**Ahsanullah University of Science and Technology (AUST)**
**Department of Mechanical and Production Engineering**

LABORATORY MANUAL

For the students of

Department of Mechanical and Production Engineering

4th Year, 1st Semester

Student Name :

Student ID :

# Department of Mechanical and Production Engineering
# Ahsanullah University of Science and Technology (AUST)

## IPE 4102: Machine Tools and Machining Sessional
## Credit Hour: 1.5

## General Guidelines:

1. Students shall not be allowed to perform any experiment without apron and shoes.
2. Students must be prepared for the experiment prior to the class.
3. Report of an experiment must be submitted in the next class.
4. Viva for each experiment will be taken on the next day with the report.
5. The report should include the following:
    - Top sheet with necessary information
    - Main objectives
    - Work material/machine/tool/equipment used (with their specifications)
    - Experimental procedures
    - Experimental setup, Experimental conditions
    - Data Sheets
    - Sample calculation
    - Result
    - Graph
    - Discussion

    i) Discuss the graphs and results
    ii) Discuss about the experimental setup if it could be improved
    iii) Discuss the different parameters that could affect the result
    iv) Discuss any assumption made
    v) Discuss any discrepancies in the experimental procedure and result
    vi) Discuss what you have learnt and the practical application of this knowledge
    vii) Finally, add the data sheet with the report.

    - Conclusions
    - Acknowledgements
    - References
6. A quiz will be taken on the experiments at the end of the semester.
7. Marks distribution:

| Total Marks: 100 | | | |
|---|---|---|---|
| **Attendance** | **Lab Reports** | **Viva** | **Quiz** |
| 10 | 40 | 20 | 30 |

**List of the Experiments:**

1. Study of Chips and Determination of Chip Reduction Co-efficient in Turning Medium Carbon Steel by coated Carbide Insert.
2. Study of Cutting Zone Temperature in Turning Medium Carbon Steel by coated Carbide Insert.
3. Study of the Alignment test of a Lathe Machine, Milling Machine, Drilling Machine and Grinding Machine.
4. Study of Gear Indexing and Manufacturing of a Spur Gear on a Knee/Column Type Milling Machine.
5. Study of Gear Indexing and Manufacturing of a Helical Gear on a Knee/Column Type Milling Machine.
6. Study of Kinematic Diagram of Engine Lathe.
7. Determination of surface roughness of workpiece at different machining operations.
8. Determination of tool wear of cutting tool.

## Books of References:

(i) Elements of Machine Tools by M. Anwarul Azim
(ii) Machine Tools by N. Chernov
(iii) Production Technology by Er. R.K. Jain
(iv) Fundamentals of Machining and Machine Tools by Boothroyd G. & Knight
(v) Introduction to Manufacturing Processes by Kalpakjian S.
(vi) Material and Process Engineering by DeGarmo E. Paul

## Experiment No: 01

**STUDY OF CHIPS AND DETERMINATION OF CHIP REDUCTION CO-EFFICIENT IN TURNING MEDIUM CARBON STEEL BY COATED CARBIDE INSERT.**

## Objectives:

i. To study different types of chip (type, shape and color)

ii. To determine chip reduction co-efficient ($\xi$)

## Theory:

## Chip Formation:

When force is applied by cutting tool against the workpiece, the uncut layer deforms first elastically followed by plastic deformation due to the shearing action near the cutting edge of the tool. Shearing takes place along a shear zone and shear is of maximum at the shear plane. After passing out of the shear plane, the deformed material slides along the tool face as chip as cutting progresses.

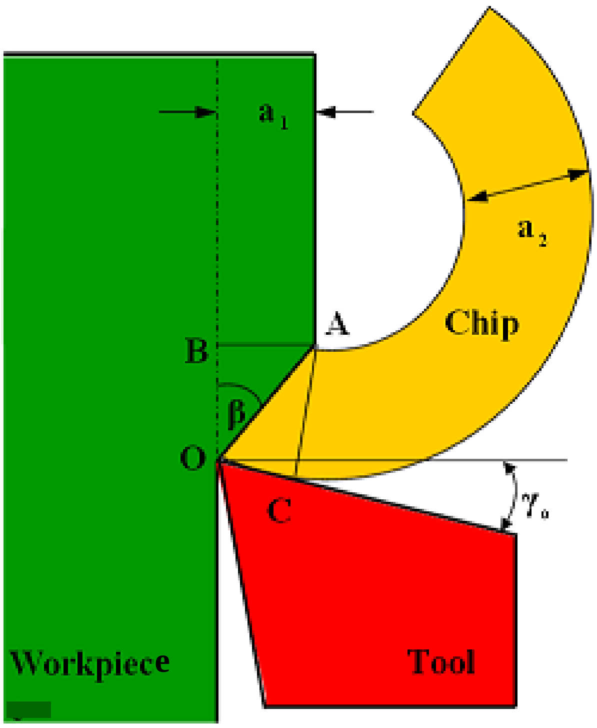



Fig.1.1: Schematic Representation of Chip Formation

**<u>Four main categories of chips (as shown in Fig. 2) are:</u>**

***Discontinuous chips:***

These chips are small segments, which adhere loosely to each other. They are formed when the amount of deformation to which chips undergo is limited by repeated fracturing. Hard and brittle materials like bronze, brass and cast iron will produce such chips.

***Continuous or 'ribbon' chips:***

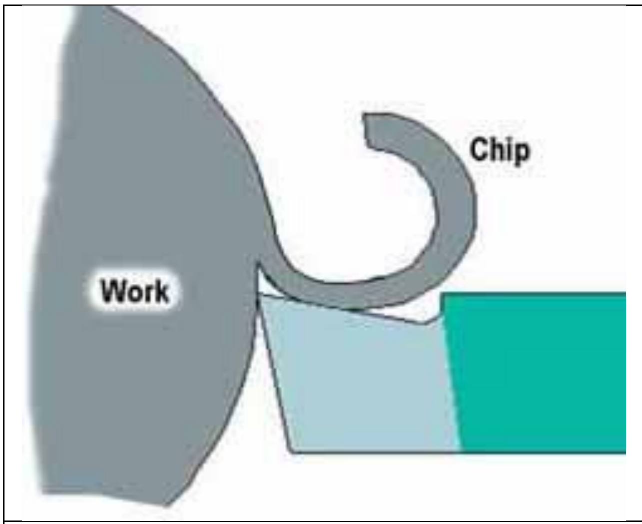
In continuous chip formation, the pressure of the work piece builds until the material fails by slip along the plane. The inside on the chip displays steps produced by the intermittent slip, but the outside is very smooth. It has its elements bonded together in the form of long coils and is formed by the continuous plastic deformation of material without fracture ahead of the cutting edge of the tool and is followed by the smooth flow of chip up the tool face.

***Continuous chip with built up edge:***

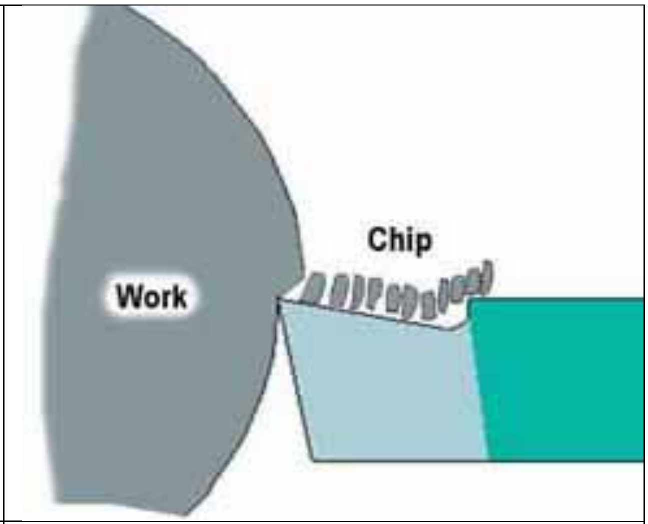
These types of chips are very similar to that of continuous type, with the difference that it is not as smooth as the previous one. This type of chip is associated with poor surface finish, but protects the cutting edge from wear due to movement of chips and the action of heat causing the increase in tool life.

***Serrated chips:***

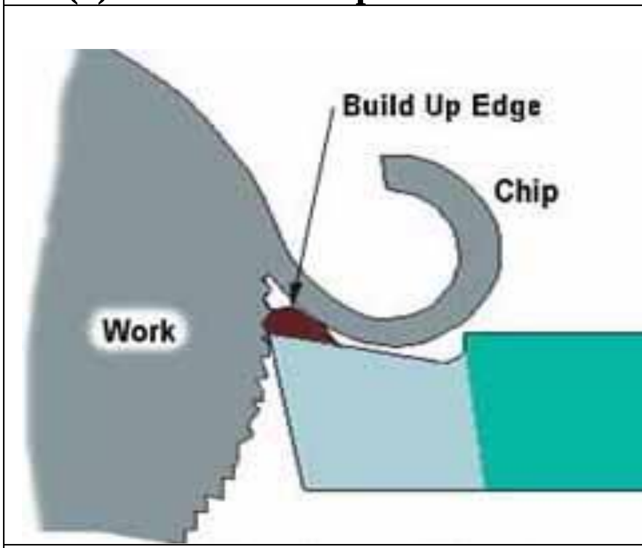
These chips are semi-continuous in the sense that they possess a saw-tooth appearance that is produced by a cyclical chip formation of altering high shear strain followed by low shear strain. This chip is most closely associated with certain difficult-to-machine metals such as titanium alloys, nickel-based super-alloys and aesthetic stainless steels when they are machined at higher cutting speeds. However, the phenomenon is also found with more common work metals (e. g. steel), when they are cut at high speeds.



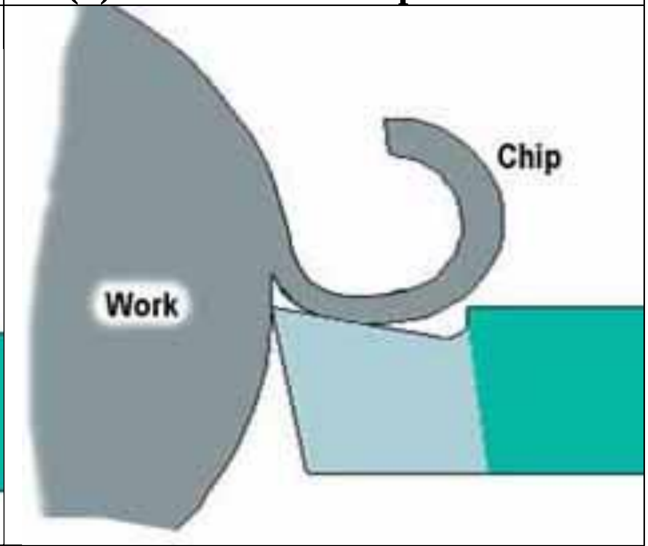

**(a) Continuous chip**




**(b) Discontinuous chip**




**(c) Continuous with built-up edge**

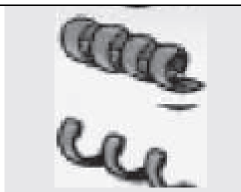



**(d) Serrated chip**

Fig.1.2: Four types of chip formation in metal cutting

**Chip Shape:**

Chip shape depends in the state of chip curling. Chip shape may be ribbon-like, helical (tubular), spiral, one turn, half turn etc.

| Chip Shape |  |  |  |  |
|---|---|---|---|---|
| Group | Half Turn | Tubular/ Helical | Spiral | Ribbon-like |

## Chip Color:

Chip color depends generally on the cutting conditions (cutting velocity, depth of cut, feed rate etc). In dry cutting the chip color is generally blue or burned blue. In wet conditions chip color generally in metallic, golden, or blue.

## Chip Reduction Co-efficient:

Chip reduction co-efficient ($\xi$) is the ratio of chip thickness ($a_2$) to uncut chip thickness ($a_1$), (as shown in Fig.1). Mathematically,

$$\xi = \frac{a_2}{a_1} = \frac{a_2}{s_0 \, Sin\, \emptyset}$$

The inverse of $\xi$ is known as cutting ratio, $r_c$. $\xi$ is an important index which indicates the degree of deformation and hence the force required. $\xi$ is affected by process parameters (i.e. $V_c$, $S_o$, t, $\gamma$ etc) and other variables (i.e. friction at too-chip interface, cutting fluid, tool material, work material etc).

## Machine, Equipment and Work Material:

i. Lathe machine
ii. Work material (medium carbon steel)
iii. Cutting tool (coated carbide)
iv. Slide calipers

## Procedure:

i. Turn the work material in an engine lathe with three different cutting velocities ($V_c$) at a constant feed rate ($S_o$) and constant depth of cut.
ii. Repeat the above procedure for three different feed rates.
iii. Collect the chips obtained
iv. Study them to identify their types, shapes and colors.
v. Calculate the chips reduction coefficient for each chip.
vi. Plot the graphs $\xi$ vs $V_c$, $\xi$ vs $S_o$

**DATA SHEET**

**Study of chips in turning medium carbon steel by coated carbide insert**

**Work material :**
**Diameter :**
**Cutting tool :**
**Material :**
**Cutting conditions**
- **Cutting velocity :**
- **Feed rate :**
- **Depth of cut :**

**Environment :**

| $S_0$ (mm/rev) | N (rpm) | $V_c$ (m/min) | $a_1$ (mm) | $a_2$ (mm) | $\xi$ | Chip | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | type | shape | color |
| | | | | | | | | |
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**Question/Answer:**

1. What is the significance of $\xi$?
2. Will $\xi$ be greater than 1 always? Why?
3. What is the difference in chips when r.p.m is high?

## Experiment No: 02

**STUDY OF CUTTING ZONE TEMPERATURE USING TOOL-WORK THERMOCOUPLE IN TURNING MEDIUM CARBON STEEL BY COATED CARBIDE INSERT.**

## Objective:

**i.** To determine temperature (θ) at chip tool interface

**Theory:**

Machining is a material removal process that typically involves the cutting of metals using different types of cutting tools in which a tool removes material from the surface of a less resistant body through relative movement of the tool and application of force and is particularly useful due to its high dimensional accuracy, flexibility of process, and cost-effectiveness in producing limited quantities of parts. Due to removal of material in the form of chips, new surfaces are cleaved from the workpiece accompanied by a large consumption of mechanical energy which in turn transformed into heat, leading to conditions of high pressure, high temperature and severe thermal conditions at the tool-chip interface. The greater the energy consumption, the greater are the temperature and frictional forces at the tool–chip interface and consequently the higher is the tool wear.

During machining heat is generated at the (a) primary deformation zone due to shear and plastic deformation (b) chip-tool interface due to secondary deformation and sliding and (c) work-tool interface due to rubbing during machining of any ductile materials. Maximum temperature has been produced at the chip-tool interface by all such heat sources which substantially influence the chip formation mode, cutting forces and tool life. The magnitude of this cutting temperature increases, though in different degree, with the increase of cutting speed, feed and depth of cut, as a result, high production machining is constrained by rise in temperature.

The average chip-tool interface cutting temperature has to measure under dry and wet conditions undertaken by simple but reliable tool-work thermocouple technique with proper calibration. This method is very useful to specify the effects of the cutting speed, feed rate and cutting parameters on the temperature. Thermocouples are conductive, rugged and inexpensive and can operate over a wide temperature range. To record emf as milivolt a digital multi-meter has been used where one end of multi-meter has been connected to the workpiece and other end to the tool.

**Machine, Equipment and Work Material:**

i. Lathe machine
ii. Work material (medium carbon steel)
iii. Cutting tool (coated carbide)
iv. Mica sheet
v. Millivoltmeter

**Procedure:**

i. Turn the work material in an engine lathe with three different cutting velocities ($V_c$) at a constant feed rate ($S_o$).
ii. Repeat the above procedure for three different feed rates.
iii. Take the mV reading from the Millivoltmeter and then determine temperature ($\theta$) at chip-tool interface from $\theta = 75.28 + 63.05\ mV - 0.57\ mV^2$
iv. Plot $\theta$ vs $V_c$; and $\theta$ vs $S_0$

**Experimental Setup for Temperature Measurement**

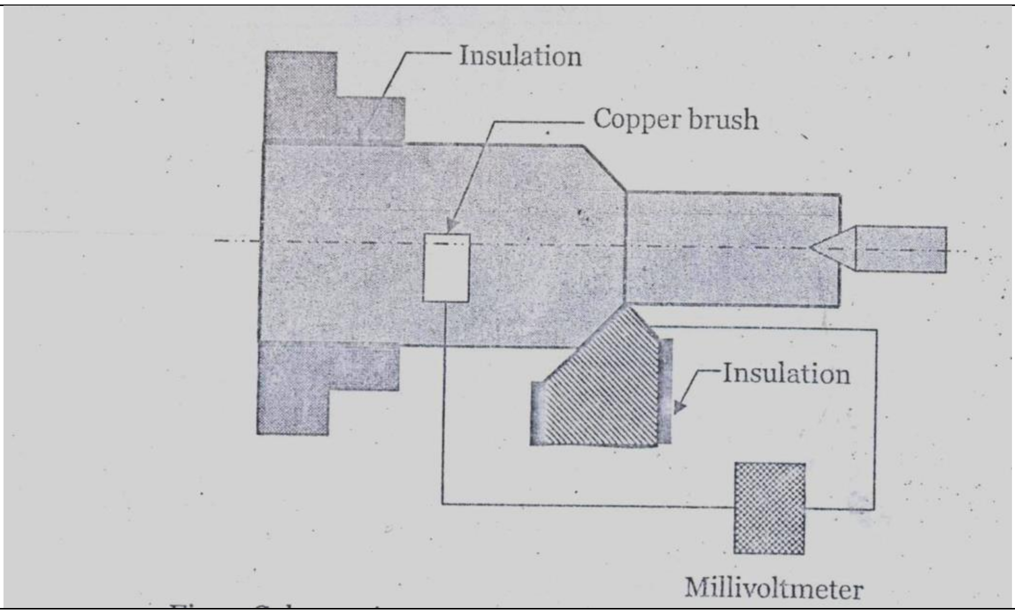


Fig.2.1: Schematic representation of temperature measurement

## DATA SHEET

## Study of cutting zone temperature in turning medium carbon steel by coated carbide insert

**Work material :**
**Diameter :**
**Cutting tool :**
**Material :**
**Cutting conditions**
- **Cutting velocity :**
- **Feed rate :**
- **Depth of cut :**

**Environment :**

| $S_0$ (mm/rev) | N (rpm) | $V_c$ (m/min) | mV | θ ($^0$C) |
|---|---|---|---|---|
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**Question/Answer:**

1. Explain seebeck effect.
2. What is the insulation procedure in this experiment? Why it is necessary?
3. What is EMF?
4. What is the relationship between cutting zone temperature and cutting velocity?

# Experiment No: 03

**STUDY OF THE ALIGNMENT TEST OF A LATHE MACHINE, MILLING MACHINE, DRILLING MACHINE AND GRINDING MACHINE.**

## Objectives:

i. To study the alignment test of a lathe machine (Chuck, tail stock, and slide ways)
ii. To study the alignment test of a Milling machine (Spindle, arbor and slide ways)
iii. To study the alignment test of a Drilling machine (Spindle and column)
iv. To study the alignment test of a Grinding machine (Magnetic chuck and worktable)

## Theory:

Alignments are a crucial step in setting up a machine to cut accurate parts. Alignment test are carried out to check the accuracy of machine tool.
Machine tools are very sensitive to impact or shock, even heavy casting standards are not always solid and rigid enough to withstand stresses due to falling during transportation, and deformations may be set up. Although the machine is always carefully adjusted and aligned when on the test stand or in the assembly department of the manufacturer, it is well known from experience that erection in the workshop is not always done with sufficient care and thus inaccuracies of the work may result from the faulty erection of the machine.
Machine tools for the workshop must be able to produce workpieces of given accuracy within prescribed limits, consistently and without requiring artistic skill on the part of the operator.
For acceptance test of a machine, its alignment test is performed and to see its dynamic stability, which may be poor though alignment tests are right, certain specific jobs are prepared and their accuracy checked.
Various tests on any machine tool are carried out, it is very essential that it should be installed in truly horizontal and vertical planes. In horizontal plane, both longitudinal and transverse directions are equally important. If, say, any long lathe bed is not installed truly horizontal the bed will undergo a deflection, thereby producing a simple bend and undesirable stresses will be introduced. If the bed is not installed truly horizontal in transverse direction, twist will be introduced. Thus, the movement of the saddle can’t be in a straight line and true geometric cylinder can’t be generated. For proper installation and maintenance of its accuracy, a special concrete foundation of considerable depth must be prepared. Also, this must be insulated from the surrounding floor by introducing some form of damping.

**Machine, Equipment and Work Material:**

i. Lathe machine
ii. Milling machine
iii. Drilling machine
iv. Grinding machine
v. Dial gauge
vi. Slide calipers
vii. Measuring tape

**Procedure:**

i. Clamp the dial gauge at different places of the machine tool.
ii. Take the reading of deflection at different places of the machine tool using dial indicator.
iii. Repeat the above procedure for other machines.
iv. Plot deflection vs distance graph.

**Assignment:**

1. Why alignment test of a machine tool is necessary?
2. What occurs if spindle alignment in lathe/ milling machine is not correct?
3. What occurs if slideway alignment in lathe/ milling machine is not correct?
4. Draw the graph and discuss about the pattern of alignment test at lathe/ milling/drilling machine in the experiment?

# Experiment No: 04

## STUDY OF GEAR INDEXING AND MANUFACTURING OF A SPUR GEAR ON A KNEE TYPE MILLING MACHINE

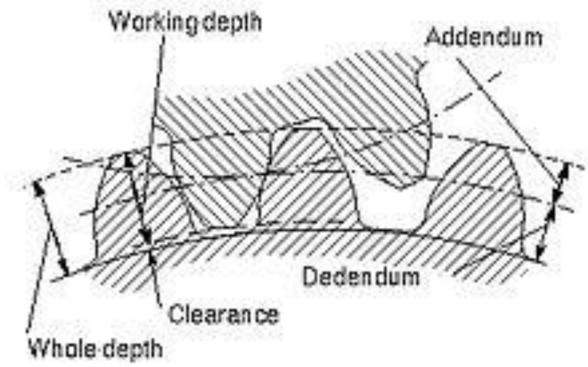
**Objective:**

i. To study the indexing a spur gear
**ii.** To manufacture a spur gear

**Theory:**
**Introduction:**

Gear is a widely used mechanical component whose primary use is to transmit power from one shaft to another. These gears are of many types namely spur gears, helical gears, worm gears etc. gear drives are used to various kinds of machines like automobiles, metal cutting tools, rolling mills, material handling equipments etc. the friction and other losses in this type of power transmission equipment is comparatively very low.

**Gear Nomenclature:**




**Addendum:** The **addendum** is the height by which a tooth of a gear projects beyond (outside for external, or inside for internal) the standard pitch circle or pitch line; also, the radial distance between the pitch circle and the addendum circle.

**Dedendum:**
is the depth of a tooth space below the pitch line. It is normally greater than the addendum of the mating gear to provide clearance.

**Dividing Heads**
A dividing head is a tool that is used to divide a circle into equal divisions. Dividing heads are employed in operations on knee type milling machine for setting the work

piece at the required angle to the table of the machine, turning the work piece through a pre-determined angle, diving circle into the required number of parts (indexing) and also for continuous rotation of the work piece in milling helical grooves with a large lead.

Fig.4.1: Dividing Head

**Types of dividing heads:**

There are dividing heads for direct indexing (called plain dividing heads), optical dividing heads and universal dividing heads. Universal dividing heads are classified as heads with and without an index plate. Index plate dividing heads are more widely used. Universal dividing heads are setup for:

a. **Simple indexing:** It consists in turning the spindle through the required angle by rotating the index crank.
b. **Differential indexing:** It is employed where simple indexing cannot be effected i.e. where an index plate with the number of holes required for simple indexing is not available.
c. **Cutting helical grooves:** In milling helical grooves, a complex helical movement is imparted to the work piece, which involves a straight movement along the work piece axis and rotation of the work about the same axis.

**Machine, Equipment and Work Material:**

i. Milling machine
ii. Work material (Gear Blank)
iii. Cutting tool (Gear Cutter)

**Necessary Calculations:**

i. Outside diameter O.D = $\frac{T+2}{P_d}$ here, T= Number of teeth to be cut

$P_d$ = Diametral Pitch

$D_p$ = Pitch Diameter

ii. $P_d = \frac{T}{Dp}$

iii. Addendum, a = $\left[\frac{1}{Pd}\right]$

iv. Clearance, c = $\left[\frac{0.157}{Pd}\right]$

v. Dedendum, b = a+c=$\left[\frac{1.157}{Pd}\right]$

vi. Full depth or Depth of cut = a+b= $\left[\frac{2.157}{Pd}\right]$

**Procedure:**

| Sr. No. | Operation | Tools / Equipment |
|---|---|---|
| 01 | Mount and align the dividing head and tailstock on machine table. | Dividing head, tail stock, dial indicator. |
| 02 | Mount the gear-milling cutter on the arbor and test for concentricity. | Gear cutter. |
| 03 | Hold the work piece on the mandrel and adjust the mandrel between centers. | Try square, slip gauges |
| 04 | Adjust the work piece to the center of cutter. | |
| 05 | Set the revolutions, and feed for milling. | |
| 06 | In the beginning the cutter should shave slightly on the work piece. | |
| 07 | Withdraw the work piece out of range of the cutter and lift the milling table by the height of the tooth depth. | |
| 08 | Milling of first tooth space. | |
| 09 | Withdraw the work piece from the cut and turn the indexing handle by the tooth pitch & mill next tooth space. | |
| 10 | Repeat the procedure for next tooth. | |

**Questions:**

1. What are the other options that can be used other than milling to manufacture a gear?
2. Differentiate simple and differential indexing.
3. What is the requirement of indexing plate or dividing plate?
4. How can you produce a spur gear having less than 40 teeth with this indexing plate?

## Experiment No: 05

**STUDY OF GEAR INDEXING AND MANUFACTURING OF A HELICAL GEAR ON A KNEE TYPE MILLING MACHINE**

## Objective:

i. To study the indexing a helical gear
**ii.** To manufacture a helical gear

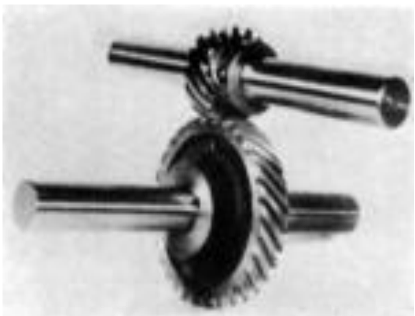
**Theory:**

**Helical Gear**

Helical gears are similar to spur gears except that their teeth are cut at an angle to the hole (axis) rather than straight and parallel to the hole like the teeth of a spur gear. Helical gears are used to connect non-intersecting shafts. Helical gears are manufactured as both *right and left-hand gears*. The teeth of a left-hand helical gear lean to the left when the gear is placed on a flat surface. The teeth of a right-hand helical gear lean to the right when placed on a flat surface. Opposite hand helical gears run on parallel shafts. Gears of the same hand operate with shafts of 90º.

*Right Hand Helical Gear*

*Left Hand Helical Gear*



*Helical Gears on Non-Parallel Shafts Shaft Angle 90°*
*Both Gears Right Hand*

## Setting up a universal diving head for milling helical grooves:

In milling helical grooves, a complex helical movement is imparted to the work piece, which involves a straight movement along the work piece axis and rotation of the work about the same axis. The work piece receives the straight movement with the work table of the machine, and rotation, from the work-table lead screw through the change gears. The table is set to the spindle axis at an angle ω equal to the helix angle of the groove being cut. In milling a left-hand groove, the table is swiveled clockwise at an angle ω, and in cutting a right hand groove, counterclockwise.

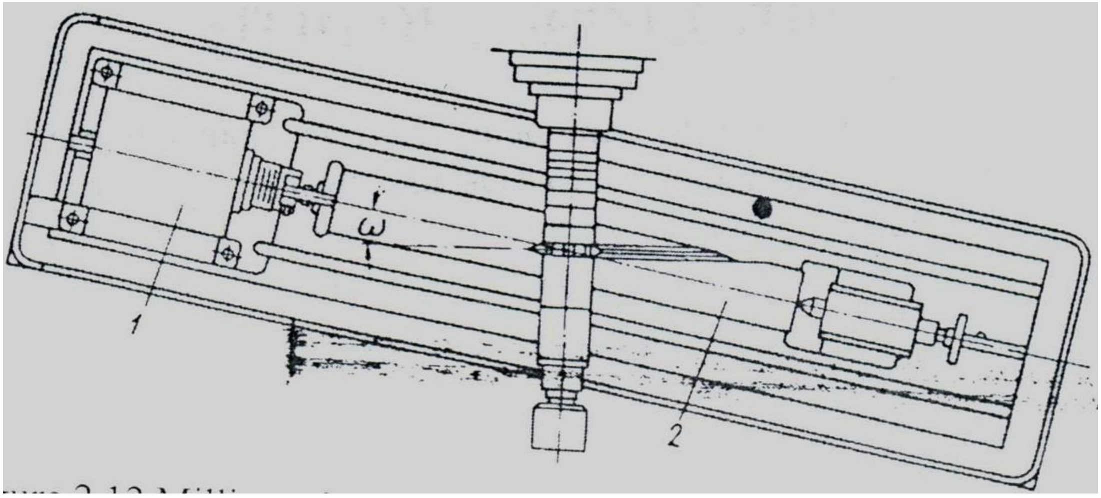


Fig.5.1: Milling of helical grooves; 1. Diving head; 2. Work piece

The set for the table is,
$\boldsymbol{\omega}$=arctan $\frac{\pi D}{P\ h.g}$

Where, D = diameter of the work piece being cut; $P_{h.g}$ = Lead of the helical groove.

If the helix ids determined by the lead angle α, the table should be set at an angle of $90^0$-α. Slow rotation is imparted to the dividing head spindle along the kinematic chain shown in figure.

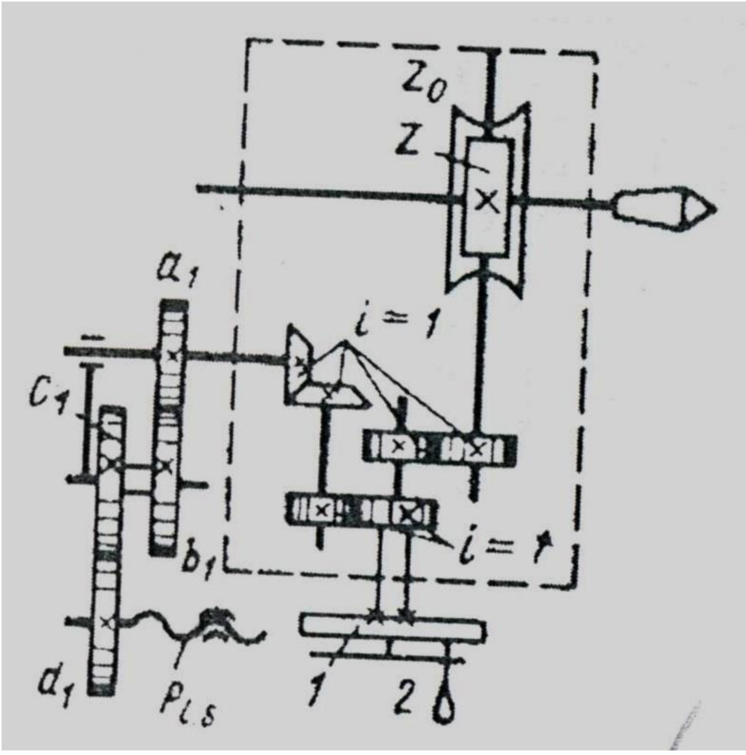



Fig.5.2: Diagram of Universal Dividing Head set-up

The kinematic balance equation of this chain for setting up change-gear train $\frac{a1}{b1}\frac{c1}{d1}$ is worked out provided that for every revolution of the work piece the work table of the machine travels by an amount equal to the lead $P_{h.g}$ of the groove being cut.

$1\frac{Z0}{Z}1.1.1\frac{a1}{b1}\frac{c1}{d1}P_{l.s} = P_{h.g}$

With Z=1, we obtain

$\frac{a1}{b1}\frac{c1}{d1}=\frac{Ph.g}{Z0Pl.s}$

Where, $P_{l.s}$ is the lead of work table lead screw, mm.

**Question/Answer:**

1. Why helical gears are better than spur gear?
2. How you cut the helical gear in vertical milling machine?
3. Name some other machine except milling in which helical gears can be cut.

# Experiment No: 06

**STUDY OF KINEMATIC DIAGRAM OF AN ENGINE LATHE.**

## Objective:

**i.** To study the kinematic diagram of an engine lathe

**Theory:**
**Movement of the machine:**
There are basically three types of movements of an engine lathe. They are-

a. Principle movement: Rotation of the spindle with the workpiece.
b. Feed movement: Longitudinal travel of the carriage and the cross traverse of the cross slide and
c. Auxiliary movement: Rapid traverse of the carriage and the cross slide in the same direction from an individual drive.

**Machine, Equipment and Work Material:**

i. Lathe machine
ii. Screw driver
iii. Wrench

**Question/Answer:**

1. Draw the kinematic diagram of the engine lathe that you have studied.
2. What are the types of gears you have seen in this experiment? Describe them all with necessary figures.

# Experiment No: 07

**DETERMINATION OF SURFACE ROUGHNESS OF WORKPIECE AT DIFFERENT MACHINING OPERATIONS.**

## Objective:

- **i.** To obtain the value of the roughness of a specimen by using Roughness Tester
- **ii.** To see the surface quality of a specimen

**Theory:**

**Surface roughness**, often shortened to **roughness**, is a component of surface texture. It is quantified by the vertical deviations of a real surface from its ideal form. If these deviations are large, the surface is rough; if they are small, the surface is smooth. Roughness plays an important role in determining how a real object will interact with its environment. Rough surfaces usually wear more quickly and have higher friction coefficients than smooth surfaces.

Although a high roughness value is often undesirable, it can be difficult and expensive to control in manufacturing. Decreasing the roughness of a surface will usually increase its manufacturing costs. This often results in a trade-off between the manufacturing cost of a component and its performance in application.

Roughness can be measured by manual comparison against a "surface roughness comparator", a sample of known surface roughness, but more generally a Surface profile measurement is made with a profilometer that can be contact (typically a diamond styles) or optical (e.g. a white light interferometer).

However, controlled roughness can often be desirable. For example, a gloss surface can be too shiny to the eye and too slippery to the finger (a touchpad is a good example) so a controlled roughness is required.

**Why do we measure surface roughness?**

The shape and size of irregularities on a machined surface have a major impact on the quality and performance of that surface, and on the performance of the end product. The quantification and management of fine irregularities on the surface, which is to say, measurement of surface roughness, is necessary to maintain high product performance.

There are two ways to measure surface roughness:

The instruments for measuring surface roughness can be broadly divided between two types.

i. contact and
ii. non-contact types

**Contact Type:**

Overview

i. The degree of roughness in the surface is measured over an arbitrary rectangular range

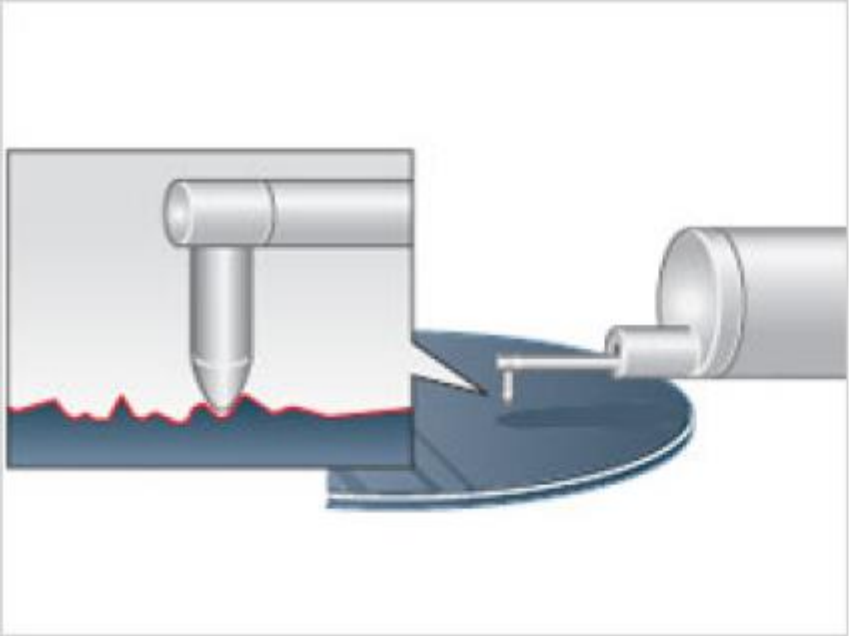


Fig.7.1: Contact-type roughness instrument

With this type, the tip of the stylus directly touches the surface of the sample. As the stylus traces across the sample, it rises and falls together with the roughness on the sample surface. This movement in the stylus is picked up and used to measure surface roughness. The stylus moves closely with the sample surface, so data is highly reliable.

**Non-Contact Type:**

The leading method of this type is light. Light emitted from the instrument is reflected and read, to measure without touching the sample. Various non-contact systems include the focus detection type, the confocal microscope type, and the interferometer type.

As they are non-contact, these systems never harm the sample and can even measure soft or viscous materials.

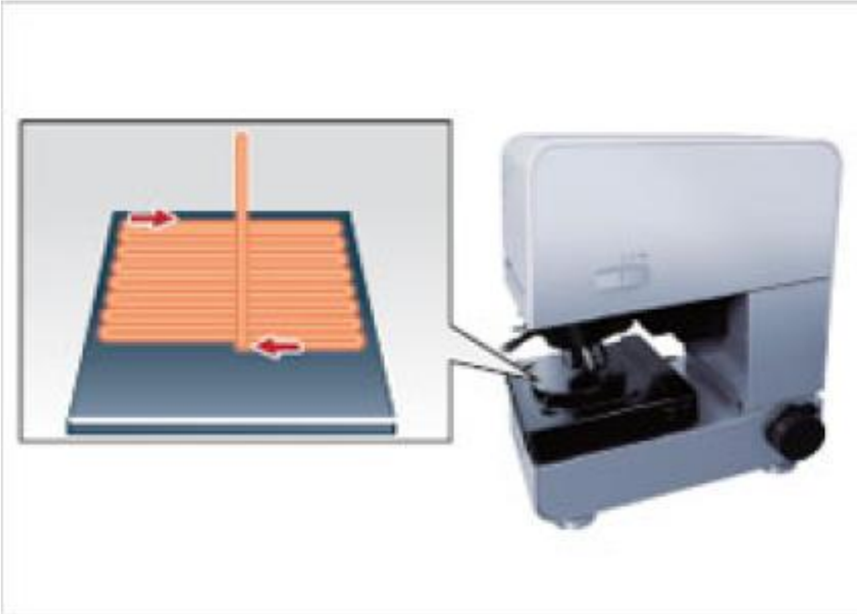


Fig.7.2: Laser microscope (focus detection system)

## Data Sheet:

| Operation Name | $S_0$ (mm/rev) | t | N (rpm) | $V_c$ (m/min) | Roughness Value, $R_a$ | | | Average |
|---|---|---|---|---|---|---|---|---|
| | | | | | 1 | 2 | 3 | |
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**Question/Answer:**

1. Which method is best, contact type or non-contact type?
2. How can you reduce surface roughness?

# Experiment No: 08

**DETERMINATION OF TOOL WEAR OF CUTTING TOOL.**

## Objective:

- **i.** To determine the value of tool wear by using Inverted Microscope
- **ii.** To learn different types of tool wear

**Theory:**

**Tool Wear:**

Productivity and economy of manufacturing by machining are significantly affected by life of the cutting tools. Cutting tools may fail by brittle fracture, plastic deformation or gradual wear. Turning carbide inserts having enough strength, toughness and hot hardness generally fail by gradual wears. With the progress of machining the tools attain crater wear at the rake surface and flank wear at the clearance surfaces, (as schematically shown in following figure.1) due to continuous interaction and rubbing with the chips and the work surfaces respectively. Among the *aforesaid* wears, the principal flank wear is the most important because it raises the cutting forces and the related problems.

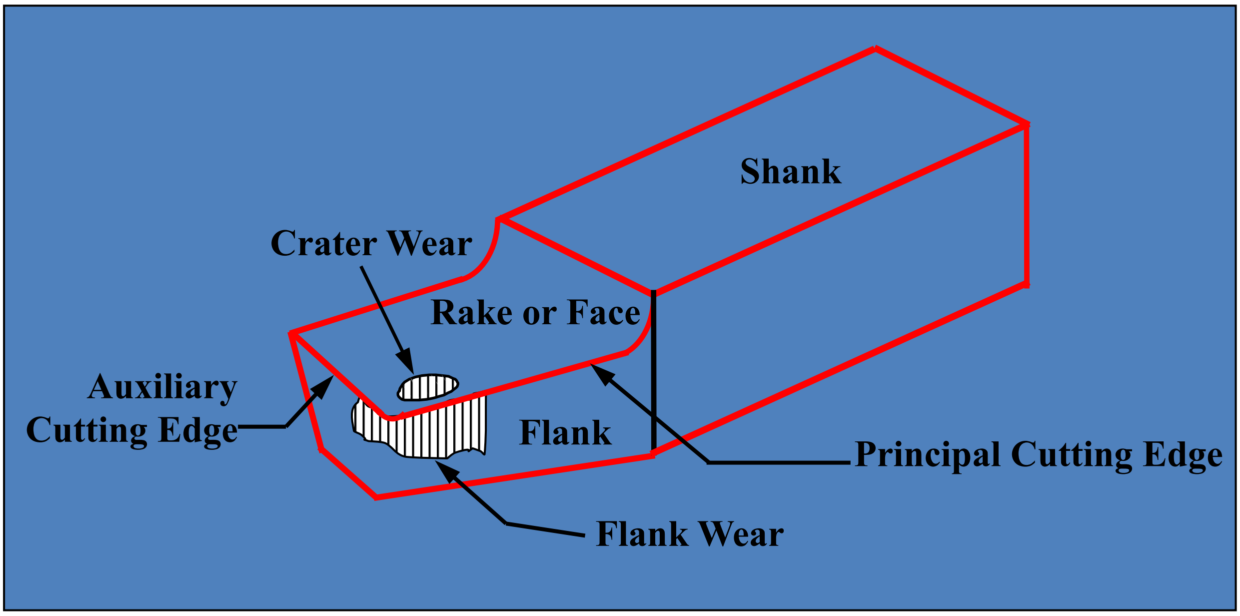



Fig.8.1: Tool Wear

**Tool wear** describes the gradual failure of cutting tools due to regular operation.

Types of wear include:

i. **flank wear** in which the portion of the tool in contact with the finished part erodes.

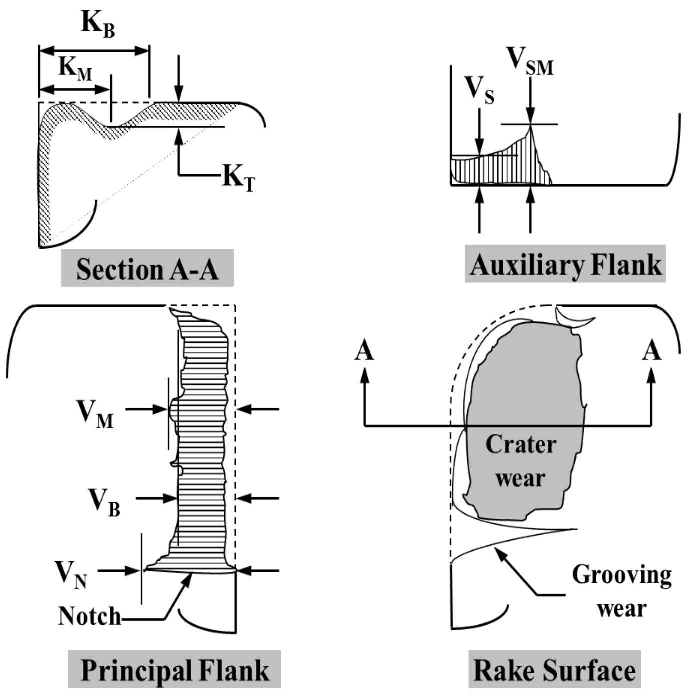
ii. **crater wear** in which contact with chips erodes the rake face. This is somewhat normal for tool wear, and does not seriously degrade the use of a tool until it becomes serious enough to cause a cutting-edge failure. Can be caused by spindle speed that is too low or a feed rate that is too high. In orthogonal cutting this typically occurs where the tool temperature is highest.

iii. **glazing** occurs on grinding wheels, and occurs when the exposed abrasive becomes dulled. It is noticeable as a sheen while the wheel is in motion.

iv. **edge wear**, in drills, refers to wear to the outer edge of a drill bit around the cutting face caused by excessive cutting speed. It extends down the drill flutes, and requires a large volume of material to be removed from the drill bit before it can be corrected.

## Major Features of Wear of Turning Tool:

- $V_B$ = Average flank wear
- $V_N$ = Flank notch wear
- $V_M$ = Maximum flank wear
- $V_S$ = Average auxiliary flank wear
- $V_{SM}$ = Maximum auxiliary flank wear
- $K_T$ = Crater depth
- $K_M$ = Distance from center of crater
- $K_B$ = Crater width



A cutting tool was rejected and further machining stopped based on one or a combination of rejection criteria:

| | | | |
|---|---|---|---|
| i. | Average Flank Wear | ≥ | 0.3 mm |
| ii. | Maximum Flank Wear | ≥ | 0.4 mm |
| iii. | Nose Wear | ≥ | 0.3 mm |
| iv. | Notching at the depth of cut line | ≥ | 0.6 mm |
| v. | Average surface roughness value | ≥ | 1.6 μm |
| vi. | Excessive chipping (flanking) or catastrophic fracture of cutting edge. | | |

**Some General effects of tool wear include:**

I. increased cutting forces
II. increased cutting temperatures
III. poor surface finish
IV. decreased accuracy of finished part
V. May lead to tool breakage

Reduction in tool wear can be accomplished by using lubricants and coolants while machining. These reduce friction and temperature, thus reducing the tool wear.

**Data Sheet:**

(machine: lathe machine, operation: turning)

| Obs. No. | rpm, N | depth of cut, t | Feed rate, $s_o$ | Operation Time or Distance | Flank Wear | | | Average Flank Wear | Crater Wear | | | Average Crater Wear |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 1 | 2 | 3 | | 1 | 2 | 3 | |
| 1. | | | | | | | | | | | | |
| 2. | | | | | | | | | | | | |
| 3. | | | | | | | | | | | | |
| 4. | | | | | | | | | | | | |

**Draw the figure of rake surface, principal flank and auxiliary flank with possible wear:**

Figure: Rake Surface with possible wear

Figure: Auxiliary Flank Surface with possible wear

Figure: Principal Flank Surface with possible wear

**Question/Answer:**

1. Is it possible to eliminate or reduce tool wear? Explain.
2. What is the effect of tool wear on machined surface?
3. Plot the graph tool wear vs time.