MALLA REDDY

COLLEGE OF ENGINEERING & TECHNOLOGY

DEPARTMENT OF MECHANICAL ENGINEERING

LABORATORY MANUAL

THERMAL ENGINEERING LAB

III B.TECH I SEMESTER
(2016-2017)

PREFACE

The primary purpose of the-laboratory 'THERMAL ENGINEERING' is-to show students the experimental methods-on thermal energies on various engines-and demonstrate their operational procedures. These values can be further used to determine other fuel properties. In order that students have a fairly good understanding of the theory underlying the experiments, the entire course is designed such that classroom lectures precede lab-work.- Students are advised to pay close attention in class so that they can perform-well in-the lab.

LAB POLICY

GROUPS

Students will be formed into groups of three or four on the first lab day. Once a student has signed up with a group, he or she may not change groups without prior approval of the instructor.

LAB REPORTS

You will perform the experiment in group, and turn in ONE REPORT PER GROUP.

Your report should be self-contained, i.e. an engineering technologist should be able to perform the experiment and duplicate your results by reading your report. DO NOT "adjust" your data to make them fit what you believe to be an acceptable value. Your report should be an accurate description of the experiment. If your results differ significantly from reference values you should check your settings carefully (calibration, wrong units, wrong calculations, etc.), and do the experiment again. Try to explain any discrepancies but do not "adjust" your data.

REPORT FORMAT:

The report must be hand written. A report should include the following in order

A. A title page, which includes the following information, in order:

1. Course Number and Section Number
2. Experiment Title
3. Names of the Group Members (who contributed to do the lab/report)
4. Due Date

B. Objective or purpose of the experiment work.

C. Theoretical aspect of the experiment.

D. Experimental procedure that explains briefly the procedure of how the experiment was performed and all the equipment used.

E. Experimental and/or calculated results. (Include all data you have taken, a sample calculation, and the results) The result table must be presented in tabular form. Also, all calculations and graphical work (e.g. graph) must be hand written/drawn.

F. Discussion of results in light of the theoretical “predictions”. Include an error analysis. Quantify the errors whenever possible.

G. Conclusions, wherein you write what you learned from the experiment. Your conclusions must summarize your report and must be based on your experimental results

Lab reports are due at the beginning of next lab. Late lab reports will not be accepted.

Note: In order to get a good grade in the lab, please follow the instructions listed below:

1. Read about the lab prior to the beginning of the lab. Do each lab with an attitude of learning.

2. Please bring your lab-manual to-the-lab. Each group should-have-at-least one -lab manual with them.

3.Students are advised-to bring-blank-and graph papers to-the-lab,-on-which -you can do calculations and draw graphs

ATTENDANCE:

Attendance will be taken at the beginning of every lab session.

STRENGTH OF MATERIALS LAB POLICY:

We want to maintain the high quality conditions of this lab for the students in future years. Thus, it is necessary for you to adhere to the established policy of NO BEVERAGES, FOOD, NEWS PAPERS, MAGAZINES, TOBACCO PRODUCTS AND ANIMALS within the Strength of Materials lab.

SAFETY:

For your own safety, please wear the pants and shoes that cover toes for this Lab. The safety goggle will be needed for several labs.

GENERAL INSTRUCTIONS

1. Every student should obtain a copy of the laboratory manual.

2. Dress code: Students must come to the laboratory wearing: (1) trousers, (ii) half-sleeve tops and (iii) Leather shoes.

Half pants, loosely hanging garments and slippers are not allowed.

3. To avoid any injury, the student must take the permission of the laboratory staffs before handling the machines.

4. EVERY STUDENT IS REQUIRED TO HANDLE THE EQUIPMENT WITH CARE.

5. Students must ensure that their work areas are clean.

6. At the end of each experiment, the student must take initials from the staff on your data/observations.

7. Laboratory report must be submitted in standard sheet, available at stores in the subsequent lab turn. Reports on ordinary sheets and computer papers will not be accepted.

8. Each member-of any group must submit lab report even if the experiment has been performed in-a group.

9. The lab report must contain:

   I. Title of the experiment,
   II. Three to four lines stating the objectives,
   III. A few lines on background;
   IV. Name of all equipments/tools used along with one line description of its use
   V. Neatly labeled sketches.

10. Student can check their laboratory reports after correction for discussion.

LIST OF EXPERIMENTS

SN	NAME OF THE EXPERIMENT
1.	I.C. ENGINE VALVE TIMING DIAGRAM
2.	I.C. ENGINE PORT TIMING DIAGRAM
3.	I.C. ENGINE PERFORMANCE TEST ON SINGLE CYLINDER 4 STROKE DIESEL ENGINE
4.	PERFORMANCE TEST ON SINGLE CYLINDER 2 – STROKE PETROL ENGINE
5.	PERFORMANCE TEST ON SINGLE CYLINDER 4 – STROKE PETROL ENGINE
6.	MORSE TEST ON 4 - CYLINDER 4 - STROKE PETROL ENGINE
7.	EVALUATION OF ENGINE FRICTION BY CONDUCTING MOTORING/RETARDATION TEST ON SINGLE CYLINDER 4 STROKE DIESEL ENGINE
8.	HEAT BALANCE TEST ON SINGLE CYLINDER 4 STROKE DIESEL ENGINE
9.	DETERMINATION OF AIR/FUEL RATIO AND VOLUMETRIC EFFICIENCY ON 4-STROKE DIESEL ENGINE
10.	DIS-ASSEMBLY/ASSEMBLY OF I.C. ENGINE
11.	PERFORMANCE TEST ON RECIPROCATING AIR COMPRESSOR
12	STUDY OF BOILERS

Experiment No. 1

I.C. ENGINE
VALVE TIMING DIAGRAM

VALVE TIMING DIAGRAM

AIM:

The experiment is conducted to

Determine the actual valve timing for a 4-stroke diesel engine and hence draw the diagram.

PROCEDURE:

1. Keep the decompression lever in vertical position.
2. Bring the TDC mark to the pointer level closed.
3. Rotate the flywheel till the inlet valves moves down i.e., opened.
4. Draw a line on the flywheel in front of the pointer and take the reading.
5. Continue to rotate the flywheel till the inlet valve goes down and comes to horizontal position and take reading.
6. Continue to rotate the flywheel till the outlet valve opens, take the reading.
7. Continue to rotate the flywheel till the exhaust valve gets closed and take the reading.

Observations

Sl. No.	Valve Position	Arc Length, S		Angle 'θ' in degrees
		cm	mm	
1	TDC – Inlet Valve open			
2	BDC – Inlet Valve Close			
3	TDC – Exhaust Valve Open			
4	BDC – Exhaust Valve Close			

Calculations

1. Diameter of the flywheel, D

$$D = \frac{\text{Circumference of the flywheel}}{\pi}$$

2. Angle 'θ' in degrees,

$$\theta = \frac{S \times 360}{D \times \pi}$$

Where,

S = Arc length, mm

RESULT:

Valve Timing diagram is drawn

Experiment No. 2

I.C. ENGINE
PORT TIMING DIAGRAM

PORT TIMING DIAGRAM

AIM:

The experiment is conducted to

Determine the actual PORT timing for a 2-stroke Petrol engine and hence draw the diagram.

PROCEDURE:

1) Bring the Piston to Top and start as if from the spark.
2) Rotate the flywheel till the Exhaust port opens and note the reading.
3) Continue the same way and note the reading for the Transfer port.
4) Continue to rotate the flywheel till the Piston moves from BDC to TDC and note down the closing of Transfer and Exhaust port readings.

Observations:

Sl. No.	Valve Position	Angle ‘θ’ in degrees
1	Transfer Port open	
2	Transfer Port Close	
3	Exhaust Port Open	
4	Exhaust Port Close	

RESULT:

Port Timing diagram is drawn.

Experiment No. 3

I.C. Engine Performance Test
Single Cylinder 4 Stroke Diesel Engine

I.C. Engine Performance Test
Single Cylinder 4 Stroke Diesel Engine

INTRODUCTION

A machine, which uses heat energy obtained from combustion of fuel and converts it into mechanical energy, is known as a Heat Engine. They are classified as External and Internal Combustion Engine. In an External Combustion Engine, combustion takes place outside the cylinder and the heat generated from the combustion of the fuel is transferred to the working fluid which is then expanded to develop the power. An Internal Combustion Engine is one where combustion of the fuel takes place inside the cylinder and converts heat energy into mechanical energy. IC engines may be classified based on the working cycle, thermodynamic cycle, speed, fuel, cooling, method of ignition, mounting of engine cylinder and application.

Diesel Engine is an internal combustion engine, which uses heavy oil or diesel oil as a fuel and operates on two or four stroke. In a 4-stroke Diesel engine, the working cycle takes place in two revolutions of the crankshaft or 4 strokes of the piston. In this engine, pure air is sucked to the engine and the fuel is injected with the combustion taking place at the end of the compression stroke. The power developed and the performance of the engine depends on the condition of operation. So it is necessary to test an engine for different conditions based on the requirement.

DESCRIPTION OF THE APPARATUS:

The test rig is built for loading mentioned below:

a. **Mechanical Loading (Water cooled)**

1. The equipment consists of **KIRLOSKAR** Diesel Engine (Crank started) of **5hp (3.7kW)** capacity and is Water cooled. The Engine is coupled to a Rope Brake Drum Dynamometer for loading purposes. Coupling is done by an extension shaft in a separate bearing house. The dynamometer is connected to the spring load assembly for varying the load.

2. Thermocouples are provided at appropriate positions and are read by a digital temperature indicator with channel selector to select the position.
3. Rota meters of range 15LPM & 10LPM are used for direct measurement of water flow rate to the engine and calorimeter respectively.
4. Engine Speed and the load applied at various conditions is determined by a Digital RPM Indicator and spring balance reading.
5. A separate air box with orifice assembly is provided for regularizing and measuring the flow rate of air. The pressure difference at the orifice is measured by means of Manometer.
6. A volumetric flask with a fuel distributor is provided for measurement and directing the fuel to the engine respectively.

EXPERIMENTATION:

AIM:

The experiment is conducted to

a. To study and understand the performance characteristics of the engine.

b. To draw Performance curves and compare with standards.

PROCEDURE:

1. Give the necessary electrical connections to the panel.
2. Check the lubricating oil level in the engine.
3. Check the fuel level in the tank.
4. Allow the water to flow to the engine and the calorimeter and adjust the flow rate to 6lpm & 3lpm respectively.
5. Release the load if any on the dynamometer.
6. Open the three-way cock so that fuel flows to the engine.
7. Start the engine by cranking.
8. Allow to attain the steady state.
9. Load the engine by slowly tightening the yoke rod handle of the Rope brake drum.
10. Note the following readings for particular condition,
    a. Engine Speed
    b. Time taken for ____cc of diesel consumption
    c. Rotameter reading.

d. Manometer readings, in cm of water &

e. Temperatures at different locations.

11. Repeat the experiment for different loads and note down the above readings.
12. After the completion release the load and then switch of the engine.
13. Allow the water to flow for few minutes and then turn it off.

OBSERVATIONS:

Sl. No.	Speed, rpm	Load Applied			Manometer Reading			Time for 10cc of fuel collected, t sec
		F1	F2	F= (F1~F2)	h1	h2	h_w = (h1+h2)	

Sl. No.	T1	T2	T3	T4	T5	T6

Sl. No.	Engine water flowrate, LPM1	Calorimeter water flowrate, LPM2

CALCULATIONS:

1. Mass of fuel consumed, m_f

$$m_f = \frac{X_{cc} \times \text{Specific gravity of the fuel}}{1000 \times t} \quad (\text{kg/sec})$$

Where,

SG of Diesel is = 0.827

Xcc is the volume of fuel consumed = 10ml

t is time taken in seconds

2. Heat Input, HI

$$HI = m_f \times \text{Calorific Value of Fuel, kW}$$

Where,

Calorific Value of Diesel = 44631.96 KJ/Kg

3. Output or Brake Power, BP

$$\text{Engine output BP} = \frac{2\Pi NT}{60000} \quad \text{kW}$$

Where,

N = speed in rpm

T = F x r x 9.81 N-m

r = 0.15m

4. Specific Fuel Consumption, SFC

$$SFC = \frac{M_f \times 3600}{BP} \quad \text{kg/kW – hr}$$

5. Brake Thermal Efficiency, ηbth%

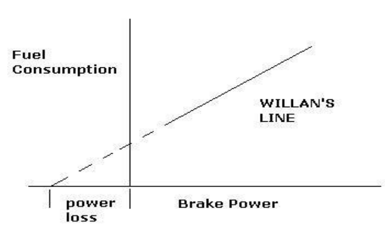
$$\eta_{bth\%} = \frac{3600 \times 100}{SFC \times CV}$$

6. Mechanical Efficiency, $\eta_{mech\%}$

$$\eta_{mech\%} = \frac{BP \times 100}{IP}$$

Determine the IP = Indicated Power, using WILLAN'S LINE method and the procedure is as below:

- Draw the Graph of Fuel consumption Vs Brake power
- Extend the line obtained till it cuts the Brake power axis
- The point where it cuts the brake power axis till the zero point will give the Power losses (Friction Power loss)
- With this the IP can be found using the relation: IP = BP + FP



TABULATION:

Sl.	Input Power	Output Power	SFC	Brake Thermal Efficiency	Mechanical Efficiency
1					
2					
3					
4					
5					

RESULT:

Graphs to be plotted:

1) SFC v/s BP
2) η_{bth} v/s BP
3) η_{mech} v/s BP
4) η_{vol} v/s BP

PRECAUTIONS:

1. Do not run the engine if supply voltage is less than 180V
2. Do not run the engine without the supply of water.
3. Supply water free from dust to prevent blockage in rotameters, engine head and calorimeter.
4. Note that the range for water supply provided is an approximate standard values, however the user may select the operating range to his convenience not less than 3 & 2 LPM for engine and calorimeter respectively.
5. Do not forget to give electrical earth and neutral connections correctly.
6. It is recommended to run the engine at **1500rpm** otherwise the rotating parts and bearing of engine may run out.

Experiment No. 4

PERFORMANCE TEST ON SINGLE CYLINDER 2 – STROKE PETROL ENGINE

PERFORMANCE TEST ON SINGLE CYLINDER 2 – STROKE PETROL ENGINE

INTRODUCTION

A machine, which uses heat energy obtained from combustion of fuel and converts it into mechanical energy, is known as a Heat Engine. They are classified as External and Internal Combustion Engine. In an External Combustion Engine, combustion takes place outside the cylinder and the heat generated from the combustion of the fuel is transferred to the working fluid which is then expanded to develop the power. An Internal Combustion Engine is one where combustion of the fuel takes place inside the cylinder and converts heat energy into mechanical energy. IC engines may be classified based on the working cycle, thermodynamic cycle, speed, fuel, cooling, method of ignition, mounting of engine cylinder and application.

DESCRIPTION OF THE APPARATUS:

The test rig is built for loading mentioned below:

a. **Electrical Dynamometer Loading (AC)**

1) The equipment consists of a **BAJAJ** make 5 port model Petrol Engine (Kick Start) of **3hp(2.2kW)** capacity and is Air cooled The Engine is coupled to a **AC Alternator** for Loading purposes. Coupling is done by an extension shaft in a separate bearing house and is belt driven. The dynamometer is provided with load controller switches for varying the load.

2) The engine is provided with modified head with cooling arrangement for different compression ratio and also has an attachment for varying the spark timing

3) Thermocouples are provided at appropriate positions and are read by digital temperature indicator with channel selector to select the position.

4) Engine Speed at various condition s is determined by a Digital RPM Indicator.

5) Load on the engine is measured by means of Electrical Energy meter.

6) A separate air box with orifice assembly is provided for regularizing and measuring the flow rate of air. The pressure difference at the orifice is measured by means of a Manometer.

7) A volumetric flask with a fuel distributor is provided for measurement and directing the fuel to the engine respectively.

EXPERIMENTATION:

AIM:

The experiment is conducted to

a. To study and understand the performance characteristics of the engine AND
b. To draw Performance curves and compare with standards.

PROCEDURE:

1. Give the necessary electrical connections to the panel.
2. Check the lubricating oil level in the engine.
3. Check the fuel level in the tank.
4. Release the load if any on the dynamometer.
5. Open the three-way cock so that fuel flows to the engine.
6. Set the accelerator to the minimum condition.
7. Start the engine by cranking.(KICK START)
8. Allow to attain the steady state.
9. Load the engine by switching on the Load controller switches provided. (Each loading is incremental of 0.5kW)
10. Note the following readings for particular condition,
    a. Engine Speed
    b. Time taken for ____cc of petrol consumption
    c. Water meter readings.
    d. Manometer readings, in cms of water &
    e. Temperatures at different locations.
11. Repeat the experiment for different loads and note down the above readings.
12. After the completion release the load (while doing so release the accelerator) and then switch of the engine by pressing the ignition cut – off switch and then turnoff the panel.

OBSERVATIONS:

Sl. No.	Speed, rpm	Load Applied	Manometer Reading, cm of water			Time for 10cc of fuel collected,	Time for 5 rev of Energy meter,
		'F' kW	h1	h2	hw = (h1+h2)	t sec	

Sl. No.	Temperature, °C	
	T1	T2

CALCULATIONS:

1. **Mass of fuel consumed, m_f**

$$M_f = \frac{X_{cc} \text{ x Specific gravity of the fuel}}{1000 \text{ x } t} \text{ kg/sec}$$

Where,

SG of Petrol is = 0.71

X_{cc} is the volume of fuel consumed = 10ml

t is time taken in seconds

2. **Heat Input, HI**

HI = m_f x Calorific Value of Fuel, kW

Where,

Calorific Value of Petrol = 43,120 KJ/Kg

3. **Output or Brake Power, BP**

$$BP = \frac{n \text{ x}3600}{K \text{ x } T \text{ x } \eta_m} \text{ kW}$$

Where,

n = No. of revolutions of energy meter (Say 5)

K = Energy meter constant

T = time for 5 rev. of energy meter in seconds

η_m = efficiency of belt transmission = 80%

4. **Specific Fuel Consumption, SFC**

$$SFC = \frac{mf \times 3600}{BP} \quad kg/kW-hr$$

5. **Brake Thermal Efficiency, $\eta_{bth\%}$**

$$\eta_{bth\%} = \frac{3600 \times 100}{SFC \times CV}$$

6. **Calculation of head of air, Ha**

$$Ha = \frac{h_w \; \rho_{water}}{\rho air}$$

Where,

ρ_{water} = 1000 Kg/m

ρ_{air} = 1.2 Kg/m @ R.T.P

h_w is the head in water column in 'm' of water

7. **Volumetric efficiency, $\eta_{vol\%}$**

$$\eta_{vol\ \%} = \frac{Q_a}{Q_{th}} \times 100$$

where,

Q_a = Actual volume of air taken

$$\mathbf{Qa} = C_d\, a \sqrt{(2gH_a)}$$

Where,

C_d = Coefficient of discharge of orifice = 0.62

a = area at the orifice, = $(\prod(0.015)^2/4)$

H_a = head in air column, m of air.

Q_{th} = Theoretical volume of air taken

$$\mathbf{Q_{th}} = \frac{(\prod/4) \times D^2 \times L \times GR \times 0.5 \times N}{60}$$

Where,

D = Bore diameter of the engine = 0.057m

L = Length of the Stroke = 0.057m

N = speed of the engine in rpm.

GR = gear ratio

1st gear = 14.47:1

2nd gear = 10.28:1

3rd gear = 7.31:1

4th gear = 5.36:1

TABULATION:

Sl.	Input Power	Output Power, BP	SFC	Brake Thermal Efficiency	Volumetric efficiency
1					
2					
3					
4					

RESULT:

Graphs to be plotted:

1. SFC v/s BP
2. η_{bth} v/s BP
3. η_{vol} v/s BP

PRECAUTIONS:

1. Do not run the engine if supply voltage is less than 180V
2. Do not run the engine without the supply of water.
3. Supply water free from dust to prevent blockage in rotameter, engine head and calorimeter.
4. Note that the range for water supply provided is an approximate standard values, however the user may select the operating range to his convenience not less than 3 & 2 LPM for engine and calorimeter respectively.
5. Always set the accelerator knob to the minimum condition and start the engine.
6. Switch off the ignition of AUXILLARY while doing in the engine arrangement.
7. Do not forget to give electrical earth and neutral connections correctly.
8. It is recommended to run the engine at **1000rpm** otherwise the rotating parts and bearing of engine may run out.

Experiment No. 5

PERFORMANCE TEST ON SINGLE CYLINDER 4 – STROKE PETROL ENGINE

PERFORMANCE TEST ON SINGLE CYLINDER FOUR STROKE PETROLENGINE

INTRODUCTION

A machine, which uses heat energy obtained from combustion of fuel and converts it into mechanical energy, is known as a Heat Engine. They are classified as External and Internal Combustion Engine. In an External Combustion Engine, combustion takes place outside the cylinder and the heat generated from the combustion of the fuel is transferred to the working fluid which is then expanded to develop the power. An Internal Combustion Engine is one where combustion of the fuel takes place inside the cylinder and converts heat energy into mechanical energy. IC engines may be classified based on the working cycle, thermodynamic cycle, speed, fuel, cooling, method of ignition, mounting of engine cylinder and application.

AIM:

To conduct a performance test on four stroke single cylinder petrol engine.

INSTRUMENTATION:

Digital RPM indicator to measure the speed of the engine.

Digital temperature indicator to measure various temperatures.

Differential manometer to measure quantity of air sucked into cylinder.

Burette with manifold to measure the rate of fuel consumed during test.

ENGINE SPECIFICATION:

ENGINE	:	YAMAHA
BHP	:	3 HP
RPM	:	3000 RPM
FUEL	:	PETROL
No OF CYLINDERS	:	SINGLE
BORE	:	70 mm
STROKE LENGTH	:	66.7 mm
STARTING	:	ROPE & PULLEY STARTING
WORKING CYCLE	:	FOUR STROKE

METHOD OF COOLING : AIR COOLED

METHOD OF IGNITION : SPARK IGNITION

ORIFICE DIA. : 20 mm

COMPRESSION RATIO : 4.67

SPARK PLUG : MICO W 160Z2

CARBURATOR : YAMAHA 1320

GOVERNOR SYSTEM : MECHANICAL GOVERNOR

TYPE : SELF EXCITED, DC SHUNT GENERATOR

POWER : 1.5 KW

SPEED : 3000 RPM

RATED VOLTAGE : 220 v DC

(Max. speed to run as dc motor : 2600 RPM)

RESISTANCE LAMP BANK SPECIFICATION:

RATING : 2.5 Kw, 1Φ(single phase)

VARIATION : In 10 steps, by dc switches.

COOLING : Air cooled

DESCRIPTION:

This engine is a four stroke single cylinder, air – cooled, spark ignition type petrol engine. It is coupled to a loading system which is in this case is a DC GENERATOR, having a resistive lamp bank which will take load with the help of dc switches and also providing motoring test facility to find out frictional power of the engine.

FUEL MEASUREMENT:

The fuel is supplied to the engine from the main fuel tank through a graduated measuring fuel engine (Burette) with 3 – way cock. To measure the fuel consumption of the engine, fill the burette by opening the cock. By starting a stop clock, measure the time taken to consume X cc of fuel by the engine.

AIR INTAKE MEASUREMENT:

The suction side of the engine is connected to an Air tank. The atmospheric air is drawn into the engine cylinder through the air tank. The manometer is provided to measure the pressure drop across an orifice provided in the intake pipe of the Air tank. This pressure drop is used to calculate the volume of air drawn into the cylinder. (Orifice diameter is 20 mm)

LUBRICATION:

The engine is lubricated by mechanical lubrication.

Lubricating oil recommended – SAE – 40 OR Equivalent.

TEMPERATURE MEASUREMENT:

A digital temperature indicator with selector switch is provided on the panel to read the temperature in degree centigrade, directly sensed by respective thermocouples located at different places on the test rig.

THERMOCOUPLE DETAILS

T1 = INLET WATER TEMPERATURE OF ENGINE JACKET & CALORIMETER.

T2 = OUTLET WATER TEMPERATURE OF ENGINE JACKET.

T3 = TEMPERATURE OF WATER OUTLET FROM CALORIMETER.

T4 = TEMPERATURE OF EXHAUST GAS INLET TO CALORIMETER.

T5 = TEMPERAUTRE OF EXHAUST GAS OUTLET FROM CALORIMETER.

T6 = AMBIENT TEMPERATURE.

LOADING SYSTEM:

The engine shaft is directly coupled to the DC Generator which can be loaded by resistive lamp bank. The load can be varied by switching ON the load bank. The load can be varied by switching ON the load bank switches for various loads.

PROCEDURE:

1. Connect the instrumentation power input plug to a 230v, 50 Hz AC single phase AC supply. Now all the digital meters namely, RPM indicator, temperature indicator display the respective readings.

2. Fill up the petrol to the fuel tank mounted behind the panel.

3. Check the lubricating oil level in the oil sump with the dipstick provided.

4. Start the engine with the help of rope and pulley arrangement.

5. Allow the engine to stabilize the speed i.e. 2800 RPM by adjusting the accelerator knob.

6. Keep the change over switch in the generator direction.

7. Apply ¼ load (1.9 Amps).

8. Notedown all the required parameters mentioned below.

a.Speed of the engine in RPM.

b.load from ammeter in amps.

c.Burette reading in cc.

d.Manometer reading in mm.

e.Time take for consumption of Xcc petrol.

f.Exhaust gas temperature in degree C.

9. Load the engine step by step with the use of dc switches provided on the load bank such as,

1/2 load = 3.2 A / 3.8 A

3/4 load = 4.7 A / 5.7 A

Full load = 6.3 A / 7.6 A

10. Note down all required readings.

OBSERVATIONS:

Sl. No.	Speed, rpm	Load Applied	Manometer Reading, cm of water			Time for 10cc of fuel collected,
		'F' kW	h1	h2	h_w = (h1+h2)	t sec

ENGINE PERFORMANCE:

1. BRAKE POWER

$$BP = \frac{VI}{1000 \times \eta_g} \text{ ………………… kW}$$

Where, V = DC voltage in volts.

I = DC current in amps.

η_g = efficiency of generator = 85%

2. MASS OF FUEL CONSUMED.

$$m_f = \frac{X \times 0.72 \times 3600}{1000 \times t} \text{ .... kg/hr}$$

Where, X = burette reading in cc

0.72 = density of petrol in gram / cc

t = time taken in seconds.

3. SPECIFIC FUEL CONSUMPTION.

$$Sfc = \frac{M_f}{BP} \text{ .... Kg/kWh}$$

4. ACTUAL VOLUME OF AIR SUCKED IN TO THE CYLINDER.

$$Va = Cd \times A \sqrt{2gH} * 3600 \text{ .... } m^3/\text{hr.}$$

$$\text{Where, } H = \frac{H \times \rho_w}{1000 \times \rho_a} \text{ .... meter of water.}$$

A = area of orifice = $\Pi d^2 / 4$

h = manometer reading in mm

ρ_w = density of water=1000 kg/m^3

ρ_a = density of air = 1.193 kg/ m^3

C_d = co-efficient of discharge = 0.62

5. SWEPT VOLUME:

$$V_S = \frac{\pi d^2}{4} L$$

Where, d = dia of bore = 70 mm

L = length of stroke = 66.7 mm

6. VOLUMETRIC EFFICIENCY:

$$\eta_v = \frac{V_a}{V_s} \times 100 \text{ ....\%}$$

7. BRAKE THERMAL OR OVER ALL EFFICIENCY

$$\eta_{bth} = \frac{BP \times 3600 \times 100}{m_f \times CV} \text{ ....\%}$$

Where, CV = calorific value of petrol = 43500 kJ / kg.

BP = Brake Power in kW.

8. INDICATED THERMAL EFFICIENCY:

$$\eta_{ith} = \frac{IP \times 3600 \times 100}{m_f \times CV} \text{ \%}$$

9. MECHANICAL EFFICIENCY:

$$\eta_{mech} = \frac{BP \times 100}{IP} \text{ ....\%}$$

Where, BP = Brake Power in kW.

IP = Indicated power in kW.

Experiment No. 6

MORSE TEST ON 4 - CYLINDER 4 - STROKE PETROL ENGINE

MORSE TEST ON
4 - CYLINDER 4 - STROKE PETROL ENGINE

INTRODUCTION

A machine, which uses heat energy obtained from combustion of fuel and converts it into mechanical energy, is known as a Heat Engine. They are classified as External and Internal Combustion Engine. In an External Combustion Engine, combustion takes place outside the cylinder and the heat generated from the combustion of the fuel is transferred to the working fluid which is then expanded to develop the power. An Internal Combustion Engine is one where combustion of the fuel takes place inside the cylinder and converts heat energy into mechanical energy. IC engines may be classified based on the working cycle, thermodynamic cycle, speed, fuel, cooling, method of ignition, mounting of engine cylinder and application.

DESCRIPTION OF THE APPARATUS:

a. **Hydraulic Dynamometer Loading**

1) The equipment consists of a Brand new **ISUZU (Ambassador) make Carburetor Version Engine** (Self started) of capacity **30kW at the charsy and 7.5kW at the crank shaft.**

2) The Engine is coupled to a Hydraulic Dynamometer for Loading purposes. The coupling is done by an **universal coupling** in a bearing house.

3) Thermocouples are provided at appropriate positions and are read by a **digital temperature indicator** with **channel selector**.

4) Rota meters of range 15LPM & 10LPM are used for direct measurement of water flow rate to the engine and calorimeter respectively.

5) The Engine Speed and the load applied at various conditions is determined by a Digital RPM Indicator and Load cell arrangement.

6) A separate air box with orifice assembly is provided for regularizing and measuring the flow rate of air. The pressure difference is measured by means of a Manometer.
7) A volumetric flask with a fuel distributor is provided for measurement and directing the fuel to the engine respectively.

EXPERIMENTATION:

AIM:

The experiment is conducted to

1. To study and understand the performance characteristics of the engine.
2. To draw Performance curves and compare with standards.

PROCEDURE:

1. Check the lubricating oil level.
2. Check the fuel level.
3. Check and Release the load on the dynamometer if loaded.
4. Check the necessary electrical connections and switch on the panel.
5. Provide the Battery Connections.
6. Allow cooling water to engine and calorimeter and set the flow to 6 & 3 LPM respectively.
7. Open the three-way cock so that fuel flows to the engine.
8. Start the engine using the starter key.
9. Set the speed of the engine. (<u>Do not exceed 3000rpm</u>)
10. Now slowly load the engine using the loading wheel of the dynamometer.
11. Set the engine speed to before rating.
12. Note the following readings.
    a. Engine Speed.
    b. Time taken for ____cc of petrol consumption

c. Rotameter readings.

d. Manometer readings, in ‘m’ of water &

e. Temperatures.

Repeat the experiment for other loadings.
After the completion release the load (while doing so release the accelerator) and then switch of the engine and the panel.

1. *Allow the water to flow for few minutes and then turn it off.

***Note:**

Allow water only to the calorimeter and not to the engine.

2. Remove earthing connection of the battery and the starter key.

OBSERVATIONS:

Sl. No.	Speed, rpm	Load Applied	Manometer Reading			Time for 10 cc of fuel collected, t sec
			h1	h2	h_w = (h_1~h_2)	

Sl. No.	T1	T2	T3	T4	T5	T6

Sl. No.	Engine water flowrate, LPM1	Calorimeter water flowrate, LPM2

CALCULATIONS:

1. Mass of fuel consumed, m_f

$$m_f = \frac{Xcc \times \text{Specific gravity of fuel}}{1000 \times t} \text{ kg/sec}$$

Where,

SG of Petrol is = 0.71

X_{cc} is the volume of fuel consumed = 10ml

t is time taken in seconds

2. Heat Input, HI

HI = m_f x Calorific Value of Fuel, kW

Where,

Calorific Value of Petrol= 43120 kJ/kg

3. Output or Brake Power, BP

$$BP = \frac{W \times N \times 0.80}{2000} \text{ kW}$$

Where,

W = Load carried by the dynamometer

= Load indicator Reading in kg

N = Speed of the engine, rpm

4. Specific Fuel Consumption, SFC

$$SFC = \frac{M_f \times 3600}{BP} \text{ kg/kW – hr}$$

5. Brake Thermal Efficiency, ηbth%

$$\eta bth\% = \frac{3600 \times 100}{SFC \times CV}$$

6. Mechanical Efficiency, ηmech%

$$\eta mech\% = \frac{BP}{IP} \times 100$$

IP is calculated using the Morse test facility

7.Calculation of head of air, Ha

$$Ha = \frac{hw \quad \rho water}{\rho air}$$

Where,

ρ_{water} = 1000 Kg/m

ρ_{air} = 1.2 Kg/m @ R.T.P

h_w is the head in water column in 'm' of water

8. Volumetric efficiency, ηvol%

$$\eta_{vol} = \frac{Qa}{Qth} \times 100$$

where,

Qa = Actual volume of air taken = Cd a √ (2gHa)

Where,

C_d = Coefficient of discharge of orifice = 0.62

a = area at the orifice, = ∏ $(0.025)^2$ /4

H_a = head in air column, m of air.

Q_{th} = Theoretical volume of air taken

$$Q_{th} = \frac{(\Pi/4) \times D^2 \times L \times N}{60}$$

Where,

D = Bore diameter of the engine = 0.084m

L = Length of the Stroke = 0.082m

N is speed of the engine in rpm.

TABULATION:

Sl.	Input Power	Output Power	SFC	Brake Thermal Efficiency	Mechanical Efficiency	Volumetric efficiency
1						
2						
3						
4						
5						

RESULT:

Graphs to be plotted:

1) SFC v/s BP
2) ηbth v/s BP
3) ηmech v/s BP
4) ηvol v/s BP

PRECAUTIONS:

1. Do not run the engine if supply voltage is less than 180V
2. Do not run the engine without the supply of water.
3. Supply water free from dust to prevent blockage in rotameters, engine head and calorimeter.
4. Note that the range for water supply provided is an approximate standard values, however the user may select the operating range to his convenience not less than 3 & 2 LPM for engine and calorimeter respectively.
5. Always set the accelerator knob to the minimum condition and start the engine.
6. Do not forget to give electrical earth and neutral connections correctly.
7. It is recommended to run the engine below **3000rpm** otherwise the rotating parts and bearing of dynamometer may run out.

TO DO MORSE TEST FOLLOW THE PROCEDURE BELOW:

1. Start the engine and set to one particular speed and note down the readings and calculate the B.P of the engine for the particular load and speed.
2. Cut - off the 1^{st} cylinder, now the speed reduces , so set the speed to the before value by releasing the load and subtract the previous value to get the IP of 1^{st} cylinder.
3. Now, repeat the step 2 for other cylinders.

OBSERVATION:

Sl. No.	Speed	Initial Load	Final Load after cylinder cut – off			
			1^{st} Cyl	2^{nd} Cyl.	3^{rd} Cyl	4^{th} Cyl
1.						
2.						
3.						

CALCULATION:

1. <u>Brake Power , BP</u>

$$BP = \frac{W \times N \times 0.8}{2000} \quad kW$$

Where,

W = Load carried by the dynamometer

= Load indicator Reading in kg

N = Speed of the engine, rpm

Note: Calculate BP for full load as well as cut-off loads

1. Indicated Power , BP

IP = IP1 + IP2 + IP3 + IP4 kW

Where,

IP1 = BP – BP1

IP2 = BP – BP2

IP3 = BP – BP3

IP4 = BP – BP4

Experiment No. 7

Evaluation of Engine Friction by conducting Motoring/Retardation Test on Single Cylinder 4 Stroke Diesel Engine

Evaluation of Engine Friction by Motoring/Retardation Test on Single Cylinder 4 Stroke Diesel Engine

INTRODUCTION

A machine, which uses heat energy obtained from combustion of fuel and converts it into mechanical energy, is known as a Heat Engine. They are classified as External and Internal Combustion Engine. In an External Combustion Engine, combustion takes place outside the cylinder and the heat generated from the combustion of the fuel is transferred to the working fluid which is then expanded to develop the power. An Internal Combustion Engine is one where combustion of the fuel takes place inside the cylinder and converts heat energy into mechanical energy. IC engines may be classified based on the working cycle, thermodynamic cycle, speed, fuel, cooling, method of ignition, mounting of engine cylinder and application.

Diesel Engine is an internal combustion engine, which uses heavy oil or diesel oil as a fuel and operates on two or four stroke. In a 4-stroke Diesel engine, the working cycle takes place in two revolutions of the crankshaft or 4 strokes of the piston. In this engine, pure air is sucked to the engine and the fuel is injected with the combustion taking place at the end of the compression stroke. The power developed and the performance of the engine depends on the condition of operation. So it is necessary to test an engine for different conditions based on the requirement.

DESCRIPTION OF THE APPARATUS:

The test rig is built for loading mentioned below:

a. Mechanical Loading (Water cooled)

1. The equipment consists of **KIRLOSKAR** Diesel Engine (Crank started) of **5hp (3.7kW)** capacity and is Water cooled. The Engine is coupled to a Rope Brake Drum Dynamometer for loading purposes. Coupling is done by an extension shaft in a separate bearing house. The dynamometer is connected to the spring load assembly for varying the load.
2. Thermocouples are provided at appropriate positions and are read by a digital temperature indicator with channel selector to select the position.
3. Rota meters of range 15LPM & 10LPM are used for direct measurement of water flow rate to the engine and calorimeter respectively.
4. Engine Speed and the load applied at various conditions is determined by a Digital RPM Indicator and spring balance reading.
5. A separate air box with orifice assembly is provided for regularizing and measuring the flow rate of air. The pressure difference at the orifice is measured by means of Manometer.
6. A volumetric flask with a fuel distributor is provided for measurement and directing the fuel to the engine respectively.

EXPERIMENTATION:

AIM:

The experiment is conducted to evaluate engine friction by conducting Motoring/retardation test on single cylinder 4- stroke diesel engine.

PROCEDURE:

1. Give the necessary electrical connections to the panel.
2. Check the lubricating oil level in the engine.
3. Check the fuel level in the tank.
4. Allow the water to flow to the engine and the calorimeter and adjust the flow rate to 6lpm & 3lpm respectively.
5. Release the load if any on the dynamometer.
6. Open the three-way cock so that fuel flows to the engine.
7. Start the engine by cranking.

8. Allow to attain the steady state.
9. Load the engine by slowly tightening the yoke rod handle of the Rope brake drum.
10. Note the following readings for particular condition,
    a. Engine Speed
    b. Time taken for ____cc of diesel consumption
    c. Rotameter reading.
    d. Manometer readings, in cms of water &
    e. Temperatures at different locations.
11. Repeat the experiment for different loads and note down the above readings.
12. After the completion release the load and then switch of the engine.
13. Allow the water to flow for few minutes and then turn it off.

Motoring Test

14. In the motoring test, the engine is first run up to the desired speed by its own power and allowed to remain at the given speed and load conditions for some time so that oil, water, and engine component temperatures reach stable conditions.
15. The power of the engine during this period is absorbed by a swinging field type electric dynamometer, which is most suitable for this test.
16. The fuel supply is then cut-off and by suitable electric-switching devices the dynamometer is converted to run as a motor to drive for 'motor' the engine at the same speed at which it was previously running.
17. The power supply to the motor is measured which is a measure of the fhp of the engine. During the motoring test the water supply is also cut-off so that the actual operating temperatures are maintained.

OBSERVATIONS:

Sl. No.	Speed, rpm	Load Applied			Manometer Reading			Time for 10cc of fuel collected, t sec
		F1	F2	F= (F1~F2)	h1	h2	h_w = (h1+h2)	

Sl. No.	T1	T2	T3	T4	T5	T6

Sl. No.	Engine water flowrate, LPM1	Calorimeter water flowrate, LPM2

CALCULATIONS:

1. Mass of fuel consumed, m_f

$$m_f = \frac{\text{Xcc x Specific gravity of the fuel}}{1000 \times t}, \text{ kg/sec}$$

Where,

SG of Diesel is = 0.827

Xcc is the volume of fuel consumed = 10ml

t is time taken in seconds

2. **Heat Input, HI**

$$HI = m_f \times \text{Calorific Value of Fuel, kW}$$

Where,

Calorific Value of Diesel = 44631.96 KJ/Kg

3. **Output or Brake Power, BP**

$$\text{Engine output BP} = \frac{2\Pi\ NT}{60000} \quad kW$$

Where,

N is speed in rpm

T = F x r x 9.81 N-m

r = 0.15m

4. **Specific Fuel Consumption, SFC**

$$SFC = \frac{m_f \times 3600}{BP} \quad kg/kW - hr$$

5. **Brake Thermal Efficiency, ηbth%**

$$\eta_{bth} = \frac{3600 \times 100}{SFC \times CV}$$

6. **Mechanical Efficiency, ηmech%**

$$\eta_{mech} = \frac{BP}{IP} \times 100$$

Determine the IP = Indicated Power, using WILLAN'S LINE method and the procedure is as below:

- Draw the Graph of Fuel consumption Vs Brake power
- Extend the line obtained till it cuts the Brake power axis
- The point where it cuts the brake power axis till the zero point will give the Power losses (Friction Power loss)
- With this the IP can be found using the relation:

  IP = BP + FP

7. **Calculation of head of air, Ha**

$$Ha = \frac{hw\ \rho water}{\rho air}$$

Where,

ρ_{water} = 1000 Kg/m

ρair = 1.2 Kg/m @ R.T.P

hw is the head in water column in 'm' of water

8. Volumetric efficiency, ηvol%

$$\eta vol\ \% = \frac{Qa}{Q_{th}} \times 100$$

where,

Qa = Actual volume of air taken = Cd a √ (2gHa)
Cd = Coefficient of discharge of orifice = 0.62
a = area at the orifice, = $(\prod(0.02)^2/4)$

Ha = head in air column, m of air.

Qth = Theoretical volume of air taken

$$\mathbf{Q_{th}} = \frac{(\prod/4) \times D^2 \times L \times N}{60}$$

Where,

D = Bore diameter of the engine = 0.08m

L = Length of the Stroke = 0.110m

N is speed of the engine in rpm.

TABULATION:

Sl.	Input Power	Output Power	SFC	Brake Thermal Efficiency	Mechanical Efficiency	Volumetric efficiency
1						
2						
3						
4						
5						

RESULT:

Graphs to be plotted:
1. SFC v/s BP
2. η_{bth} v/s BP
3. η_{mech} v/s BP
4. η_{vol} v/s BP

PRECAUTIONS:

1. Do not run the engine if supply voltage is less than 180V
2. Do not run the engine without the supply of water.
3. Supply water free from dust to prevent blockage in rotameters, engine head and calorimeter.
4. Note that the range for water supply provided is an approximate standard values, however the user may select the operating range to his convenience not less than 3 & 2 LPM for engine and calorimeter respectively.
5. Do not forget to give electrical earth and neutral connections correctly.
6. It is recommended to run the engine at **1500rpm** otherwise the rotating parts and bearing of engine may run out.

TO DO RETARDATION TEST FOLLOW THE PROCEDURE BELOW:

1. Start the engine as given in the main procedure and allow it to attain steady state.
2. From the RPM controller set the speed (say 1000rpm) and cut - off the fuel flow to the engine by the valve provided near the fuel filter.
3. Immediately trigger the timer and note the time when its stops, means at the set speed.
4. Also, open the fuel flow when the timer stops.
5. Now, repeat steps 1 to 4 for different speeds (say 900,800.. upto 400rpm).
6. Next, Load the engine at 25% of the full load and repeat the steps 1 to 5.
7. Repeat the step 1 to 6 for different percentages of loading (say

50% & 75%)

8. Draw the graph of SPEED vs TIME OF SPEED DROP for different loading conditions.
9. From the graph note the time for given speed difference (Say 100, 200 or any rpm) for no load and load condition and do the calculations as mentioned below.

CALCULATIONS:

1. Frictional Torque, Tf

$$T_f = \left(\frac{t_3}{t_2 - t_3}\right) T_{given\ load} \qquad Nm$$

Where,

T = Torque at the given load, Nm.

T_f = Frictional Torque, Nm.

t3 = time for reduction of speed at given load. t2 = time for reduction of speed at no load.

2. Friction Power, FP

$$FP = \frac{2 \pi N T_f}{60,000}$$

Experiment No. 8

Heat Balance Test on

Single Cylinder 4 Stroke Diesel Engine

Heat Balance Test on Single Cylinder 4 Stroke Diesel Engine

INTRODUCTION

A machine, which uses heat energy obtained from combustion of fuel and converts it into mechanical energy, is known as a Heat Engine. They are classified as External and Internal Combustion Engine. In an External Combustion Engine, combustion takes place outside the cylinder and the heat generated from the combustion of the fuel is transferred to the working fluid which is then expanded to develop the power. An Internal Combustion Engine is one where combustion of the fuel takes place inside the cylinder and converts heat energy into mechanical energy. IC engines may be classified based on the working cycle, thermodynamic cycle, speed, fuel, cooling, method of ignition, mounting of engine cylinder and application.

Diesel Engine is an internal combustion engine, which uses heavy oil or diesel oil as a fuel and operates on two or four stroke. In a 4-stroke Diesel engine, the working cycle takes place in two revolutions of the crankshaft or 4 strokes of the piston. In this engine, pure air is sucked to the engine and the fuel is injected with the combustion taking place at the end of the compression stroke. The power developed and the performance of the engine depends on the condition of operation. So it is necessary to test an engine for different conditions based on the requirement.

DESCRIPTION OF THE APPARATUS:

The test rig is built for loading mentioned below:

a. **Mechanical Loading (Water cooled)**

1. The equipment consists of **KIRLOSKAR** Diesel Engine (Crank started) of **5hp (3.7kW)** capacity and is Water cooled. The Engine is coupled to a Rope Brake

Drum Dynamometer for loading purposes. Coupling is done by an extension shaft in a separate bearing house. The dynamometer is connected to the spring load assembly for varying the load.

2. Thermocouples are provided at appropriate positions and are read by a digital temperature indicator with channel selector to select the position.
3. Rota meters of range 15LPM & 10LPM are used for direct measurement of water flow rate to the engine and calorimeter respectively.
4. Engine Speed and the load applied at various conditions is determined by a Digital RPM Indicator and spring balance reading.
5. A separate air box with orifice assembly is provided for regularizing and measuring the flow rate of air.
6. The pressure difference at the orifice is measured by means of Manometer.
7. A volumetric flask with a fuel distributor is provided for measurement and directing the fuel to the engine respectively.

EXPERIMENTATION:

AIM:

The experiment is conducted to check the heat balance of I.C. Engine

PROCEDURE:

1. Give the necessary electrical connections to the panel.
2. Check the lubricating oil level in the engine.
3. Check the fuel level in the tank.
4. Allow the water to flow to the engine and the calorimeter and adjust the flowrate to 6lpm & 3lpm respectively.
5. Release the load if any on the dynamometer.
6. Open the three-way cock so that fuel flows to the engine.
7. Start the engine by cranking.
8. Allow to attain the steady state.
9. Load the engine by slowly tightening the yoke rod handle of the Rope brake drum.
10. Note the following readings for particular condition,

a. Engine Speed
b. Time taken for ____cc of diesel consumption
c. Rotameter reading.
d. Manometer readings, in cms of water &
e. Temperatures at different locations.

11. Repeat the experiment for different loads and note down the above readings.
12. After the completion release the load and then switch of the engine.
13. Allow the water to flow for few minutes and then turn it off.

OBSERVATIONS:

Sl. No.	Speed, rpm	Load Applied			Manometer Reading			Time for 10cc of fuel collected, t sec
		F1	F2	F= (F1~F2)	h1	h2	h_w = (h1+h2)	

Sl. No.	T1	T2	T3	T4	T5	T6

Sl. No.	Engine water flowrate, LPM1	Calorimeter water flowrate, LPM2

CALCULATIONS:

1. **Mass of fuel consumed, m_f**

$$m_f = \frac{Xcc \times \text{Specific gravity of the fuel}}{1000 \times t} \ \text{kg/sec}$$

Where,

SG of Diesel is = 0.827

Xcc is the volume of fuel consumed = 10ml
t is time taken in seconds

2. **Heat Input, HI**

HI = mf x Calorific Value of Fuel , kW

Where,
Calorific Value of Diesel = 44631.96 KJ/Kg

3. **Output or Brake Power, BP**

$$\text{Engine output BP} = \frac{2\Pi NT}{60000} \quad \text{kW}$$

Where,

N is speed in rpm

T = F x r x 9.81 N-m
r = 0.15m

4. **Specific Fuel Consumption, SFC**

$$SFC = \frac{mf \times 3600}{BP} \quad \text{kg/kW – hr}$$

5. **Brake Thermal Efficiency, ηbth%**

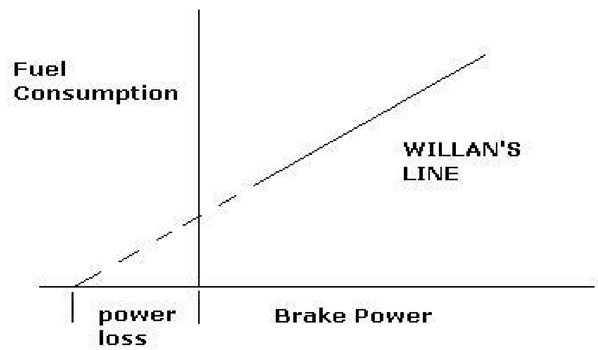
$$\eta_{bth} = \frac{3600 \times 100}{SFC \times CV}$$

6. **Mechanical Efficiency, ηmech%**

$$\eta_{mech} = \frac{BP}{IP} \times 100$$

Determine the IP = Indicated Power, using WILLAN'S LINE method and the procedure is as below:

- Draw the Graph of Fuel consumption Vs Brake power
- Extend the line obtained till it cuts the Brake power axis
- The point where it cuts the brake power axis till the zero point will give the Power losses (Friction Power loss)
- With this the IP can be found using the relation:
  IP = BP + FP



7. Calculation of head of air, Ha

$$Ha = \frac{h_w\, \rho_{water}}{\rho air}$$

Where,

$\rho_{water} = 1000\ Kg/m^3$

$\rho_{air} = 1.2\ Kg/m^3$ @ R.T.P

h_w is the head in water column in 'm' of water

8.Volumetric efficiency, ηvol%

$$\eta vol\ \% = \frac{Qa}{Qth} \times 100$$

where,

Qa = Actual volume of air taken = Cd a √ (2gHa)

Cd = Coefficient of discharge of orifice = 0.62

a = area at the orifice, = (∏(0.02)^2 /4)

Ha = head in air column, m of air.

Qth = Theoretical volume of air taken

$$Qth = \frac{(\Pi/4) \times D^2 \times L \times N}{60}$$

Where,

D = Bore diameter of the engine = 0.08m
L = Length of the Stroke = 0.110m
N = speed of the engine in rpm.

TABULATION:

Sl.	Input Power	Output Power	SFC	Brake Thermal Efficiency	Mechanical Efficiency	Volumetric efficiency
1						
2						
3						
4						
5						

Heat Balance Sheet Calculations IN SECONDS basis:

1. Heat Input --- A

$$A = m_f \times \text{Calorific Value} \quad kW$$

2. Heat to BP --- B

$$B\,P = \frac{2\Pi NT}{60000} \quad kW$$

3. Heat to cooling water --- C

$$C = mwe \times Cpw \times (Tei - Teo) \quad kW$$

Where

m_{we} = cooling water flow rate to the engine from rotameter

= LPM1/60 kg/sec

C_{pw} = Specific Heat of water = 4.18 kJ/kg

4. Heat to exhaust gases --- D

$$D = m_{wc} \times C_{pw} \times (T_{ci} - T_{co}) \times [(T_{gci} - T_a)/(T_{gco} - T_{gci})] \quad kW$$

Where

m_{wc} = water flow rate in kg/sec

= LPM2/60 kg/sec

C_{pw} = Specific Heat of water

T_a = Engine surrounding temperature.

T_{gci} = Gas inlet temp to calorimeter

T_{gco} = Gas outlet temp from calorimeter

T_{ci} = Water Inlet temp to calorimeter

T_{co} = Water outlet temp from calorimeter

5. Heat Unaccounted

E = A – (B+C+D) kW

HEAT BALANCE SHEET:

Sl. No.	Particulars	Heat Content kW	%
1	Heat Input -- A		100
2	Heat to BP -- B		B/A =
3	Heat to Cooling Water -- C		C/A =
4	Heat to Exhaust Gases -- D		D/A =
5	Heat Unaccounted -- E		E/A =

RESULT:

Heat balance test is conducted on IC Engine

PRECAUTIONS:

1. Do not run the engine if supply voltage is less than 180V
2. Do not run the engine without the supply of water.
3. Supply water free from dust to prevent blockage in rotameters, engine head and calorimeter.
4. Note that the range for water supply provided is an approximate standard values, however the user may select the operating range to his convenience not less than 3 & 2 LPM for engine and calorimeter respectively.
5. Do not forget to give electrical earth and neutral connections correctly.
6. It is recommended to run the engine at **1500rpm** otherwise the rotating parts and bearing of engine may run out.

Experiment No. 9

Determination of Air/Fuel Ratio and Volumetric Efficiency on 4-Stroke Diesel Engine

Determination of Air/Fuel Ratio and Volumetric Efficiency on 4-Stroke Diesel Engine

AIM: To determine A/F Ratio and Volumetric Efficiency on the four stroke twin cylinder diesel engine

DESCRIPTION: The A.C. generator is fixed to the Engine shaft and is mounted on a M.S. Channel Frame. Panel board is used to fix burette with 3-way cock, digital RPM indicator and "U" tube manometer

INSTRUMENTATION:

1. Thermocouples are provided at appropriate positions and are read by a digital temperature indicator with channel selector to select the position.
2. Rota meters of range 15LPM & 10LPM are used for direct measurement of water flow rate to the engine and calorimeter respectively.
3. Engine Speed and the load applied at various conditions is determined by a Digital RPM Indicator and spring balance reading.
4. A separate air box with orifice assembly is provided for regularizing and measuring the flow rate of air. The pressure difference at the orifice is measured by means of a Manometer.
5. A volumetric flask with a fuel distributor is provided for measurement and directing the fuel to the engine respectively.

PROCEDURE:

1. Do not run the engine if supply voltage is less than 180V
2. Do not run the engine without the supply of water.
3. Supply water free from dust to prevent blockage in rotameters, engine head and calorimeter.
4. Note that the range for water supply provided is an approximate standard values, however the user may select the operating range to his convenience not less than 3 & 2 LPM for engine and calorimeter respectively.
5. Do not forget to give electrical earth and neutral connections correctly.
6. Frequently, at least once in three months, grease all visual moving parts.
7. At least once in week, operate the unit for five minutes to prevent any clogging

of moving parts.

8. It is recommended to run the engine at **1500rpm** otherwise the rotating parts and bearing of engine may run out.

FUEL MEASUREMENT

The fuel supplied from the main fuel tank through a measuring burette with 3 way manifold system. To measure the fuel consumption of the engine fill the burette by opening the cock measure the time taken to consume X cc of fuel.

AIR INTAKE MEASUREMENT:

The suction side of the engine is connected to an Air tank. The atmospheric air is drawn into the engine cylinder through the air tank. The manometer is provided to measure the pressure drop across an orifice provided in the intake pipe of the Air tank. This pressure drop is used to calculate the volume of air drawn into the cylinder. (Orifice diameter is 20 mm)

OBSERVATIONS:

Sl. No.	Speed, rpm	Load Applied			Manometer Reading			Time for 10cc of fuel collected, t sec
		F1	F2	F= (F1~F2)	h1	h2	hw = (h1+h2)	

Sl. No.	T1	T2	T3	T4	T5	T6

Sl. No.	Engine water flowrate, LPM1	Calorimeter water flowrate, LPM2

CALCULATIONS:

Mass of fuel consumed, m_f

$$m_f = \frac{\text{Xcc x Specific gravity of the fuel}}{1000 \times t} \quad \text{kg/sec}$$

Where,

SG of Diesel is = 0.827

Xcc is the volume of fuel consumed = 10ml

t is time taken in seconds

Heat Input, HI

$$HI = mf \times \text{Calorific Value of Fuel, kW}$$

Where,

Calorific Value of Diesel = 44631.96 KJ/Kg

Output or Brake Power, BP

$$\text{Engine output BP} = \frac{2\Pi \; NT}{60000} \quad \text{kW}$$

Where,

N is speed in rpm

T = F x r x 9.81 N-m

r = 0.15m

Specific Fuel Consumption, SFC

$$SFC = \frac{mf \times 3600}{BP} \quad \text{kg/kW – hr}$$

Brake Thermal Efficiency, ηbth%

$$\eta bth\% = \frac{3600 \times 100}{SFC \times CV}$$

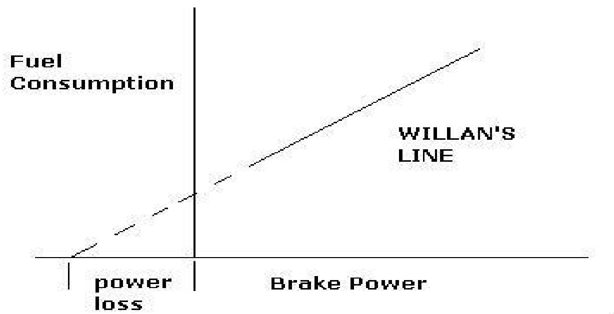
Mechanical Efficiency, ηmech%

$$\eta mech\% = \frac{BP}{IP} \times 100$$

Determine the IP = Indicated Power, using WILLAN'S LINE method and the procedure is as below:

- Draw the Graph of Fuel consumption Vs Brake power
- Extend the line obtained till it cuts the Brake power axis
- The point where it cuts the brake power axis till the zero point will give the Power losses (Friction Power loss)
- With this the IP can be found using the relation:

  IP = BP + FP



<u>Calculation of head of air, Ha</u>

$$Ha = \frac{hw \quad \rho water}{\rho air}$$

Where,

ρwater = 1000 Kg/m

ρair = 1.2 Kg/m @ R.T.P

hw is the head in water column in 'm' of water

<u>Volumetric efficiency, ηvol%</u>

$$\eta vol\ \% = \frac{Qa}{Qth} \times 100$$

where,

Qa = Actual volume of air taken = Cd a √ (2gHa)

Where,

Cd = Coefficient of discharge of orifice = 0.62 a =

area at the orifice, = (∏(0.02) /4)

Ha = head in air column, m of air.

Qth = Theoretical volume of air taken

$$Qth = \frac{(\Pi/4) \times D^2 x\ L \times N}{60}$$

Where,

D = Bore diameter of the engine = 0.08m
L = Length of the Stroke = 0.110m
N is speed of the engine in rpm.

Air Fuel Ratio:

M_a/M_f =

TABULATION:

Sl.	Input Power	Output Power	SFC	Brake Thermal Efficiency	Mechanical Efficiency	Volumetric efficiency
1						
2						
3						
4						

PRECAUTIONS:

1. Do not run the engine if supply voltage is less than 180V
2. Do not run the engine without the supply of water.
3. Supply water free from dust to prevent blockage in rotameters, engine head and calorimeter.
4. Note that the range for water supply provided is an approximate standard values, however the user may select the operating range to his convenience not less than 3 & 2 LPM for engine and calorimeter respectively.
5. Do not forget to give electrical earth and neutral connections correctly.
6. Frequently, at least once in three months, grease all visual moving parts.
7. At least once in week, operate the unit for five minutes to prevent any clogging of moving parts.
8. It is recommended to run the engine at **1500rpm** otherwise the rotating parts and bearing of engine may run out.

Experiment No. 10

Dis-assembly/Assembly of I.C. Engine

Dis-assembly/Assembly of I.C. Engine

AIM:
Dismantling and reassembling of a 4 stroke petrol engine.

Apparatus:
Spanner set, Work bench, screw driver, spark plug spanner, spark plug cleaner, tray, kerosene oil, cotton waste, hammer, oil can etc.

Theory:
In 1878, a British engineer introduced a cycle which could be completed in two strokes of piston rather than four strokes as is the case with the four-stroke cycle engines. In this engine suction and exhaust strokes are eliminated. Here instead of valves, ports are used. The exhaust gases are driven out from engine cylinder by the fresh charge of fuel entering the cylinder nearly at the end of the working stroke. A two-stroke petrol engine is generally used in scooters, motor cycles etc. The cylinder L is connected to a closed crank chamber C.C. During the upward stroke of the piston M, the gases in L are compressed and at the same time fresh air and fuel (petrol) mixture enters the crank chamber through the valve.

Different Parts of I.C. Engine

Cylinder, Cylinder head, Piston, Piston rings, Gudgeon pin, Connecting rod, Crankshaft, Crank, Engine bearing, Crank case, Flywheel etc.

Parts of a 4- Stroke Petrol Engine

Cylinder Head

Also referred to as the top end, the cylinder head houses the pistons, valves, rocker arms and camshafts.

Valves

A pair of valves, used for controlling fuel intake and exhaust, is controlled by a set of fingers on the camshaft called lobes. As the intake valve opens, a mixture of fuel and air from the carburetor is pulled into the cylinder. The exhaust valve expels the spent air/fuel mixture after combustion.

Camshaft

Usually chain or gear-driven, the camshaft spins, using its lobes to actuate the rocker arms. These open the intake and exhaust valves at preset intervals.

The Piston

The piston travels up and down within the cylinder and compresses the air/fuel mixture to be ignited by a spark plug. The combustive force propels the piston downward. The piston is attached to a connecting rod by a wrist pin.

Piston rings:

These are circular rings which seal the gaps made between the piston and the cylinder, their object being to prevent gas escaping and to control the amount of lubricant which is allowed to reach the top of the cylinder.

Gudgeon-pin:

This pin transfers the thrust from the piston to the connecting-rod small-end while permitting the rod to rock to and fro as the crankshaft rotates.

Connecting rod:

This acts as both a strut and a tie link-rod. It transmits the linear pressure impulses acting on the piston to the crankshaft big-end journal, where they are converted into turning-effort.

Crankshaft

The crankshaft is made up of a left and right flywheel connected to the piston's connecting rod by a crank pin, which rotates to create the piston's up-and-down motion. The cam chain sprocket is mounted on the crankshaft, which controls the chain that drives the camshaft.

Carburetor

The carburetor is the control for the engine. It feeds the engine with a mixture of air and petrol in a controlled volume that determines the speed, acceleration and deceleration of the engine. The carburetor is controlled by a slide connected to the throttle cable from the handlebar twist grip which adjusts the volume of air drawn into the engine.

Procedure:

1) Dismantle the following system

a) Fuel supply system

b) Electrical system

2) Remove the spark plug from the cylinder head.

3) Remove the cylinder head nut and bolts.

4) Separate the cylinder head from the engine block.

5) Remove the carburetor from the engine.

6) Open the crank case.

7) Remove piston rings from the piston.

8) Clean the combustion chamber.

9) Reassemble the components vice versa.

Precautions:

* Don’t use loose handle of hammer.
* Care must be taken while removing the components.

Result:

A 4 – stroke petrol engine has been dismantled and reassembled.

Experiment No. 11

PERFORMANCE TEST ON RECIPROCATING AIR COMPRESSOR

PERFORMANCE TEST ON RECIPROCATING AIR COMPRESSOR

INTRODUCTION

A COMPRESSOR is a device, which sucks in air at atmospheric pressure & increases its pressure by compressing it. If the air is compressed in a single cylinder it is called as a Single Stage Compressor. If the air is compressed in two or more cylinders it is called as a Multi Stage Compressor.

In a Two Stage Compressor the air is sucked from atmosphere & compressed in the first cylinder called the low-pressure cylinder. The compressed air then passes through an inter cooler where its temperature is reduced. The air is then passed into the second cylinder where it is further compressed. The air further goes to the air reservoir where it is stored.

DESCRIPTION OF THE APPARATUS:

1. Consists of Two Stage Reciprocating air compressor of 3hp capacity. The compressor is fitted with similar capacity Motor as a driver and 160lt capacity reservoir tank.
2. Air tank with orifice plate assembly is provided to measure the volume of air taken and is done using the Manometer provided.
3. Compressed air is stored in an air reservoir, which is provided with a pressure gauge and automatic cut-off.
4. Necessary Pressure and Temperature tappings are made on the compressor for making different measurements
5. Temperature is read using the Digital temperature indicator and speed by Digital RPM indicator.

EXPERIMENTATION:

AIM:

The experiment is conducted at various pressures to

1. Determine the Volumetric efficiency.
2. Determine the Isothermal efficiency.

PROCEDURE:

1. Check the necessary electrical connections and also for the direction of the motor.

2. Check the lubricating oil level in the compressor.

3. Start the compressor by switching on the motor.

4. The slow increase of the pressure inside the air reservoir in observed.

5. Maintain the required pressure by slowly operating the discharge valve (open/close). (Note there may be slight variations in the pressure readings since it is a dynamic process and the reservoir will be filled continuously till the cut-off.)
6. Now note down the following readings in the respective units,

Speed of the compressor.

Manometer readings.

Delivery pressure.

Temperatures.

Energy meter reading.

6. Repeat the experiment for different delivery pressures.

7. Once the set of readings are taken switch of the compressor.
8. The air stored in the tank is discharged. Be careful while doing so, because the compressed air passing through the small area also acts as a air jet which may damage you or your surroundings.

9. Repeat the above two steps after every experiment.

OBSERVATIONS:

Sl. No.	Compressor Speed, N rpm	Delivery Pressure, 'P' kg/cm^2	Time for 'n' revolutions of energy meter, 'T' sec	Manometer meter reading in 'm'		
				h1	h2	Hw
1						
2						
3						
4						
5						

CALCULATIONS:

1. Air head causing flow, **ha**

$$ha = \frac{h_w \rho_{water}}{\rho_{air}} \quad \text{m of air}$$

Where,

h_w is Water column reading in m of water,
ρ_{water} is density of the water = 1000 kg/m^3

ρ_{air} is the density of the air = 1.293 kg/m^3

2. Actual vol. of air compressed at RTP, **Qa**

$$Qa = Cd\ a \sqrt{(2gha)} \quad m^3/s$$

Where,

ha is air head causing the flow in m of air.
Cd = co efficient of discharge of orifice = 0.62
a = Area of orifice = $(\prod d)^2 / 4$
d = diameter of orifice = 0.02m

3. Theoritical volume of air compressed Qth,

$$Qth = \frac{(\prod/4) \times D^2 \times L \times N}{60} \quad m^3/s$$

Where,
D is the diameter of the LP cylinder = 0.07m.
L is Stroke Length = 0.085m
N is speed of the compressor in rpm

4. Input Power, IP

$$\text{Input Power} = \frac{3600 \times n \times \eta_m}{K \times T}, \quad kW$$

Where,

n = No. of revolutions of energy meter (Say 5)

K = Energy meter constant ___ revs/kW-hr

T = time for 5 rev. of energy meter in seconds

η_m = efficiency of belt transmission = 75%

5. Isothermal Work done, WD

$$WD = \rho a \times Qa \ln r \ kW$$

Where,

ρ_{air} = is the density of the air = 1.293 kg/^{m3}

Qa = Actual volume of air compressed.

r = Compression ratio

$$r = \frac{\text{Delivery gauge pressure} + \text{Atmospheric pressure}}{\text{Atmospheric pressure}}$$

Where Atmospheric pressure = 101.325 kPa

NOTE: To convert delivery pressure from kg/cm[to kPa

multiply by 98.1

6. Volumetric efficiency, ηvol

$$\eta vol = Qa/Qth \times 100$$

7. Isothermal efficiency, η_{iso}

$$\eta_{iso} = \frac{\text{Isothermal work done}}{IP} \times 100$$

TABULATIONS:

Sl. No	Head of air ha, m	Act. Vol. of air compressed Qa mZ/s	Theo. Vol. of air compressed Qth, mZ/s	Isothermal work done kW	Iso Thermal Efficiency ηiso, %	Volumetric Efficiency, ηvol, %
1						
2						
3						
4						
5						
6						

PRECAUTIONS:

1. Do not run the blower if supply voltage is less than 380V
2. Check the direction of the motor, if the motor runs in opposite direction change the phase line of the motor to run in appropriate direction.
3. Do not forget to give electrical earth and neutral connections correctly.

RESULT:

Volumetric efficiency, η_{vol} = ---------

Isothermal efficiency, η_{iso} = -----------

GRAPHS TO BE PLOTTED:

1. Delivery Pressure vs. ηvol
2. Delivery Pressure vs. ηiso

Experiment No. 12

STUDY OF BOILERS

STUDY OF BABCOCK-WILCOX BOILER

Aim: To study Babcock-Wilcox boiler.

Theory: Evaporating the water at appropriate temperatures and pressures in boilers does the generation of steam. A boiler is defined as a set of units, combined together consisting of an apparatus for producing and recovering heat by igniting certain fuel, together with arrangement for transferring heat so as to make it available to water, which could be heated and vaporized to steam form. One of the important types of boilers is Babcock-Wilcox boiler.

Observation: In thermal powerhouses, Babcock Wilcox boilers do generation of steam in large quantities.

The boiler consists essentially of three parts.

1. **A number of inclined water tubes**: They extend all over the furnace. Water circulates through them and is heated.
2. **A horizontal stream and water drum**: Here steam separate from the water which is kept circulating through the tubes and drum.
3. **Combustion chambers**: The whole of space where water tubes are laid is divided into three separate chambers, connected to each other so that hot gases pass from one to the other and give out heat in each chamber gradually. Thus the first chamber is the hottest and the last one is at the lowest temperature. All of these constituents have been shown as in fig.

The Water tubes 76.2 to 109 mm in diameter are connected with each other and with the drum by vertical passages at each end called

headers. Tubes are inclined in such a way that they slope down towards the back. The rear header is called the **down-take header** and the front header is called the **uptake header** has been represented in the fig as DC and VH respectively.

Whole of the assembly of tubes is hung along with the drum in a room made of masonry work, lined with fire bricks. This room is divided into **three compartments A, B, and C** as shown in fig, so that first of all, the hot gases rise in A and go down in B, again rises up in C, and then the led to the chimney through the smoke chamber C. A **mud collector M** is attached to the rear and lowest point of the boiler into which the sediment i.e. suspended impurities of water are collected due to gravity, during its passage through the down take header.

Below the front uptake header is situated the grate of the furnace, either automatically or manually fired depending upon the size of the boiler. The direction of hot gases is maintained upwards by the **baffles.**

In the steam and water drum the steam is separated from the water and the remaining water travels to the back end of the drum and descends through the down take header where it is subjected to the action of fire of which the temperature goes on increasing towards the uptake header. Then it enters the drum where the separation occurs and similar process continuous further.

For the purpose of super heating the stream addition sets of **tubes of U-shape** fixed horizontally, are fitted in the chamber between the water tubes and the drum. The steam passes from the steam face of the drum downwards into the super heater entering at its upper part, and spreads towards the bottom .Finally the steam enters the **water box ,** at the bottom in a super heated condition from where it is taken out through the outlet pipes.

The boiler is fitted with the usual mountings like **main stop valve, safety valve, and feed valve,** and **pressure gauge.**

Main stop valve is used to regulate flow of steam from the boiler, to steam pipe or from one steam one steam pipe to other.

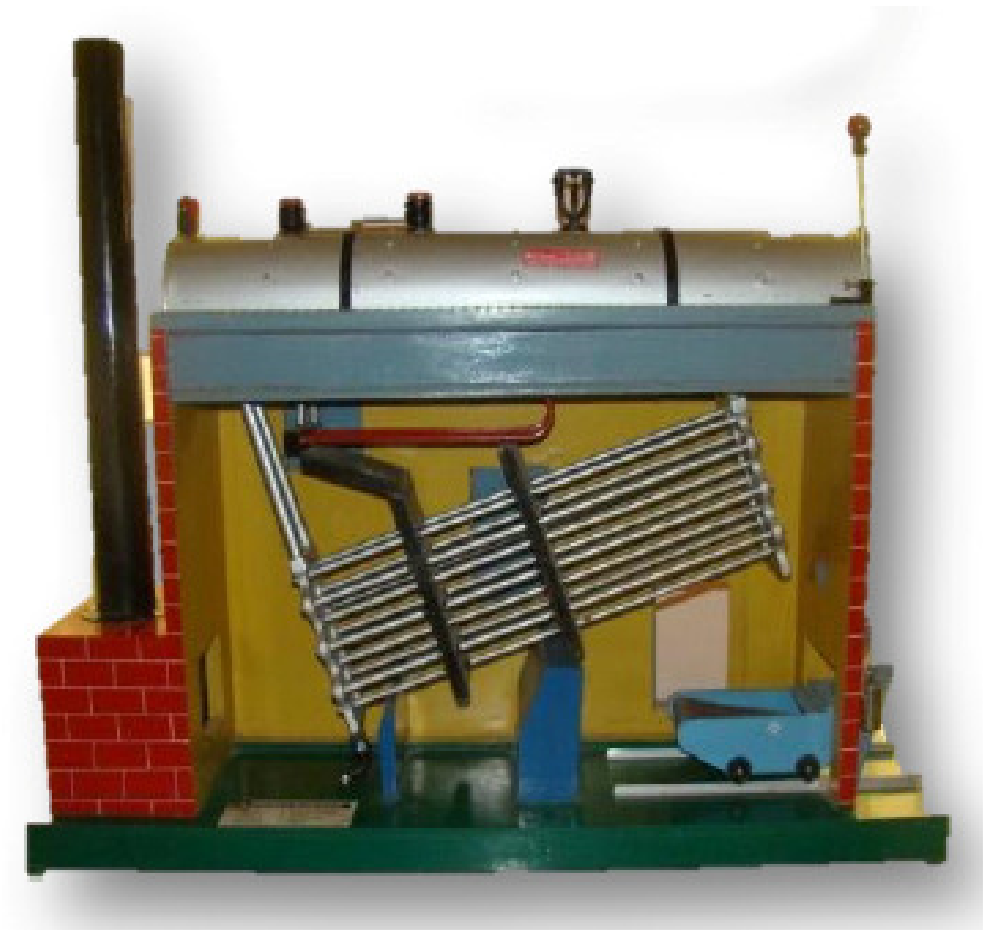
The function of safety valve is used to safe guard the boiler from the hazard of pressures higher than the design value. They automatically discharge steam from the boiler if inside pressure exceeds design-specified limit.

Feed check valve is used to control the supply of water to the boiler and to prevent the escaping of water from boiler due to high pressure inside.

Pressure gauge is an instrument, which record the inside pressure of the boiler.

When steam is raised from a cold boiler, an arrangement is provided for flooding the super heater. By this arrangement the super heater is filled with the water up to the level. Any steam is formed while the super heater is flooded is delivered to the drum ultimately when it is raised to the working pressure. Now the waterr is drained off from the super heater through the cock provided for this purpose, and then steam is let in for super heating purposes.

Result: The Babcock – Wilcox boiler is studied.



BABCOCK-WILCOX BOILER

STUDY OF LANCASHIRE BOILER

AIM: To study Lancashire boiler.

Theory: Evaporating the water at appropriate temperatures and pressures in boilers does the generation of system. A boiler is defined as a set of units, combined together consisting of an apparatus for producing and recovering heat by igniting certain fuel, together with arrangement for transferring heat so as to make it available to water, which could be heated and vaporized to steam form. One of the important types of boilers is Lancashire boiler.

Observation: Lancashire boiler has two large diameter tubes called **flues**, through which the hot gases pass. The water filled in the main shell is heated from within around the flues and also from bottom and sides of the shell, with the help of other masonry ducts constructed in the boiler as described below.

The main boiler shell is of about 1.85 to 2.75 m in diameter and about 8 m long. Two large tubes of 75 to 105 cm diameter pass from end to end through this shell. These are called **flues.** Each flue is proved with a **fire door** and a **grate** on the front end. The shell is placed in a placed in a masonry structure which forms the external flues through which, also, hot gases pass and thus the boiler shell also forms a part of the heating surface. The whole arrangement of the brickwork and placing of boiler shell and flues is as shown in fig.

SS is the boiler **shell** enclosing the main **flue tubes**. SF are the **side flues** running along the length of the shell and BF is the **bottom flue**. Side and bottom flues are the ducts, which are provided in masonry itself.

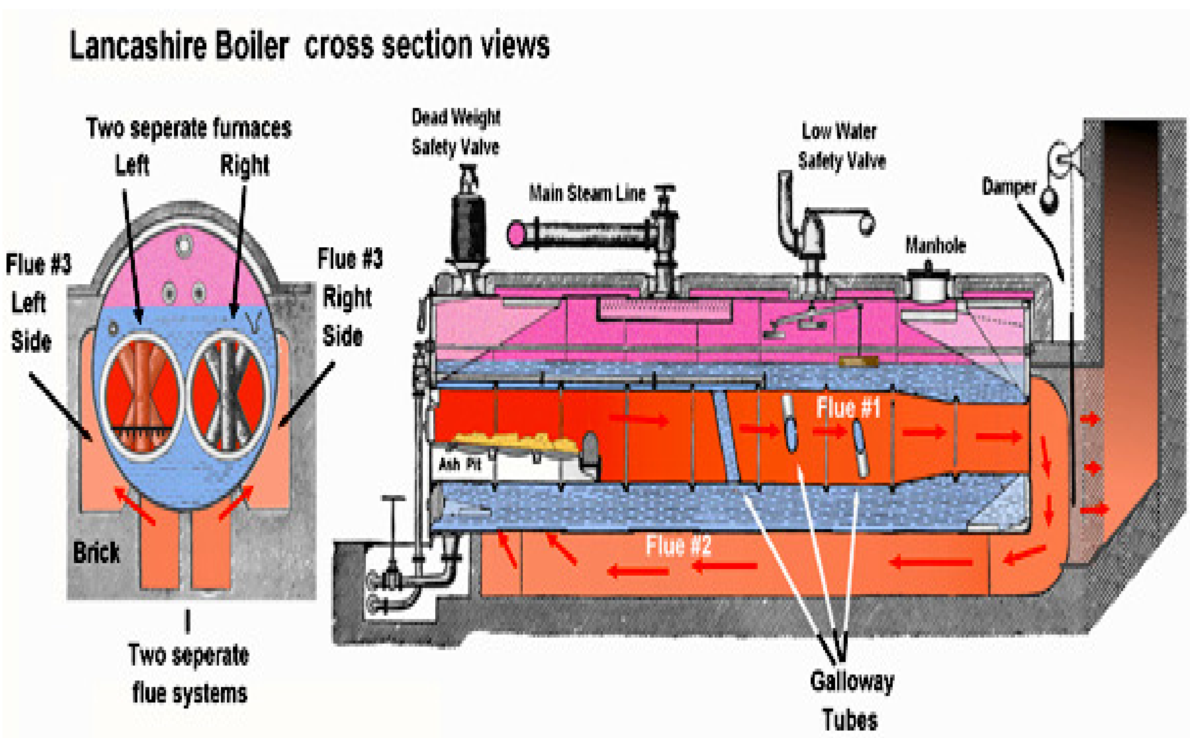
The draught in this boiler is produced by chimney. The hot gases starting from the grate travel all along the flues tubes; and thus transmits heat through the surface of the flues. On reaching at the back end of the boiler they go down through a passage, they heat water through the lower portion of the main water shell. On reaching again at front end they bifurcate to the side flues and travel in the forward direction till finally they reach in the smoke chamber from where they pass onto chimney.

During passage through the side flues also they provide heat to the water through a part of the main shell. Thus it will be seen that sufficient amount of area is provided as heating surface by the flue tubes and by a large portion of the shell

Operating the dampers L placed at the exit of the flues may regulate the flow of the gases. Suitable firebricks line the flues. The boiler is equipped with suitable firebricks line the flues. The boiler is equipped with suitable mountings and accessories.

There is a special advantage possessed by such types of boilers. The products of combustion are carried through the bottom flues only after they have passed through the main flue tubes, hence the hottest portion does not lie in the bottom of the boiler, where the sediment contained in water as impurities is likely to fall. Therefore there are less chances of unduly heating the plates at the bottom due to these sediments.

Result: The Lancashire boiler is studied.



MALLA REDDY

COLLEGE OF ENGINEERING & TECHNOLOGY

(AUTONOMOUS)

DEPARTMENT OF MECHANICAL ENGINEERING

MACHINE TOOLS AND METROLOGY LAB

LABORATORY MANUAL

B.TECH -III YEAR - I SEMESTER
(2016-2017)

PART-I

MACHINETOOLS LAB

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- Surface grinding (Plain surface)
- Tool and Cutter (V Tool and sidetool)
- Cylindrical Grinding(Step Grinding)
-

SAFETY PRECAUTIONS:

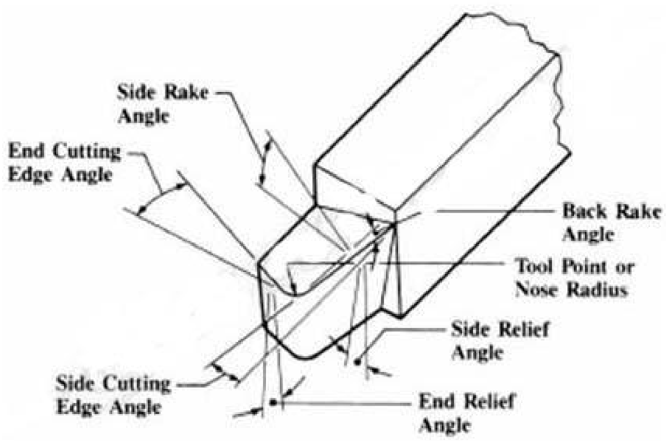
1. Attention to be paid for clamping the job, tool, tool holders or supporting items.
2. Care should be taken for avoiding accidental contact with revolving cutters.
3. Break the sharp edges in jobs
4. Do not handle chips with bare hands, use brush or hand gloves.
5. Pay attention while selecting tools or blades for the proposed use to avoid accidents.
6. Do not remove chip while machine is running.
7. Ensure proper bucking of m/c slides or pay attention or alertness.
8. Care should be taken while selecting rapid or feed .
9. Follow safety precautions while approach with cutter to avoid tool damage.
10. Use coolants for heat dissipation.
11. Use goggles for sparks, spatters, avoid the watch clearly with bare eyes.
12. Avoid sharp edge tools.
13. Ensure clamping on surface grinding m/c before take a cut.
14. Select proper speed or feed or depth of cut.
15. Aim for easy chip disposal system.

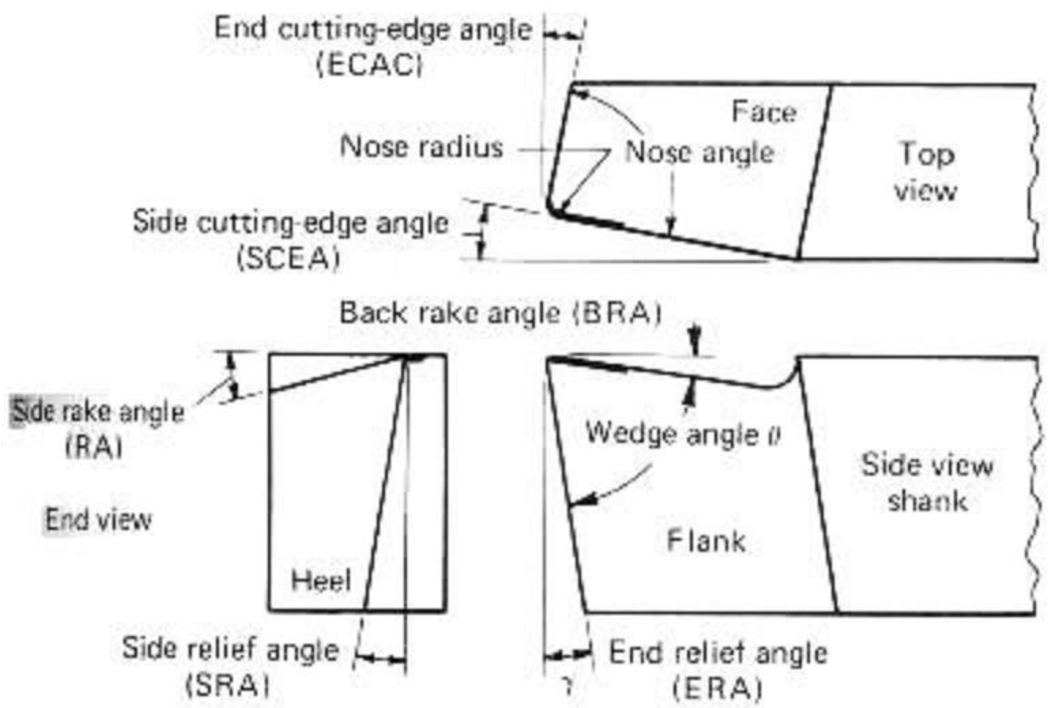
PROBABLE ACCIDENTS:

1. Before switching on any machine tool, work piece, tool or tool holder or any supporting assembly like tailstock in lathe to be clamped properly.
2. The chief hazard associated is accidental contact with moving cutter
3. Hazard of sharp edge contact with chips while machining.
4. Selection of no. of teeth or blade size on primer hacksaw machine.
5. Ramming of chips when machine in motion viz. shaping or slotting.
6. Locking of tables and ensure the feed.
7. Switch on the connection selection of lever (rapid/feed).
8. Approach the tool to the work piece while machining at slow pace to avoid cutting tool damage.
9. Flying sparks in welding.

- Holding of heated parts after machining, welding or spot welding.
- Magnetic clamping refines starting the surface grinding.
- Selection of proper depth cut or feeds or any machine.
- Chip disposal system to the accident free.

1. NOMENCLATURE OF SINGLE POINT CUTTING TOOL





1: Side Cutting Edge Angle:

The angle between side cutting edge and the side of the tool shank is called side cutting edge angle. It is often referred to as the lead angle.

2: End Cutting Edge Angle:

The angle between the end cutting edge and a line perpendicular to the shank of the tool shank is called end cutting edge angle.

3: Side Relief Angle:

The angle between the portion of the side flank immediately below the side cutting edge and a line perpendicular to the base of the tool.

4: End Relief Angle:

The angle between the end flank and the line perpendicular to the base of the tool is called end relief angle.

5: Back Rake Angle:

The angle between the face of the tool and line perpendicular to the base of the tool measures on perpendicular plane through the side cutting edge. It is the angle which measures the slope of the face of the tool from the nose, towards the rack. If the slope is downward the nose it is negative back rake.

6: Side Rake Angle:

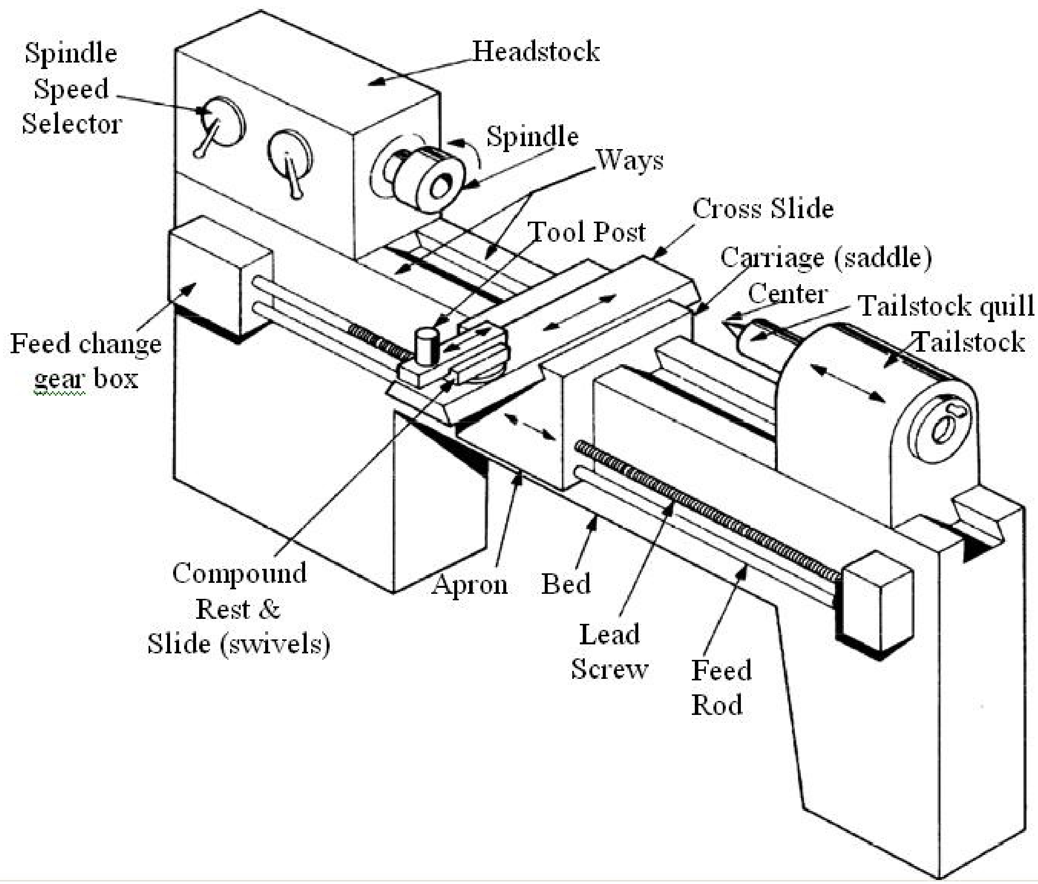
The angle between the face of the tool and a line parallel to the base of the tool measured on plane perpendicular to the base and the side edge. It is the angles that measure the slope of the tool face from the cutting edge, if the slope is towards the cutting edge it is negative side rake angle and if the slope is away from the cutting edge, it is positive side rake angle. If there is no slope the side rake angle is zero.

2. INTRODUCTION OF GENERAL PURPOSE OF MACHINES

Various machining purpose used these all type of mechanical machining machines are Lathe machine, Shaper machine, Slotting machine, Planning machine, Drilling machine, Boring machine, Milling machine, Grinding machine, Lapping machine Honing machine and Broaching machine

These machines are to producing various operations like namely Facing, Chamfering, Step turning, Taper turning, Plain turning, Knurling, Grooving, Thread cutting, Drilling, Tapping, Precision grinding, Cylindrical grinding, Surface grinding, grinding of tool angles e.t.c.

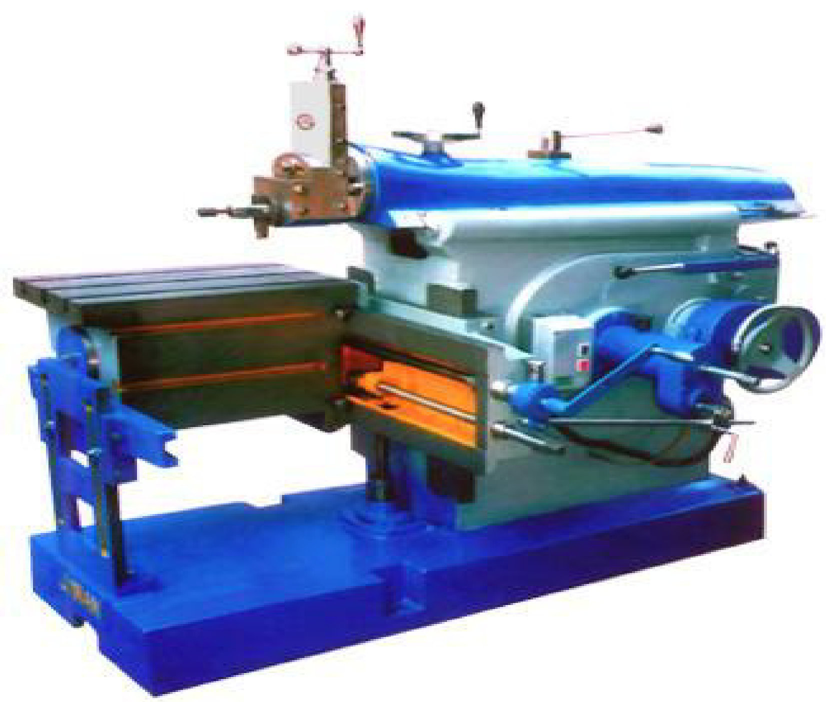
LATHE MACHINE:



A lathe s a machine tool which rotates the workpiece on its axis to perform various operations such as cutting, sanding, knurling, drilling, or deformation with tools that are applied to the workpiece to create an object which has symmetry about an axis of rotation.

Lathes are used in woodturning, metalworking, metal spinning, and glass working. Lathes can be used to shape pottery, the best-known design being the potter's wheel. Most suitably equipped metalworking lathes can also be used to produce most solids of revolution, plane surfaces and screw threads or helices. Ornamental lathes can produce three-dimensional solids of incredible complexity. The material can be held in place by either one or two centers, at least one of which can be moved horizontally to accommodate varying material lengths. Other work holding methods include clamping the work about the axis of rotation using a chuck to a faceplate, using clamps or dogs.

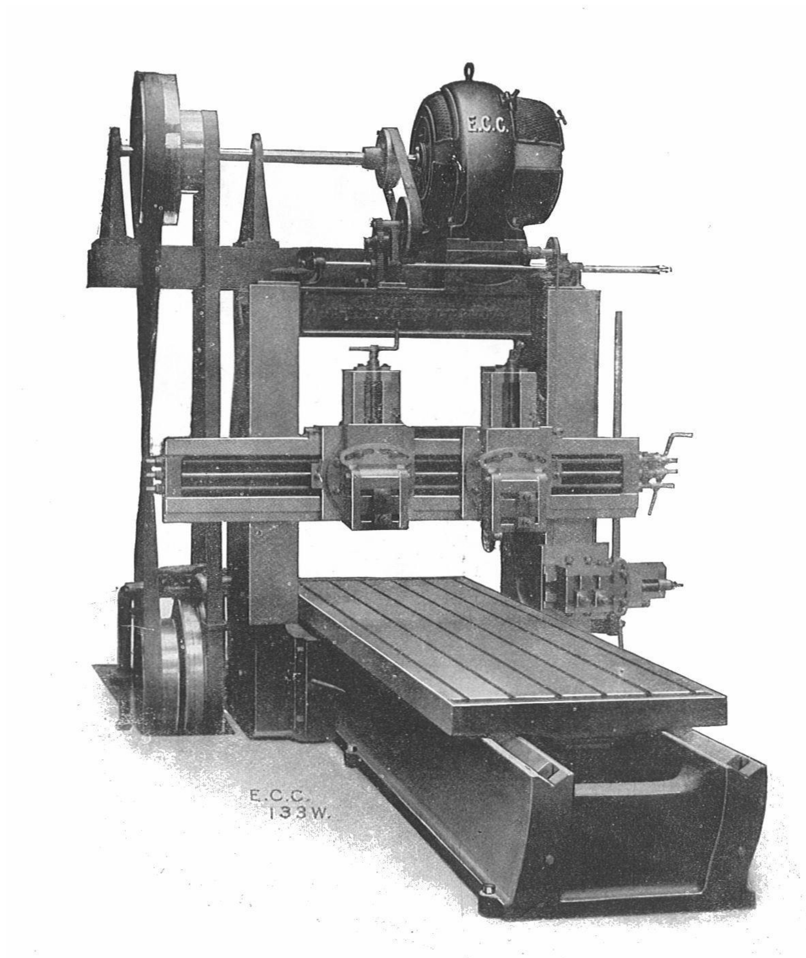
SHAPER MACHINE:



A shaper is a type of machine tool that uses linear relative motion between the workpiece and a single-point cutting tool to machine a linear tool path. Its cut is analogous to that of a lathe, except that it is linear instead of helical. (Adding axes of motion can yield helical tool paths, as also done in helical planning.) A shaper is analogous to a planer, but smaller, and with the cutter riding a ram that moves above a stationary workpiece, rather than the entire workpiece moving beneath the cutter. The ram is moved back and forth typically by a crank inside the column; hydraulically actuated shapers also exist.

A shaper is a type of machine tool that uses linear relative motion between the workpiece and a single-point cutting tool to machine a linear tool path. Its cut is analogous to that of a lathe, except that it is linear instead of helical. (Adding axes of motion can yield helical tool paths, as also done in helical planning.) A shaper is analogous to a planer, but smaller, and with the cutter riding a ram that moves above a stationary workpiece, rather than the entire workpiece moving beneath the cutter. The ram is moved back and forth typically by a crank inside the column; hydraulically actuated shapers also exist.

PLANNING MACHINE:



A planer is a type of metalworking machine tool that uses linear relative motion between the workpiece and a single-point cutting tool to machine a linear tool path. Its cut is analogous to that of a lathe, except that it is linear instead of helical. (Adding axes of motion can yield helical tool paths; see "Helical planing" below.) A planer is analogous to a shaper, but larger, and with the entire workpiece moving on a table beneath the cutter, instead of the cutter riding a ram that moves above a stationary workpiece. The table is moved back and forth on the bed beneath the cutting head either by mechanical means, such as a rack and pinion drive or a leadscrew, or by a hydraulic cylinder.

DRILLING MACHINE:

A drill or drill motor is a tool fitted with a cutting tool attachment or driving tool attachment,usually a drill bit or driver bit, used for drilling holes in various materials or fastening various materials together with the use of fasteners. The attachment is gripped by a chuck at one end of the drill and rotated while pressed against the target material. The tip, and sometimes edges, of the cutting tool does the work of cutting into the target material. This may be slicing off thin shavings (twist drills or auger bits),grinding off small particles (oil drilling), crushing and removing pieces of the workpiece (SDS masonry drill), countersinking, counterboring, or other operations.

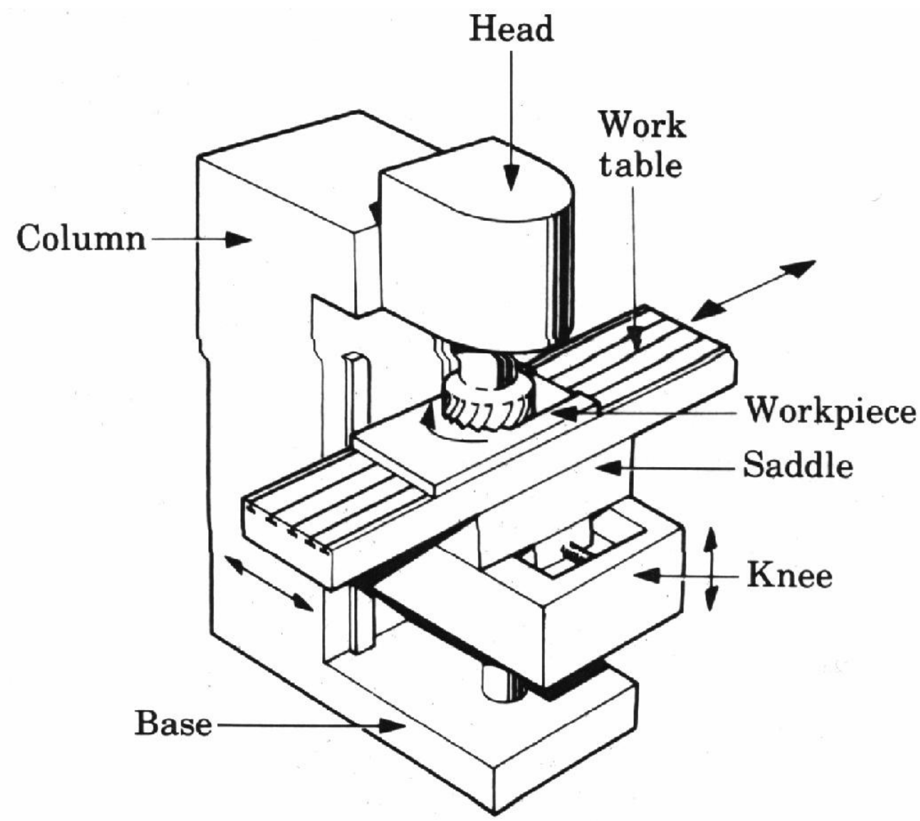
Drills are commonly used in woodworking, metalworking, construction and do-it-yourself projects. Specially designed drills are also used in medicine, space missions and other applications.

BORING MACHINE:

In machining, boring is the process of enlarging a hole that has already been drilled (or cast), by means of a single-point cutting tool (or of a boring head containing several such tools), for example as in boring a cannon barrel. Boring is used to achieve greater accuracy of the diameter of a hole, and can be used to cut a tapered hole.

There are various types of boring. The boring bar may be supported on both ends (which only works if the existing hole is a through hole), or it may be supported at one end. Line boring (line boring, line-boring) implies the former. Backboring (back boring, back-boring) is the process of reaching through an existing hole and then boring on the "back" side of the workpiece (relative to the machine headstock).

MILLING MACHINE:

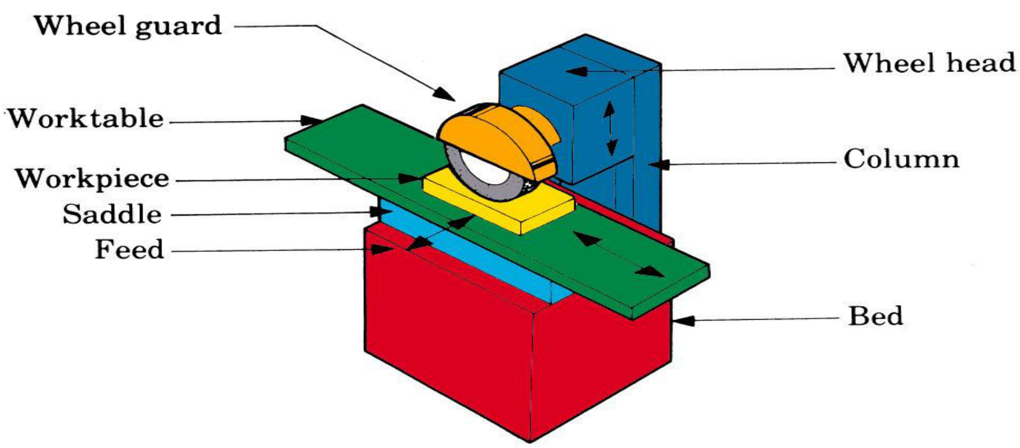


A milling machine (also see synonyms below) is a machine tool used to machine solid materials.

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 drill press, this holds the workpiece stationary as the drill moves axially to penetrate the material, milling machines also move the workpiece radially against the rotating milling cutter, which cuts on its sides as well as its tip. Workpiece and cutter movement are precisely controlled to less than 0.001 in (0.025 mm), usually by means of precision ground slides and lead screws or analogous technology. Milling machines may be manually operated, mechanically automated, or digitally automated via computer numerical control (CNC).

Milling machines can perform a vast number of operations, from simple (e.g., slot and keyway cutting, planing, drilling) to complex (e.g., contouring, die sinking). Cutting fluid is often pumped to the cutting site to cool and lubricate the cut and to wash away the resulting swarf.

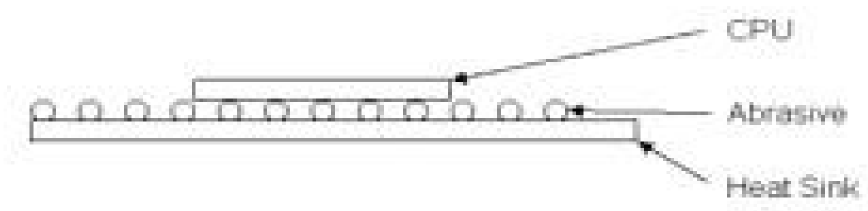
GRINDING MACHINE:



A grinding machine, often shortened to grinder, 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 work piece 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 work piece can be moved whilst the grind head stays in a fixed position. Very fine control of the grinding head or table’s position is possible using a Vernier calibrated hand wheel, or using the features of numerical controls.

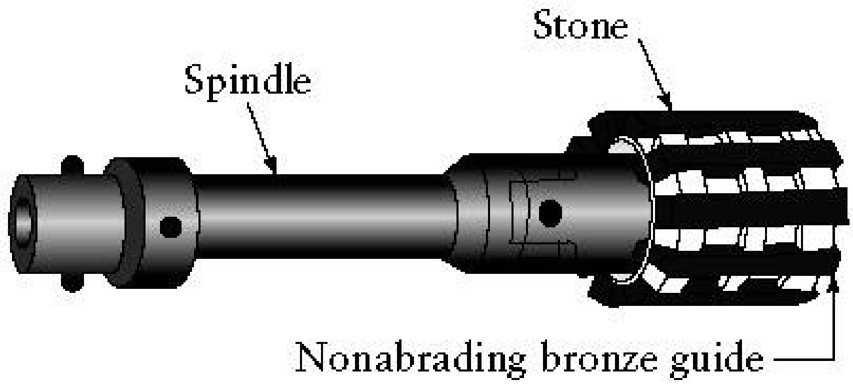
LAPPING MACHINE



Lapping is a machining operation, in which two surfaces are rubbed together with an abrasive between them, by hand movement or by way of a machine. This can take two forms. The first type of lapping (traditionally called grinding), typically involves rubbing a brittle material such as glass against a surface such as iron or glass itself (also known as the "lap" or grinding tool) with an abrasive such asaluminum oxide, jeweller's rouge, optician's rouge, emery, silicon carbide, diamond, etc., in between them. This produces microscopic concordat fractures as the abrasive rolls about between the two surfaces and removes material from both.

The other form of lapping involves a softer material such as pitch or a ceramic for the lap, which is "charged" with the abrasive. The lap is then used to cut a harder material—the workpiece. The abrasive embeds within the softer material which holds it and permits it to score across and cut the harder material. Taken to the finer limit, this will produce a polished surface such as with a polishing cloth on an automobile, or a polishing cloth or polishing pitch upon glass or steel.

HONING MACHINE

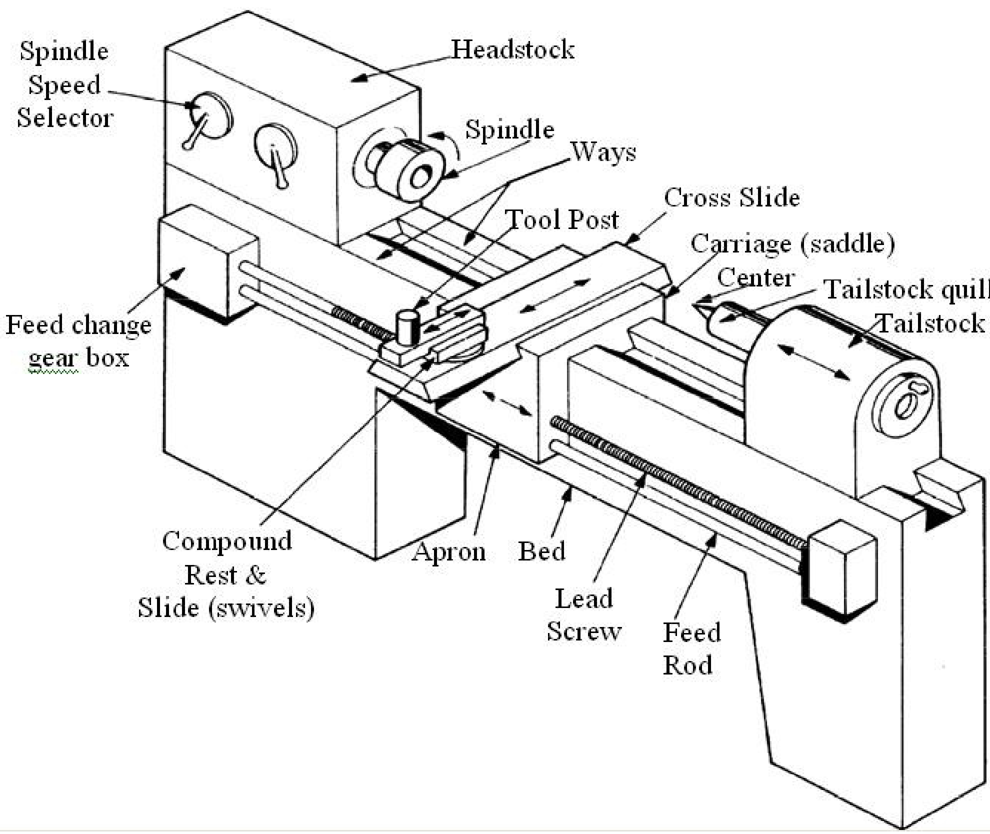


Typical applications are the finishing of cylinders for internal combustion engines, air bearing spindles and gears. Types of hone are many and various but all consist of one or more abrasive stones that are held under pressure against the surface they are working on.

In everyday use, a honing steel is used to hone knives, especially kitchen knives, and is a fine process, there contrasted with more abrasive sharpening. Other similar processes are lapping and super finishing.

LATHE MACHINE

PARTS OF LATHE MACHINE:



3. LATHE MACHINE

INTRODUCTION:

The lathe, probably one of the earliest machine tools, is one of the most versatile and widely used machine tool, so also known as mother machine tool.

An engine lathe is the most basic and simplest form of the lathe. It is called so because in early lathes, power was obtained from engines.

The job to be machined is held and rotated in a lathe chuck; a cutting tool is advanced which is stationary against the rotating job. Since the cutting tool material is harder than the work piece, so metal is easily removed from the job.

Some of the common operations performed on a lathe are facing, turning, drilling, threading, knurling, and boring etc.

LATHE MACHINE PARTS

Bed: Supports all other machine parts.

Carriage: Slides along the machine ways.

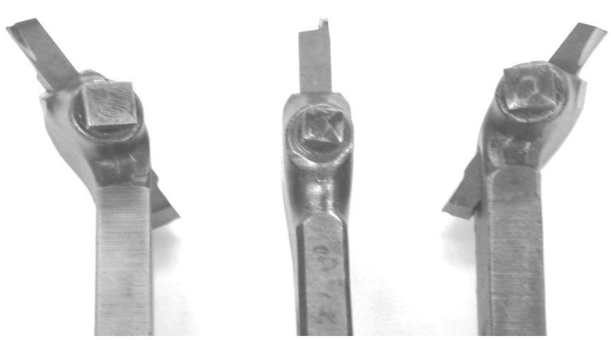
Head stock: Power train of system (spindle included).

Tail Stock: Fixes piece at end opposite to the head stock.

Swing: Maximum diameter of the machinable piece.

Lead screw: Controls the feed per revolution with a great deal of precision.

LATHE TOOLS: Left handed, Right handed, Threading, Boring, Groove, Parting (Cut-Off)



CUTTING SPEEDS:

Typical Lathe Cutting Speeds:

Nominal cuts

-30 - 800 ft./min.

Roughing cuts

- Depth of cut greater then .02 in
- Feed speed of .008 - .08 in/rev.

Finishing Cuts

- Lower than roughing cuts

TURNING OPERATIONS:

Turning (Performed on lathe)

- Part is moving and tool is stationary.

Used to make parts of round cross section – Screws, shafts, pistons

Number of various lathe operations

- Turning, facing, boring, drilling, parting, threading

LATHE OPERATIONS:

2. LATHE -PLAIN TURING, STEP TURNING, TAPER TURNING, KNURLING AND CHAMFERING

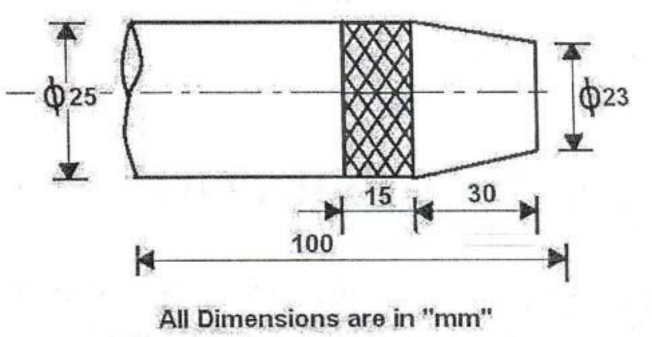
1. AIM:
To perform various lathe operations such as plain turning, taper turning knurling and chamfering on a given material made of Mild steel.

2. MATERIAL REQUIRED:
A mild steel bar of 22 mm diameter and 95 mm length.

3. TOOLS AND EQUIPMENT USED:

H.S.S. single point cutting tool,
Parting tool,
Knurling tool,
Chuckey,
Tool post key,
Outside caliper,
Steel rule.

DIAGRAM:



S NO.	SEQUENCE OF OPERATIONS	CUTTING TOOL USED
1.	Facing	H.S.S Single Point tool
2.	Rough turning	H.S.S Single Point tool
3	Finish turning	H.S.S Single Point tool
4	Step turning	Parting tool
5	Taper turning	H.S.S Single Point tool
6	Knurling	Knurling tool
7	Chamfering	H.S.S Single Point tool

5. TYPES OF OPERATION:

Facing Operation

Facing is the operation of machining the ends of a piece of work to produce a flat surface square with the axis. The operation involves feeding the tool perpendicular to the axis of rotation of the work piece.

A regular turning tool may be used for facing a large work piece. The cutting edge should be set at the same height as the center of the work piece. The tool is brought into work piece from around the center for the desired depth of cut and then is fed outward, generally by hand perpendicular to the axis of rotation of the work piece.

Rough Turning Operation

Rough turning is the operation of removal of excess material from the work piece in a minimum time by applying high rate of feed and heavy depth of cut. The depth of cut for roughing operations in machining the work ranges from 2 to 5 mm and the rate of feed is from 0.3 to 1.5 mm per revolution of the work.

Finish Turning Operation

It requires high cutting speed, small feed, and a very small depth of cut to generate a smooth surface. The depth of cut ranges from 0.5 to 1 mm and feed from 0.1 to 0.3 mm per revolution of the work piece.

Step Turning

Is the operation of making different diameters of desired length. The diameters and lengths are measured by means of outside caliper and steel rule respectively.

Taper Turning

A taper may be defined as a uniform increase or decrease in diameter of a piece of work measured along its length. In a lathe, taper turning means to produce a conical surface by gradual reduction in diameter from a cylindrical work piece.

The amount of taper in a work piece is usually specified by the ratio of the difference in diameters of the taper to its length. This is termed as the conicity designated by the letter 'K'.

$$K = (D-d) / L$$

Where, D = Large diameter of taper in mm

d = small diameter of taper in mm

L = length of tapered part in mm

A taper may be turned by any one of the following methods:

a) Form tool method

b) Tail stock set over method

c) Swiveling the compound rest and

d) Taper turning attachment

Taper turning by swiveling the compound rest:

This method employs the principle of turning taper by rotating the work piece on the lathe axis and feeding the tool at an angle to the axis of rotation of the work piece. The tool mounted on the compound rest is attached to a circular base, graduated in degrees, which may be swiveled and clamped at any desired angle. Once the compound rest is set at the desired half taper angle, rotation of the compound slide screw will cause the tool to be fed at that angle and generate a corresponding taper.

The setting of the compound rest is done by swiveling the rest at the half taper angle. This is calculated by the equation.

$$\tan \alpha = (D-d) / 2L$$

Where α = Half taper angle

Knurling

Knurling is the process of embossing a diamond shaped pattern of the surface of a work piece. The purpose of knurling is to provide an effective gripping surface on a work piece to proven it from slipping when operated by hand. Knurling is performed by a special knurling tool which consists of a set of hardened steel rollers in a holder with the teeth cut on their surface in a definite pattern. The tool is held rigidly on the tool post and the rollers are pressed against the revolving surface of work piece to squeeze the metal against the multiple cutting edges, producing depressions in a regular pattern on the surface of the work piece.

Knurling is done at the slowest speed and oil is flowed on the tool and work piece. Knurling is done at the slowest speed and oil is flowed on the tool and work piece to dissipate heat generated during knurling. The feed varies from 1 to 2 mm per revolution.

CHAMFERING

Chamfering is the operation of beveling the extreme end of a work piece. This is done to remove the burrs, to protect the end of the work piece from being damaged and to have a better look. The operation may be performed after the completion of all operations. It is an essential operation after thread cutting so that the nut may pass freely on the threaded work piece.

6. METAL CUTTING PARAMETERS

The cutting speed of a tool is the speed at which the metal is removed by the tool from the work piece. In a lathe, it is the peripheral speed of the work past the cutting tool expressed in meters/minute

(I) CUTTING SPEED (V) = Π DN/1000, M/MIN

Where, D = Diameter of the work in min
N = RPM of the work

(II) FEED:

The feed of a cutting tool in a Lathe work is the distance the tool advances for each revolution of the work. Feed is expressed in mm/rev.

(III) DEPTH OF CUT:

The depth is the perpendicular distance measured from the machined surface to the uncut surface of the work piece.

Depth of cut = (d1-d2) / 2

Where, d1 = Diameter of the work surface before machining d2 = Diameter of the work surface after machining

While using HSS tool for turning mild steel work piece. The following parameters are to be chosen.

(iv) Rough Turning Operation:

Cutting speed (V) = 25m/min, feed(f) = 0.2 mm/rev,
Depth of cut(t) = 1 mm

(v) Finish turning operation:

Cutting speed (V) = 40m/min, feed(f) = 0.1 mm/rev,
Depth of cut(t) = 0.2 mm

(vi) Tool geometry:

Back rake angle = 7^0,
End relief angle = 6^0
Side relief angle = 6^0,

End cutting edge angle = 15^0
Side cutting edge angle = 15^0,
Nose radius = 2 mm

PROCEDURE:

1. The work piece and HSS single point cutting tool are securely held in the chuck and tool post respectively.
2. Operations such as facing, rough turning and finish turning are performed on a given mild steel bar one after the other in sequence up to the dimensions shown. Then the step turning is performed using parting tool.
3. Then the compound rest is swiveled by calculated half taper angle and taper is generated on the work piece. Rotation of the compound slide screw will cause the tool to be fed at the half-taper angle.
4. HSS single point cutting tool is replaced by the knurling tool and knurling operation is performed at the slowest speed of the spindle.
5. The knurling tool is replaced by the HSS single point tool again; the work piece is removed from the chuck and refixed with the unfinished part outside the chuck. This part is also rough turned, finish turned and facing is done for correct length.
6. Finally, the chamfering is done at the end of the work piece.

PRECAUTIONS:

1. Operate the machine at optimal speeds
2. Do not take depth of cut more than 2 mm.
3. Knurling should be done at slow speeds and apply lubricating oil while knurling
4. Care should be taken to obtain the required accuracy.

RESULT: Required specimen obtained according to specified operaions(plane turning, tapper turning and chamfering) with given dimensions

2. LATHE -THREAD CUTTING

1. AIM:

V-thread cutting on a lathe forming right hand and left hand metric threads as shown in fig.and under cutting operation

2. MATERIAL REQUIRED

Mild steel bar of 24 mm diameter and 100 mm length

3. TOOLS AND EQUIPMENT

H.S.S. single point cutting tool,

Grooving tool,

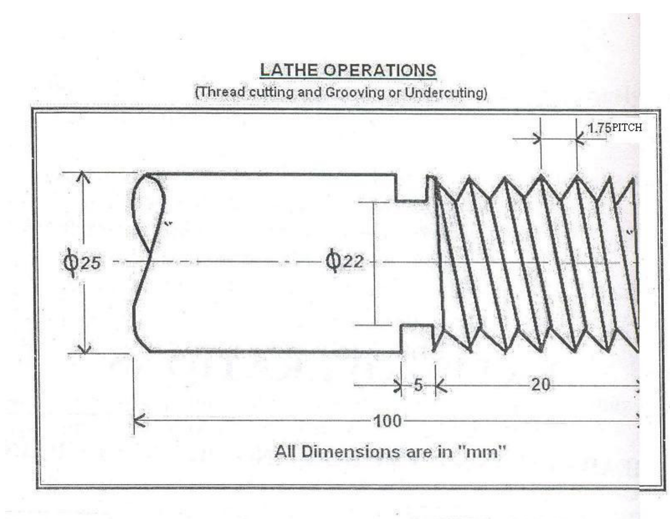
Threading tool thread gauge,

Outside caliper,

Chuck key,

Tool post key,

Steel rule.



5. PRINCIPLE OF THREAD CUTTING

S.No.	Sequence of Operations	Cutting tool used
1	Facing	H.S.S Single Point cutting tool
2	Rough turning	H.S.S Single Point cutting tool
3	Finish turning	H.S.S Single Point cutting tool
4	Step turning	H.S.S Single Point cutting tool
5	Grooving	Grooving tool
6	Thread cutting	Threading tool
7	Chamfering	H.S.S Single Point cutting tool

The principle of thread cutting is to produce a helical groove on a cylindrical or conical surface by feeding the tool longitudinally when the job is revolved between centers or by a chuck. The longitudinal feed should be equal to the pitch of the thread to be cut per revolution of the work piece. The lead screw of the lathe, through which the saddle receives its traversing motion, has a definite pitch. A definite ratio between the longitudinal feed and rotation of the head stock spindle should therefore be found out so that the relative speeds of rotation of the work and the lead screw will result in the cutting of a screw of the desired pitch.

This is affected by change gears arranged between the spindle and the lead screw or by the change gear mechanism or feed box used in a modern lathe.

Calculation of change-wheels, metric thread on English lead screw:

To calculate the wheels required for cutting a screw of certain pitch, it is necessary to know how the ratio is obtained and exactly where the driving and driven wheels are to be placed. Suppose the pitch of a lead screw is 12 mm and it is required to cut a screw of 3 mm pitch, then the lathe spindle must rotate 4 times the speed of the lead screw that is

$$\frac{\text{Spindle turn}}{\text{Lead screw turn}} = \quad \text{Means that we must have}$$

$$\frac{\text{Driver teeth}}{\text{Driver teeth}} = \quad \text{Since a small gear rotates faster than a larger one with which it is connected.}$$

Hence we may say,

$$\frac{\text{Driver teeth}}{\text{Driver teeth}} = \frac{\text{Lead screw turn pitch of the screw to be cut}}{\text{spindle turn pitch of the lead screw}}$$

In BRITISH SYSTEM

$$\frac{\text{Driver teeth}}{\text{Driver teeth}} = \frac{\text{Threads per inch on lead screw}}{\text{Threads per inch on work}}$$

Often engine lathes are equipped with a set of gears ranging from 20 to 120 teeth in steps of 5 teeth and one translating gear of 127 teeth. The cutting of metric threads on a lathe with an English pitch lead screw may be carried out by a translating gear of 127 teeth.

$$\frac{\text{Driver teeth}}{\text{Driver teeth}} = \frac{5\,p\,n}{127}$$

Where,

p = pitch of the thread to be cut
and N= threads per inch on lead
screw

This is derived as follows:

Driver teeth		pitch of the work			p		pn
Driver teeth	=	pitch of the lead screw	=		(1/n) x (127/5)	=	127
Since, pitch =		1					
		No. of threads per inch					

THREAD CUTTING OPERATION:

In a thread cutting operation, the first step is to remove the excess material from the work piece to make its diameter equal to the major diameter of the screw thread. Change gears of correct size are then fitted to the end of the bed between the spindle and the lead screw.

The shape or form of the thread depends on the shape of the cutting tool to be used. In a metric thread, the included angle of the cutting edge should be ground exactly 60^0. the top of the tool nose should be set at the same height as the center of the work piece. A thread tool gauge is usually used against the turned surface to check the cutting tool, so that each face of the tool may be equally inclined to the center line of the work piece as shown.

The speed of the spindle is reduced by one half to one – fourth of the speed require for turning according to the type of the material being machined and the half – nut is then engaged. The depth of cut usually varies from 0.05 to 0.2 mm is given by advancing the tool perpendicular to the axis of the work.

After the tool has produced a helical groove up to the desired length of the work, the tool is quickly withdrawn by the use of the cross slide, the half-nut disengaged and the tool is brought back to the starting position to give a fresh cut. Before re-engaging the half-nut it is necessary to ensure that the tool will follow the same path it has traversed in the previous cut, otherwise the job will be spoiled.

Several cuts are necessary before the full depth of thread is reached arising from this comes the necessity to "pick-up" the thread which is accomplished by using a chasing dial or thread indicator.

Chasing dial or thread indicator

The chasing dial is a special attachment used in modern lathes for accurate "picking up" of the thread. This dial indicates when to close the split of half nuts. This is mounted on the right end of the apron. It consists of a vertical shaft with a worm gear engaged with the lead screw. The top of the spindle has a revolving dial marked with lines and numbers. The dial turns with the lead screw so long the half nut is not engaged.

If the half-nut is closed and the carriage moves along the dial stands still. As the dial turns, the graduations pass a fixed reference line. The half-nut is closed for all even threads when any line on the dial coincides with the reference line. For all odd threads, the half-nut is closed at any numbered line on the dial determined from the charts. If the pitch of the thread to be cut is an exact multiple of the pitch of the lead screw, the thread is called even thread, if otherwise the thread is odd thread.

In a chasing dial, the rule for determining the dial division is: In case of metric threads, the product of the pitch of lead screw and the no. of teeth on the worm wheel must be an exact multiple of the pitch of the threads to be cut. In case of English threads, the product of the threads per inch to be cut and the number of teeth on the worm wheel must be an exact multiple of the number of threads per inch of the lead screw. For example, if the pitch of the lead screw is 6 mm and the worm wheel has 15 teeth.

The product will be 90. so any pitch which is exactly divisible by 90, such as 1, 1.25, 2.25,3,3.75,4.5,5,6,7.5,9,10,15,30,45,90 may be picked up when any line of the dial coincides with the reference line.

Right hand and left-hand thread:

If the bolt advances into the nut when rotated in clockwise direction, the thread is called right-hand thread. When cutting a right-hand thread the carriage must move towards the head stock.

If the bolt advances into the nut when rotated in counter-clockwise direction, the thread is called left-hand, for a left hand thread the carriage moves away from the head stock and towards the tail stock. The job moves as always in the anti-clock wise direction when viewed from the tail stock end. The direction at which the carriage moves in relation to lathe head stock is controlled by means of the tumbler gears or bevel gear feed reversing mechanism.

PROCEDURE:

1. The work piece and HSS single point cutting tool are fixed in chuck and tool post respectively.
2. Operations such as facing, rough turning finish turning and step turning are performed on the given mild steel bar one after the other in sequence up to the dimensions shown.
3. Single point cutting tool is replaced by a grooving tool and grooving operation is performed at half of the normal spindle speed.
4. The grooving tool is replaced by a threading tool. Right hand and left hand metric threads are cut on the work piece up to the required length at $1/4^{th}$ of the normal speed of the spindle.
5. Threading tool replaced by a single point cutting tool again and finally chamfering is done at right end of the work piece at normal spindle speed.

PRECAUTIONS:

1. Low spindle speeds should be used for accurate threads in thread cutting operation.
2. Ensure correct engage and dis-engage of half-nut.
3. Plenty of oil should be flowed on the work and tool during thread cutting.

RESULT: Required specimen obtained according to specified operations(thread cutting and under cutting) with given dimensions

DRILLING MACHINE:

4. DRILLING MACHINE

Drilling machine is a machine tool designed for drilling holes in metallic and non metallic materials. The cutting tool is a multi-point cutting tool, known as drill.

PRINCIPAL PARTS OF THE DRILLING MACHINE

1. Head: Head contains the electric motor, v pulleys and v belt which transmit rotary motion to the drill spindle at a no. of speeds.
2. Spindle: spindle is made up of alloy steel. It rotates as well as moves up and down in a sleeve.
3. Drill chuck: It is held at the end of the drill spindle and in turn it holds the drill bit.
4. Adjustable table: It is supported on the column of the drilling machine and can be moved vertically and horizontally. It also carries slots for bolts clamping.
5. Base: It supports the column, which, in turn, supports the table, head etc.
6. Column: It is a vertical round or box section, which rests on the base and supports the head and the table.

WORKING PRINCIPLE AND OPERATION OF DRILLING MACHINE

Drilling machine is used to produce holes in the work piece the end cutting tool used for drilling holes in the work piece is called the drill. The drill is placed in the chuck and when the machine is 'ON' the drill rotates. The linear motion is given to the drill towards the work piece, which is called feed.

In order to remove the chips from the hole, drill is taken out from the hole so the combination of rotary and linear motion produces the hole in the work piece.

DRILLING OPERATIONS

The following are the most common operations performed on the drilling machine:

1. Drilling: it is an operation of producing a circular hole in a work piece by forcing a drill in the work piece.
2. Boring: it is an operation of enlarging a hole that has already been drilled. Single point cutting tool is used in boring.
3. Reaming: Reaming is done with reamers. It is done to generate the hole of proper size and finish after drilling
4. Tapping: It is an operating of producing internal threads in a hole by means of a tap.

5. Counter Boring: It is an operation of enlarging the entry of a drilled hole to accommodate the bolt head etc. Counter boring tool does it.
6. Spot Facing: It is an operation done on the drilled hole to provide smooth seat for bolt head.
7. Counter Sinking: It is an operation to bevel the top of a drilled hole for making a conical seat. A counter sunk drill is used in this operation.

DRILLING (CUTTING) SPEED AND FEED

Cutting Speed: Cutting speed in drilling is the peripheral speed of the drill relative to the work.

Cutting speed = D.N/1000 m/min

Where D = Diameter of drill in mm\
N = Work speed in r.p.m

Feed: Feed of a drill is the distance it moves into the work with each revolution of the spindle. It is generally measured in mm/revolution of the spindle.

Over-arm: the over arm is mounted on and guided by the top of the column. It is adjusted in and out by hand to the position of maximum support for the arbor and then clamped.

Spindle: The spindle is mounted on the upper part of the column. It receives power from the motor through belts, gears, clutches etc. and can be rotated at different speeds by the step cone pulley drive or by gearing arrangement and transmits it to arbor or sub-arbor.

Arbor: The arbor is the extension of the spindle on which all the various cutters are mounted. It is tapered at one end to fit the spindle nose and has two slots to fit the nose keys for locating and driving it.

DRILLING AND INTERNAL THREADING

1. **AIM:** To drill the given work piece as required and then to perform internal threading operations on the given specimen.

2. **MATERIALS REQUIRED:** mild steel specimen, coolant (oil and water mixture), lubricant oil, nut and bolt.

3. **MACHINE REQUIRED**: Drilling machine

4. **MEASURING INSTRUMENTS**: Vernier calipers

5. CUTTING TOOLS:

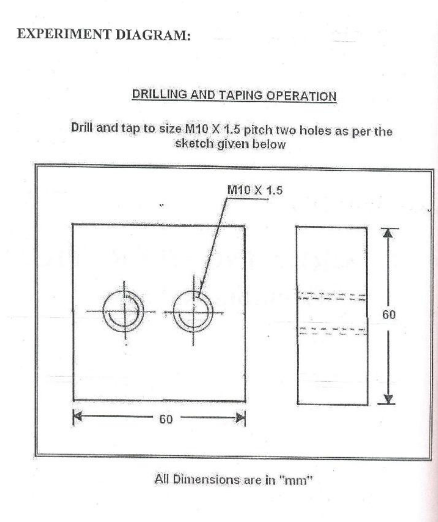
Button pattern stock,

Dies,

Drill bids,

Hand taps,

Tap wrench.



6. MARKING TOOLS: Dot punch

Work holding fixtures:

Bench vice,

V-Block

Miscellaneous tools:

Brush,

Allen Keys

7. SEQUENCE OF OPERATIONS:

a. Mark the center of hole and center punching

b. Drill bid

$D_d = d_h - p$

Where,

D_h - dia. of the hole,

d_d – dia. of drill bid, p =

pitch

Use the suitable drill

size for required

tapping D=Dia. of tap

Tap Drill size = (D-1.3p)+0.2 – for metric threads

c. Chamfering of specimen

d. Use the sequential tapping as tap set 1,2,3

e. Internal taping of drilled specimen

f. Filling of specimen on which external threading to be done

g. Measuring the diameter of the specimen & choosing of dies according to it

h. Dieing operation (external threading) of the specimen.

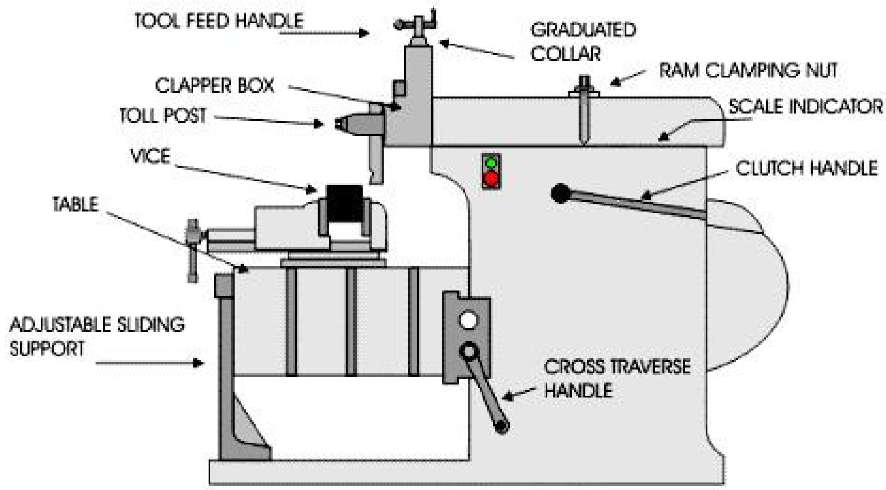
PRECAUTIONS:

1. Coolant has to be sued while drilling
2. Lubricating oil has to be used to get smooth finish while tapping.

RESULT: Required specimen obtained according to specified Operations (drilling and tapping operations) with given dimensions

SHAPER MACHINE

PARTS OF SHAPER MACHINE:



5. SHAPING

1. AIM: To perform V and Dovetail machining & U-cut on the given work piece.

2. MATERIALS REQUIRED: Mild steel / Cast iron / Cast Aluminum.

3. MACHINE REQUIRED: Shaping machine

4. MEASURING INSTRUMENTS:

   Vernier calipers,

   Vernier height gauge,

   Dial indicator,

   Required steel ball.

5. CUTTING TOOLS

   H.S.S tool bit,

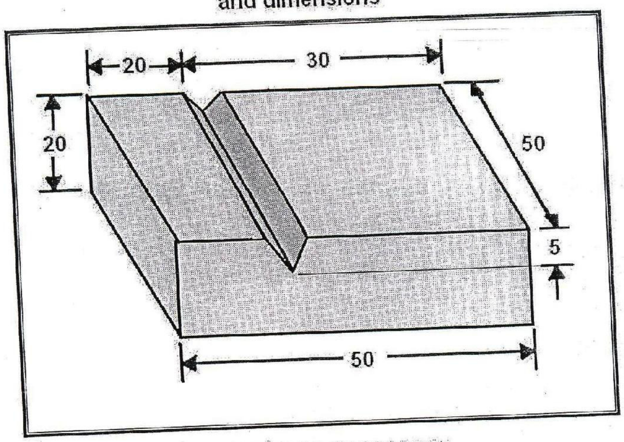
   V tool,

   Plain tool,

Grooving tool.

Experiment Diagram:

Machine V Groove of 45 for the given specimen
and dimensions



SHAPING OPERATION

All dimensions are in "mm"

SEQUENCE OF OPERATIONS:

1. Measuring of specimen.
2. Fixing of specimen in the machine vice of the shaping machine
3. Giving the correct depth and automatic feed for the slot is to be made.
4. Check the slot with the Vernier calipers & precision measurement by slip gauges at the end.

7. THEORY

The shaper also called shaping machine, is a reciprocating type of machine tool in which the ram moves the cutting tool backward and forward in a straight line to generate the flat surface. The flat surface may be horizontal, inclined or vertical.

Principal Parts of a Shaper

i. Base: It is a heavy and robust cast iron body which acts as a support for all other parts of the machine which are mounted over it.

ii. Column (body): it is a box type iron body mounted upon the base. It acts as housing for the operating mechanism of the machine, electrical, cross rail and ram. On the top it is having two guide ways open which the ram reciprocates.

iii. Cross-rail: it is a heavy cast iron construction, attached to the column at its front on the vertical guide ways. It carries two mechanisms, one for elevating the table and the other for cross travel of the table.

iv. Table: it is made of cast iron and used for holding the work piece. T slots are provided on its top and sides for securing the work on to it. It slides along the cross rail to provide feed to the work.

v. Ram: It reciprocates on the guide ways provided above the column. It carries the tool head and mechanism for adjusting the stroke length.

vi. Tool Head: It is attached to the front portion of the ram and is used to hold the tool

vii. rigidly. It also provides the vertical and angular movement to the tool for cutting.

Working principle and operation of a Shaper:

In a shaper, a single point cutting tool reciprocates over the stationary work piece. The work piece is rigidly held in a vice or clamped directly on the table. The tool is held in the tool head mounted on the ram of the machine. When the ram moves forward, cutting of material takes place. So, it is called cutting stroke. When the ram moves backward, no cutting of material takes place so called idle stroke.

The time taken during the return stroke is less as compared to forward stroke and this is obtained by quick return mechanism. The depth of cut is adjusted by moving the tool downward towards the work piece.

Principle of Quick return motion: (Crank and Slotted level type)

In the extreme position, the slotted lever AL occupies the positions AL_1, and AL_2 and the cutting tool is at the end of the stroke. The forward or cutting stroke occurs when the crank rotates from the position CB_1 to CB_2 (or through an angle) in the clockwise direction. The return stroke occurs when the crank rotates from the position CB_1 to CB_2 (or through an angle) in the clockwise direction. Since the crank rotates at a uniform speed, so

Time of cutting stroke = $\beta/\alpha = \alpha / (360^0 - \beta)$ or $(360^0 - \alpha) / \alpha$ Time of cutting stroke

Travel of tool or length of stroke = $R_1R_2 =$ L1L2 = 2AI X CB/AC

It can easily be seen that the angle β is more than α. Since the crank rotates with uniform angular speed, therefore from equation (1), it can be concluded that the return stroke is completed with in shorter time. Thus, it is a quick return motion mechanism.

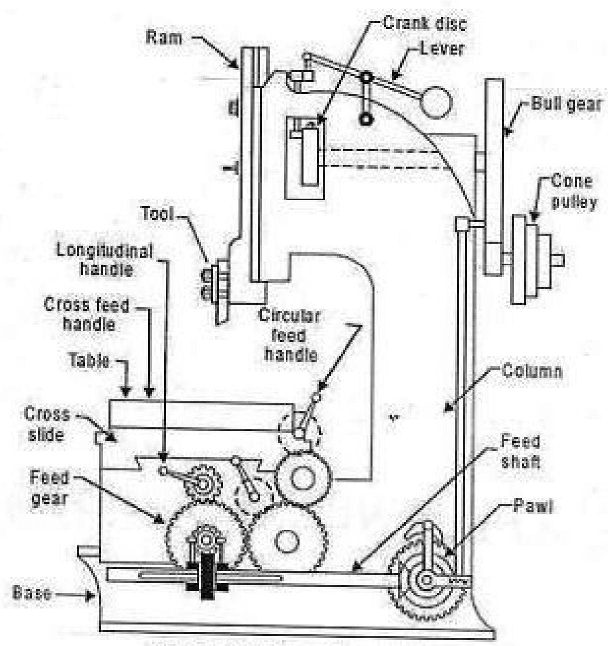
8. PRECAUTIONS:

1. The shaping machine must be stopped before setting up or removing the work piece
2. All the chips should be removed from the cutter.

9. **RESULTS**: Required specimen obtained according to specified operations(shaping and grooving operations) with given dimensions

SLOTING MACHINE

PARTS OF SLOTTING MACHINE:

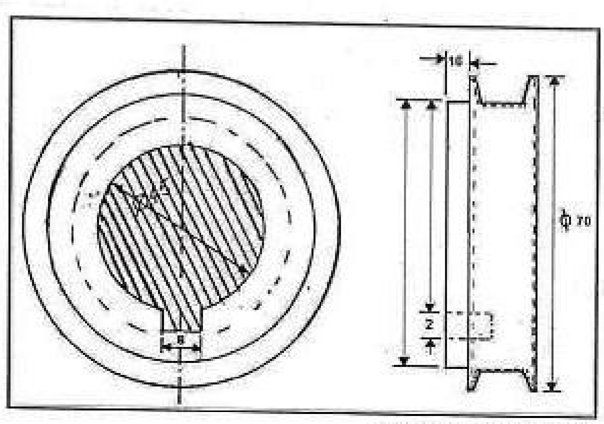


Slotter and its various parts

EXPERIMENTAL DIAGRAM:

SLOTING OPERATION

Make a slot in cast iron pulley as per sketch given dimensions



All dimensions are in "mm"

6. SLOTTING

1. AIM: to make a slot on the given work piece.

2. MATERIALS REQUIRED: mild steel, aluminum.

3. MACHINE REQUIRED: slotting machine

4. MEASURING INSTRUMENTS: Vernier calipers slip gauges.

5. CUTTING TOOLS: H.S.S.Tool bit of the required slot size.

6. SEQUENCE OF OPERATIONS:
   - Fix the specimen in the three-jaw chuck of the slotting machine
   - By giving the required feed and depth of cut, the required slot is being made progressively

7. **PROCEDURE:**
   1. Fix the work piece in the head stock chuck firmly
   2. Turning tool is fixed in the tool post and centering is to be done
   3. Turn the job to get a Dia of required length
   4. Facing is to be done on one side of the job
   5. Drill bit of 8 mm diameter is fixed on tail stock and centering of work piece is to be done by feeding through tail stock.
   6. Drill bit of 25 mm diameter is fixed in tail stock
   7. Drill through a hole of 25 mm diameter in the work piece feeding the tail stock.
   8. Boring tool is the fixed on tail stock to perform boring operation to get a hole of required diameter
   9. Fit the job in reverse position in the chuck
   10. Facing of other side of the work piece is to be done to get the required length of the job
   11. Drilled work piece is fixed on slotting machine.
   12. A slot of required depth is made

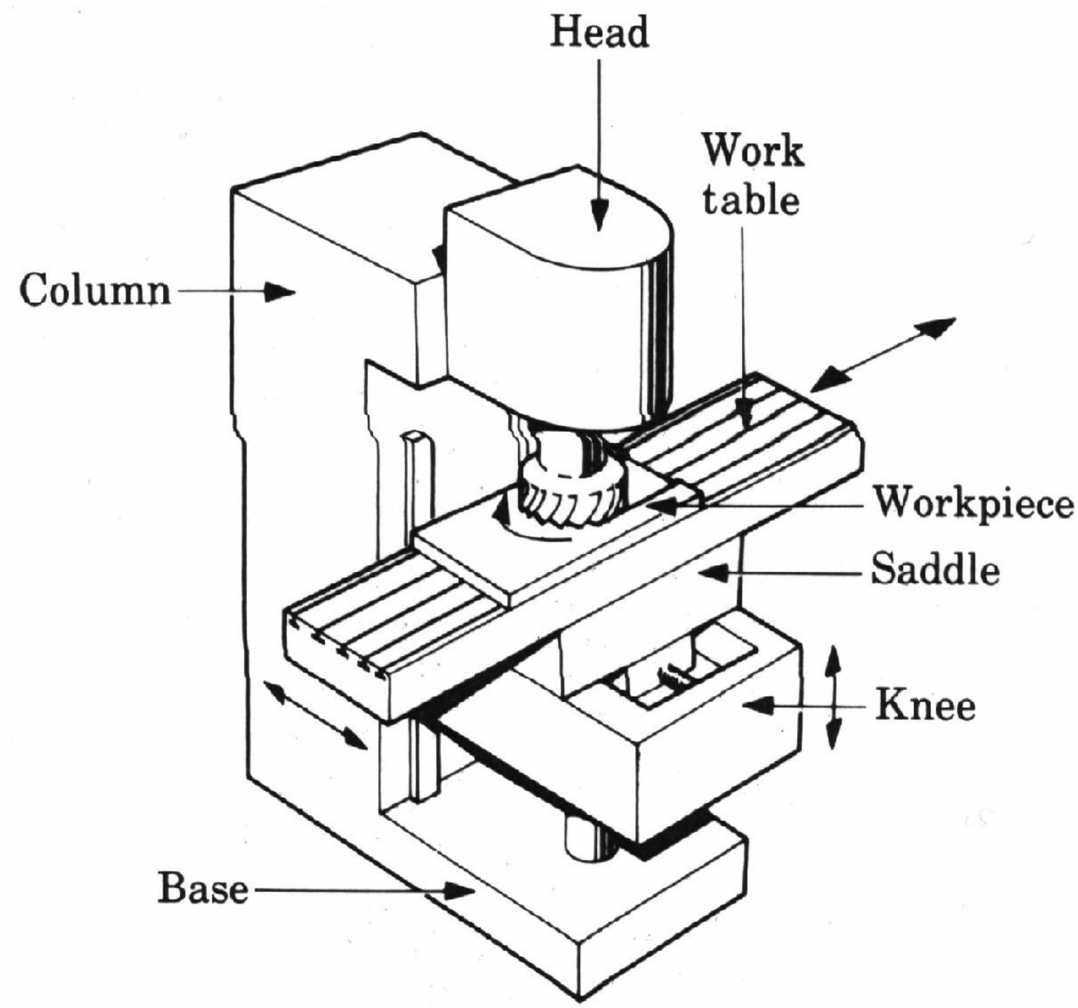
PRECAUTIONS:

1. Choose proper feed and depth of cut.
2. Feed should be controlled to avoid any damage to the cutting tool
3. Lock the index table before starting the operation.
4. Care has to be taken so as to maintain the right feed of the material.
5. Work-wheel interface zone is to be flooded with coolant
6. Dressing of grinding wheel to be done before commencement of cutting action, intermittent dressing also to be done if wheel is loaded.

RESULTS: Required specimen obtained according to specified operations (drilling, borring and slotting) with given dimensions

MILLING MACHINE

PARTS OF MILLING MACHINE:



7. PLANE MILLING OPERATION

1. AIM: To perform plane milling operation on the given specimen (mild steel) & get to its correct dimensions.
2. MATERIALS REQUIRED: mild steel specimen.
3. MACHINE REQUIRED: milling machine
4. MEASURING INSTRUMENTS: Vernier calipers

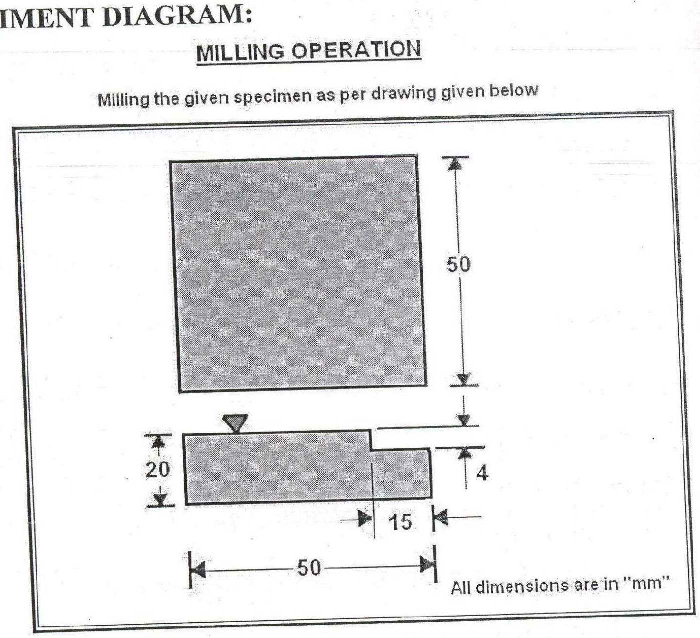
5.CUTTING TOOLS: Plane (face) milling cutter

6. MARKING TOOLS: steel rule, scriber

   a. Work holding fixtures: work piece supporting fixtures

   b. Miscellaneous tools: Hammer, brush, Allen keys

EXPERIMENT DIAGRAM:



7. SEQUENCE OF OPERATIONS:SE

i. Measuring of specimen
ii. Fixing of specimen in the milling m/c.
iii. Giving the correct depth and automatic feed cut the specimen
iv. Check the specimen with Vernier caliper at the end.

8. THEORY:

Milling machine is a machine tool in which metal is removed by means of a revolving cutter with many teeth (multipoint), each tooth having a cutting edge which removes the metal from the work piece. The work may be fed to the cutter, longitudinally, transversely or vertically, the cutter is set to a certain depth of cut by raising the table. This machine is very much suitable in tool room work due to its variety of operations, better surface finish and accuracy.

Specification: The milling machine is specified by its table working surface, its longitudinal, cross and vertical transverse, knee movement in degrees, range and number of spindle speeds, available power of the machine and machine type.

9. PRINCIPAL PARTS OF A MILLING MACHINE

Base: It is the foundation of the machine upon which all other parts are mounted. It is generally made of grey cast iron to absorb shock and vibration. Sometime it also serves as a reservoir for cutting fluid.

Column: It is the main supporting frame mounted vertically on one side of the base. The motor and other driving mechanisms are contained in it.

It supports and guides the knee in its vertical travel. It carries the jack for elevating the knee.

Knee: The Knee projects from the column and slides up and down on its face. It supports the saddle and table. It is partially supported by the elevating screw which adjusts its height. It carries the table feed mechanism and controls to feed in longitudinal, cross, vertical, and rotation etc. by hand power or machine power.

Saddle: The saddle supports and carries the table and is adjustable transversely on ways on top of the knee. It is provided with graduation for exact movement and can be operated by hand or power.

Table: The table rests on ways on the saddle and travels longitudinally in a horizontal plane. It supports the work pieces fixtures etc.

10. PROCEDURE:

1. The dimensions of the given rod are checked with the steel rule.
2. The given rod is fixed in the vice provided on the machine table such a, one end of it is projected outside the jaws of the vice.
3. A face milling cutter is mounted on the horizontal milling machine spindle and one end of the rod is face milled, by raising the table so that the end of the rod faces the cutter.
4. The rod is removed from the vice and fitted in the reverse position.
5. The other end of rod is face milled such that, the length of the job is exactly 100 mm.
6. The table is lowered and the rod is removed from the vice and refitted in it such that, the top face of the rod is projected from the vice jaws.
7. The face milling cutter is removed from the spindle and the arbor is mounted in the spindle; followed by fixing the plain milling cutter.
8. The top surface of the job is slab milled; first giving rough cuts followed by a finish cut.
9. The job is removed from the vice and refitted in it such that, the face opposite to the above, comes to the top and projects above the vice jaws.
10. The top surface of the job is milled in stages; giving finish cuts towards the end such that, the height of the job is exactly 40 mm.
11. The burrs if any along the edges, are removed with the help of the flat file.

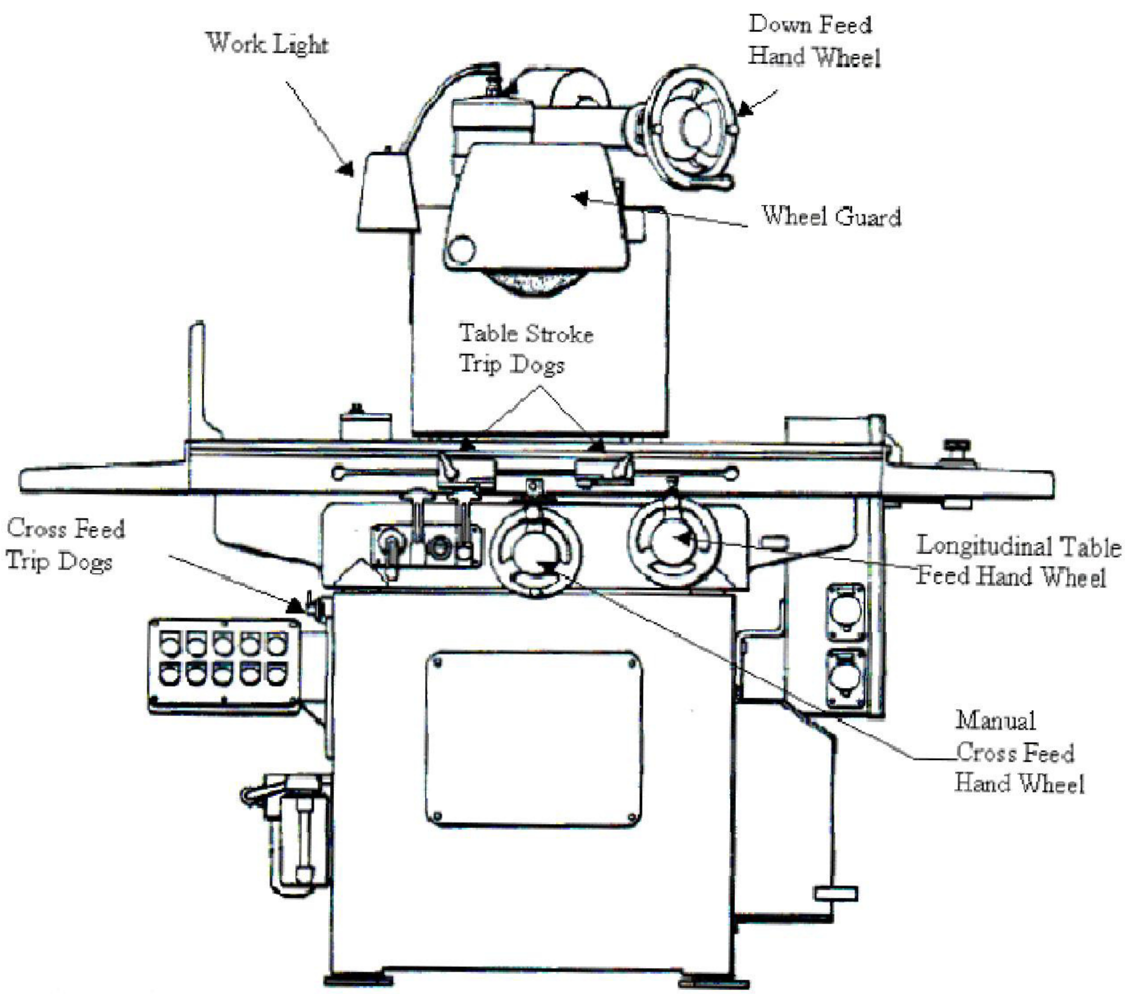
PRECAUTIONS:

1. The milling machine must be stopped before setting up or removing a work piece, cutter or other accessory
2. Never stop the feeding of job when the cutting operation is going on, otherwise the tool will cut deeper at the point where feed is stopped.
3. All the chips should be removed from the cutter. A wiping cloth should be placed on the cutter to protect the hands.
   The cutter should be rotated in the clockwise direction only for right handed tools.
4. The work piece and cutter should be kept as cool as possible (i.e. coolant should be used where necessary to minimize heat absorption).
5. The table surface should be protected with a wiping cloth.
6. Tool must be mounted as close to the machine spindle as possible.

RESULT: The rectangular block of 50 x 40 x 100 mm, is thus obtained, by following the stages described above.

SURFACE GRINDING MACHINE

PARTS PRECISION SURFACE GRINDING MACHINE:



8.PRECISION SURFACE GRINDING

1. AIM: To perform surface grinding operation on the given work piece.

2. MATERIALS REQUIRED: mild steel specimen.

3. MACHINE REQUIRED: surface grinding machine

4. MEASURING INSTRUMENTS:
   Vernier calipers,

   Micrometer.

5. CUTTING TOOLS: Diamond point dressing block

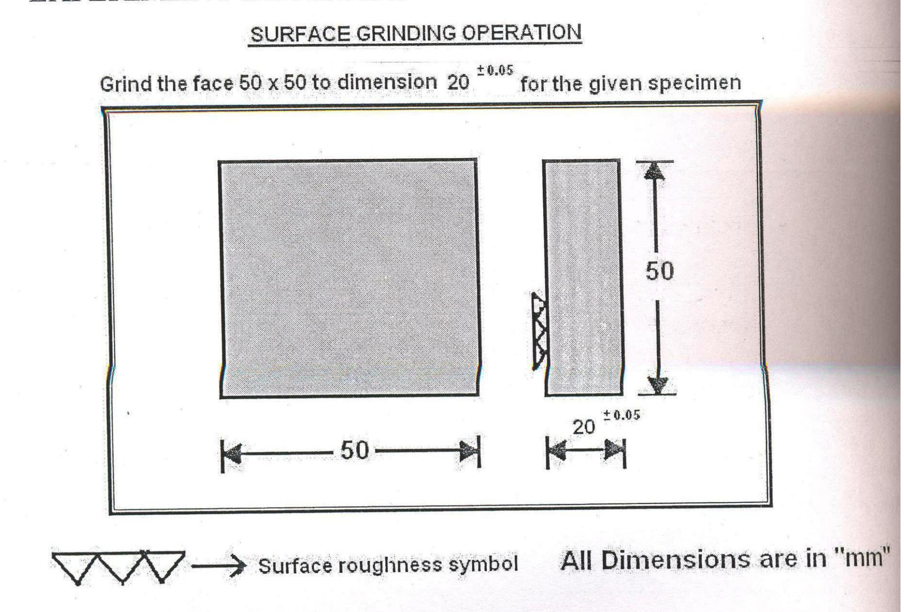
6. WORK HOLDING FIXTURES: Magnetic chuck

7. MISCELLANEOUS TOOLS:

    Wire brush (for cleaning the formed chips),

    Lubricant(coolant),

EXPERIMENT DIAGRAM:



8. SEQUENCE OF OPERATIONS:

- Measuring of specimen using Vernier caliper, screw gauge micro meter
- Fix the work piece on to specimen & lock the magnetic chuck
- Move the specimen close to the moving grinding wheel so that it touches the specimen.
- Perform the surface grinding operation.
- Check the final dimension using Vernier caliper, screw gauge micro- meter.

9. THEORY:

Finish Grinding: Grinding is a metal cutting operation performed by means of a rotating abrasive wheel that acts as a cutting tool. This is used to finish work pieces whi8ch must show a high surface quality, accuracy of shape and dimension. Mostly grinding is the finishing operation because it removes comparatively little metal, usually 0.25 to50.5 mm in most operations and the accuracy in dimensions is in the order of 0.00025 mm.

10. PROCEDURE:

1. Work piece is mounted on magnetic table, so that the line along face of grinding wheel coincides with the edge of work piece.
2. Depth of cut is given to work piece by down feed hang wheel.
3. The work piece is reciprocates under wheel and the table feeds axially between passes to produce flat surface and to get required size of work piece.

11. PRECAUTIONS:

1. Coolant usage is compulsory as the speeds employed are very high and continuous application of coolant is necessary for ductile materials like-steel etc.
2. The grinding tools are first dressed properly.
3. Care has to be taken so as to maintain the right feed of the material.
4. Work-wheel interface zone is to be flooded with coolant
5. Dressing of grinding wheel to be done before commencement of cutting action, intermittent dressing also to be done if wheel is loaded.

RESULTS: Required specimen obtained according to specified operations (surface grinding operation) with given dimensions

PLANNING MACHINE

PLANING MACHINE

INTRODUCTION

Planing is one of the basic operations performed in machining work and is primarily intended for machining large flat surfaces. These surfaces may be horizontal, vertical or inclined. In this way, the function of a planning machine is quite similar to that of a shaper except that the former is basically designed to undertake machining of such large and heavy jobs which are almost impractical to be machined on a shaper or milling, etc. It is an established fact that the planning machine proves to be most economical so far as the machining of large flat surfaces is concerned. However, a palning machine differs from a shaper in that for machining, the work, loaded on the table, reciprocates past the stationary tool in a planer, whereas in a shaper the tool reciprocates past the stationary work.

WORKING PRINCIPLE OF A PLANER:

The principle involved in machining a job on a planer is illustrated in fig. Here, it is almost a reverse case to that of a shaper. The work is rigidly held on the work table or a platen of the machine. The tool is held vertically in the tool-head mounted on the cross rail. The work table, together with the job, is made to reciprocate past the vertically held tool. The indexed feed after each cut is given to the tool during the idle stroke of the table.

PART-II

METROLOGY LAB

LIST OF EXPERIMENT

1. MEASUREMENT WITH VERNIER HEIGHT GAUGE & DEPTH GAUGE.
2. DIMENSIONAL MEASUREMENTS (Vernier Calipers, Micrometer, Boredial Gauge).
3. ANGLE MEASUREMENT USING BEVEL PROTRACTOR AND SINE BAR.
4. VERNIER GEAR TOOTH CALIPERS.
5. TOOL MAKERS MICROSCOPE.
6. SURFACE ROUGHNESS MEASUREMENT.
7. 2 WIRE AND 3 WIRE METHOD.

MEASUREMENT WITH VERNIER HEIGHT GAUGE & DEPTH GAUGE

AIM: 1.To measure the height of the object using vernier height gauge. 2. To measure the depth of the object using Depth gauge.

INSTRUMENTS USED:

1. Surface 2. Vernier height gauge 3. Specimens 4.Depth Gauge

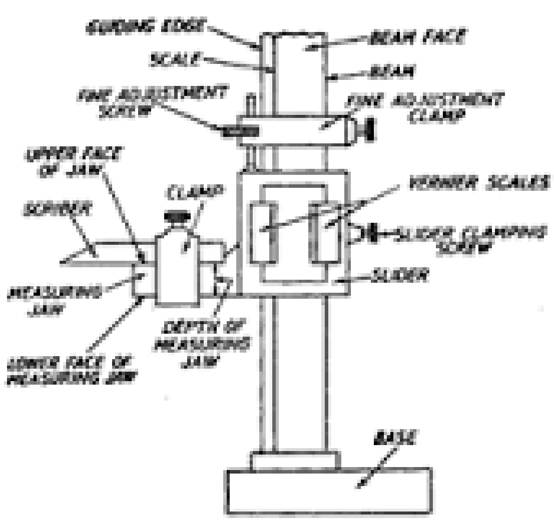
THEORY:

Vernier Height Gauge:

Vernier height gauge is a sort of Vernier calipers equipped with a special with a base and other attachment, which make the instrument suitable for height measurement. Along with sliding jaw assembly arrangement is provided to carry a removable clamp.

The upper and lower surfaces of the measuring jaws are parallel to base, so that it can be used for measurements over or under surfaces.

The vernier height gauge is mainly used in the inspection of parts and layout work. The vernier height gauge can be used to scribe lines at certain distance above surface with a scribing attachment in pace of measuring jaw. Dial indicators can also be attached in the clamp and many exact measurements can be made as it exactly gives the indication when the dial tip is touching the surface. Surface plates as datum surface are used for the above measurements.



PROCEDURE:

1. Place the object and the vernier height gauge on the surface plate.
2. Note the value on the scale when the moving jaw is touching the bottom of the object.
3. Take the moving /sliding jaw to the top of the object and note down the value on the scale.
4. The difference between 3&2 will give the height of the object.

Vernier Depth Gauge:

Vernier Depth Gauge is used to measure the depth of holes, slots and recesses, to locate center distances etc. It consists of

1. A sliding head having flat and true base free from curves waviness.
2. A graduated beam known as main scale. The sliding head slides over the graduated beam.
3. An auxiliary head with a fine adjustment and a clamping screw.
4. A beam is perpendicular to the base in both direction and its ends square and flat. The end of the sliding head can be set at any point with fine adjustment locked and read from the Vernier provided on it.

PROCEDURE:

1. Held the base on the reference surface.
2. Lower the beam in to the hole until it contacts the bottom surface of the hole.
3. Make final adjustment with fine adjustment screw.
4. Tighten the clamping screw and remove the instrument from the hole and take the reading in the same way as vernier.
5. Least count = -------------mm.

S.NO.	Main scale reading MSR(mm)	Vernier scale reading VSR(mm)	Measured reading=mm MSR+(VSRXL.C)

PRECAUTIONS:

1. The height gauges should be kept in their case when not in use.
2. Measuring jaws should be handled carefully.
3. While using the Dept gauge, it should be ensured that the reference surface, on which the depth gauge is rested, is satisfactorily true, flat and square.

RESULT:

- The heights of the given objects measured with vernier height gauge are tabulated above.
- The depth of the holes measured with Vernier depth gauge are tabulated above.

2. DIMENSIONAL MEASUREMENTS

OBJECTIVE:

The objective is to familiarize students with the use of vernier calipers, Micrometer screw gauges. The write –up for this experiment will be submitted at the end of the laboratory period. Drawings of the parts to be measured in the lab are available from the Teaching Assistant for the purposes of dimensioning. No aids other than calculators are allowed to be used.

THEORY:

Definition: Least Count – the smallest degree by which two measurements may be differentiated with a particular instrument; generally considered to be of the same order as the smallest division in the instruments' scale. The Least Count is a measure of the accuracy of a measuring instrument.

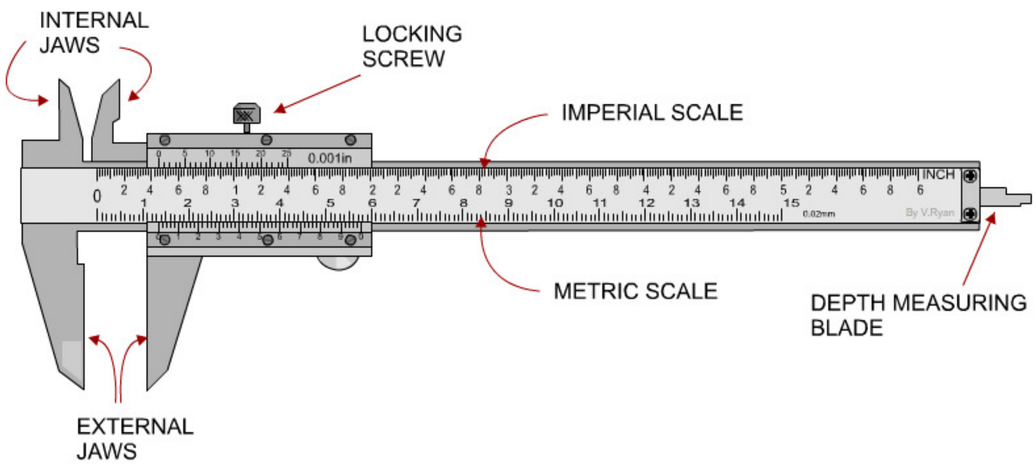
VERNIER CALLIPERS:

A vernier caliper (Figure 1) consists of a rule with a main engraved scale and a movable jaw with an engraved vernier scale. The main scale is calibrated in centimeters (cm) with a millimeter (mm) least count, and the movable vernier scale that divides the least count on the main scale in to 50 equal sub-divisions. The span of the upper jaw is used to measure the inside diameter of an object such as hollow cylinders or holes. The leftmost mark on the vernier scale is the zero mark, which is often unlabeled. The measurement is made by closing the jaws on the object to be measured and reading where the zero mark on the vernier scale falls on the main scale. The first two significant figures are read directly from the main scale. This is known as the main scale reading.

The next significant figure is the fractional part of the smallest subdivision on the main scale (in this case, mm). If a vernier mark coincides with a mark on the main scale, then the mark number is the fractional part of the main scale division. Before making a measurement, the zero of the vernier calliper should be checked with the jaws completely closed. It is possible that the caliper not being properly will produce systematic error. In this case, a zero correction must be made for each reading. The least of the vernier caliper is calculated by equation (1).

$$1)\ \text{Least Count} = \frac{\text{Value of the smallest division on main scale}}{\text{Number of divisions on vernier scale}}$$

2) Measurement = Main scale reading + conceding vernier scale division ×Least count



OBSERVATIONS :

Dimension	MSR	VC	VSR= MSR+LC	Reading

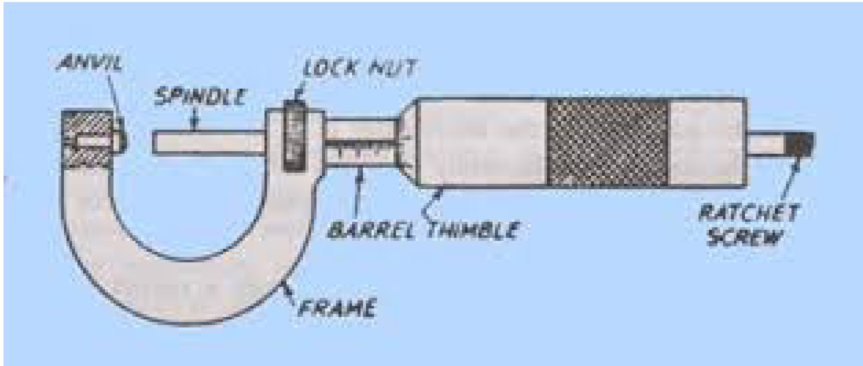
MICROMETER SCREW GAUGE:

A **micrometer (Figure 2)** consists of a movable spindle (jaw) that advances toward another parallel-faced jaw, called an anvil, by rotating the thimble. The thimble rotates over an engraved sleeve or barrel that is mounted on a solid frame. Most micrometers are equipped with a ratchet, at the far right in figure 2, which allows slippage of the screw mechanism when a small constant force is exerted on the jaw. This permits the jaw to be tightened on an object with the same amount of force each time. The axial main scale on the sleeve is calibrated in mm and the thimble scale is the vernier scale and is usually divided into increments of 0.01mm.

The **pitch** of a screw is the distance between two consecutive screw threads and is the lateral linear distance the screw moves when turned through one rotation. The axial line on the sleeve main scale serves as a reading line. If a micrometer does not have 0.5 mm divisions on the main scale, you must determine whether the thimble is in its first rotation or second. If it has 50 divisions on the thimble and completes 1 mm in two rotations, each division on the thimble gives 0.01 mm.

Measurements are taken by noting the reading *x* on the main scale of the sleeve. Note the position of the edge of the thimble on the main scale and the position of the reading line on the thimble scale. Multiply this reading with 0.01 mm and add to x

3) Least Count = Pitch (Distance between two consecutive threads of screw) ÷ Number of divisions on thimble scale
4) Measurement = Main scale reading + coinciding thimble scale division ×Least count



OBSERVATIONS:

DIMENSIONS	PSR	HSR	PSR+HSR*LC	READINGS

MEASUREMENTS:

How to Use Vernier Callipers:

In the machining process, we use vernier callipers or a micrometer for taking measurements. General analog vernier calipers as shown in Figure 1 can measure with the minimum unit of 1/20 mm. Several types of digital vernier calipers as shown in Figure 2 can measure with the minimum unit of 1/100 mm.

Examples:

The vernier calipers can measure a side length, an outer and inner diameter, and a depth as shown in Figures 3 to 6.

Keep a perpendicular position in measuring:

The vernier calipers must be kept the perpendicular position in measuring. Typically, when a beginner measures the size of a complex shaped part, the result can be inaccurate as the measuring device is often not maintained parallel to measured piece.

How to Use a Micrometer

When close tolerances are required, measurements are taken with a micrometer due to its superior accuracy over a vernier caliper. The micrometer as shown in Figure 7 can measure with the minimum unit of 1/1000 mm.

When do you use the vernier calipers and micrometer?

The "For & Against" of using micrometers and vernier calipers are:

Vernier Calliper:

For: A large range of measurements can be made using the one measuring device. **Against:** The majority of vernier calipers do not provide sufficient accuracy for close tolerance measurements.

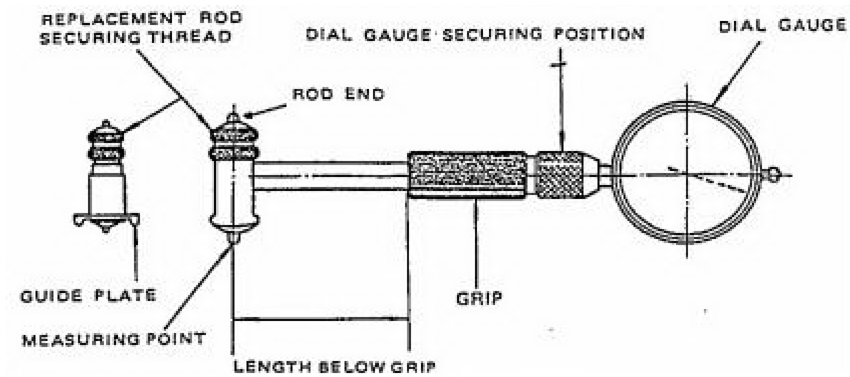
Micrometer:

For: The micrometer provides a grater degree of accuracy for close tolerance work.

Against: Due to the limited size range for a given micrometer, it is necessary to have a number of micrometers to cater for the full range of measurements you may encounter.

Bore Dial Gauge:

It is used for measuring internal diameter of a hole, which is machined. The bore dial gauge consists of one fixed measuring head and one movable measuring head. The movement of the movable measuring rod is transmitted to dial indicator by push rod through a spring actuated hinged member. Thus the horizontal movement of the rod is transmitted into vertical direction gives indication of variatopn of size. The calibrated rods are made in different sizes and sometimes number of short rods threaded at the ends are used in combination to get different desired lengths



PROCEDURE:

The measuring head is placed in contact with the surface of hole & movement of measuring head contact point is transmitted to the amplifying mechanism by the calibrated rods and its shown on the dial indicator. These calibrated rods are located in tabular supports between the head and dial units. The readings from dial indicator are tabulated

OBSERVATIONS:

S.NO	DIAMETER	TRIAL 1	TRIAL 2	AVERAGE	MEASURED DIAMETER

Note: Please avoid dropping the tools as this can lead to irreparable damage to the precision instruments. The tools are coated with a light film of oil to prevent corrosion. Please do not remove this oil. A cloth has been provided to clean your hands after use.

RESULTS:

The specifications of the given component are measured with vernier caliper, outside micrometer & bore dial gauge.

3.ANGLE MEASUREMENT USING BEVELPROTACTOR & SINEBAR

AIM: To measure the angle of the given wedge using Since bar & Bevel Protractor

INSTRUMENTS USED:

1. Sine bar 2. Work piece 3. Dial Gauge
4. Slip gauges 5. Bevel Protractor.

SINE BAR:

THEORY:

The sine principle uses the ratio of the length of two sides of a right triangle in deriving a given angle. The accuracy with which the sine principle can be put to use is dependent in practice, on some form of linear measurement. The sine bar in itself is not a complete measuring instrument. Sine bars in conjunction with slip gauges constitute a very good device for the precise measurement of angles. The arrangement is based on the fact that for any particular angle θ the sides of a right angled triangle will have precise ratio, i.e,

$$\mathbf{Sin\theta = h/l}$$

If **h** and **l** could be measured accurately, θ can be obtained accurately. The value of h is built-up by slip gauges and value 'l' is constant for a given sine bar.

Sine bars are used either to measure angles very accurately or for locating any work to a given angle within very close limits. Sine bars are made from high carbon, high chromium, corrosion resistant steel, hardened, ground and stabilized. Two cylinders of equal diameter are attached at the ends. The axes of these two cylinders are mutually parallel to each other and also parallel to and at equal distance from the upper surface of the sine bar. The distance between the axes of the two cylinders is exactly 100, 200 and 300 mm in metric system.

PROCEDURE:

1. Place the work piece/wedge above the sine bar and make it horizontal with the base.
2. The dial gauge is then set at one end of the work moved along the upper surface of the component.
3. If there is any variation in parallelism of the upper surface of the component and the surface plate, it is indicated by the dial gauge.
4. The combination of the slip gauges is so adjusted that the upper surface is truly parallel with the surface plate.
5. Note down the values of the slip gauges.
6. Calculate the angle using the formula.

$$\theta = \mathrm{Sin}^{-1}(h/l)$$

7. Repeat the procedure 3 or 4 times and take the average.

OBSERVATIONS:

S.No.	HEIGHT(h)	LENGTH(l)	ANGLE

BEVEL PROTRACTOR:

A universal bevel protractor is used to measure angles between two planes. This consists of stem, which is rigidly attached to main scale and a blade, which is attached to the Vernier scale and can be rotated to read angles. To improve the accessibility, the blade can also slide.

The least count is calculated by knowing the value of the smallest division on the main scale and number of division on the Vernier scale. It should be noted that the divisions on the main scale is in degrees and that the fractional divisions of degrees are minutes (i.e. with 60 minutes/degree, denoted). To measure angle between two planes, rest the stem on one of the planes (reference plane). Rotate the blade such that blade is flush with second plane. Readings are taken after ensuring that the stem and blade are in flush with the two planes. Lock the protractor at this point and note sown the readings.

OBSERVATIONS:

S.NO.	ANGLE MEASURED

.

RECAUTIONS:

1. The sine bar should not be used for angle greater than 60^0 because any possible error in construction is accentuated at this limit.

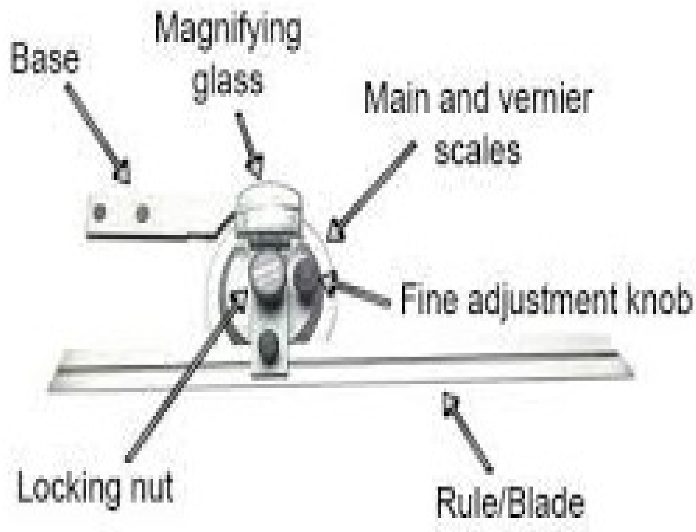
2. A compound angle should not be formed by mis-aligning of work piece with the sine bar. This can be avoided by attaching the sine bar and work against an angle plate.

3. As far as possible longer sine bar should be used since using longer sine bars reduces many errors.

RESULT:

The angle of the given specimen measured with the sine bar is

- The angle of the given specimen measured with the Bevel Protractor is


Base
Magnifying glass
Main and vernier scales
Fine adjustment knob
Locking nut
Rule/Blade

4.VERNIER GEAR TOOTH CALLIPER

AIM:

To measure the thickness of gear teeth at the pitch line or chordal thickness of teeth and the distance from the top of a tooth the chord i.e. Addendum using gear tooth caliper.

EQUIPMENT REQUIRED:

1. Gear tooth Vernier caliper
2. Spur gear of known module
3. Surface plate

THEORY:

Tooth thickness is the arc distance measured along the pitch circle from its intercept with one flank to its intercept with the other flank of the tooth.

Tooth thickness = II m/2 where m is the module

m=D/N

N=no. of teeth

D=Pitch circle diameter of the gear.

Addendum is the radial distance from the tip of a tooth to the pitch circle.

In the most of the cases, it is sufficient to measure the chordal thickness i.e. the chord joining the intersection of the tooth profile with the pitch circle because it is difficult to measure length of the arc directly.

DESCRIPTION:

Tooth thickness caliper consists of a slide which moves vertically with the help of knob. The jaw moves horizontally with the help of know there by varying the gap between them. An adjustable tongue, each of which is adjusted independently by adjusting screw on graduated bars, measures the thickness of a tooth at pitch line and the addendum.

PROCEDURE:

1. The given gear caliper is held over the gear and the slide is moved down so that it touches the top of the gear tooth.
2. The jaws are made to have contact with the tooth on either side by adjusting the knob.
3. The reading on vertical scale i.e. addendum is noted down.
4. The reading on horizontal scale i.e. tooth thickness is noted down.
5. The above procedure is repeated for five times and readings are noted.

Least count of given caliper:

TOOTH THICKNESS

S.No.	M.S.R	V.S.R	TOTAL = MAR +VSR X L.C.

ADDENDUM:

S.No.	M.S.R	V.S.R	TOTAL = MAR +VSR X L.C.

RESULT:

The Addendum of the given spur gear =______________________

The tooth thickness of the given spur gear = ___________________

5.TOOL-MAKER'S MICROSCOPE

AIM: To measure the pitch &angle of the screw thread.

APPARATUS: Tool makers microscope, screw thread specimen

THEORY: Tool makers microscope is based on the Principle of optics. The microscope consists of a heavy-duty hallow-duty hallow base, which accommodates the illuminating unit underneath, and above this on the top surface of the base, the work table carriage is supported on ball and controlled by micrometer screws. Projecting up from the rear of the base is a column, which carries the microscope unit and various interchangeable eyepieces.

The chief applications of the tool room microscope are as follows

1. The determination of relative position of various points on work.
2. Measurement of angle by using a protractor eyepiece.
3. Comparison of thread forms with master profiles engraved in the eyepiece, measurement of pitch and effective diameter.

SPECIFICATION:

MAGNIFICATION : 30X (Standard)

OBJECTIVE : 2X

EYEPIECE : W.F.15X with cross rectile

FIELD OF VIEW : 8mm. (approx)

WORKING DISTANCE : 80mm

OBSERVATION TUBE : monocular inclined at 30 degree

STAND : large and heavy base provide extra overall rigidity to the instrument

MEASUREMENT STAGE : 150X150.

Size travel up to 50mm in each direction, least count 6 minutes.

CONSTRUCITON OF MICROSCOPE

BASE:

The study base rest on three support two of which are adjustable for leveling the instrument. The base has built in all electrical transformers and their control panel and transmitted illuminator with green filter.

ARM:

The arm has a groove guide on which the microscope tube is vertically adjusted by rack and pinion system.

FOCUSSING MECHANISM:

The course focusing movement provided in the microscope tube separately. The coarse motion is knurled knob on both side of the tube and ha as the total travel of 200mm. Its also lock any position by lever, this movement is characterized by its exceptionally smooth and accurate precision. The vertical travel or measurement up to 10mm, thickness can be read by the depth dial gauge. The thickness is being measured with the difference of two different focusing of object. The least count of gauge is 0.01.

EYEPIECE PROTRACTOR

This unique protractor head graduated 0 to 360 degree with adjustable vernier reading to 6 minutes cross line incorporated in the protractor head rotating in the optical axis of the microscope the cross line graticule is replaceable with many other measuring graticules.

MEASURING STAGE

The stage plate is of 150 X 150 mm having very smooth and precise movements in both axis with special ball racers arrangements. The travel of the stage is 25mm. in both direction with precise imported micrometer head, least count 0.01 or 0.005mm. The stage has two T-slots for mounting accessories like rotary stage, center holding device attachment and V-block etc.

ROTARY STAGE

A rotating stage is fixed in T-slots of square plate having 360 degree graduations on its periphery with vernier reading to6 minute, and lock screw. All types of horizontal angular measurements can be done with this stage.

ILLUMINATING SYSTEM

Two possible range of illuminating system are provided with standard equipment to meet every application, operated through 6 volts solid state variable light control built in transformer.

1. Sub-stage transmitted light from a bottom source providing collimated green filter halogen light for viewing contours and transparent objects.
2. Surface incident illuminator for shadow free lighting, for high power examination of opaque objects.

PROCEDURE:

MEASUREMENT OF SCREW THREAD PITCH

1. The image of the thread profile is set so that some of the profile coincides with the cross hair as seen on the ground-glass screen.
2. The reading on thimble of the longitudinal micrometer screw is noted down.
3. Then the part is traversed by the micrometer screw until a corresponding point on the profile of the next thread coincides with the cross hairs.
4. The reading on thimble is again noted and the difference in two readings gives the actual pitch of the screw.

MEASUREMENT OF ANGLE OF THREAD

1. It is determined by rotating the screen until a line on the screen coincides with one flank of the thread profile
2. The angle of screen rotation is noted and then the screen is further rotated till the same line coincides with the other flank of thread. The difference in two angular readings gives the actual angel of thread on the screw.

PITCH OF THE THREAD

.

S.No.	Initial micrometer readings on thread pitch A (mm)	Final micrometer readings on thread pitch B (mm)	Pitch of the thread B-A (mm)

FLANK ANGLE OF THE THREAD:

S. No.	Intial flank angle A (Deg)	Final flank angle B (Deg)	Flank angle = B-A (Deg)

PRECAUTIONS:

1. The coincidence on the component & cross hairs must be carefully matched.
2. Eyepieces are to be handled carefully.
3. Don’t expose eyes directly to the light source.

RESULT:

The pitch and flank angle of the given object is measured with toolmakers microscope are tabulated.

6. SURFACE ROUGHNESS MEASUREMENT

AIM:

To measure the surface roughness of a given specimen

APPARATUS: SURF TEST 301

Introduction:

Surface Roughness is like a fingerprint left behind by the manufacturing process.

1. The surface irregularities of small wavelength are called primary texture or roughness these are caused by direct action of the cutting elements on the material i.e., cutting tool shape, feed rate or by some other disturbances such as friction, wear or corrosion.
2. The surface considerable wavelength of a periodic character are called secondary texture or waviness. These irregularities result due to inaccuracies of slides, wear of guides, misalignment of centers, non-linear feed motion, vibrations of any kind etc.

Elements of Surface Texture

Actual Surface: It refers to the surface of apart which is actually obtained after manufacturing process.

Nominal surface: A nominal surface is theoretical, geometrically perfect surface which does not exist in practice, but it is an average of the irregularities that are superimposed on it.

Profile: It defined as contour of any section through a surface.

Lay: It is the direction of predominant surface pattern produced by the tool marks or scratches, generally surface roughness is measured perpendicular to the lay. **Sampling Length:** It is the length of the profile necessary for the evaluation of the irregularities to be taken in to account

Roughness Height: This is rated as the arithmetical average deviation expressed in micro-meters normal to an imaginary center line, running through the profile **Roughness Width**: Roughness width is the distance parallel to the normal surface between successive peaks or ridges that constitute the predominant pattern of the roughness.

Measuring instruments:

1. Profilo graph

This is an optical instrument and is used for direct measure of the surface quality. The principle of operation is shown in fig.1 A finely pointed stylus mounted in the pickup unit, is traversed across the surface either by hand or motor drive. The work to be tested is placed on the table of the instrument. It is traversed by means of a lead screw. The stylus, which is pivoted to a mirror, moves over a tested surface. A light source sends a beam of light through lens and a precision slit to the oscillating mirror. The reflected beam of light is directed to a revolving drum, upon which a sensitized film is arranged. The drum is rotated through 2-bevel gears from the same lead screw. A profilograph will be obtained from the sensitized film, that may be subsequently analyzed to determine the value of the surface roughness.

2. Tomlinson surface meter

This is purely a mechanical lever operated piece of equipment. The diamond stylus on the recorder is held by spring pressure against the surface of a lapped steel cylinder. The stylus attached to the bodyof the instrument by means of a leaf spring and it has some height adjustment. The lapped cylinder is supported on one side by the stylus and on the other by two fixed rollers as shown in fig.2

The stylus is restrained from all motions except the vertical one by the tension in the coil and leaf spring. The tensile forces in these two springs also keep the lapped cylinder in horizontal positon. Alight arm is attached to the lapped steel cylinder, and it carries at its tip a diamond scriber which leans against a smoked glass.

While traversing across the surface of the job, any vertical movement of the stylus caused by the surface irregularities causes the lapped cylinder to roll. Thus, vertical movement coupled with horizontal movement produces a track on the glass magnifies in vertical direction and there being no horizontal magnification.

3. Taylor-Hobson-Talysurf

Taylor-Hobson-Talysurf is a stylus and skid type of instrument working on carrier modulating principle. Its response is more rapid and accurate as compared to Tomlinson Surface Meter. The measuring head of this instrument consists of sharply pointed diamond stylus of about 0.002mm tip radius and skip or shoe which is drawn across the surface by means of a motorized driving unit.

In this instrument the stylus is made to race the profile of the surface irregularities, and the oscillatory movement of the stylus is converted in to changes in electric current by the arrangement as shown in fig.3 The arm carrying the stylus forms an armature which pivots about the centre piece of E-shaped stamping. On two legs of (outer pole pieces) the E-shaped stamping there are coils carrying an a.c current. These two coils with other two resistances form an oscillator. As the armature is pivoted about the central leg, any movement of the stylus causes the air gap to vary and thus the amplitude of the original a.c current flowing in the coils is modulated. The output of the bridge thus consists of modulation only as shown in fig3 this is further demodulated so that the current now is directly proportional to the vertical displacement of the stylus. The demodulated output is caused to operate a pen recorder to produce permanent record and the meter to give numerical assessment directly.

DESCRIPTION OFSURFTEST SJ-301

The surftest SJ-301 is a stylus type surface roughness measuring instrument developed for shop floor use. The SJ-301 is capable of evaluating surface texture with variety of parameters according to various national standards and international standard. The measurement results are displayed digitally/graphically on the touch panel, and output to the built-in printer.

The stylus of the SJ-301 detector unit traces the minute irregularities of the work piece surface. Surface roughness is determined from the vertical stylus displacement produced during traversing over the surface irregularities. The measurement results are displayed digitally/graphically on the touch panel.

OBSERVATIONS:

Specimen. No.	R_a Microns	R_q Microns	R_z Microns	R_t Microns	Rsk	Rku
1.						
2.						
3.						
4.						
5.						

Result: The various roughness parameters for different specimens are tabulated.

NUMERICAL ASSESSMENT OF SURFACE ROUGHNESS

This section gives definition (calculation methods) of the roughness parameters that can be measured with the SJ-301.

Arithmetic mean deviation of the profile, Ra

Ra is arithmetic mean of the absolute values of the profile deviation (Yi) from the mean line.

$$Ra = 1/N \sum_{i=1}^{N} | Y_i |$$

For ANSI, Ra is defined over the entire evaluation length.

Root- mean – square deviation of the profile, Rq

Rq is the square root of the arithmetic mean of the squares of profile deviations (Yi) from the mean line.

$$Ra = (1/N \sum_{i=1}^{N} Y_i^{2})^{½}$$

Maximum height of the profile, Ry (DIN, ANSI)

Maximum height of the profile, Rz (DIN, ISO, ANSI, JIS'01)

Obtain the sum Zi of profile peak height Pi and profile valley depth Vi for each sampling length. The maximum value value of all Zi's over the evaluation length is defined as Ry (DIN, ANSI). And the mean value is Rz (DIN, ISO, ANSI). In the following figure Zn corresponds to Ry (DIN, ANSI, JIS'01).

Rz (DIN) = Z1+Z2+Z3+Z4+Z5/5

(Where, the number of the sampling lengths is 5)

- Profile peak/profile peak height and profile valley/profile valley depth of assessed profiles a portion that projects upward (convex) from the mean line of the assessed profile is called the "profile valley".

The distance between the mean line and the highest point of the peak is the "profile peak height". The distance between the mean line and the lowest point of the profile valley is the "profile valley depth"

Maximum profile height, Rp (DIN, ISO, JIS'94, JIS'01)

- Obtain the profile peak height Rpi for each sampling length of the assessed profile. The mean of the Rpi's obtained over the evaluation length is the Rp.
- Rp = Rp1+Rp2+Rp3+Rp4+Rp5/5

  (Where , the number of the sampling lengths is 5)
- Rp (ANSI, JIS'82) is the maximum profile peak height over the evaluation length.

Ten-point height of irregularities, Rz (JIS'82, JIS '94)

Sum of the mean height of the five highest profile peaks and the mean depth of five deepest profile valleys measured from a line parallel to the mean line.

$$Rz\ (JIS'82, JIS'94) = 1/5 \quad Ra = 1/N \sum_{i=1} | Yi |$$

Profile peak/profile peak height and profile valley/profile valley depth of assessed profiles

The distance between the mean line and the highest point of the profile peak is the "profile peak height". The distance between the mean line and the lowest point of the profile valley is the "profile valley depth".

However, if the distance (between the mean line and the highest point of the profile peak or lowest point of the profile valley) is less than 10% of the Ry value, it is not regarded as the profile peak height or profile valley depth, respectively.

Kurtosis of the profile, Ku

Ku represents the degree of concentration around the mean line of an amplitude distribution curve. The kurtosis of a profile, Ku, is given by the following formula.

$U = 1/Rq^4$. Rz (JIS'82, JIS'94) = 1/5 Ra = 1/N ∑ | Yi |

i = 1

Arithmetic mean slope of the profile, a

a is the arithmetic mean of the absolute values of the local slope of the profile. The local slope of the profile dz/dx is given by the following formula.

Dzi/dxi = 1/60 x (zi+3 – 9zi+2 + 45zi+1 – 45zi-1 + 9zi-2 – zi+3)

(Where, the zi is the height of the i'th point and the x is the distance to the adjacent data point.)

Root-mean-square slope of the profile, q

q is the square root of arithmetic mean of the squares of the local slope dz/dx of the profile.

VIVA – QUESTIONS

1. What is the use of angle plates?
2. Name some angle measuring devices?
3. What is the least count of mechanical Bevel Protractor?
4. What is the least count of optical Bevel Protractor?
5. What is a sine bar?
6. What are the limitations of Sine bar?
7. What is the difference between the sine bar and sine center?
8. What is the use of V-block?
9. What is the purpose of adjusting nuts in a micrometer?
10. What is the least count of dial indicator?
11. How do you specify sine bar?
12. How to maintain constant pressure in micrometer?
13. What are the applications of Gear toothvernier caliper?

14. How do we check the profile of a Gear tooth?
15. Name some angle measuring devices?
16. Why do we use Feeler gauges?
17. What are slip gauges and why do we use them?
18. What are slip gauges and why do we use them?
19. Explain zero error and zero correction in case of micrometers?
20. What is the principle involved in sprit levels?
21. What is the least count of digitsl vernier caliper?
22. What is the difference between vernier height gauge, vernier depth gauge, and vernier caliper?
23. Explain briefly about the different types of micrometers?
24. What is the least count of a micrometer and how is it determind?
25. What is the range of dial bore gauge?
26. Define the following terms a) Roughness b) Waviness c) Lay d) Sampling Length
27. Explain the terms R_a , R_z , RMS.
28. What type of micrometer is used for measuring longer internal length?
29. What are the applications of Toolmakers microscope?
30. State the principle involved in Toolmakers microscope?
31. How to change the magnification in Toolmakers microscope?
32. What are the various methods of measuring surface roughness?
33. Explain the use of dial bore gauge?
34. What are the precautions to be taken while using slip gauges?
35. What is the least count of a Vernier caliper having 20divisions on Vernier scale, matching with 19 divisions of main sale?