ \pi/4x\ d^2$ =... mm^2

Load taken by the Specimen at the time of failure, W=N

Strength of rod against Shearing = $f x 2x\ \pi/4x\ d^2$

$$f = W/2x\ \pi/4x\ d^2\ N/mm^2$$

S.No	Material	Diameter in mm	Cross sectional area in mm	Non load in N	Shear strength N/mm	Breaking load in N
1						
2						

PRECAUTIONS:

1. The measuring range should not be changed at any stage during the test.

2. The inner diameter of the hole in the shear stress attachment should be slightly greater than that of the specimen.

3. Measure the diameter of the specimen accurately.

RESULT:

The Shear strength of mild steel specimen is found to be = --------------------N/mm^2

TORSION TEST ON MILD STEEL RODS

Ex.No : 3

Date :

AIM:

To Identify the Torsional Strength on given Mild Steel rod specimen.

THEORY

To conduct torsion test on mild steel or cast iron specimen to determine modulus of rigidity.

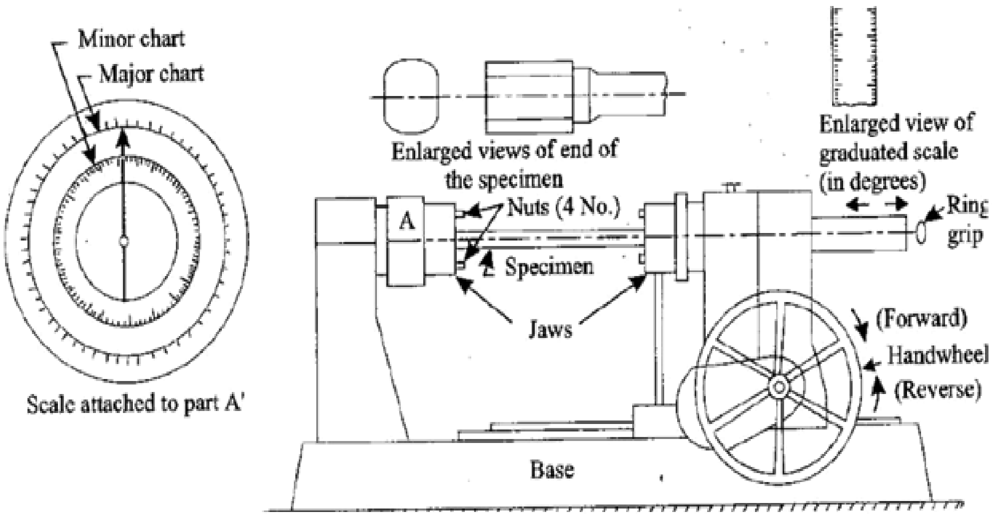
CONCEPT

For transmitting power through a rotating shaft it is necessary to apply a turning force. The force is applied tangentially and in the plane of transverse cross section. The torque or twisting moment may be calculated by multiplying two opposite turning moments. It is said to be in pure torsion and it will exhibit the tendency of shearing off at every cross section which is perpendicular to the longitudinal axis.

APPARATUS:

1. A torsion testing machine.
2. Twist meter for measuring angles of twist
3. A steel rule and Vernier Caliper or micrometer.

DIAGRAM



TORSION EQUATION:

Torsion equation is given by below

$T/J = \tau/R = G\theta/L$

$G = T\,L/J\,\theta$ N/mm^2

T= maximum twisting torque (N mm)

J = polar moment of inertia (mm^4) = $\pi\, d^4/32$ τ = shear stress

(N/mm^2) G = modulus of rigidity (N/mm^2) θ = angle of twist in

radians

L= length of shaft under torsion (mm)

- **Assumptions made for getting torsion equation**

1. The material of the shaft is uniform throughout.
2. The shaft, circular in section remain circular after loading.
3. Plane sections of shaft normal to its axis before loading remain plane after the torque have been applied.
4. The twist along the length of the shaft is uniform throughout.
5. The distance between any two normal-sections remains the same after the application of

torque.

6. Maximum shear stress induced in the shaft due to application of torque does not exceed its elastic limit.

PROCEDURE:

1. Select the driving dogs to suit the size of the specimen and clamp it in the machine by adjusting the length of the specimen by means of a sliding spindle.

2. Measure the diameter at about three places and take the average value.

3. Choose the appropriate range by capacity change lever

4. Set the maximum load pointer to zero.

5. Set the protractor to zero for convenience and clamp it by means of knurled screw.

6. Carry out straining by rotating the hand wheel in either direction.

7. Load the machine in suitable increments.

8. Then load out to failure as to cause equal increments of strain reading.

9. Plot a torque- twist (T- θ) graph.

10. Read off co-ordinates of a convenient point from the straight line portion of the torque twist (T-θ) graph and calculate the value of G by using relation.

OBESERVATION & TABULATION

Gauge length of the specimen L = ………

Diameter of the specimen d = ……… Polar

moment of inertia $J = \pi d^4/32$ =........

Sl. No.	Torque, Kg-cm	Torque,	Angle of twist		Modulus	Average G,
		N - mm	Degrees	Radians	Rigidity, G	N/mm^2
					N/mm^2	

FORMULA USED & CALCULATION:

$T/ I_p = C\theta / L$

T-Torque

I_p= polar moment of inertia,

$J= \pi /32\times d^4$

θ =Angle of Twist

$C= T\ \theta / I_pL$

C- Modulus of Rigidity

L= gauge length

GRAPH:

Torque Vs Angle of Twist

PRECAUTIONS:

1. Measure the dimensions of the specimen carefully
2. Measure the Angle of twist accurately for the corresponding value of Torque.
3. The specimen should be properly to get between the jaws.
4. After breaking specimen stop to m/c.

RESULT:

Thus the torsion test on given mild steel specimen is done and the modulus of rigidity is -------N/mm^2.

IMPACT TEST ON METAL SPECIMEN

Ex.No: 4

Date :

AIM:

To determined impact strength of steel.

OBJECTIVE

To find the impact strength of steel by Charpy Impact Test

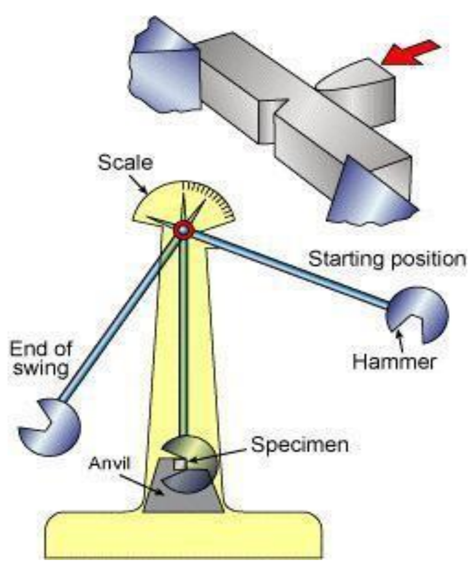
THEORY

An impact test signifies toughness of material that is ability of material to absorb energy during plastic deformation. Static tension tests of unnotched specimens do not always reveal the susceptibility of a metal to brittle fracture. This important factor is determined by impact test. Toughness takes into account both the strength and ductility of the material. Several engineering materials have to withstand impact or suddenly applied loads while in service. Impact strengths are generally lower as compared to strengths achieved under slowly applied loads. Of all types of impact tests, the notch bar tests are most extensively used. Therefore, the impact test measures the energy necessary to fracture a standard notch bar by applying an impulse load. The test measures the notch toughness of material under shock loading. Values obtained from these tests are not of much utility to design problems directly and are highly arbitrary. This test can also be used to assess the ductile brittle transition temperature of the material occurring due to lowering oftemperature

APPARATUS:

1. Impact testing machine
2. A steel specimen 10 mm x 10 mm X 55mm

DIAGRAM



PROCEDURE

In the Izod Impact Test, the specimen is positioned vertically. On the other hand, it is positioned horizontally in the Charpy Impact Test.

1. With the striking hammer (pendulum) in safe test position, firmly hold the steel specimen in impact testing machines vice in such a way that the notch faces s the hammer and is half inside and half above the top surface of the vice.
2. Bring the striking hammer to its top most striking position unless it is already there, and lock it at that position.
3. Bring indicator of the machine to zero, or follow the instructions of the operating manual supplied with the machine.
4. Release the hammer. It will fall due to gravity and break the specimen through its momentum, the total energy is not absorbed by the specimen. Then it continues to swing. At its topmost height after breaking the specimen, the indicator stops moving, while the pendulum falls back. Note the indicator at that topmost final position.
5. The specimen is placed on supports or anvil so that the blow of hammer is opposite to the notch.

OBESERVATIONS:

1. Impact value of - Mild Steel ------------ N-m
2. Impact value of - Brass ----------------N-m
3. Impact value of - Aluminum ------------ N-m

PRECAUTIONS:

1 Measure the dimensions of the specimen carefully.

2 Locate the specimen (Charpy test) in such a way that the hammer, strikes it at the middle. Note down readings carefully

RESULT:

1. The energy absorbed for Mild Steel is found out to be (K)-------Joules.
2. The energy absorbed for Brass is found out to be (K) -----Joules.
3. The energy absorbed for Aluminum is found out to be (K)------Joules
4. Impact strength of the specimen, (K/A) = ------------J/mm^2

HARDNESS TEST ON METAL SPECIMEN

Ex.No: 5

Date :

AIM:

To find the hardness of given material

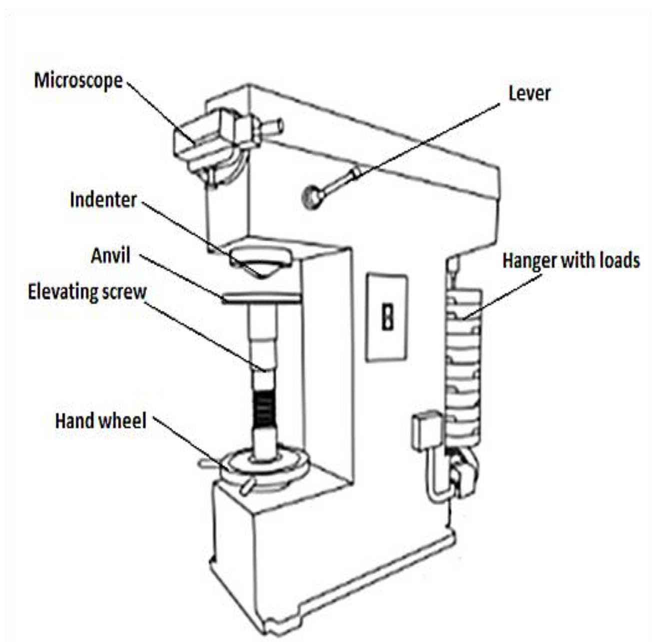
OBJECTIVE

To conduct hardness test on mild steel, carbon steel, brass and aluminum specimens.

APPARATUS:

- Hardness tester,
- Soft and hard mild steel specimens, brass, aluminum etc.

DIAGRAM:



THEORY

The hardness of a material is resistance to penetration under a localized pressure or resistance to abrasion. Hardness tests provide an accurate, rapid and economical way of determining the resistance of materials to deformation. There are three general types of hardness measurements depending upon the manner in which the test is conducted:

A. Scratch hardness measurement,

B. Rebound hardness measurement

C. Indention hardness measurement.

In scratch hardness method the material are rated on their ability to scratch one another and it is usually used by mineralogists only. In rebound hardness measurement, a standard body is usually dropped on to the material surface and the hardness is measured in terms of the height of its rebound. The general means of judging the hardness is measuring the resistance of a material to indentation. The indenters usually a ball cone or pyramid of a material much harder than that being used. Hardened steel, sintered tungsten carbide or diamond indenters are generally used in indentation tests; a load is applied by pressing the indenter at right angles to the surface being tested. The hardness of the material depends on the resistance which it exerts during a small amount of yielding or plastic. The resistance depends on friction, elasticity, viscosity and the intensity and distribution of plastic strain produced by a given tool during indentation.

1.BRINELL HARDNESS TEST

Ex.No: 5A

Date :

AIM:

To find the brinell‟s hardness number of the given metals using brinell‟s hardness testing machine.

OBJECTIVE

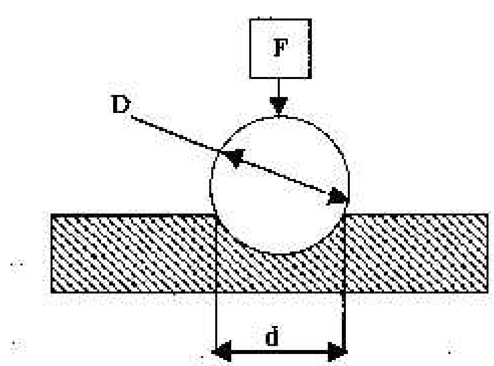
To conduct Brinell hardness test on mild steel, carbon steel, brass and aluminum specimens.

APPARATUS:

- ❖ Brinell hardness machine,
- ❖ Test specimen.
- ❖ Brinell Microscope

THEORY

INDENTATION HARDNESS -A number related to the area or to the depth of the impression made by an indenter or fixed geometry under a known fixed load. This method consists of indenting the surface of the metal by a hardened steel ball of specified diameter D mm under a given load F(kgf) and measuring the average diameter d mm of the impression with the help of Brinell microscope fitted with a scale. The Brinell hardness HB is defined, as the quotient of the applied force F divided by the spherical area of the impression HB = Test load in kgf/surface area of indentation.



Brinell's hardness number (HB) is given by

$$HB = \frac{\text{Load on ball in kg}}{\text{Surface area of indentation in sq.mm}}$$

$$= \frac{2P}{\pi D(d-\sqrt{D^2-d^2})}$$

Where: P=load in kg
D=diameter of indentor in mm
d=average diameter of impression in mm

PROCEDURE:

- Select the proper diameter of the indentor and load.
- Start the machine by pushing the green button of starter and allow oil to circulate for few minutes.
- Keep the hand lever in position A.
- Place the specimen securely on the testing table. Turn the hand wheel in clockwise direction,

so that the specimen will push the indentor and will show a reading on dial gauge. The movement will continue until the long pointer will stop at „0‟ and small pointer at red dot when the initial load of 250kg is applied. If little error exists the same can be adjusted by rotating the outer ring dial gauge.

- Turn the handle from position „A‟ to „B‟ so that the total system is brought into action.
- When the long pointer of dial gauge reaches a steady position, the load may be released by taking back the lever to position „A‟.
- Turn back the hand wheel and remove the specimen.
- The diameter of the impression can be found by using optical microscope.
- Read the hardness number from the tables.

TABLE & OBSERVATIONS:

SL.No	Material	Load	Diameter of impression(mm)	BHN(kg/mm^2)
1				
2				
3				
4				

PRECAUTIONS:

1. Brielle test should be performed on smooth, flat specimens from which dirt and scale have been cleaned.

2. The test should not be made on specimens so thin that the impression shows through the metal, nor should impression be made too close to the edge of a specimen.

RESULT:

The hardness of the metal is found to be

i) Hard steel =

ii) Unhardened Steel =

1.ROCKWELL HARDNESS TEST

Ex.No: 5B

Date :

AIM:

To find the Rockwell hardness number of the given metals using Rockwell hardness testing machine.

OBJECTIVE

To conduct Rockwell hardness test on mild steel, carbon steel, brass and aluminum specimens.

APPARATUS:

- Hardness tester,
- Soft and hard mild steel specimens, brass, aluminum

PROCEDURE:

1. Adjust the weights on the plunger of dash pot according to Rockwell scale as shown in chart.
2. Keep the lever in position A.
3. Place the specimen on testing table.
4. Turn the hand wheel clockwise, on that specimen will push the indentor and the small pointer moves to the red spot (Do not turn the wheel in a way to cross the red spot). The long pointer automatically stops at zero on black scare. If there is any resistance, unload and check the weights, indentor and the gap between inner faces of hanger and Turn the lever from position A to B slowly so that the total load into brought in to action without any jerks.
5. The long pointer of dial gauge reaches a study position when indentation is complete. Take back the lever to position A slowly.
6. Read the figure against the long pointer. That is direct reading of the hardness of specimen.
7. Turn back the hand wheel and remove the specimen.
8. Repeat the procedure 3 to 4 times.

\TABLE & OBSERVATIONS:

S.NO	Material	Rockwell Scale Of Weights Placed			Rock Well
		Scale	Weight	Indentor	
1					
2					
3					
4					

PRECAUTIONS:

- ❖ Select the proper indentor and load to suit the material under the Test.
- ❖ Surface to be tested must be sufficiently smooth and free from any defects.
- ❖ The surface under the test must be at right angle to the axis of the indentor.
- ❖ Diamond indentor has highly polished surface and is Susceptible to damage if not handled properly.

RESULT:

1. The rock well hardness number for Mild Steel is _________
2. The rock well hardness number for Copper is ____________
3. The rock well hardness number for Aluminum ___________
4. The rock well hardness number for Brass is _____________

DEFLECTION TEST ON BEAMS

1.BENDING TEST ON CANTILEVER BEAM

Ex.No: 6A

Date :

AIM:

This experiment is to demonstrate the effect of distance at which the load acting from the fixed end on deflection of the beam.The effects of young‟s modulus of the material of the beam using different materials bars.The effect of the type of cross section on the deflection because of the effect of moment of inertia of the beam.

OBJECTIVE

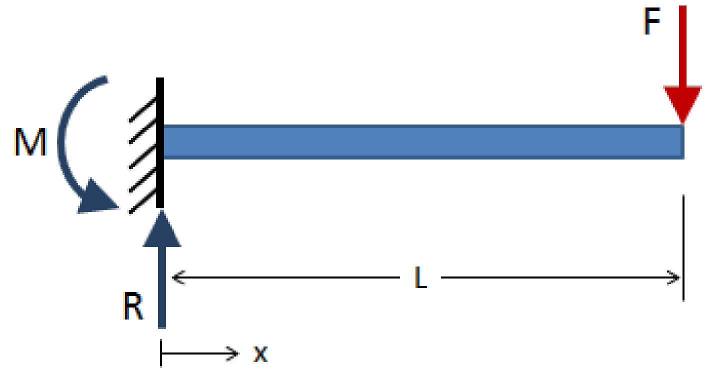
To determine the bending stress of the Cantilever Beam

APPARATUS:

1. Deflection of beam apparatus
2. Pan
3. Weights
4. Beam of different cross-sections and material

THEORY:

A Cantilever is a Beam one end of which is clamped and other end is free. A beam with a length L and is fixed at one end and the other end is free. Let the moment of inertia of the Beam is „I‟ about it‟s neutral axis and the Young‟s Modulus be ‟E‟.



1.Moment of inertia about the neutral axis $I = \frac{bh^3}{12}$ 2

2. Deflection at the end where point load is acting = = δ

3. The deflection at the end (Max deflection) δ is related to the load „W"", length „L" moment of Inertia „I" and Young"s Modulus „E" through the equation

$$\delta = \frac{Wl^3}{3EI}$$

We need to observe and understand following things

- If load is doubled deflection will also be doubled
- If span is doubled deflection increases y 8 times.
- If Young"s Modulus of material is more, then deflection will be less.
- If Moment of Inertia is increased the deflection will reduced

PROCEDURE:

1. Clamp the Beam horizontally on the clamping support at one end.

2. Measure the length of cantilever L (distance from clamp end to loading point)

3. Fix the dial gauge under the beam at the loading point to Read down-ward moment and set to zero.

4. Hang the loading Pan at the free end of the cantilever.

5. Load the cantilever with different loads (W) and note the dial gauge readings (δ)

6. Change the length of cantilever for two more different lengths repeat the experiment.

7. Change the position of cantilever and repeat the experiment for the other value of I for rectangular cross-section.

OBSERVATIONS:

1. Independent Variables:

- Load
- Span
- Moment of Inertia (By choosing different sections)
- Young"s Modulus (By choosing different Materials)

2. Dependent Variable

- Bending Deflection (δ)

3. Derived Variable

- Bending Stiffness

TABULATION

Sl No.	Beam Material	Cross Section	Y.M.E N/mm^2	M.I.I.Mm^4	Span L (mm)	Load W in N	Deflection δ in mm	Bending Stiffness N/mm

Bending stress f =

GRAPHS:

1. Deflection Vs W, L, I and
2. E Stiffness Vs W, L, I and E

PRECAUTIONS:

1. Beam should be positioned horizontally
2. The length of the cantilever should be measured properly
3. The dial gauge spindle knob should always touch the beam at the bottom of loading point.
4. Loading hanger should be placed at known distance of cantilever length.
5. All the errors should be eliminated while taking readings.
6. Elastic limit of the Bema should not exceed.

RESULT

Bending Stress in Cantilever Beam is -------------------------------

2.BENDING TEST ON SIMPLY SUPPORT BEAM

Ex.No: 6B

Date :

AIM:

To determined young‟s modulus of elasticity of material of beam simply supported at ends.

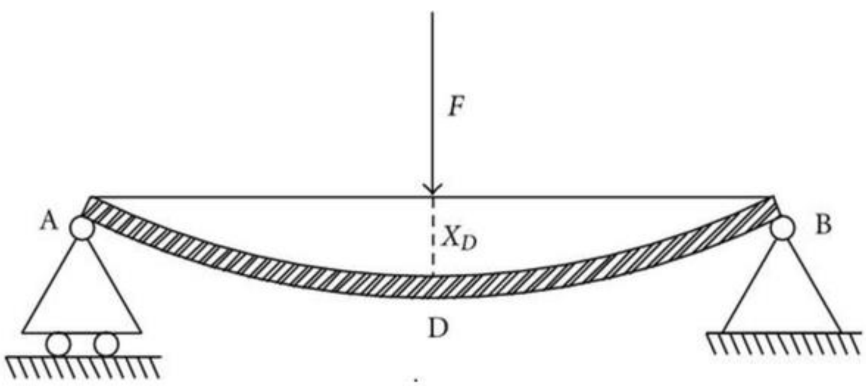
OBJECTIVE:

To find the values of bending stresses and young‟s modulus of elasticity of the material of a beam simply supported at the ends and carrying a concentrated load at the center.

APPARATUS:

i. Deflection of beam apparatus
ii. Pan
iii. Weights
iv. Beam of different cross-sections and material

THEORY:



If a beam is simply supported at the ends and carries a concentrated load at its center, the beam bends concave upwards. The distance between the original position of the beams and its position after bending at different points along the length of the beam, being maximum at the center in this case. This difference is known as „deflection‟ In this particular type of loading the maximum amount of deflection (δ) is given by the

$$\delta = \frac{Wl^3}{48EI} \quad \ldots\ldots\ldots\ldots\ldots \text{(i)}$$

$$E = \frac{Wl^3}{48\delta I} \quad \ldots\ldots\ldots\ldots\ldots \text{(ii)}$$

W = Load acting at center, N

L = Length of the beam between the supports mm

E = Young"s modulus of material of the beam, N/mm^2

I = Second moment of area of the cross- section (i.e, moment of Inertia) of the beam, about the neutral axis, mm^4

Bending Stress

As per bending equation $$\frac{M}{I} = \frac{\sigma_b}{Y}$$

Where

M = Bending Moment N-mm
I = Moment of inertia mm^4
σ_b = Bending stress, N/mm^2 , and

Y = Distance of the top fibre of beam from the neutral axis

PROCEDURE:

1. Adjust cast- iron block along the bed so that they are symmetrical with respect to the length of the bed.
2. Place the beam on the knife edges on the block so as to project equally beyond each knife edge. See that the load is applied at the center of the beam
3. Note the initial reading of Vernier scale.
4. Add a weight of 20N (say) and again note the reading of the Vernier scale.
5. Go on taking readings adding 20N (say) each time till you have minimum six readings.
6. Find the deflection (δ) in each case by subtracting the initial reading of Vernier scale.
7. Draw a graph between load (W) and deflection (δ). On the graph choose any two convenient points and between these points find the corresponding values of W and δ. Putting these Values in the relation

$$\delta = \frac{Wl^3}{48EI}$$

Calculate the value of E

8. Calculate the bending stresses for different loads using relation

$$\delta_b = \frac{MY}{I}$$

TABULATION

Sl No	Load W (N)	Bending Moment $M = \frac{Wl}{4}(N - mm^3)$	Bending Stress δ_b	Deflection δ	Young"s Modulus of elasticity

PRECAUTIONS

- Make sure that beam and load are placed a proper position.
- The cross- section of the beam should be large.
- Note down the readings of the Vernier scale carefully

RESULT:

1. The young"s modulus for steel beam is found to be -----N/mm^2.
2. The young"s modulus for wooden beam is found to be -----N/mm^2

COMPRESSION TEST ON HELICAL SPRINGS

OPEN & CLOSED COIL HELICAL SPRING

Ex.No: 7

Date :

AIM:

To Test the properties of given spring

OBJECTIVE:

To determine the stiffness of spring, modulus of rigidity of the spring wire and maximum strain energy stored.

APPARATUS:

i. Spring testing machine.

ii. A spring

iii. Vernier caliper, Scale.

iv. Micrometer.

THEORY:

This is the test to know strength of a material under compression. Generally compression test is carried out to know either simple compression characteristics of material or column action of structural members. It has been observed that for varying height of member, keeping cross-sectional and the load applied constant, there is an increased tendency towards bending of a member. Member under compression usually bends along minor axis, i.e, along least lateral dimension. According to column theory slenderness ratio has more functional value. If this ratio goes on increasing, axial compressive stress goes on decreasing and member buckles more and more. End conditions at the time of test have a pronounced effect on compressive strength of materials. Effective length must be taken according to end conditions assumed, at the time of the test. As the ends of the member is made plain and fit between two jaws of the machine, fixed end is assumed for calculation of effective length. Effective length is taken as 0.5 L where L is actual length of a specimen.

PROCEDURE:

1. Measure the diameter of the wire of the spring by using the micrometer.
2. Measure the diameter of spring coils by using the Vernier caliper
3. Count the number of turns.
4. Insert the spring in the spring testing machine and load the spring by a suitable weight and note the corresponding axial deflection in tension or compression.
5. Increase the load and take the corresponding axial deflection readings.
6. Plot a curve between load and deflection. The shape of the curve gives the stiffness of the spring.

OBESERVATION:

Least count of micrometer = ……mm

Diameter of the spring wire, d =………mm (Mean of three readings)

Least count of Vernier caliper = ……mm

Diameter of the spring coil D = ……mm (mean of three readings)

Number of turns N =

TABULATION

Sl.No	Load in N	Scale readings(mm)		Deflection(mm)	Rigidity modulus N/mm^2	Stiffness in N/mm
1						
2						
3						
4						
5						

CALCULATION

(i) Inner diameter of spring di = mm

(ii) Outer diameter of spring do= mm

(iii) Length of the spring L = mm

(iv) Number of turns n = 10

(v) Material of spring =

(vi)Young's modulus E = 2×10^5

1. Deflection α: 64 WR 3 N Sec α [cos 2 α / N + 2Sin 2 α /E] N/mm2

Where,

W=Load applied in Newton

R=Mean radius of spring coil = (D-d) / 2

N= Number of turns

a=Helix angle of spring

N=Modulus of rigidity of spring Material

E=Young's modulus of the spring material

2. Tan α = pitch / $2\pi R$

3. Pitch = (L-d) / n

Where,

d= Diameter of spring wire in mm

L= Length of spring in mm

N= No of turns in spring

4. Stiffness of spring (K) = w / d

Where,

d=Deflection of spring in mm

W=Load applied in Newton's

5. Maximum Energy Stored = 0.5 x W_{Max}

Where,

W_{Max} = Maximum load applied

δ_{Max} = Maximum deflection

PRECAUTIONS

1.Place the specimen at center of compression pads,
2. Stop the machine as soon as the specimen fails.
3. Cross sectional area of specimen for compression test should be kept large as compared to the specimen for tension test: to obtain the proper degree of stability

RESULT

Under compression test on open coil helical spring

1. Rigidity Modulus (N) = N/mm

2. Stiffness of spring (K) = N/mm

3. Maximum energy stored =

STRAIN MEASUREMENT USING ROSETTE STRAIN GAUGE

Ex.No: 8

Date :

AIM:

To Measure the Normal strains along different directions in the underlying surface of the test part

OBJECTIVE:

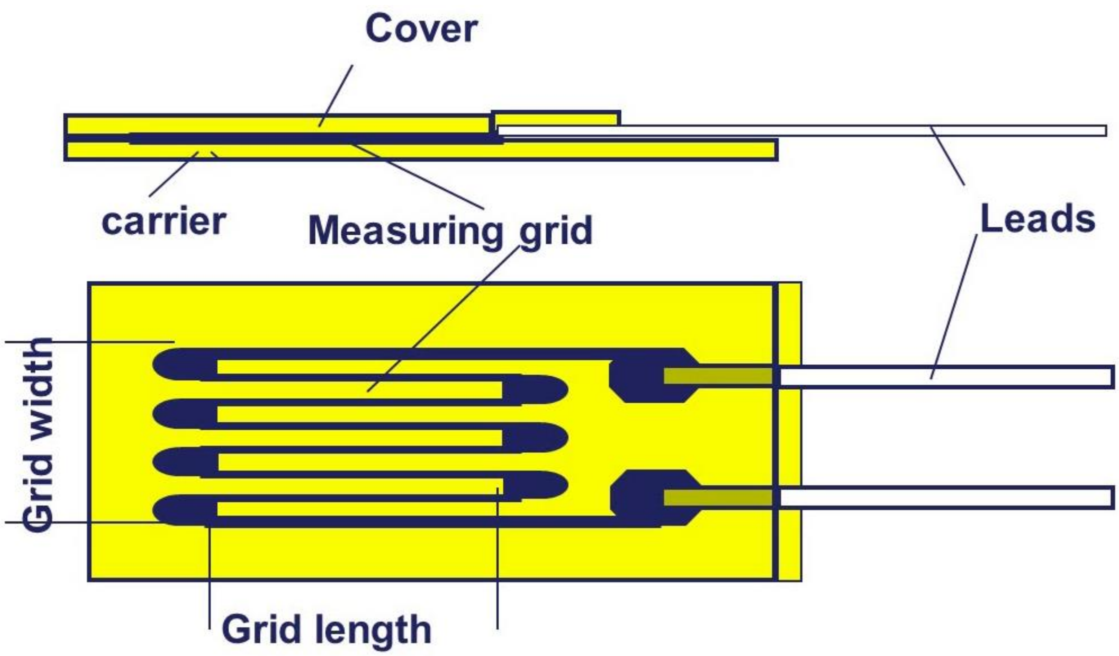
To obtain the principal strains and stresses, Principal directions of independent closely positioned gage grids

THEORY :

A strain gauge is a device which is used to measure strain (deformation) on an object subjected to forces. Strain can be measured using various types of devices classified depending upon their principle of operation. Some of them are as follows:

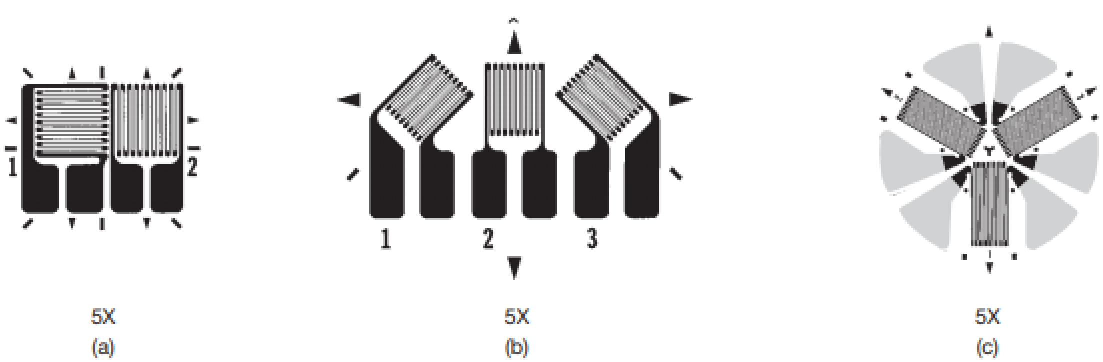
1. Mechanical type
2. Optical type
3. Pneumatic type
4. Electrical type earlier

Mechanical type of device such as extensometer or extension meter was used to measure strain by measuring change in length. Photoelectric strain gauge was also introduced which uses a light beam to produce electric current corresponding to deformation. The most commonly used strain gauge is an electrical resistance strain gauge. This strain gauge works on the principle that when a metallic wire type gauge is strained (here due to forces on object in contact), the resistance of the wire will be changed due to changes in its length, diameter and resistivity. Resistance (R) = ρL A Where ρ is resistivity; L is length of wire; A is area of cross section of wire. This change in resistance will be in proportion with the strain produced which can be easily measured using Wheatstone bridge.



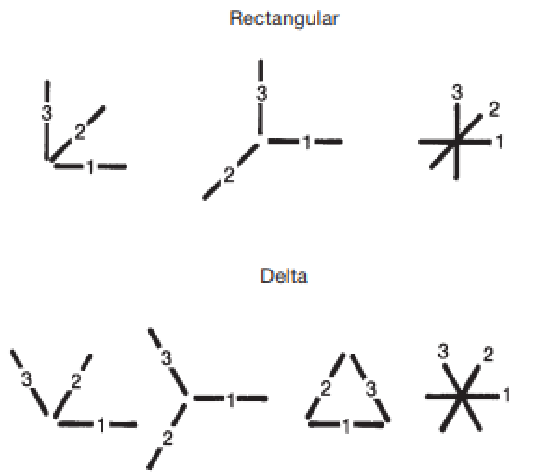
To meet the foregoing requirements, the Micro Measurements manufactures three basic types of strain gauge rosettes (each in a variety of forms):

- Tee: two mutually perpendicular grids.
- 45°-Rectangular: three grids, with the second and third grids angularly displaced from the first grid by 45° and 90°, respectively.
- 60°-Delta: three grids, with the second and third grids 60° and 120° away, respectively, from the first grid. Representative gage patterns for the three rosette types are reproduced.



Basic rosette types, classified by grid orientation: (a) tee; (b) 45°-rectangular; (c) 60° delta.

In common with single-element strain gages, rosettes are manufactured from different combinations of grid alloy and backing material to meet varying application requirements. They are also offered in a number of gage lengths, noting that the gage length specified for a rosette refers to the active length of each individual grid within the rosette. As illustrated below



Geometrically different, but functionally equivalent configurations of rectangular and delta rosettes.

Rectangular and delta rosettes may appear in any of several geometrically different, but functionally equivalent, forms. Guidance in choosing the most suitable rosette for a particular application is provided in Section 2.0, where selection considerations are reviewed.

ROSETTE SELECTION CONSIDERATIONS

A comprehensive guide for use in selecting Micro Measurements strain gages is provided in Reference 1. This publication should first be consulted for recommendations on the strain-sensitive alloy, backing material, self-temperature-compensation number, gage length, and other strain gage characteristics suitable to the expected application. In addition to basic parameters such as the foregoing, which must be considered in the selection of any strain gage,

Two other parameters are important in rosette selection.

1.The rosette type — tee, rectangular, or delta

2. The rosette construction — planar (single plane) or stacked (layered).

EFFECT OF HARDENING- IMPROVEMENT IN HARDNESS AND IMPACT RESISTANCE OF STEELS

Ex.No: 9

Date :

AIM:

To observe the property changes of Steel material due to hardening process

OBJECTIVE:

To identify and compare the material properties with and without hardening process

METAL HARDENING

The use of this treatment will result in an improvement of the mechanical properties, as well as an increase in the level of hardness, producing a tougher, more durable item. Alloys are heated above the critical transformation temperature for the material, then cooled rapidly enough to cause the soft initial material to transform to a much harder, stronger structure. Alloys may be air cooled, or cooled by quenching in oil, water, or another liquid, depending upon the amount of alloying elements in the material. Hardened materials are usually tempered or stress relieved to improve their dimensional stability and toughness. Steel parts often require a heat treatment to obtain improved mechanical properties, such as increasing increase hardness or strength. The hardening process consists of heating the components above the critical (normalizing) temperature, holding at this temperature for one hour per inch of thickness cooling at a rate fast enough to allow the material to transform to a much harder, stronger structure, and then tempering. Steel is essentially an alloy of iron and carbon; other steel alloys have other metal elements in solution. Heating the material above the critical temperature causes carbon and the other elements to go into solid solution. Quenching "freezes" the microstructure, inducing stresses. Parts are subsequently tempered to transform the microstructure, achieve the appropriate hardness and eliminate the stresses.

PROCESS AND EFFECTS OF HARDENING

The Hall–Petch method, or grain boundary strengthening, is to obtain small grains. Smaller grains increase the likelihood of dislocations running into grain boundaries after shorter distances, which are very strong dislocation barriers. In general, smaller grain size will make the material harder. When the grain size approach sub-micron sizes, some materials may however become softer. This is simply an effect of another deformation mechanism that becomes easier, i.e. grain boundary sliding. At this point, all dislocation related hardening mechanisms become irrelevant.

- In work hardening (also referred to as strain hardening) the material is strained past its yield point, e.g. by cold working. Ductile metal becomes harder and stronger as it's physically deformed. The plastic straining generates new dislocations. As the dislocation density increases, further dislocation movement becomes more difficult since they hinder each other, which means the material hardness increases.
- In solid solution strengthening, a soluble alloying element is added to the material desired to be strengthened, and together they form a “solid solution”. A solid solution can be thought of just as a "normal" liquid solution, e.g. salt in water, except it is solid. Depending on the size of the dissolved alloying element's ion compared to that of the matrix-metal, it is dissolved either substitutionally (large alloying element substituting for an atom in the crystal) or interstitially (small alloying element taking a place between atoms in the crystal lattice). In both cases, the size difference of the foreign elements make them act as sand grains in sandpaper, resisting dislocations that try to slip by, resulting in higher material strength. In solution hardening, the alloying element does not precipitate from solution.
- Precipitation hardening (also called *age hardening*) is a process where a second phase that begins in solid solution with the matrix metal is precipitated out of solution with the metal as it is quenched, leaving particles of that phase distributed throughout to cause resistance to slip dislocations. This is achieved by first heating the metal to a temperature where the elements forming the particles are soluble then quenching it, trapping them in a solid solution. Had it been a liquid solution, the elements would form precipitates, just as supersaturated saltwater would precipitate small salt crystals, but atom diffusion in a solid is very slow at room temperature. A second heat treatment at a suitable temperature is then required to age the material. The elevated temperature allows the dissolved elements to diffuse much faster, and form the desired

precipitated particles. The quenching is required since the material otherwise would start the precipitation already during the slow cooling. This type of precipitation results in few large particles rather than the, generally desired, profusion of small precipitates. Precipitation hardening is one of the most commonly used techniques for the hardening of metal alloys.

- Martensitic transformation, more commonly known as quenching and tempering, is a hardening mechanism specific for steel. The steel must be heated to a temperature where the iron phase changes from ferrite into austenite, i.e. changes crystal structure from BCC (body-centered cubic) to FCC (face-centered cubic). In austenitic form, steel can dissolve a lot more carbon. Once the carbon has been dissolved, the material is then quenched. It is important to quench with a high cooling rate so that the carbon does not have time to form precipitates of carbides. When the temperature is low enough, the steel tries to return to the low temperature crystal structure BCC. This change is very quick since it does not rely on diffusion and is called a martensitic transformation. Because of the extreme supersaturation of solid solution carbon, the crystal lattice becomes BCT (body-centered tetragonal) instead. This phase is called martensite, and is extremely hard due to a combined effect of the distorted crystal structure and the extreme solid solution strengthening, both mechanisms of which resist slip dislocation.

APPLICATION

- ❖ Machine cutting tools (drill bits, taps, lathe tools) need be much harder than the material they are operating on in order to be effective.
- ❖ Knife blades – a high hardness blade keeps a sharp edge.
- ❖ Bearings – necessary to have a very hard surface that will withstand continued stresses.
- ❖ Armor plating - High strength is extremely important both for bullet proof plates and for heavy duty containers for mining and construction.
- ❖ Anti-fatigue - Martensitic case hardening can drastically improve the service life of mechanical components with repeated loading/unloading, such as axles and cogs.

TEMPERED MATERIAL BRITTLE HARDNESS TEST

Ex.No: 10

Date :

AIM:

To find the brinell hardness number of tempered metals and hardened material.

OBJECTIVE:

To Test and identify property changes of material due to hardening process

APPARATUS:

- Brinell hardness testing machine
- Specimen of Tempered metal
- Specimen of Hardened metal
- Brinell microscope

THEORY:

Hardness represents the resistance of material surface to abrasion, scratching and cutting, hardness after gives clear identification of strength. In all hardness testes, a define force is mechanically applied on the test piece for about 15 seconds. The indentor, which transmits the load to the test piece, varies in size and shape for different tests. Common indenters are made of hardened steel or diamond. In Brinell hardness testing, steel balls are used as indentor. Diameter of the indentor and the applied force depend upon the thickness of the test specimen, because for accurate results, depth of indentation should be less than 1/8 of the thickness of the test pieces. According to the thickness of the test piece increase, the diameter of the indentor and force are changed.

Knowledge of the specimen:

Load is applied on the specimen the band of the slide of the machines which is operated of handling and watching the specimen the diameter of the indentor is which helps of traveling microscope.

Specification of Hardness Testing machine and Indentors:

A hardness test can be conducted on Brinell testing m/c, Rockwell hardness m/c or vicker testing m/c.

the specimen may be a cylinder, cube, think or thin metallic sheet. Its specification are as follows:

1. Ability to determine hardness upto 500BHN.
2. Diameter of ball (as indentor) used D = 2.5mm, 5mm, 10mm.
3. Maximum application load = 3000kgf.
4. Method of load application = Lever type
5. Capability of testing the lower hardness range = 1 BHN on application of 0.5Dload

PROCEDURE

- Insert ball of dia 'D' in ball holder of the m/c.
- Make the specimen surface clean by removing dust, dirt, oil and grease etc.
- Make contact between the specimen surface and the ball by rotating the jack adjusting wheel.
- Push the required button for loading.
- Pull the load release level and wait for minimum 15 second. The load will automatically apply gradually
- Remove the specimen from support table and locate the indentation so made.
- View the indentation through microscope and measure the diameter'd' by micrometer fitted on microscope.
- Repeat the entire operation, 3-times.

TABULATION

S.No.	Type of Specimen	Ball Diameter in mm	Load applied P in'kgf.	Diameter of indentations'' (mm)	P/D2	BHN
1	Tempered Specimen					
2	Hardened Specimen					

FORMULA USED

1. Area of indentation $A=\pi\times d/2(D- \sqrt{D^2-d^2})$

2. BHN = Load Applied (kgf.)/ Spherical surface area indentation (in mm.)

PRECAUTIONS:

1. The specimen should be clean properly.
2. Take reading more carefully and correct.
3. Place the specimen properly.
4. Jack adjusting wheel move slowly
5. After applying load remove the load.

RESULT:

The brinell hardness number of the given specimen are found out and tabulated

MICROSCOPIC EXAMINATION

Ex.No: 11

Date :

AIM:

To examine the microstructure of a given plain carbon steel sample before and after heat treatment.

OBJECTIVE:

To Show the changes in micro structure of material due to hardening process

APPARATUS:

- Belt grinder
- Simple disc polishing machine
- Stretching agent
- Emery sheet
- Muffle furnace

THEORY:

Sample specimen:

i) Unbalanced specimen

ii) Harden specimen

iii) Tempered specimen

Steel can be heat treated to high temperature to achieve the requirement harden and strength. The high operating stress need the high strength of hardened structure similarly tools such as like knives etc. as quenched hardened steels are so, brittle than even slight compact cause fracture. The heat treatment that reduces the brittleness of steel without significantly lowering the hardness and strength. Hardened steel must be tempered before use.

Importance:

Hardening:

To increase the strength and hardness

To improve the mechanical properties Hardening temperature-90 0c

Holding time-1 hr Quenching medium - Water.

Tempering:

To reduce the stress & reduce the brittleness

Tempering temperature-320° C

Holding time-1 hr

Quenching medium-Air

The specimen and is heated at a temperature which is determined using the microstructure the specimen quenching into oil. The given three samples are subjected to The specimen and is heated at a temperature which is determined using the microstructure the specimen quenching into oil. The given three samples are subjected t the study of microstructure of the hardened metal. The micro structure of the unhardened sample is studied and hardness is found. The furnace which is maintained at temperature at 900° C for hardening. The sample is added to get austenite structure. The third sample is subjected to tempering process of is hold at 830 is furnace for this and quenched in air. The micro structure of the third specimen is studied and hardness is formed.

PROCEDURE

- Specimen is heated to temperature which is determined using the microscopic structure the specimen is quenched in oil.
- The given samples are subjected to the study of micro structure and hardness.
- The remaining two specimens is quenched into the furnace which is maintained at the temperature 9000c for hardening process
- The microstructure of the hardened sample is subjected and hardness is found.
- The specimen is then taken from the furnace and immediately quenched in oil

TABULATION

SAMPLES	SAMPLES-I (Before hardening)	SAMPLES-I (After hardening)	SAMPLES-II (After tempering)
MICROSTRUCTURE	Structure1	Structure 2	Structure 3
HARDENING			
HARDENING & TEMPERING			

OBSERVATION

Specimen: Low Carbon Steel Magnification: 2%

Metal Composition: 80%Ferrite, 20% Pearlite

Hardness test: RC

Load: 100 kg

Indentor:1 20^{o} C

PRECAUTIONS

1. Test piece should be clean properly.
2. Test piece should be straight.

RESULT

Thus the microstructure and the hardness of the given sample are studied and treatment is tabulated.

VIVA QUESTIONS

1. Define Hooke's Law.

2. Define Strength of materials

3. What is stress?

4. What is strain?

5. What is deformation?

6. How is deformation calculated?

7. Say something on Rigid Body.

8. Say something on deformable solids.

9. Differentiate simple and compound stress.

10. What is stiffness?

11. Types of stresses.

12. Types of strains.

13. What is volumetric strain?

14. Differentiate Tensile Strain and Tensile stress.

15. Differentiate Compressive Strain and Compressive stress.

16. Differentiate Shear Strain and Shear stress.

17. What is factor of safety?

18. What is Ultimate strength?

19. What is working stress?

20. What is Yield Strength?

21. Define Stiffness of a helical spring.

22. Differentiate between closed and open coil helical spring.

23. Principle of Superposition in bars of varying cross section.

24. Types of Loads.

25. Explain torque.

26. What is Torsional force?

27. What is torsional rigidity?

28. Define Centripetal force.

29. Define Centrifugal force.

30. Explain Radius of gyration.

31. What is calibration?

32. Tell about Moment of inertia.

33. What is Inertia?

34. Polar moment of inertia.

35. Say something on Traction.

36. Explain about Principal plane.

37. Explain about Principal axis.

38. Draw Shear force diagram for a cantilever beam with UDL and point load.

39. Draw Shear force diagram for a SSB with UDL and point load

40. What are SSB, Fixed Beams, Hinged Beams.

41. Explain the equilibrium condition for a body

42. Differentiate between Bar and column

43. Types of beams.

44. What is Shear centre?

45. Tell something on elastic constants.

46. What is Poisson's ratio?

47. Differentiate Longitudinal and Lateral Strain.

48. Relation between Bulk Modulus and Young's modulus.

49. Explain about modulus of rigidity.

50. What is Strain energy?

51. What is Resilience?

52. Define proof of resilience.

53. Define modulus of resilience.

54. How is potential energy related to strain energy

55. Explain Castigliano's Theorem.

56. What is slenderness ratio?

57. When do we call the failure to be fatigue?

58. Explain sudden impact.

59. Explain about buckling in a beam.

60. Why is it necessary to check hardness?

61. Enumerate the advantages of Rockwell Hardness test over Brinell hardness test.

62. Differentiate between pneumatic and hydraulic pumps

63. Unit of force, deflection, stress, strain, E, K, G.

64. Purpose of UTM.

65. Define a Hydraulic jack.

66. What is torsional bending?

67. What is axial load?

68. Say something on ageing factor.

69. Define Section modulus.

70. What is a composite beam?