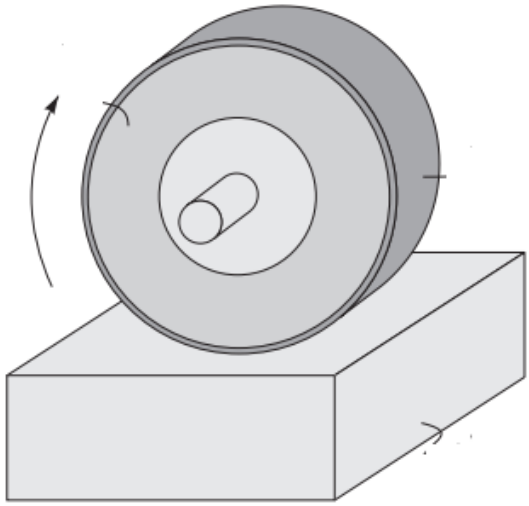
MACHINING

Level-III

Based on October 2023, Curriculum Version II



Module Title: - Perform Advanced Grinding Operations

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Acronyms

ISO. International Standard Organization

IT . International tolerance

TTLM. Teaching, Training and Learning Materials

OHS Occupational healthy and safety

SPC Statistical Process Control

Introduction to the Module

In Machining occupation, Perform Advanced Grinding Operations helps the trainees to identify the different types of grinding machines and operate Grinding machines for machining operation. So this module covers the units of Grinding Fundamentals ,Advanced Grinding Operations, Tool and Cutter Grinding operation and Component Conformance

in order to produce the quality products in competitive industry.

This module is designed to meet the industry requirement under Machining occupational standard, particularly for the unit of competency: Perform Advanced Grinding Operations

This module covers the units :

- Grinding Fundamentals
- Advanced Grinding Operations
- Tool and Cutter Grinding operation
- Component Conformance

Learning Objective of the Module which lets the trainees to:-

- Set up work
- Perform advanced grinding operations
- Perform tool and cutter grinding operation
- Check components for conformance to specifications

Module Instruction

For effective use this modules trainees are expected to follow the following module instruction:

1. Read the information written in each unit
2. Accomplish the self-checks at the end of each unit
3. Perform operation sheets which were provided at the end of units
4. Do the “LAP test” given at the end of each unit and
5. Read the identified reference book to get more knowledge as well as to do examples and exercise

Unit One:-Grinding Fundamentals

This unit to provide you the necessary information regarding the following content coverage and topics:

- Introduction to Grinding Operations
- Types of Grinding Machine
- Sequence of Operations
- Work Holding Device
- Grinding wheels
- Grinding Coolant

This unit will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

- Understand the Purpose and types of advanced grinding machine.
- Identify types of advanced grinding machine.
- Identify Work holding devices.
- Observe OHS requirements

1.1 Introduction to Advanced Grinding Operations.

Advanced grinding machine operations refer to the utilization of specialized techniques and processes to achieve high precision, productivity, and efficiency in grinding operations. These techniques are typically employed in industries such as aerospace, automotive, tool and die making, and precision manufacturing where tight tolerances and surface finish requirements are crucial.

The field of grinding technology continues to evolve, and new techniques and processes are constantly being developed to meet the demands of modern manufacturing.

To get the maximum benefit from the training, it is essential that you use every opportunity to consolidate what you observe and to interact between yourself and trains in charge of your training. On compilation of the training and though the hands-on practice given, within a self-study environment and the sub course text, you will acquire some of the advanced skills and techniques involved with these processes.

1.2.**Types of Grinding Machine**

There are many forms of grinding, but the four major industrial grinding

• Cylindrical grinding

• Center less grinding

• Internal grinding

• Surface grinding

1.2.1 Cylindrical Grinders

This machine is used primarily for grinding cylindrical surfaces, although tapered and simple format surfaces may also be ground. They may be further classified according to the method of supporting the work. Diagrams illustrating the essential difference in supporting the work between centers and centerless grinding are shown in figure below. In the centerless type the work is supported by the work rest the regulating wheel, and the grinding wheel itself. Both types use plain grinding wheels with the grinding face as the outside diameter.

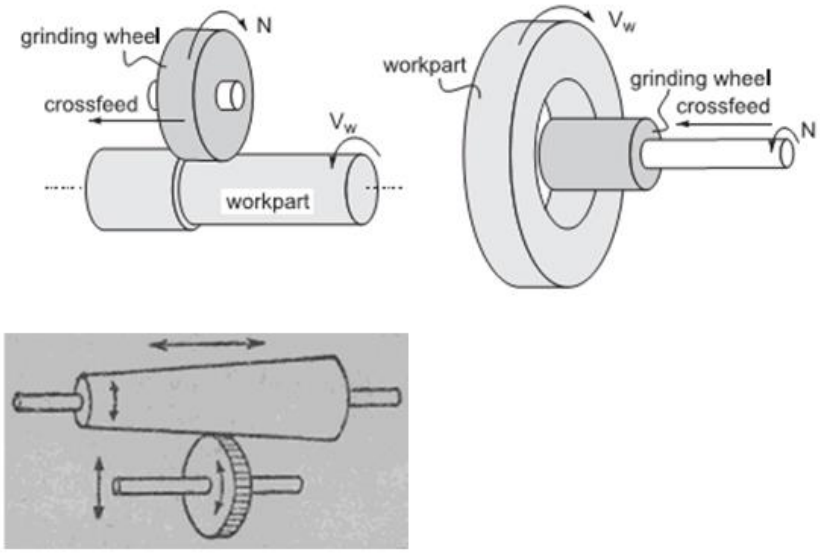


Figure 1.1. Types of Cylindrical grinding operations: external, internal, and taper (from left to right)

1. 2.2 Centerless Grinders

Centerless grinding process plays an important role in the sphere of grinding. As the name implies, the work is not supported between centers but is held against the face of grinding wheel by the combination of supporting rest and a regulating wheel. Thus centereless grinding does not require centre holes, drivers and other fixtures or holding the workpiece. During the process, the workpiece is supported on a work rest blade and the regulating wheel holds the workpiece against the horizontal force of action controlling its size and imparting the necessary rotational and longitudinal feed. The blade on the work rest gives the necessary support to the workpiece against the cutting forces. The thickness of the blade is usually slightly less than the diameter of the workpiece for smaller diameters and maximum thickness is around 20 mm. The slope (—2 ° to 8°) of its edge with the regulating wheel provides the V formation into which the work seats. Work guides are also used to keep the work parallel with the space between the wheels. The speed of regulating wheel varies from 15 to 60 meters/mm. (while the speed of grinding wheel is maintained at 1800 meters/minutes). The work picce is usually ground with its centre above the line of centers of the wheels by about half the diameter of work piece, the maximum value being 12 mm.

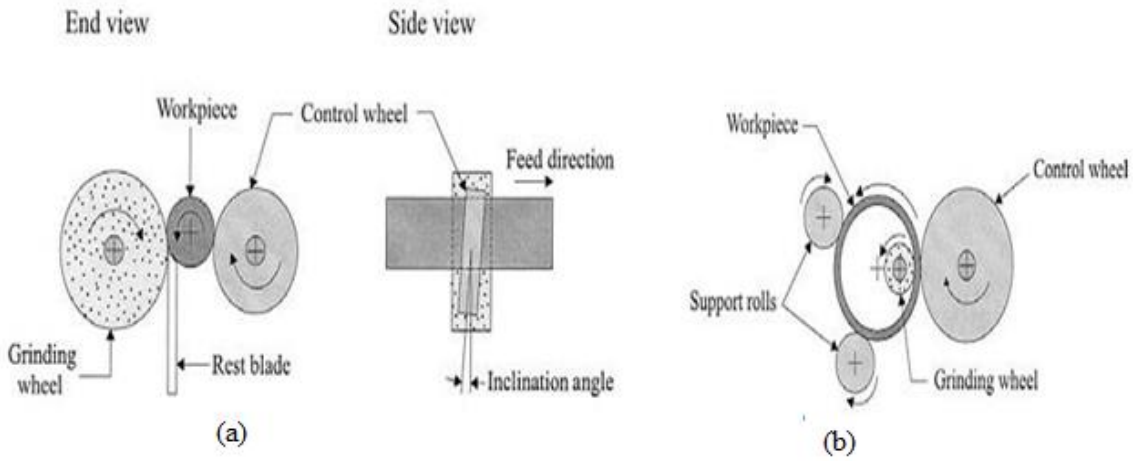


Figure 1.2: Center less (a) internal and (b) external grinding.

1.2.3 Internal Grinders

There are several types of internal grinders Listed below are the proper procedures and methods to perform internal grinding. Internal grinding is done with the universal tool and cutter grinder with an internal grinding attachment . Note that the belt and pulleys are exposed; during actual operation, this area should be covered with a guard. Since internal grinding uses small grinding wheels, the spindle and quill must operate at a high speed to get the required surface feet per minute (SFPM). Most internal grinding attachments come with several sizes of quills. Use the largest one possible for the hole being ground. The smaller quills tend to spring away from the work easily and produce tapers and irregularities.

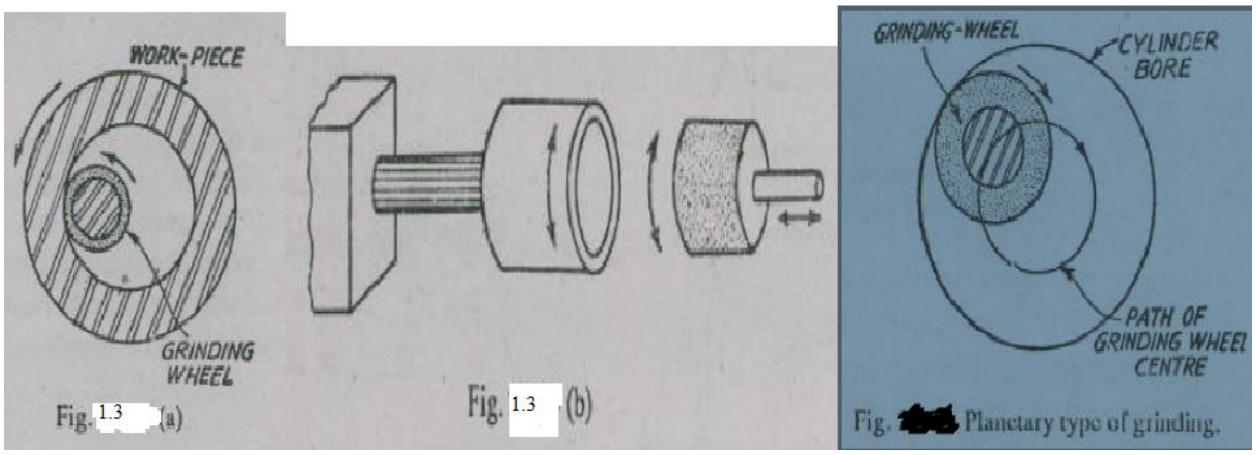


Figure1.3. Internal grinding setups.

1.2.4 Surface Grinding

Grinding flat or plane surfaces is known as surfaces grinding. Two general types of machines have been developed for this purpose; those of the planer type with a reciprocating table and those having a rotating worktable. Each machine has the possible variation of a horizontal or vertical positioned grinding wheel spindle. The four possibilities of construction are illustrated below figure.

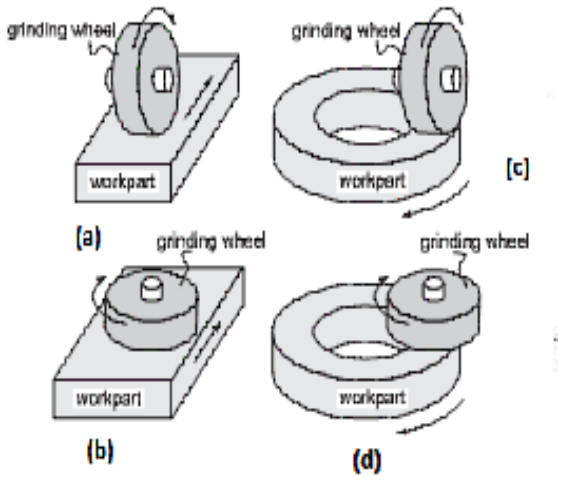


Figure1.4. Types of surface grinding machines

1.3. Sequence of Operations

The following sequence is provided as a step-by-step example of a typical surface grinding operation.

Adjust the surface grinding machine so that grinding head and worktable are absolutely parallel.

- Place a grinding wheel of the proper grain, grade, structure, and bond on the wheel spindle.
- Place the guard over the wheel and check security of all adjustable members of the grinding machine for rigidity and lack of backlash.
- True and dress the grinding wheel.
- Mount the work piece to the worktable. Make sure the surface to be ground is parallel to the worktable and the grinding wheel.
- Adjust wheel speed, work speed, and work feed.
- Proceed with grinding, adjusting depth of cut as necessary. Check for accuracy between each cut and determine that the work piece is square and the wheel is not out of alignment. If it is necessary to use more than one grinding wheel to complete the grinding, each wheel should be trued and dressed after it is mounted.

1.4.Work Holding Devices

The job or work piece and the cutting tools essentially need to be properly mounted in the machine tool for achieving desired performance of the machining system. The work is held in the various types of work holding devices like three jaw chuck, four jaw chuck, combination chuck, magnetic chuck, hydraulic chuck, face plate, driving plate, angle plate and lathe carriers. The work holding method affects the production time as it changes set up times.

The principal methods of holding work for grinding in a plain or universal cylindrical grinding machine are between centers, and in a chuck or on a faceplate. In most surface grinding operations, a workpiece is usually held to the reciprocating worktable by a magnetic chuck, a universal vice or clamped directly to the table.

1.4.1 Magnetic Chuck

The chuck is a work-holding device (either electromagnetic or vacuum), that is used to hold

the material in place while it is being worked on. It can do this one of two ways; metallic pieces are held in place by a magnetic chuck, while nonmetallic pieces are vacuumed in place. The two types of magnetic chucks are permanent magnet and electric. The electric chucks are built in larger sizes and are more powerful. However, the permanent-magnet chucks are less dangerous, since accidental release of work (due to power failure) is not likely to occur.

Much work done on a surface grinder is flat work pieces, it is held in position by a magnetic chuck, This holds the work by exerting a magnetic force. Demagnetizer can be used to neutralize part after being clamped in magnetic chuck. Frequently, work mounted on a magnetic chuck comes magnetized and must be demagnetized before it can be used. The use of a permanent magnet eliminates cords needed for electromagnets and the danger of electrical connection being broken accidentally permitting work to fly off the chuck. For either chuck, work will not remain in place unless it contacts at least two magnetic poles of the chuck.

You cannot hold nonmagnetic materials in a magnetic chuck unless you use special setups. Non- magnetic materials (aluminum, brass, etc.) can be ground by bracing with steel blocks or parallels to prevent movement. Double-faced masking tape can be used to hold thin sections of nonmagnetic materials.

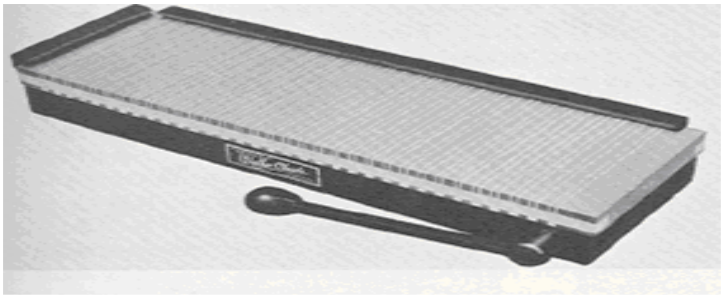


Figure 1.5 . Magnetic chuck

1.4.2 Universal Vice:

universal vise usually used when complex angles are needed to be grind on a work piece. It be can mounted directly on the worktable of the grinder or on the magnetic chuck and set up the work by rotating the swivel base through 360° in a horizontal plane and the intermediate

swivel, so you can position the surface to be ground at any angle.

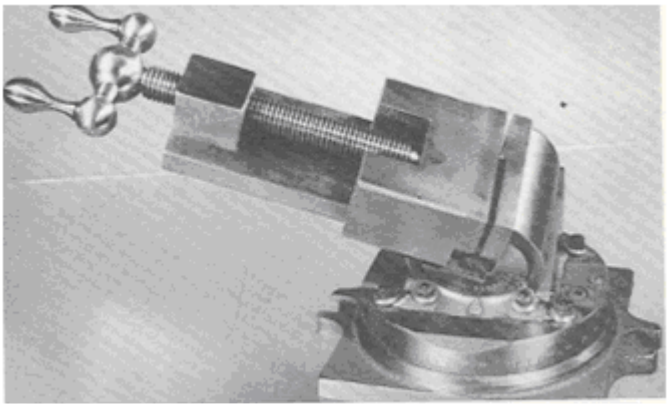


Figure 1.6 . A universal Vise

1.4.3 Chuck and Faceplate

Chucks and faceplates are used in a similar manner to those used on a lathe.

1. Four-jaw independent chucks and

2. Three-jaw chucks with reversible jaws

3. An indexing head with centers

Faceplates are often used for work that cannot be readily held in a chuck and are commonly used for holding work requiring internal grinding operations. The work piece is fixed to the faceplate with clamps and packing pieces of the correct height can be used to provide clearance for the grinding wheel.



Figure 1.7. four jaw, three jaw and Face plate

Other ways to mount work on a surface grinder:

The work piece is manually clamped to a lathe dog, powered by the faceplate, that holds the piece in between two centers and rotates the piece. The piece and the grinding wheel rotate in opposite directions and small bits of the piece are removed as it passes along the grinding wheel. In some instances special drive centers may be used to allow the edges to be ground.

Table 1.1 Work-Holding Methods and Devices for Cylindrical Grinding

Designation	**Description**	**Discussion**
Centers, nonrotating (—dead‖), with drive plate	Headstock with nonrotating spindle holds the center. Around the spindle, an independently supported sleeve carries the drive plate for rotating the work. Tailstock for opposite center.	The simplest method of holding the work between two opposite centers is also the potentially most accurate, as long as correctly prepared and located center holes are used in the work.
Centers, driving type	Word held between two centers obtains its rotation	Eliminates the drawback of the common center-type

	from the concurrently applied drive by the live headstock spindle and live tailstock spindle.	grinding with driver plate, which requires a dog attached to the workpiece. Driven spindles permit the grinding of the work up to both ends.
Chuck, geared, or cam-actuated	Two, three, or four jaws moved radially through mechanical elements, hand-, or power-operated, exert concentrically acting clamping force on the workpiece.	Adaptable to workpieces of different configurations and within a generally wide capacity of the chuck. Flexible in uses that, however, do not include high-precision work.
Chuck, diaphragm	Force applied by hand or power of a flexible diaphragm causes the attached jaws to deflect temporarily for accepting the work, which is held when force is released.	Rapid action and flexible adaptation to different work configurations by means of special jaws offer varied uses for the grinding of disk-shaped and similar parts.
Collets	Holding devices with externally or internally acting clamping force, easily adapt-able to power actuation, assuring high centering accuracy.	Limited to parts with previously machined or ground holding surfaces, because of the small range of clamping movement of the collet jaws.
Face plate	Has four independently actuated	Used for holding bulky parts, or
Magnetic plate	Flat plates, with pole distribution adapted to the	Applicable for light cuts such as are frequent in tool

	work, are mounted on the spindle like chucks and may be used for work with the locating face normal to the axis.	making, where the rapid clamping action and easy access to both the O.D. and the exposed face are some-times of advantage.
Steady rests	Two basic types are used: (a) the two-jaw type supporting the work from the back (back rest), leaving access by the wheel; (b) the three-jaw type (center rest).	A complementary work-holding device, used in conjunction with primary work holders, to provide additional support, particularly to long and/or slender parts.
Special fixtures	Single-purpose devices, designed for a particular workpiece, primarily for providing special locating elements.	Typical work pieces requiring special featuring are, as examples, crankshafts where the holding is combined with balancing functions; or internal gears located on the pitch circle of the teeth for O.D. grinding.

1.4.Grinding wheels

Grinding is a material removal process in which abrasive particles (made of crushed or ground abrasive grains) are contained in a bonded grinding wheel that operates at very high surface speeds. A grinding wheel consists of a closely packed abrasive particle (grains) that are held together by bonding material. The bonding material holds the particles in place and establishes the shape and structure of the wheel. The grinding wheel is usually disk shaped and is precisely balanced for high rotational speeds.

When a grinding wheel is functioning properly, the abrasive grains cut very small chips from

the workpiece and at the same time a portion of the bond of the wheel is worn away. As long as the bond is being worn away as fast as the abrasive grains of the wheel become dull, the wheel will continue to work well. If the bond is worn away too rapidly, the wheel is too soft and will not last as long as it should. If the cutting grains wear down faster than the bond, the face of the wheel becomes glazed and the wheel will not cut freely.

The grinding wheel has abrasive grains enveloped in a matrix of bonding .These grains are of irregular shape and randomly dispersed within the matrix. Owing to this random dispersion, three mechanisms of interactions exist between the grains and the workpiece: cutting, plowing, and rubbing. Only cutting causes material removal, while plowing only causes deformation of the surface . The abrasive particles are hard, brittle refractory materials that are classified according to their hardness, toughness, and friability (capacity to fracture and yield another cutting edge, in contrast to gradual wear into a dull shape)

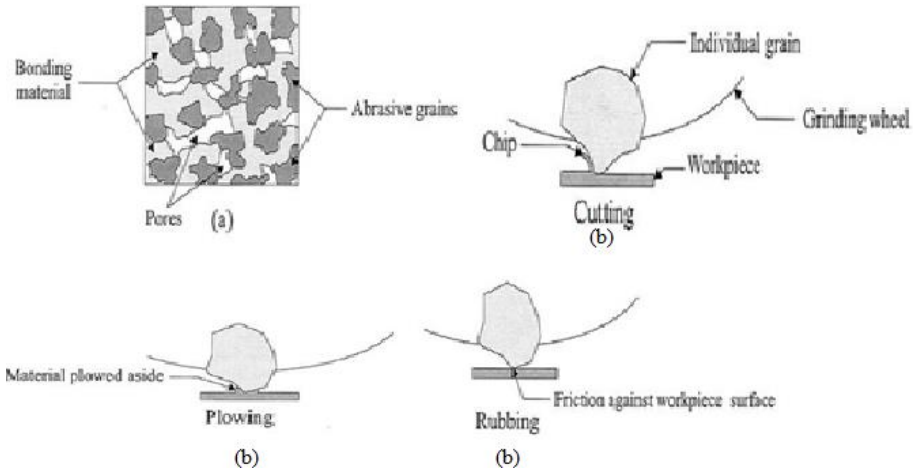


Figure 1.8 (a) Grinding wheel structure; (b) material removal.

1.4.1 Types of Grinding wheels

A **grinding wheel** is an expendable wheel that carries an abrasive compound on its periphery. These wheels are used in grinding machines. The wheel is generally made from a matrix of coarse particles pressed and bonded together to form a solid, circular shape,

various profiles and cross sections are available depending on the intended usage for the wheel. They may also be made from a solid steel or aluminum disc with particles bonded to the surface. Materials used are generally silicon carbide and diamond with a vitrified bonding agent. In production grinding, a wide array of materials are used. Wheels with different abrasives, structure, bond, grade, and grain sizes are available. The abrasive is the actual cutting material, such as cubic boron nitride, zirconium aluminum oxide, manufactured diamonds, ceramic aluminum oxide, aluminum oxide, and others. The abrasive is selected based on the hardness of the material being cut. The structure of the wheel refers to the density of the wheel (bond and abrasive versus airspace). A less-dense wheel will cut freely, and has a large effect on surface finish. A less dense wheel is able to take a deeper or wider cut with less coolant, as the chip clearance on the wheel is greater. The grade of the wheel determines how tightly the bond holds the abrasive. Grade affects almost all considerations of grinding, such as wheel speed, coolant flow, maximum and minimum feed rates, and grinding depth. Grain size determines the physical abrasive size in the wheel. A larger grain will cut freely, allowing fast cutting but poor surface finish. Ultra-fine grain sizes are for precision finish work, where a fine surface finish is required. The wheel bonding agent determines how the wheel holds the abrasives. This affects finish, coolant, and minimum/maximum wheel speed. The manufacture of these wheels is a precise and tightly controlled process, due not only to the inherent safety risks of a spinning disc, but also the composition and uniformity required to prevent that disc from exploding due to the high stresses produced on rotation. Grinding wheels are self sharpening to a small degree, for optimal use they may be dressed and trued by the use of grinding dressers. **Dressing** the wheel refers to removing the current layer of abrasive, so that a fresh and sharp surface is exposed to the work surface. **Truing** the wheel makes the grinding surface parallel to the grinding table or other reference plane, so the entire grinding wheel is even and produces an accurate surface. The wheel type (e.g.:- cup or plain wheel below) fit freely on their supporting arbors, the necessary clamping force to transfer the rotary motion being applied to the 6 wheels side by identically sized flanges (metal discs). The paper blotter shown in the images is intended to distribute this clamping force evenly across the wheels surface.

1.4.1.1 Cup wheel

A **cup wheel** as pictured to the right is predominantly used in Tool and Cutter grinders where orientation of the wheel and a slim profile are required. These wheels are used (and dressed) on the side face and have the advantage of producing a truly flat surface on the side of lathe tools. They are used in jig grinders to produce flat surfaces or counter bores.



Figure 1.9. Cup wheel

1.4.1.2 Straight wheel

To the left is an image of a **straight wheel**. These are by far the most common style of wheel and can be found on bench or pedestal grinders. They are used on the periphery only and therefore produce a slightly concave surface (*hollow ground*) on the part. This can be used to advantage on many tools such a chisels.



Figure 1.10. Straight wheel

1.4.1.3 Cylinder wheel

Cylinder wheels provide a long, wide surface with no center mounting support (hollow). They can be very large, up to 12" in width. They are used only in vertical or horizontal spindle grinders.

1.4.1.4 Tapered wheel

A straight wheel that tapers outward towards the center of the wheel. This arrangement is stronger than straight wheels and can accept higher lateral loads.

1.4.1.5 Straight cup

Straight cup wheels are an alternative to cup wheels in tool and cutter grinders, where having an additional radial grinding surface is beneficial.

1.4.1.6 Dish cup

A very shallow cup-style grinding wheel. The thinness allows grinding in slots and crevaces. It is used primarily in cutter grinding and jig grinding.

1.4.1.7 Saucer wheel

A special grinding profile that is used to grind milling cutters and twist drills. It is most common in non-machining areas, as saw filers use saucer wheels in the maintenance of saw blades

Diamond wheel

1.4.1.8 Diamond wheels are grinding wheels with industrial diamonds bonded to the periphery. They are used for grinding extremely hard materials such as carbide tips, gemstones or concrete. The saw pictured to the right is a slitting saw and is designed for slicing hard materials, typically gemstones.



Figure 1.11 Diamond wheel

1.4.1.9 Diamond Mandrels

Diamond mandrels are very similar to their counterpart, a diamond wheel. They are tiny diamond rasps for use in a jig grinder doing profiling work in hard material.

1.4.2 Wheel Selection

Available in standard sizes or customized to specific grinding applications, wheels are manufactured to suit the grinding needs of all customer requirement. Since there are as many types of wheels as there are grinding applications, correct wheel selection is of critical importance.

1.4.3 Factors affecting the Selection of a Grinding Wheel

Keep in mind that a grinding wheel is a form of cutting tool, and except in the case of wheel for general purpose grinding, the abrasive, grit size, grade and structure, bond type should be selected to fit the particular job on which the wheel is to be used, just as a cutter, drill or tap is selected for its specific job.

To select the grinding wheel, there are eight factors which affect the choice of the grinding wheel specifications. There are:

1. Grinding wheel manufactures instruction.
2. Material to be ground and its hardness.
3. Amount of stock to be removed and finish required.
4. Are of grinding contact.
5. Severity of the grinding operation.
6. Wheel speed.
7. Feed rate
8. Operating technique.

Suggestions:

- First consider the material to be ground and its hardness. These effect the choice of abrasive, grift size, and grade or hardness of the wheel.

- Aluminum oxide are best for steels, while Silicon carbide abrasives are better suited to grinding cast iron, nonferrous metals and nonmetallic materials.
- A relatively fine grit size works best on taking heavier cuts can be used advantageously on soft and ductile materials that are readily penetrated.
- The hardness of the material to be ground also affects choice of the wheel grade or hardness. A harder grade can be used on soft, easily penetrated materials than on

hard materials which naturally tend to dull the wheel faster. The softer grades release the dull grains more readily to present new, sharp grains to the work.

- Second factor, in selecting a wheel in the amount of stock to be removed and the finish required. These affect the choice of grift size and bond as follows:

- A relatively coarse grit size is selected for rapid stock removal without regard for finish as rough grinding; a fine grift should be used where a high finish is desired.
- Vitrified bonded wheels are generally used where a commercial finish satisfactory. The organic bonds, resinoid, rubber and shellac, produce the highest finish.
- 3. The area of grinding contact between the wheel and the work affects the choice of grift size and grade.
- A coarse grift is required when the contact area is relatively large, as in surface grinding with cup wheels, cylinders or segments, to provide adequate chip clearance between the abrasive grains. As area of contact becomes smaller and the unite pressure tending to break down the wheel face becomes greater, finer grit wheels should be used.
- As to the grade or hardness, on large area of contact a soft grade will provide normal breakdown of the wheel, insuring continuous, free-cutting action. A harder grade, on the other hand, is needed to stand up under the increasingly higher unit pressure as the area of contact becomes smaller.
- The severity of the grinding operation affects the choice of abrasive and grade.
- A tough abrasive like 4A Aluminum Oxide should be used for rough, heavy duty grinding of steel.
- The milder abrasives like 32 and 38 Aluminum Oxide are best for lighter precision grinding operations on steels and semisteels, while the intermediate 57 and 19 Aluminum Oxide abrasives are used for precision and semiprecision grinding of both mild and hard steels.
- The severity of the grinding operation also influences the choice of grade. Hard grade provide durable wheels for rough grinding such as snagging, while medium and

softer grade wheels can be used for precision type operations which are less severe on the wheel.

- The speed at which the grinding wheel is to be operated often dictates the type of bond. Vitrified bonded wheels should not be used at speeds over 6,500 s.f.p.m. With few exceptions, when the speed exceeds this figure, resinoid, rubber or shellac bonded wheels should be used. Note, the safe operating speed shown on the tag, wheel or blotter must never be exceeded.

  Feed rate

- The higher the feed rate, the greater the grinding pressure is. If the grinding speed of workpiece must be increased, the feed rate will be increased, then the wear of the wheel will be faster. Therefore a harder grinding wheel is required.
- A standard wheel marking system is used for the identifying five major factors in grinding wheel selection:

Type of abrasive

- Grit size
- Grade or hardness
- Structure
- Bond

First Symbol: Type of Abrasive

A wheel marked **A 60-J8V** indicates the following:

A – Fused aluminum oxide

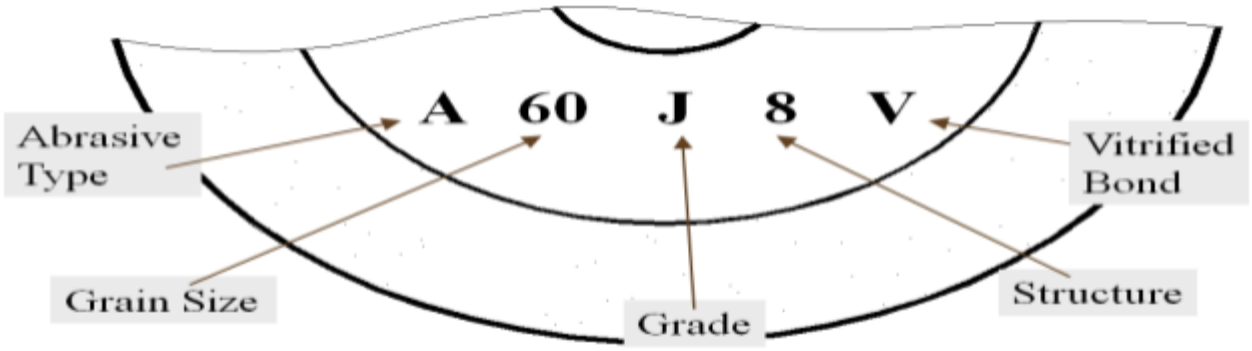


Figure 1.12: Grinding Wheel Marking

Second Symbol: Grit Size

The following scale can be used to determine grit:

4	36	46	60	100	120	240	500
Coarse				*Medium*		*Fine*	

Third Symbol: Grade of Hardness

- Hardness grade is a measure of bond strength of the grinding wheel.
- Bond material holds abrasive grains together in the wheel.
- The stronger the bond, the harder the wheel.
- Hardness grade is a measure of bond strength of the grinding wheel.

- ✓ **A to G are softer.**
- ✓ **H to P are more medium grades.**
- ✓ **R to Z are harder.**

Fourth Symbol: Structure

- **Structure**, the spacing of the abrasive grains in the wheel is indicated by numbers.

- 1 is a dense structure.
- 8 is a more medium structure.
- 15 is an open structure.

Fifth Symbol: Bond

Bond is identified by letter according to the following:

- V – Vitrified
- B – Resinoid

- R – Rubber
- E – Shellac
- M – Metal

Table 1.2 grinding Wheel Selection Chart

WA	60	K	7	V
ABRASIVES	GRIT SIZE	GRADE	STRUCTURE	BOND TYPE
A Regular Aluminium Oxide WA White Aluminium Oxide 19A Mixture of A&WA FA Semi-friable Aluminium Oxide PA,RA Pink Aluminium Oxide SA(HA) Single Crystal Aluminium Oxide 23A Mixtue of A$SA AZ Zirconium Oxide C Black Silicon Carbide GC Green Silicon Carbide RC Mixture of C&GC	10 Coarse 12 14 16 20 24 30 36 46 54 60 To 80 100 120 150 180 220 280 320 400 500 600 800 1000 1200 Fine	A Soft B C D E F G H I J K To L M N O P Q R S T U V W X Y Z Hard	1 Dense 2 3 4 5 6 7 To 8 9 10 11 12 13 14 Open	V : Vitrified B : Resinoid R : Rubber O : MgO E : Epoxy

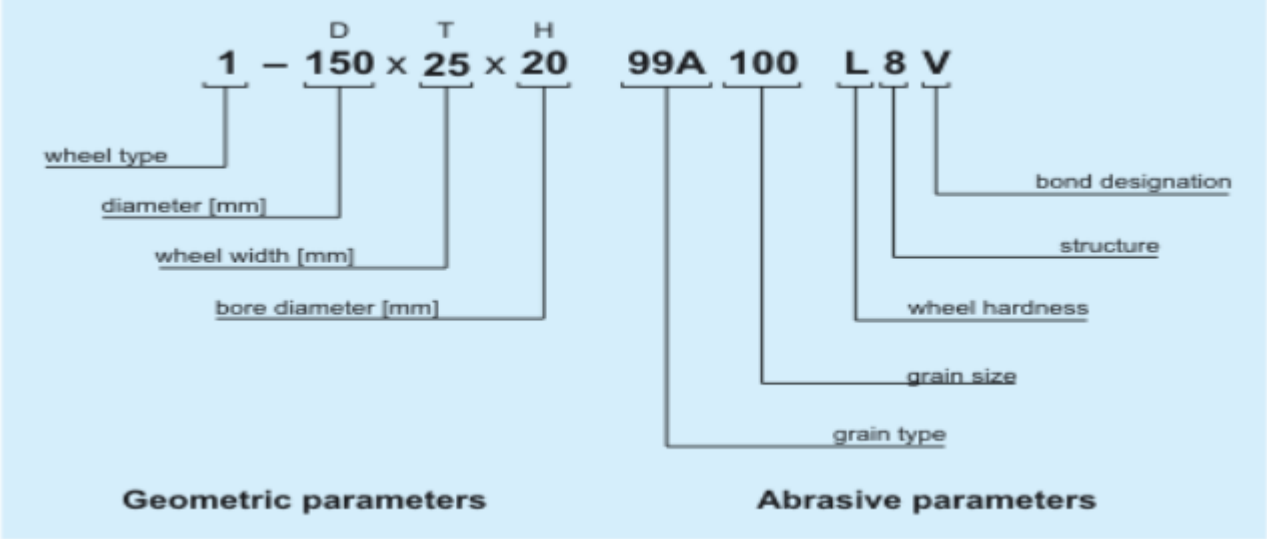


Figure 1.12 Grinding Wheel Selection Chart

Table 1.3 Grit Size Vs Form Radius

Work Radius (mm)	Grit Size	Abrasive Particle Dia. (microns)
1	36	500
0.75	46	350
0.50	60	250
0.40	80	177
0.20	120	100
0.13	180	70
0.10	220	60

1.4.6 Grinding Process - Wet or Dry

The grade of the wheel is influenced by whether the operation is wet or dry. During dry grinding with vitrified wheels, in order to minimize the heat generated, soft grade wheels should be used. These can be at least one or two grades softer than the ones chosen for wet grinding operations. In wet grinding applications, where coolants reduce the heat, harder grade wheels can be used.

1.4.7 Peripheral Speed of the Wheel

The speed at which the grinding edge of the wheel passes the work surface is called the 'Peripheral Speed' of the wheel. This is a very important factor in grinding wheel selection. The maximum operating speed for standard vitrified wheels can be up to 60 m/s. This is indicated on the blotter or on the face of the wheel. Organically bonded wheels (resinoid, rubber or shellac) are used for most applications where the required speed rate is up to 48 m/s. Higher speeds for reinforced products can go up to 100mps. Reducing the wheel speed reduces the wheel hardness.

Table 1.4 Effect of speed on grinding action:

Speed	Effect on Grinding Action when Speed is	
	Increased	Decreased
Wheel Speed	Harder	Softer
Work Speed	Softer	Harder
Traverse Speed	Softer	Harder
Infeed rate	Softer	Harder

1.4.8 Area of Grinding Contact - Large or Small

The area of grinding contact influences the selection of wheel grade and grit size. As far as wheel grade is concerned, it is normal practice to use soft grade wheels where the area of grinding contact is large and harder grade wheels where the area of grinding contact is small. In surface grinding, for instance, where the area of grinding is large, coarser grit, open structure wheels are recommended. Conversely, fine grit, closer structure wheels are ideal for use in narrower and close precision areas of contact, as in cylindrical grinding operations.

1.5 Grinding Coolant:

One of the most critical factors in achieving a good finish is the Grinding Fluid or Coolant. Grinding fluids are used to lubricate, reduce and dissipate the heat generated during a grinding operation. Other functions of the coolant are as follows:

- Dissipation of the heat generated during grinding thus keeping the work and wheel cool and reducing work distortion due to heat.
- As a lubricant, it reduces the amount of friction between the cutting tool and the chip.
- Influences the form of chip.
- Reduces the diamond dressing tool while dressing.
- Reduces loading to improve finish.
- Assists in keeping work area clean

1.5.1 Types of Coolants

Coolants can be classified as follows:

- Neat Cutting Oils
- Water based Cutting Fluids.

Water based fluids can be further classified as Synthetic, Emulsion and Semi - Synthetic.

- **Synthetic**

Synthetic metal working fluids are fluids which are free from mineral oil. The constituents are finely distributed in water and form a transparent solution. The mineral oil free chemical solutions contain corrosion inhibitors and wetting agents. They have exceptional cooling and lubricating properties especially in very high speed cutting applications and hence are ideally suited for high speed CNC machines.

- **Emulsion**

The most common form of water miscible metal working fluid is the emulsion. An emulsion is a dispense system which arises through mixing together of two liquids which are not soluble in each other. Emulsions basically contain higher proportion of mineral oil viz- 30 to 70% along with corrosion inhibitors and wetting agents. Product concentrates are diluted with water to form milky, opaque emulsions. Some fluids in the above category contain synthetic lubricants and/or EP additives to extend their application range and enable the fluid to perform more difficult operations.

- **Semi Synthetic**

Semi Synthetic is so called because they form in the main, clear emulsion combined with synthetic or natural emulsifiers. They contain 10 to 30% mineral oil, corrosion inhibitors and wetting agents. Product concentrates are dissolved in water to form stable, translucent mixes.

1.5.2 Selection of Coolants

Coolant type selection is based on the following factors:

- Application type & severity of operation, e.g. stock removal
- Nature of machine operation (cutting method)
- Water quality (Soft, Hard, Chloride, Sulphate, Bi-carbonate %)
- Material to be machined
- Surface finish
- Filtration system in the machine tool

Good housekeeping is essential for effective and optimal use of grinding fluid. We would suggest selection and application of coolants for specific needs be discussed with your selected coolant supplier.

Self-Check -1.1

Part:I choose the correct answer for the following questions

1. ___wheels are used (and dressed) on the side face and have the advantage of producing a truly flat surface on the side of lathe tools

   a. Cup wheel
   b. Straight wheel
   c. Cylinder wheel
   d. Dish cup
2. __is a very shallow cup-style grinding wheel.

   a. Straight cup
   b. Saucer wheel
   c. Dish cup
   d. Straight wheel
3. Which one of the following is the Factors affecting the Selection of a Grinding Wheel?
   a. Material to be ground and its hardness
   b. Stock removal and surface finish
   c. The grinding process - wet or dry
   d. All

Part II: Answer the following Questions accordingly

1. When select the grinding wheel, there are eight factors which affect the choice of the grinding wheel specifications. Please list five out of eight factors.
2. Aluminum oxide grinding wheel are best for what?
3. A standard wheel marking system is used for the identifying factors in grinding wheel selection. Please all five major factors?
4. A wheel marked WA 80-L9B, Please indicates the following.

Part III: Fill in the blank space

The spacing of the abrasive grains in the wheel is indicated by numbers.

1. number 1 is indicate _____ structure.
2. number 8 is indicate _____ structure.
3. number 15 is indicate _____ structure.
4. _____ are used for grinding extremely hard materials such as carbide tips, gemstones or concrete.

Unit TWO: Advanced Grinding Operations

This unit to provide you the necessary information regarding the following content coverage and topics:

- OHS Requirements
- Machines set up
  - Wheel Balancing
  - Wheel Dressing
  - Work piece set up
- Grinding Operations
  - surface grinding
  - cylindrical grinding
  - center less grinding

This unit will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

- Understand how to set up machines.
- Identify wheel balance and wheel dressing.
- Operate different grinding machines.
- Observe OHS requirements

2.1. OHS and Workshop Safety

Safety is the safe of being free from danger. Occupational health and safety (OHS) information is discussed and shared with colleagues. As always we should be aware of safety requirements and attempt to observe safety rules in order to eliminate serious injury to ourselves or others. Personnel working with machines must be aware of the risks involved and follow safe work practices. Basic cause of accidents is faulty attitude toward safety, Failure to recognize danger and Emotion. Machine operator should follow safety precautions required in terms of personal safety, work shop safety, and tools and equipment safety to avoid injuries.

2.2 Pre-operational safety

- Check workspaces and walkways to ensure no slip/trip hazards are present.
- Ensure all guards and safety shields are in position before starting the grinder.
- Ensure that the wheels do not touch the work rest and that the gap between wheel and rest is no greater than 1.5mm.
- Check grinding wheels for cracks (Ring Test) before mounting
- Check that wheels are running true and are not glazed or loaded.
- Locate and ensure you are familiar with the operation of the ON/OFF starter.
- Faulty equipment must not be used. Immediately report any suspect machine.
- On bench grinders, adjust tool rest 1/16 to 1/8 inch from the wheel

2.3 Operational Safety Checks

Wear goggles for all grinding machine operations

- Stand to the side of the wheels when starting up.
- Let the wheels gain maximum speed before starting to grind.
- Do not grind on the side of the wheel.
- Small objects must not be held by hand.
- Never adjust the work piece or work mounting devices when the machine is operating
- Never leave the machine running unattended.

- Do not bend down near the machine whilst it is running.
- Never force the work piece against a wheel.
- Do not exceed recommended depth of cut for the grinding wheel or machine.
- Slowly move the work piece across the face of the wheel in a uniform manner.
- Coolant spilt on the floor should be immediately absorbed.
- Use proper wheel guards on all grinding machines.

2.4 Potential Hazards

1. Hot Metal
2. Sparks
3. Noise
4. Sharp edges and burns
5. Entanglement
6. Wheels _run on‘ after switching off
7. Eye injuries

- **Forbidden**
  - Work piece must never be held with gloves, cloth, apron or pliers
  - Grinding nonferrous metals

2.2.Machines Set up

2.2.1 **Wheel Balancing:**

Grinding wheel balancing is a crucial process in precision grinding operations to ensure the optimal performance of the grinding wheel and the quality of the ground surface. Balancing the grinding wheel helps to minimize vibrations, reduce wear on the machine spindle and bearings, and improve the accuracy and surface finish of the workpiece. Here's an overview of the grinding wheel balancing process:

Wheel Inspection: Before balancing the grinding wheel, it's important to inspect it for any damage or irregularities. Check for cracks, chips, or other defects that could affect the balance or integrity of the wheel. If any issues are found, replace the wheel before proceeding.

Mounting the Wheel: Proper mounting of the grinding wheel is essential for effective balancing. Follow the manufacturer's instructions for mounting the wheel securely on the machine spindle, using the correct flanges, nuts, and washers. Ensure that the wheel is centered and securely tightened.

Static Balancing: Static balancing is a basic method used to identify and correct imbalance in a grinding wheel. It involves finding the heavy spots on the wheel and adding weights to counterbalance them. Here are the steps for static balancing: Mounting the Wheel: Proper mounting of the grinding wheel is essential for effective balancing. Follow the manufacturer's instructions for mounting the wheel securely on the machine spindle, using the correct flanges, nuts, and washers. Ensure that the wheel is centered and securely tightened.

Static Balancing: Static balancing is a basic method used to identify and correct imbalance in a grinding wheel. It involves finding the heavy spots on the wheel and adding weights to counterbalance them. Here are the steps for static balancing:

- Place the grinding wheel on a balancing arbor or a balancing stand, ensuring that it is level and free to rotate.
- Rotate the wheel and observe any movement or oscillation. The heavy spot will cause the wheel to settle at the lowest point.
- Mark the heavy spot with a chalk or a marker.
- Add small weights (balancing weights) to the opposite side of the heavy spot. The amount of weight added depends on the size and type of wheel.
- Continue adding and adjusting the weights until the wheel remains stationary in any position.

Dynamic Balancing: Dynamic balancing is a more advanced method that involves measuring and correcting the imbalance of the grinding wheel while it is rotating at operating speed. This method provides more accurate balancing and is typically performed using specialized balancing equipment. The process involves the following steps:

1. Mount the grinding wheel on a balancing machine or spindle designed for dynamic balancing.
2. Start the machine and let the wheel reach its operating speed.
3. Measure the imbalance using vibration sensors or balancing equipment. The sensors will detect the amount and location of the imbalance.
4. Add or remove weights in specific locations on the grinding wheel to minimize the imbalance. This can be done by attaching or removing balancing weights or by drilling holes and filling them with epoxy or lead shot.
5. Repeat the measurement and adjustment process until the imbalance is reduced to an acceptable level.

Final Inspection: After balancing the grinding wheel, perform a final inspection to ensure that the wheel is mounted securely, rotates smoothly without vibration, and meets the required specifications and tolerances.

It's important to note that the specific balancing procedure may vary depending on the type of grinding machine, wheel size, and balancing equipment available. Always follow the manufacturer's guidelines and recommendations for your particular grinding machine and wheel. Proper and regular wheel balancing is essential for safe and efficient grinding operations.

2.2.2 Wheel Balancing System:

Grinding wheels are balanced for normal use. However, for certain grinding applications, closer limits of wheel balance are required. In such cases the machine manufacturer's instructions should be followed. Using an out-of-balance wheel can result in damage both to the wheel and the spindle.

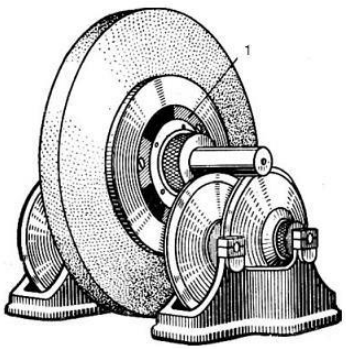


Figure 2.1. Revolving-disk wheel balancing stand.

Blotters:

Blotters are very important in the operation of a grinding wheel. These are made of a flexible and compressible material, like cardboard or plastic of around 0.2 to 1.0 mm thickness and are placed between the flange and the grinding wheel. Blotters of identical sizes are usually fixed to both sides of the wheel face or supplied loose with the wheel.

Wheel Truing and Dressing

Wheel turning and dressing are two important processes in grinding operations that involve the preparation and maintenance of the grinding wheel. Let's take a closer look at each process:

Wheel Turning:

Wheel turning, also known as wheel profiling or wheel truing, is the process of reshaping the grinding wheel to restore its original shape and dimensions. Over time, the grinding wheel can become worn, lose its balance, or develop an irregular profile due to wear or loading. Wheel turning is performed to eliminate these issues and ensure the wheel's optimal performance. Here are the key steps involved in wheel turning:

Mount the Wheel: Securely mount the grinding wheel on a suitable wheel spindle or balancing arbor, following the manufacturer's instructions.

Wheel Profiling: Use a specialized wheel dressing tool or a diamond dressing tool to profile the grinding wheel. The tool is applied to the rotating wheel to remove the worn or irregular areas and restore the desired shape. This can be done by traversing the dressing tool across the width or circumference of the wheel.

Control Wheel Speed: Adjust the speed of the wheel turning operation to ensure safe and effective profiling. The speed should be appropriate for the wheel size, material, and type, as recommended by the manufacturer.

Check Wheel Balance: After wheel turning, it is important to check the balance of the wheel using dynamic balancing techniques. This helps to ensure that the wheel is properly balanced and free from vibrations during grinding operations.

Wheel Dressing

Wheel dressing is the process of conditioning the grinding wheel's cutting surface by removing dull abrasive grains, glazing, or clogging to expose fresh abrasive grains and maintain the wheel's cutting efficiency. Wheel dressing helps to optimize the wheel's performance, achieve desired surface finishes, and prevent excessive heat buildup. Here are the steps involved in wheel dressing:

Select Dressing Method: Choose an appropriate dressing method based on the type of wheel, the material being ground, and the desired surface finish. Common dressing methods include:

Mechanical Dressing: This involves using a dressing tool, such as a single-point diamond dresser, dressing stick, or abrasive wheel, to physically remove material from the grinding wheel.

Electrolytic Dressing: In this method, an electric current is passed through a conductive dressing tool to electrolytic ally remove the bond material and expose fresh abrasive grains.

Chemical Dressing: Chemical dressing involves using specific chemical agents or solutions to dissolve or break down the bond material and remove clogged abrasive grains.

Dressing Tool Setup: Set up the dressing tool in the appropriate holder or fixture, ensuring that it is securely mounted and aligned properly with the grinding wheel.

Dressing Process

Bring the dressing tool into contact with the rotating grinding wheel. Depending on the dressing method, traverse the dressing tool across the width or circumference of the wheel, or apply the chemical dressing solution to the wheel's surface. The goal is to remove the worn or clogged abrasive material and expose fresh abrasive grains.

- Control Dressing Parameters: Adjust the dressing parameters, such as feed rate, depth of cut, and dressing tool speed, to achieve the desired dressing effect. These parameters may vary depending on the dressing method and the specific grinding application.
- Clean the Wheel: After dressing, it is important to clean the grinding wheel to remove any debris, swarf, or dressing residue. This can be done using a wheel dresser,

compressed air, or brushes.

- Proper wheel turning and dressing are essential for maintaining the performance, accuracy, and longevity of grinding wheels. Following the manufacturer's guidelines and recommendations for your specific wheel type, machine, and application is crucial to ensure safe and efficient grinding operations.

Guideline For Dressing

- When it comes to dressing a grinding wheel, following guidelines and best practices is crucial to ensure optimal results and prolong the life of the wheel. Here are some general guidelines for dressing a grinding wheel:
- Understand the Wheel Properties: Familiarize yourself with the type of grinding wheel you are working with, including its abrasive material, grit size, hardness, and bond type. Different wheels have specific characteristics that influence the dressing process.
- Safety First: Before starting the dressing process, ensure that you are wearing appropriate personal protective equipment (PPE) such as safety glasses, gloves, and a face shield. Dressing can generate sparks and debris, so a safe work environment is necessary.
- Choose the Right Dressing Method: Select the appropriate dressing method based on your specific application, wheel type, and desired results. Common methods include mechanical dressing (using a diamond dresser or dressing stick), electrolytic dressing, and chemical dressing. Consult the manufacturer's recommendations for guidance.
- Mount the Dressing Tool Correctly: Ensure that the dressing tool is securely mounted and aligned properly. It should be firmly fixed in the dressing holder or fixture to prevent any movement during the dressing process. Improper mounting can lead to inaccuracies or damage to the wheel or dressing tool.
- Determine Dressing Parameters: Set the dressing parameters according to the specific requirements of your grinding application. This includes parameters such as dressing feed rate, depth of cut, and dressing tool speed. Consult the manufacturer's recommendations for the optimal dressing parameters for your wheel.
- Control Dressing Pressure: Apply consistent and appropriate pressure during the

dressing process. Too much pressure can cause excessive wheel wear, while too little pressure may result in ineffective dressing. Maintain a steady pressure and ensure uniform contact between the dressing tool and the wheel surface.

- Consider Dressing Overfeeds: In some cases, dressing the wheel with an overfeed can help break down the bond and expose fresh abrasive grains more effectively. This is particularly useful for wheels that tend to glaze or clog. However, excessive overfeed can cause wheel damage, so it's important to find the right balance.

- Monitor Dressing Progress: Keep a close eye on the dressing process to ensure that the wheel is being properly dressed and the desired results are achieved. Monitor the wheel surface and adjust the dressing parameters if necessary.
- Clean the Wheel: After dressing, clean the grinding wheel surface to remove any debris, scarf, or dressing residue. This can be done using a wheel dresser, compressed air, or brushes. A clean wheel surface ensures optimal grinding performance
- Regular Maintenance: Incorporate regular wheel dressing into your maintenance routine to maintain wheel performance and prevent excessive wear or damage. The frequency of dressing will depend on factors such as the type of material being ground, wheel wear, and the specific application.
- Remember to always refer to the manufacturer's guidelines and recommendations for dressing your specific grinding wheel. Following these guidelines will help you achieve optimal results, prolong the life of the wheel, and ensure safe and efficient grinding operations.

Caution: Extreme care must be taken when hand dressing. The grinding wheel guard and shield must be in place, the work rest must be correctly positioned to support and serve as a guide for the dresser, and personal goggles must be worn.

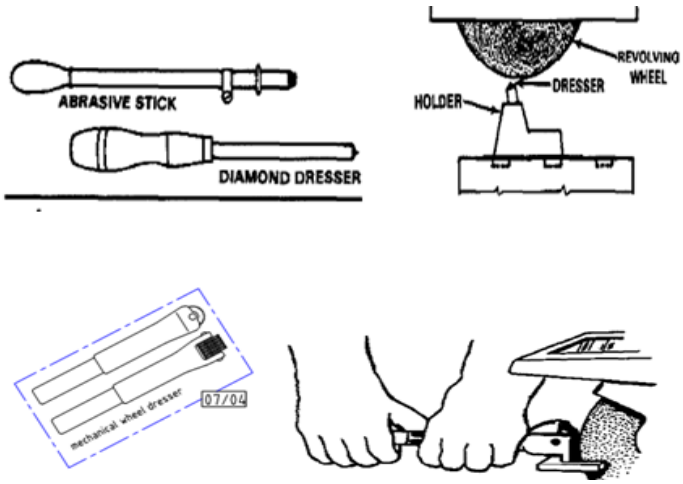


Figure 2.2 hand-held wheel Dressing tool

Diamond wheel dressing tool

When surface grinding an object, one must keep in mind that the **shape of the wheel** will be transferred to the material of the object like a mirror image. It is common practice to what is called "**dress**" the stone. This is done by using a **diamond** to remove the abrasive material not wanted and to give the desired geometry.

The diamond dressing tool should be clamped firmly, as close as possible to the diamond, in the universal tooth rest in place of the tooth rest post. Insecurity or excessive overhang induces vibration and chatter which is detrimental to the work and the diamond. The diamond should touch on the wheel axis centre line with the diamond axis inclined at about 100 degrees to give "drag" effect or trailing cut.

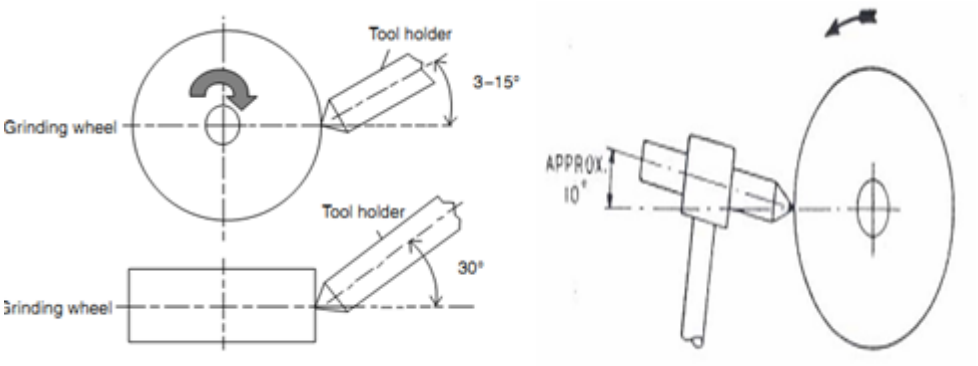


Figure 2.3 Diamond truing and dressing of GWs and Depth of cut

splintering or breaking out to provide new, sharp cutting edges for a free-cutting grinding wheel topography.

The objective in dressing, by an optimum selection of the set-up values – such as the depth of cut and the dresser in feed and through optimum conditions for the dresser, is not to damage the surface structure of the grinding wheel. If the dressing forces are too high, this can result in damage in the form of cracking of the abrasive or damage to the bond, thereby leading to premature break-out of the abrasive grains. Damage such as this results in reduced wheel life and shorter dressing intervals.

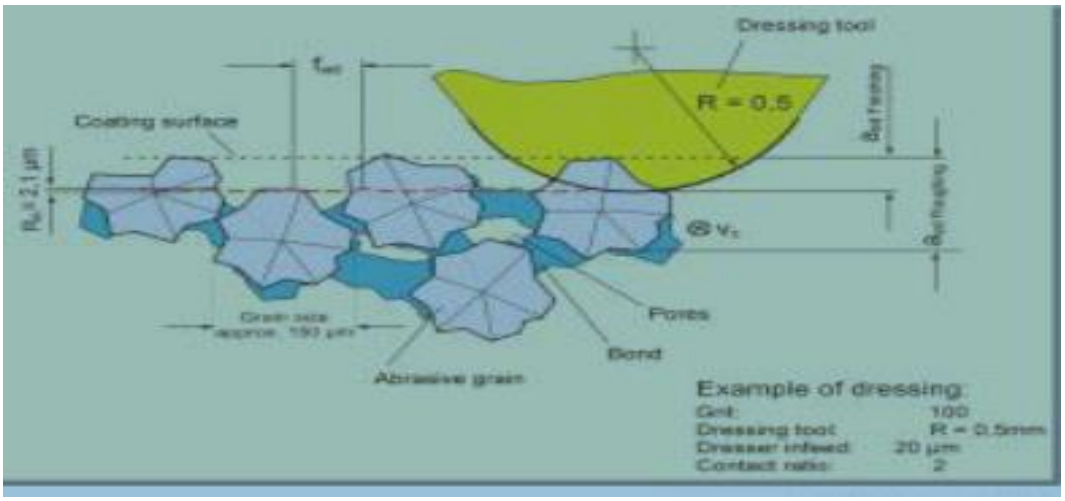


Figure 2.4. Size relationships in form dressing

Therefore, the main influential factors in dressing are

- Geometry and kinematics (i.e. contact ratio and speed ratio) and

- Diamond coating

NOTES: A properly balanced and dressed wheel will enable the following to be achieved:

- Vibration will be reduced dramatically
- Grinding your tools will be easier
- You will get better edges
- Your grinding wheels will last longer

2.2.3 Work piece set up

Mounting Work piece for Cylindrical Grinding

Cylindrical grinding may be done with the work piece setup between centers, held in the chuck and supported by a center rest, or clamped to the faceplate as in lathe setups. Use the following methods when mounting the work piece between centers: Use a dead center in the tailstock spindle. This method is preferred because it eliminates any error caused by wear in the machine's spindle bearings. Before grinding check the accuracy and alignment of centers and correct if necessary.

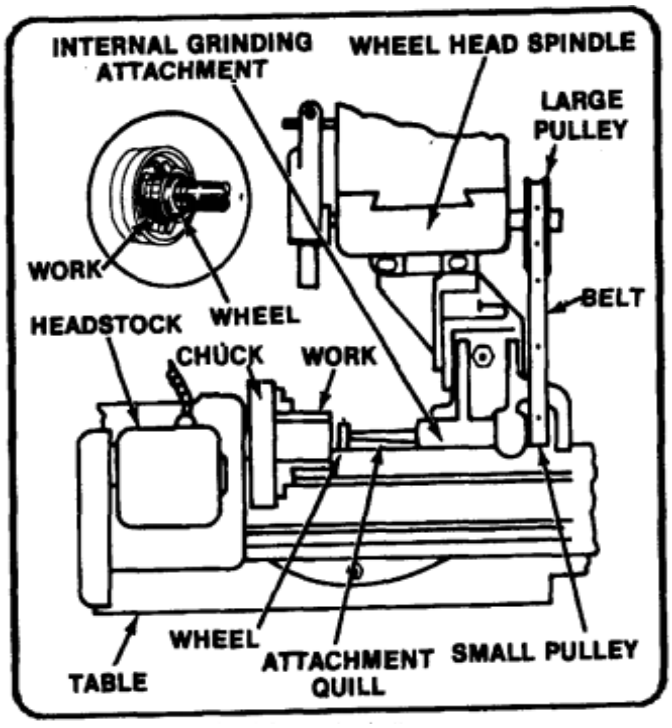
After the centers are accurate, align the centers by one of the methods prescribed for aligning lathe centers. Position the work piece between the centers, and use a lathe dog to revolve the work piece. Use the following methods and procedures when mounting the work piece for conical grinding. Work pieces for conical grinding can be set up in a chuck or between centers. The table is swiveled to the required taper by means of the graduations on the end of the table

Since the table on a universal grinder is limited as to the degree that it can be swiveled, steep conical tapers are normally ground by swiveling the headstock to the angle of the taper desired

Remember when a work piece is to be conically ground, the work piece axis and the grinding wheel axis must be at the same height. Otherwise, the work piece will not be ground at the correct angle.

Work piece Mounted for Internal Grinding

Listed below are the proper procedures and methods to perform internal grinding. Internal grinding is done with the universal tool and cutter grinder with an internal grinding attachment (Figure below). Note that the belt and pulleys are exposed; during actual operation, this area should be covered with a guard. Since internal grinding uses small grinding wheels, the spindle and quill must operate at a high speed to get the required SFPM. Most internal grinding attachments come with several sizes of quills. Use the largest one possible for the hole being ground. The smaller quills tend to spring away from the work easily and produce tapers and irregularities.



Figuer.2.5 internal grinding setup

One condition that is more pronounced in internal grinding than in external grinding is that the larger area of contact may cause the wheel to load and glaze quickly which in turn causes vibration and produces poor surface finishes. Therefore, it is important to pay particular attention to the condition of the wheel and to use either a coarser grain wheel to provide more chip clearance or a softer grade wheel that will break down more easily. During grinding, let the grinding wheel run out of the end of the hole for at least one-half the width of the wheel face but not more than two-thirds. If the wheel clears the work each time the table

reciprocates, it will grind bell-mouthed hole because of spring in the quill. Internal conical tapers can also be ground on a universal grinding machine, using a combination of the rules for external conical grinding and those for straight internal grinding. The main thing to remember is to be sure that the axis of the quill is at center height with the axis of the work.

Mounting Work piece for Surface grinding

A work piece for surface grinding is usually held to the reciprocating worktable by a magnetic chuck. It may also be held in a vise or clamped directly to the table.

The two types of magnetic chucks are permanent magnet and electric. The electric chucks are built in larger sizes and are more powerful. However, the permanent-magnet chucks are less dangerous, since accidental release of work (due to power failure) is not likely to occur.

Mounting Work piece for Tool and Cutter Grinding

Listed below are methods for mounting workplaces when using the tool and cutter grinder: A work piece for tool and cutter grinding is usually held between centers or on a fixture clamped to the table. The work piece is mounted in the same manner as for cylindrical grinding, except the lathe dog if not used. When a fixture is used, the work piece is placed in the fixture and the fixture is clamped to the table.

2.3 **Grinding Operations**

2.3.1 Surface Grinding

Surface grinding is a common grinding process used to achieve precise and smooth surface finishes on flat or planar work pieces. It involves the use of a rotating grinding wheel with abrasive particles bonded to its surface to remove material from the work piece. Here's an overview of the surface grinding process:

- Work piece Setup: Prepare the work piece by cleaning it and securely fixing it to a magnetic chuck, vacuum chuck, or other suitable holding device. Ensure proper alignment and support to prevent work piece movement during grinding.
- Grinding Wheel Selection: Choose the appropriate grinding wheel based on the material being ground, the desired surface finish, and the grinding machine's

specifications. Select a wheel that is compatible with the machine's spindle speed, size, and type (e.g., straight wheel, cup wheel, or segmental wheel).

- Machine Setup: Set up the surface grinding machine by adjusting the wheel speed, table traverse speed, and depth of cut as per the manufacturer's recommendations. Ensure the machine is in good working condition and all safety measures are in place.
- Wheel Dressing: Dress the grinding wheel using a diamond dresser or dressing stick to expose fresh abrasive grains, remove irregularities, and maintain the wheel's shape and cutting efficiency. The dressing process can be done manually or using an automatic dressing system.
- Grinding Process: Start the surface grinding machine and bring the grinding wheel into contact with the workpiece. Adjust the table traverse speed and depth of cut to remove material gradually. Move the wheel back and forth across the workpiece in a precise and controlled manner, maintaining a consistent pressure and feed rate.
- Coolant/Lubricant Application: Apply coolant or lubricant to control heat generation, flush away swarf, and improve surface finish. Use the recommended coolant/lubricant and ensure proper flow and coverage. The coolant/lubricant can be applied through nozzles or delivered through the grinding wheel.

- Monitoring and Adjustments: Continuously monitor the grinding process, including the surface finish, dimensional accuracy, and temperature. Make adjustments to the machine settings, coolant/lubricant flow, or dressing as necessary to maintain the desired results.
- Workpiece Inspection: After grinding, inspect the workpiece using appropriate measuring instruments such as calipers, micrometers, or surface roughness testers. Verify the dimensional accuracy, surface finish, and other specifications against the desired tolerances and quality standards.
- Wheel Cleaning and Maintenance: After the grinding operation, clean the grinding wheel to remove swarf, debris, and dressing residue. Inspect the wheel for wear or damage and perform any necessary maintenance or replacement.

- Documentation and Quality Control: Maintain proper documentation of the grinding parameters, workpiece specifications, and inspection results. Follow quality control procedures to ensure consistency, traceability, and adherence to customer requirements.
- Surface grinding can be performed manually or using computer numerical control (CNC) machines for more automated and precise operations. The specific steps and parameters may vary depending on the machine type, workpiece material, and desired surface finish. Always refer to the manufacturer's guidelines and best practices for your particular surface grinding machine to ensure safe and efficient operations.

2.3.2 Cylindrical Grinding

Cylindrical grinding is a machining process used to achieve precise and cylindrical-shaped surfaces on cylindrical workpieces. It involves the use of a rotating grinding wheel to remove material from the workpiece and create the desired shape and surface finish. Here's an overview of the cylindrical grinding process:

- Workpiece Setup: Prepare the cylindrical workpiece by cleaning it and securely fixing it between centers, in a chuck, or on a special fixture designed for cylindrical grinding. Ensure proper alignment and support to prevent workpiece movement during grinding.
- Grinding Wheel Selection: Choose the appropriate grinding wheel based on the material being ground, the desired surface finish, and the grinding machine's specifications. Select a wheel that is compatible with the machine's spindle speed, size, and type (e.g., straight wheel, recessed wheel, or cup wheel).
- Machine Setup: Set up the cylindrical grinding machine by adjusting the wheel speed, workpiece rotation speed (if applicable), table feed rate, and depth of cut as per the manufacturer's recommendations. Ensure the machine is in good working condition and all safety measures are in place.
- Wheel Dressing: Dress the grinding wheel using a diamond dresser or dressing stick to expose fresh abrasive grains, remove irregularities, and maintain the wheel's shape

and cutting efficiency. Dressing can be done manually or using an automatic dressing system.

- Grinding Process: Start the cylindrical grinding machine and bring the grinding wheel into contact with the workpiece. Adjust the table feed rate and depth of cut to remove material gradually. Move the wheel longitudinally along the length of the workpiece while it rotates to achieve the desired cylindrical shape. The traverse and in-feed rates can be controlled manually or through CNC.
- Coolant/Lubricant Application: Apply coolant or lubricant to control heat generation, flush away swarf, and improve surface finish. Use the recommended coolant/lubricant and ensure proper flow and coverage. The coolant/lubricant can be applied through nozzles or delivered through the grinding wheel.
- Monitoring and Adjustments: Continuously monitor the grinding process, including the surface finish, dimensional accuracy, and temperature. Make adjustments to the machine settings, coolant/lubricant flow, or dressing as necessary to maintain the desired results.
- Workpiece Inspection: After grinding, inspect the cylindrical workpiece using appropriate measuring instruments such as calipers, micrometers, or roundness testers. Verify the dimensional accuracy, surface finish, and other specifications against the desired tolerances and quality standards.
- Wheel Cleaning and Maintenance: After the grinding operation, clean the grinding wheel to remove swarf, debris, and dressing residue. Inspect the wheel for wear or damage and perform any necessary maintenance or replacement.
- Documentation and Quality Control: Maintain proper documentation of the grinding parameters, workpiece specifications, and inspection results. Follow quality control procedures to ensure consistency, traceability, and adherence to customer requirements.
- Cylindrical grinding can be performed manually or using computer numerical control (CNC) machines for more automated and precise operations. The specific steps and

parameters may vary depending on the machine type, workpiece material, and desired surface finish. Always refer to the manufacturer's guidelines and best practices for your particular cylindrical grinding machine to ensure safe and efficient operations.

2.3.3 Center less Grinding

Center less grinding is a machining process used to achieve precise and consistent diameter control on cylindrical workpieces without the need for centers or fixtures. It involves the use of a regulating wheel, a grinding wheel, and a workpiece support blade to remove material and create the desired shape and surface finish. Here's an overview of the centerless grinding process:

- Workpiece Setup: Prepare the cylindrical workpiece by cleaning it and ensuring it has a consistent diameter along its length. The workpiece is placed on the workpiece support blade, which rests on the regulating wheel and supports the workpiece during grinding.
- Grinding Wheel and Regulating Wheel Selection: Choose the appropriate grinding wheel and regulating wheel based on the material being ground, the desired surface finish, and the grinding machine's specifications. Select wheels that are compatible with the machine's spindle speed, size, and type.

- Machine Setup: Set up the centerless grinding machine by adjusting the grinding wheel height, regulating wheel angle, workpiece support blade position, and other machine parameters as per the manufacturer's recommendations. Ensure the machine is in good working condition and all safety measures are in place.
- Wheel Dressing: Dress the grinding wheel and regulating wheel using diamond dressers to expose fresh abrasive grains, remove irregularities, and maintain the wheels' shape and cutting efficiency. Dressing can be done manually or using an automatic dressing system.
- Grinding Process: Start the centerless grinding machine and adjust the grinding wheel and regulating wheel speeds, as well as the workpiece feed rate. The regulating wheel controls the rotational speed and feed rate of the workpiece, while the grinding wheel

removes material from the work piece. The workpiece is fed between the wheels and supported by the workpiece support blade.

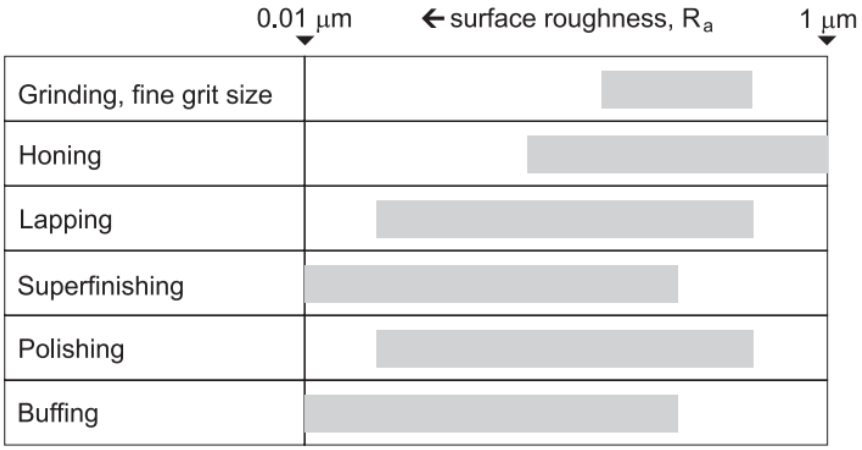
- Coolant/Lubricant Application: Apply coolant or lubricant to control heat generation, flush away swarf, and improve surface finish. Use the recommended coolant/lubricant and ensure proper flow and coverage. The coolant/lubricant can be applied through nozzles or delivered through the grinding wheel.
- Monitoring and Adjustments: Continuously monitor the centerless grinding process, including the surface finish, dimensional accuracy, and temperature. Make adjustments to the machine settings, coolant/lubricant flow, or dressing as necessary to maintain the desired results.
- Workpiece Inspection: After grinding, inspect the workpiece using appropriate measuring instruments such as calipers, micrometers, or roundness testers. Verify the dimensional accuracy, surface finish, and other specifications against the desired tolerances and quality standards.
- Wheel Cleaning and Maintenance: After the grinding operation, clean the grinding wheel, regulating wheel, and workpiece support blade to remove swarf, debris, and dressing residue. Inspect the wheels and blades for wear or damage and perform any necessary maintenance or replacement.

- Documentation and Quality Control: Maintain proper documentation of the grinding parameters, workpiece specifications, and inspection results. Follow quality control procedures to ensure consistency, traceability, and adherence to customer requirements.
- Center less grinding offers advantages such as high production rates, consistent diameter control, and the ability to grind long and thin work pieces. However, it requires skill and experience to set up and operate the machine effectively. Always refer to the manufacturer's guidelines and best practices for your particular centerless grinding machine to ensure safe and efficient operations.

Performing Grinding operation

As the name of this group of abrasive operations suggests, their objective is to achieve

superior surface finish up to mirror-like finishing and very close dimensional precision. The finishing operations are assigned as the last operations in the single part production cycle usually after the conventional or abrasive machining operations, but also after net shape processes such as powder metallurgy, cold flashless forging, etc. The finishing processes discussed in this section include **honing, lapping, super finishing, polishing, and buffing.** The typical surface finishes for these operations are presented in the figure. Also presented for comparison are surface roughness values for fine grit size grinding.

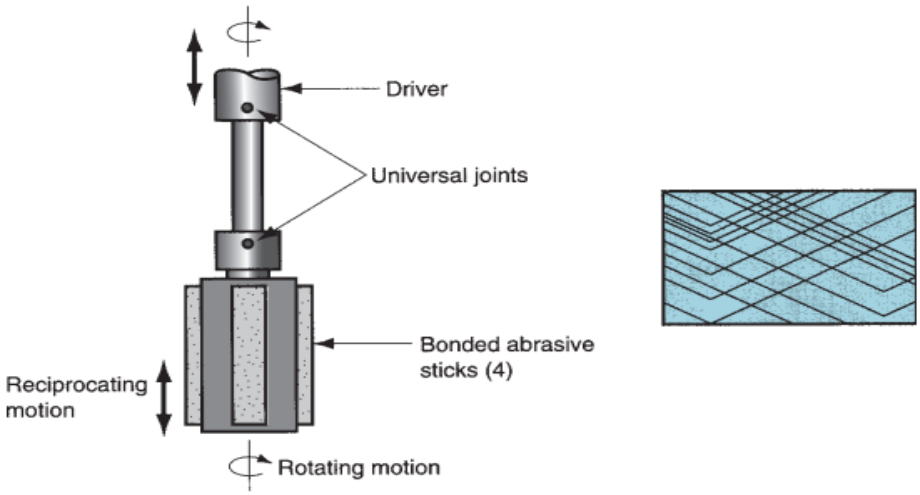


Honing

Honing is a finishing process performed by a honing tool, which contains a set of three to a dozen and more bonded abrasive sticks. The sticks are equally spaced about the periphery of the honing tool. They are held against the work surface with controlled light pressure, usually exercised by small springs. The honing tool is given a complex rotational and oscillatory axial motion, which combine to produce a crosshatched lay pattern of very low surface roughness:

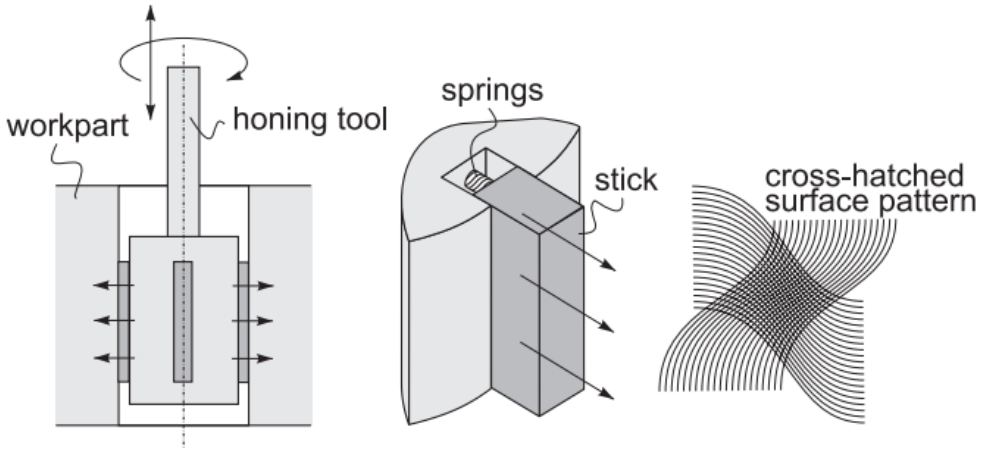
In addition to the surface finish of about 0.1 μm, honing produces a characteristic crosshatched surface that tends to retain lubrication during operation of the component, thus contributing to its function and service life. A cutting fluid must be used in honing to cool and lubricate the tool and to help remove the chips. A common application of honing is to finish the holes. Typical

examples include bores of internal combustion engines, bearings, hydraulic cylinders, and gun barrels.



(a) The honing tool used for internal bore surface, and

(b) Cross-hatched surface pattern created by the action of the honing tool.



Finguer 2.6 Schematics of honing process showing the honing tool, how the abrasive sticks are pressed against the work surface by springs, and the resulting surface pattern.

Lapping

In lapping, instead of a bonded abrasive tool, oil-based fluid suspension of very small free abrasive grains (aluminum oxide and silicon carbide, with typical grit sizes between 300 and 600) called a lapping compound is applied between the work piece and the lapping tool.

The lapping tool is called a lap, which is made of soft materials like copper, lead or wood.

The lap has the reverse of the desired shape of the work part. To accomplish the process, the lap is pressed

against the work and moved back and forth over the surface in a figure-eight or other motion pattern, subjecting all portions of the surface to the same action. Lapping is sometimes performed by hand, but lapping machines accomplish the process with greater consistency and efficiency. The cutting mechanism in lapping is that the abrasives become embedded in the lap surface, and the cutting action is very similar to grinding, but a concurrent cutting action of the free abrasive particles in the fluid cannot be excluded. Lapping is used lo produce optical lenses, metallic bearing surfaces, gages, and other parts requiring very good finishes and extreme accuracy.

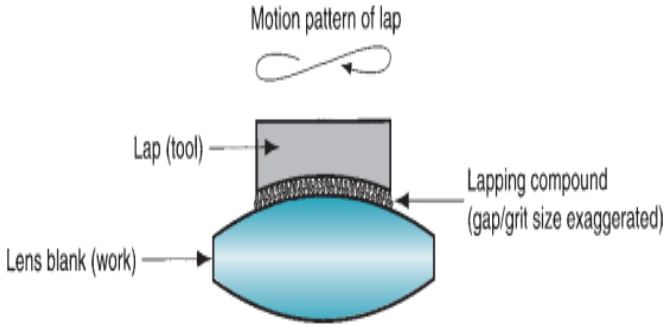


Figure 2.7 **lapping process in lens-making.**

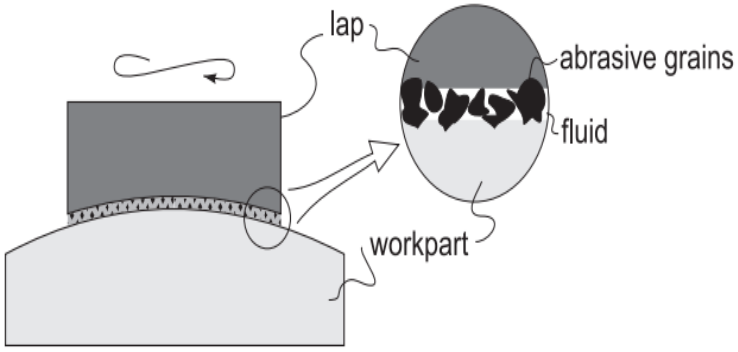


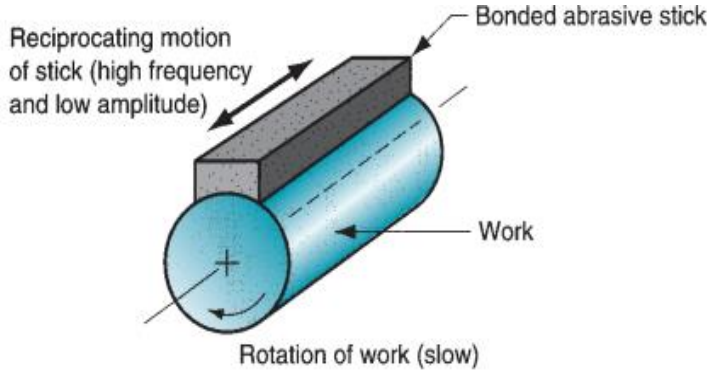
Figure 2.8 Schematics of lapping process showing the lap and the cutting action of suspended abrasive particles.

Super finishing

Super finishing is a finishing operation similar to honing, but it involves the use of a single

abrasive stick. The reciprocating motion of the stick is performed at higher frequency and smaller amplitudes. Also, the grit size and pressures applied on the abrasive stick are smaller. A cutting fluid is used to cool the work surface and wash away chips. In super finishing, the cutting action terminates by itself when a lubricant film is built up between the tool and work surface. Thus,

super finishing is capable only of improving the surface finish but not dimensional accuracy. The result of these operating conditions is mirror like finishes with surface roughness values around 0.01 μm. super finishing can be used to finish flat and external cylindrical surfaces.



.

Figure **2.9 Super finishing on an external cylindrical surface.**

Polishing And Buffing

Polishing is a finishing operation to improve the surface finish by means of a *polishing wheel* made of fabrics or leather and rotating at high speed. The abrasive grains are glued to the outside periphery of the polishing wheel. Polishing operations are often accomplished manually. *Buffing* is a finishing operation similar to polishing, in which abrasive grains are not glued to the wheel but are contained in a buffing compound that is pressed into the outside surface of the *buffing wheel* while it rotates. As in polishing, the abrasive particles must be periodically replenished. As in polishing, buffing is usually done manually, although machines have been designed to perform the process automatically. Polishing is used to remove scratches and burrs and to smooth rough surfaces while butting is used to provide attractive surfaces with high luster.

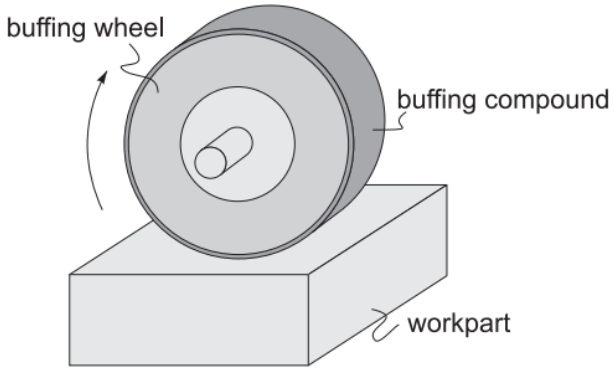


Figure 2.10 Schematics of the buffing operation.

Self-Check 2.1

Instructions: read and answer the following questions (2points)

1. ___ produces a characteristic crosshatched surface that tends to retain lubrication during operation of the component.

a. Polishing
b. Buffing
c. Super finishing
d. Honing

2. __is a finishing operation similar to honing, but it involves the use of a single abrasive stick.

a. Buffing
b. Polishing
c. Super finishing
d. Lapping

3. The abrasive grains are glued to the outside periphery of the polishing wheel in___.

a. Buffing
b. Polishing
c. Honing
d. Lapping

4. __is used to produce optical lenses, metallic bearing surfaces, gages, and other parts requiring very good finishes and extreme accuracy.

a. Lapping
b. Buffing
c. Polishing

5-Honing Work piece is usually held to the reciprocating worktable by a magnetic chuck indicates.

a. Work piece Mounted for Internal Grinding
b. Mounting Work piece for Surface grinding
c. Mounting Work piece for Tool and Cutter Grinding
d. Mounting Work piece for Cylindrical Grinding

6-work piece setup between centers, held in the chuck and supported by a center rest, or clamped to the faceplate indicates

A -Mounting Work piece for Cylindrical Grinding
b- Work piece Mounted for Internal Grinding
c- Mounting Work piece for Tool and Cutter Grinding
d -Mounting Work piece for Surface grinding

Part-II: Answer the following questions accordingly.

1. list five Safety Precautions.
2. list five main parts of the surface grinders.
3. What is a diamond wheel dresser?
4. Aluminum oxide grinding wheel are best for what?
5. A standard wheel marking system is used for the identifying factors in grinding wheel selection. Please all five major factors?

Part-III: Answer the following questions accordingly

1. List duties of operator while setting up working

2. Write the two common methods of aligning the vise with the machines?

3. What are the accessories of cylindrical grinding machines?

Operation Sheet 2.1

Operation Title: Perform wheel dressing Operation

Purpose: To assure fresh abrasive grains. And balanced grinding wheel .

Safe working area

- ✓ Properly operated tools and equipment
- ✓ Appropriate working cloths fit with the body

Equipment Tools and Materials:

- ✓ Grinding machine
- ✓ Grinding wheel
- ✓ Adjustable wrench
- ✓ Revolving-disk wheel balancing stand
- ✓ Wheel dressing tool
- ✓ Goggles
- ✓ Wheel balancing

Quality Criteria: Assured performing of all the activities according to the procedures

Precautions:

- ✓ Wearing proper clothes, eye glass, glove
- ✓ Make working area hazard free
- ✓ Read and interpret manual which guide you how to use tools and equipment

Steps in doing the task

Instruction : Remove the worn or clogged abrasive material from grinding wheel by using hand-held wheel Dressing tool in order to get expose fresh abrasive grains.

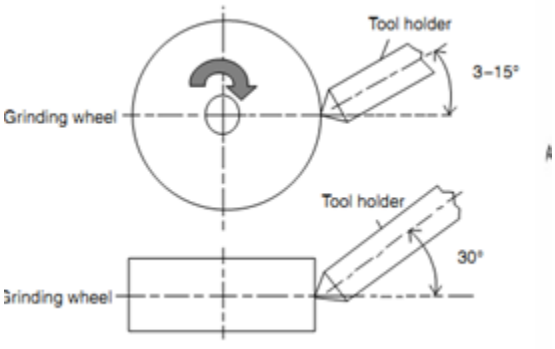
Step - 1 – Select Mechanical Dressing Method:

Step - 2 - Dressing Tool Setup: Set up the dressing tool in the appropriate holder or fixture, ensuring that it is securely mounted and aligned properly with the grinding wheel.

Step - 3 - Dressing Process: Bring the dressing tool into contact with the rotating grinding wheel. Depending on the dressing method, traverse the dressing tool across the width or circumference of the wheel to the wheel's surface. The goal is to remove the worn or clogged abrasive material and expose fresh abrasive grains.

Step - 4 - Control Dressing Parameters: Adjust the dressing parameters, such as feed rate, depth of cut, and dressing tool speed, to achieve the desired dressing effect. These parameters may vary depending on the dressing method and the specific grinding application.

Step - 5 - Clean the Wheel: After dressing, it is important to clean the grinding wheel to remove any debris, scarf, or dressing residue. This can be done using a wheel dresser, compressed air, or brushes.



LAP Test

Practical Demonstration

Name: _____ **Date: _____**

Time started: _____ **Time finished: _____**

Instruction: Perform the following tasks

Task 1 : Perform Grinding wheel dressing

Unit THREE: Tool and Cutter Grinding operation

This unit to provide you the necessary information regarding the following content coverage and topics:

- Tool grinding operation
- Sharpening cutters

This unit will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

- Identify Tool grinding machines.
- Perform tool sharpening.

3.1 Tool grinding operation

Tool grinding is a machining operation that involves the sharpening or shaping of cutting tools, such as drills, end mills, reamers, and other types of tools used for cutting, milling, drilling, or shaping workpieces. The goal of tool grinding is to restore or enhance the tool's cutting performance, accuracy, and longevity. Here's a general overview of the tool grinding process:

- Tool Inspection: Before grinding, inspect the tool for any damage, wear, or chips. Check the tool geometry, such as rake angle, relief angle, and clearance angles, to ensure it meets the desired specifications. Any defects or excessive wear should be addressed or repaired before proceeding with grinding.
- Grinding Wheel Selection: Choose the appropriate grinding wheel based on the type of tool material, the desired surface finish, and the grinding machine's specifications. Different grinding wheels, such as diamond, cubic boron nitride (CBN), or aluminum oxide wheels, may be used depending on the tool material and application.
- Machine Setup: Set up the tool grinding machine by adjusting the wheel speed, workpiece holding mechanism, and other machine parameters as per the manufacturer's recommendations. Ensure the machine is in good working condition and all safety measures are in place.
- Wheel Dressing: Dress the grinding wheel using a diamond dresser or dressing stick to expose fresh abrasive grains, remove irregularities, and maintain the wheel's shape and cutting efficiency. Dressing can be done manually or using an automatic dressing system.
- Grinding Process: Start the tool grinding machine and bring the grinding wheel into contact with the tool. Adjust the machine parameters, such as wheel speed, feed rate, and depth of cut, based on the tool material and desired grinding outcome. Move the tool against the rotating grinding wheel in a controlled manner to remove material and shape the tool.
- Cooling and Lubrication: Apply coolant or lubricant during the grinding process to

control heat generation, flush away swarf, and improve surface finish. Use the recommended coolant/lubricant and ensure proper flow and coverage. The coolant/lubricant can be applied through nozzles or delivered through the grinding wheel.

- Monitoring and Adjustments: Continuously monitor the grinding process, including the tool's temperature, surface finish, and dimensional accuracy. Make adjustments to the machine settings, coolant/lubricant flow, or dressing as necessary to maintain the desired results.
- Inspection and Quality Control: After grinding, inspect the tool using appropriate measuring instruments, such as optical comparators, tool microscopes, or gauges, to verify the tool's dimensions and geometry. Check the cutting edges for sharpness and uniformity. Ensure that the tool meets the required specifications and quality standards.
- Documentation: Maintain proper documentation of the grinding parameters, tool specifications, and inspection results. This documentation is useful for tracking tool performance, identifying maintenance needs, and ensuring consistency in future grinding operations.

Tool grinding may involve different techniques and approaches depending on the specific tool and its intended application. Advanced tool grinding machines may incorporate CNC technology for precise and automated grinding operations. Always refer to the manufacturer's guidelines and best practices for your specific tool grinding machine and tool type to ensure safe and efficient operations.

3.2 Sharpening Cutters

Sharpening cutters is an important process to maintain the cutting performance and longevity of the tools. The specific method of sharpening cutters can vary depending on the type of cutter being sharpened. Here are some general steps to sharpen common types of cutters:

Inspect the Cutter: Before sharpening, carefully inspect the cutter for any damage, wear, or chips. Check the cutting edges, teeth, or inserts for signs of wear or dullness. If there are any

significant defects or damage, it may be necessary to replace the cutter rather than attempting to sharpen it.

Determine Sharpening Method: Different types of cutters require different sharpening methods. For example:

Single-point cutters, such as lathe tools or fly cutters, can often be sharpened using a bench grinder or dedicated tool grinder. The grinding wheel should be carefully dressed to the appropriate shape and angle for the specific cutter geometry.

Multi-tooth cutters, such as milling cutters or saw blades, may require specialized sharpening equipment, such as a tool and cutter grinder or a sharpening jig designed for that particular cutter type.

Secure the Cutter: Use a vise, collet, or appropriate holding fixture to securely hold the cutter during sharpening. Ensure that the cutter is properly aligned and supported to maintain accuracy and prevent damage.

Grinding/Sharpening Process: Depending on the sharpening method and equipment being used, follow these general steps:

For bench grinders or tool grinders, carefully apply the cutter to the grinding wheel, ensuring that you maintain the correct angle and profile for the cutting edge. Move the cutter across the wheel with smooth and even motions, applying light pressure. Avoid overheating the cutter by periodically dipping it in water or using coolant/lubricant.

For specialized sharpening equipment, such as tool and cutter grinders, follow the manufacturer's instructions to set up the machine and perform the sharpening operation. This may involve adjusting various parameters, such as wheel speed, feed rate, and cutter positioning.

Cooling and Inspection: During the sharpening process, it is important to prevent excessive heat buildup that can affect the cutter's hardness and performance. Use coolant/lubricant or periodically cool the cutter to avoid overheating. After sharpening, carefully inspect the cutting edges to ensure they are sharp, symmetrical, and free from defects.

Finishing and Honing (Optional): Depending on the cutter type and desired cutting performance, a final finishing or honing step may be required. This can be done using fine-

grit sharpening stones, honing tools, or polishing compounds to achieve a smooth and sharp cutting edge.

Remember to follow the manufacturer's guidelines and best practices for sharpening the specific type of cutter you are working with. It may also be beneficial to seek guidance from experienced professionals or tool manufacturers to ensure proper sharpening techniques and achieve optimal results.

Grinding of the taper:

The left forefinger lies between grinding support and tool, the thumb is on the tool.

The right hand presses the tool against the wheel in horizontal position at the same time revolving it quickly around its own axis**.**

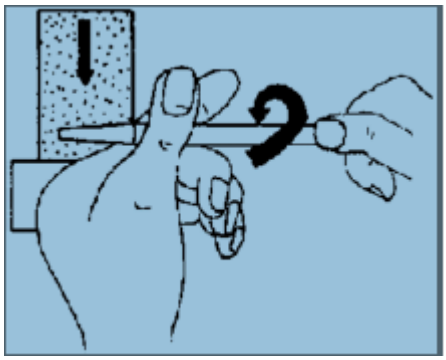


Figure 3.1 Position of the hands when grinding the taper of a scriber

Grinding of the principal cutting edges:

The drill is held between the left forefinger and thumb and guided in such a way that the left principal cutting edge comes in a horizontal position in front of the grinding wheel, the drill itself lies horizontally at an angle of incidence of approximately 58° from the left.

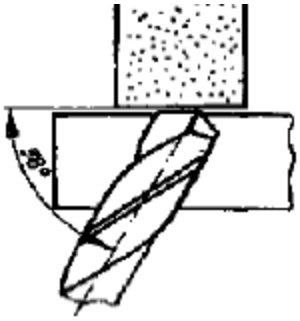


Figure ***3.2*** Position of the drill

With slight pressure the drill is led by the right hand upwards from the wheel and, at the same time, slightly pushed to the right - it is lifted above.

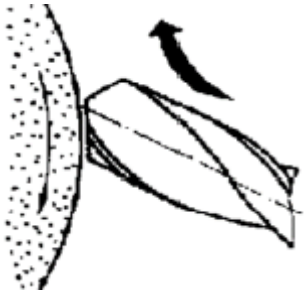


Figure 3.3 Upward movement of the drill

Checking

After every grinding operation the angle has to be checked by the grinding gauge, the evenness and cleanliness of the surface ground is judged by the eye.

Recommended values:

- Point angle between the principal edges by gauge (118º standard drill point)
- Chisel edge must be exactly in the middle and have an angle of 55°
- Flanks shall taper off at 4 - 6° behind the principal cutting edges

Grinding faults:

- Point angle, angle of clearance, complementary angle of the chisel edge angle too large or too small

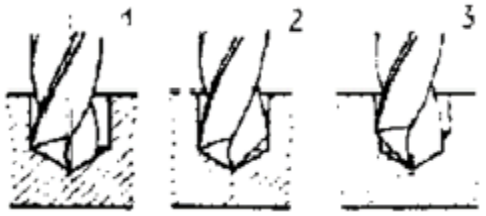


Figure 3.4 Consequences of grinding faults (explanations 1,2,3 in the text

Principal cutting edges (1) different in length (drill out of center - bore hole too big)

Principal cutting edges at unequal (2) angles (shoulder in the bore hole)

Principal cutting edges different in length and unequal angles of the principal cutting edges

(3) Incompletely ground principal cutting edges (drill does not cut**)**

Pointing of the chisel edge:

With drills of a diameter of more than 10 mm the chisel edge is vertically ground at the right edge of the grinding wheel or at the dish wheel in order to reduce the squeezing negative effect of the chisel edge.

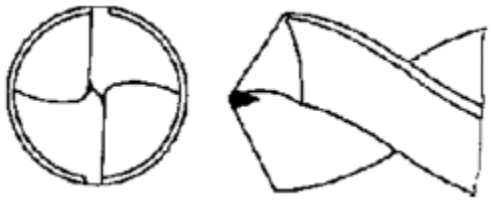


Figure ***3.5 Pointed drill***

Self-check 3.1

Instructions: choose the correct answer for the following questions

1. From the following which one is not the type of grinding machine?
   a. Internal grinder
   b. Cylinder wheel
   c. Surface grinder
   d. Universal grinders
2. The work piece is not held between centers in which types of grinding machine?.
   a. Center less
   b. Surface grinder
   c. Universal grinders
   d. Cylindrical grinder
3. _____ is performed at very high depths of cut and very low feed rates;
   a. External cylindrical grinding
   b. Internal cylindrical grinding
   c. Creep Feed Grinding
   d. surface grinding
4. ___is used to grind plain flat surfaces
   a. Universal grinders
   b. Cylindrical grinder
   c. Center less
   d. Surface grinder

Test II: Short Answer Questions

Answer the following questions accordingly**.**

1. List duties of grinding machine operator
2. Write down all the safety requirements for grinding machine.
3. Write three examples of Hazards parts of machines?
4. What are the common causes of grinding accidents?

Operation Sheet 3.1

Operation Title: Perform tool grinding operation

Purpose: To get the correct and sharp edge of the lathe turning tool

Safe working area

- ✓ Properly operated tools and equipment
- ✓ Appropriate working cloths fit with the body

Equipment Tools and Materials:

- ✓ Grinding machine
- ✓ Lathe cutter HSS
- ✓ Goggles
- ✓ Gauge
- ✓ Protector

Quality Criteria: Assured performing of all the activities according to the procedures

Precautions:

- ✓ Wearing proper clothes, eye glass, glove
- ✓ Make working area hazard free
- ✓ Read and interpret manual which guide you how to use tools and equipment

Steps in doing the task

Step - 1 –, Inspect the tool for any damage, wear, or chips. Check the tool geometry, such as rake angle, relief angle, and clearance angles, to ensure it meets the desired specifications. Any defects or excessive wear should be addressed or repaired before proceeding with grinding.

Step 2. Choose the appropriate grinding wheel

Step 3. Set up the tool grinding machine by adjusting the wheel speed, workpiece holding mechanism and ensure the machine is in good working condition and all safety measures are in place.

Step 4. Start the tool grinding machine and bring the grinding wheel into contact with the tool. Adjust the machine parameters, such as wheel speed, feed rate, and depth of cut,

Step 5. Apply coolant or lubricant during the grinding process to control heat generation

Step 6. Continuously monitor the grinding process, including the tool's temperature, surface finish, and dimensional accuracy.

Step 7. Inspect the tool using tool gauges, or protractor to verify the tool's dimensions and geometry. Check the cutting edges for sharpness and uniformity. Ensure that the tool meets the required specifications and quality standards.

LAP Test
Practical Demonstration

Name: _____ **Date: _____**

Time started: _____ **Time finished: _____**

Instruction: Perform the following tasks

Task 1: Perform Lathe cutting tool Grinding

Unit FOUR: Check components for conformance to specifications

This unit to provide you the necessary information regarding the following content coverage and topics:

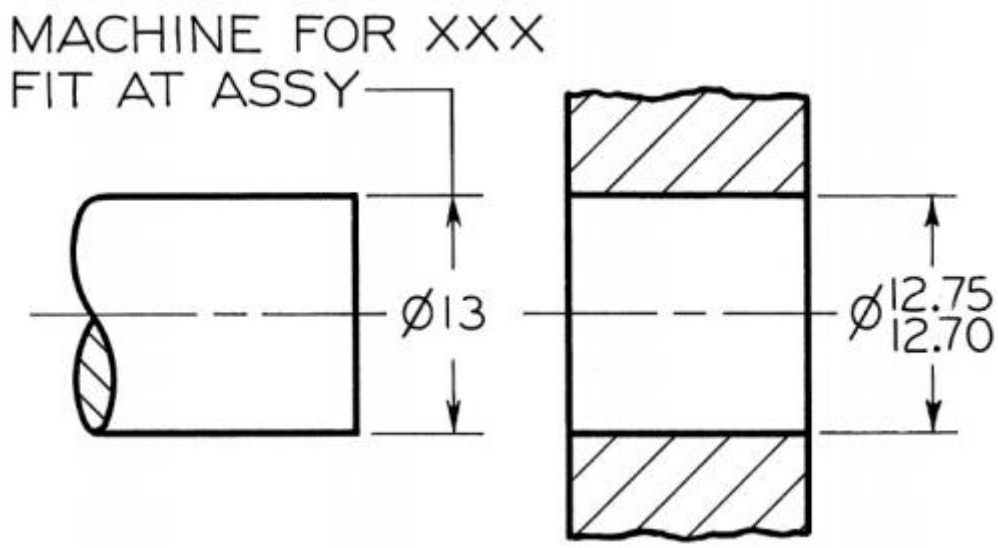
- Grade of tolerance and specification .
- Checking Components

This unit will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

- approve quality of products
- Identify grade of tolerance.

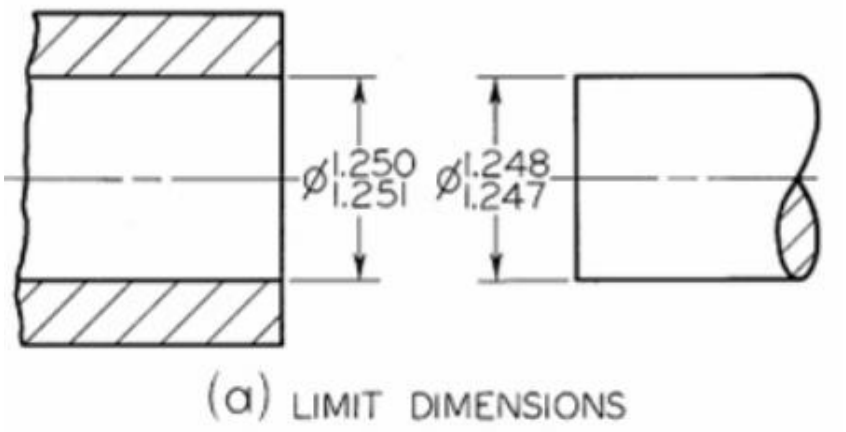
4.1 Grade of Tolerance and Specification

indicated to be made to fit at assemble, as example below.



- **Size Designations**

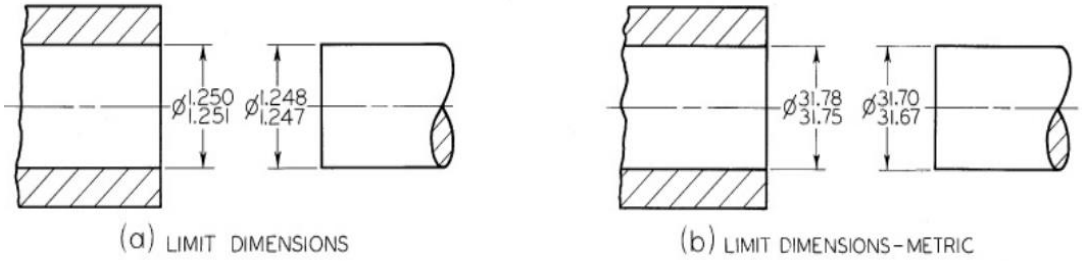
Normal size is used for general identification and is usually expressed in decimals or common fractions. In figure (a), the normal size of both hole and shaft would be 1.25".



Basic size, or basic dimension, is the theoretically exact size from which limits of size are determined by applying allowance and tolerance. It is the size from which limits are determined for the size, shape, or location of a feature. For above example, the basic size is the same as the normal size, 1, 25 inch.

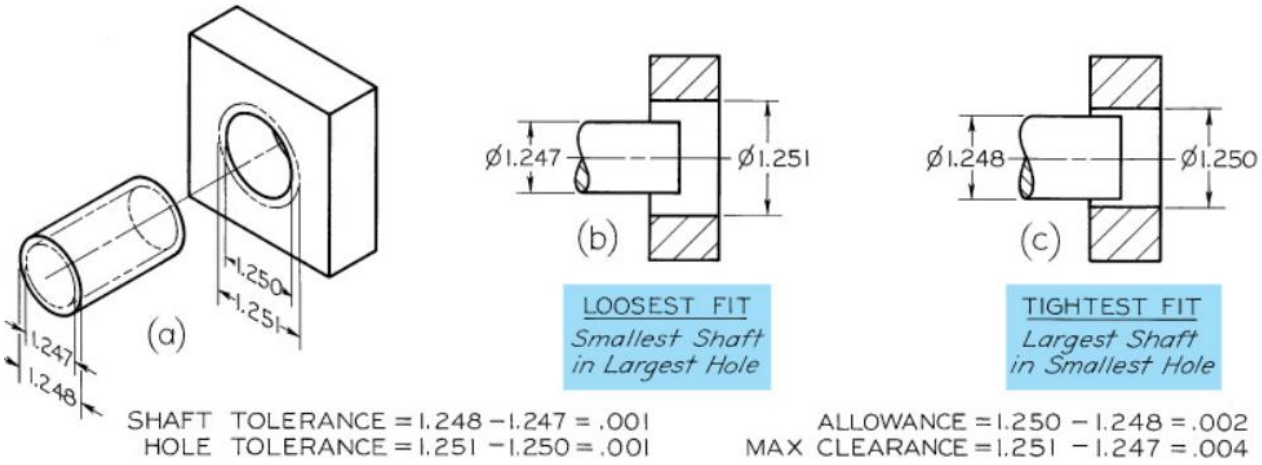
- **Tolerance** is the total amount a specific dimension can vary. Tolerance are assigned so that any mating parts will fit together, as shown in (a). In this case,

the actual hole may not be less than 1.25 inch and not more than 1.251 inch; these are the limits for dimension, and the difference between is the Tolerance. A metric version is shown in (b).



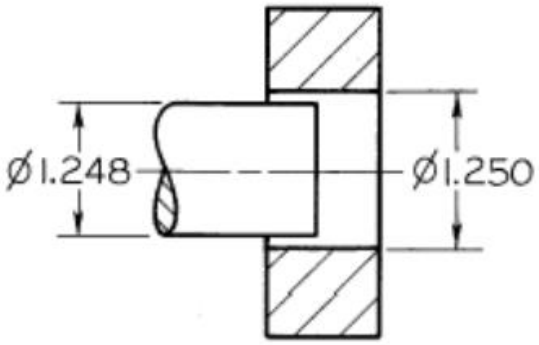
- **Allowance**

In Fig. (a), the max. Shaft is shown solid and the min. shaft is shown phantom. The difference is .001". This difference .001" is the tolerance for the shaft. Similarly, the tolerance for the hole is .001". The loosest fit, or maximum clearance, occurs when the smallest shaft is in the largest hole, as shown in (b). The tightest fit is shown in (c).



The difference between the largest allowable shaft size and the smallest allowable hole size is called allowance.

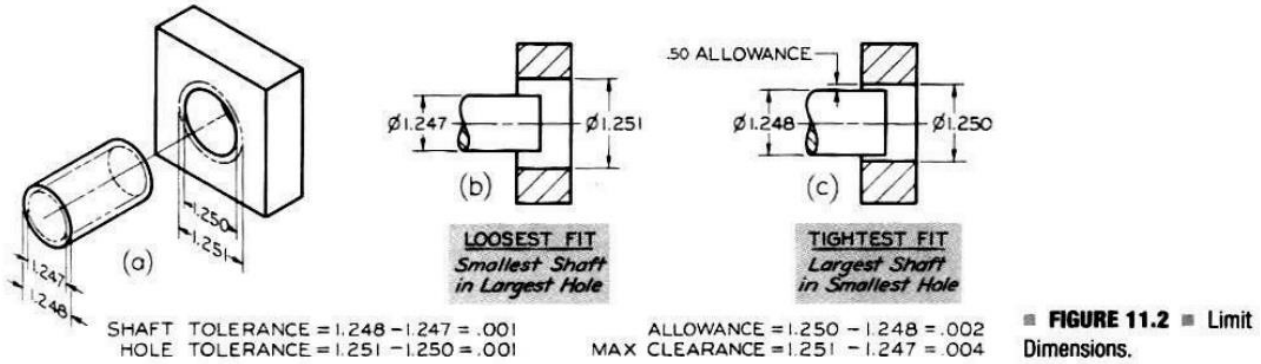
When parts are required to fit properly in assembly but not to be interchangeable, parts are not always toleranced but sometimes just



ALLOWANCE = 1.250 − 1.248 = .002
MAX CLEARANCE = 1.251 − 1.247 = .004

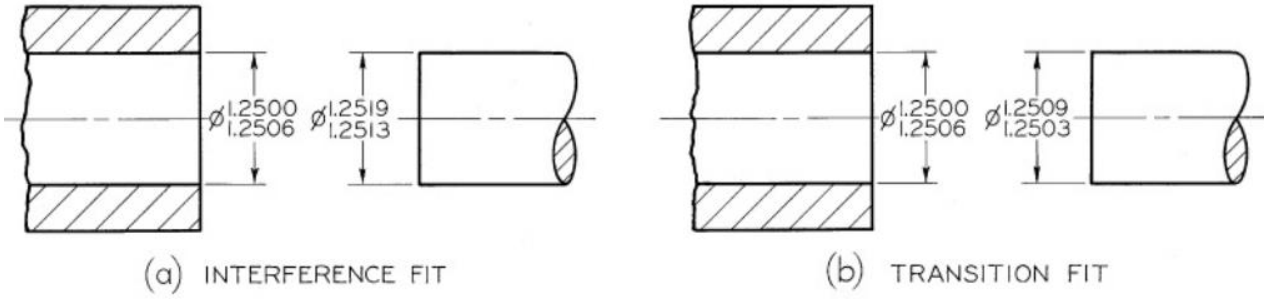
- **Fits between Mating Parts**

Clearance Fit, where an internal member fits into an external member (as a shaft in a hole), always has space or clearance between the parts. See example below.



■ **FIGURE 11.2** ■ Limit Dimensions.

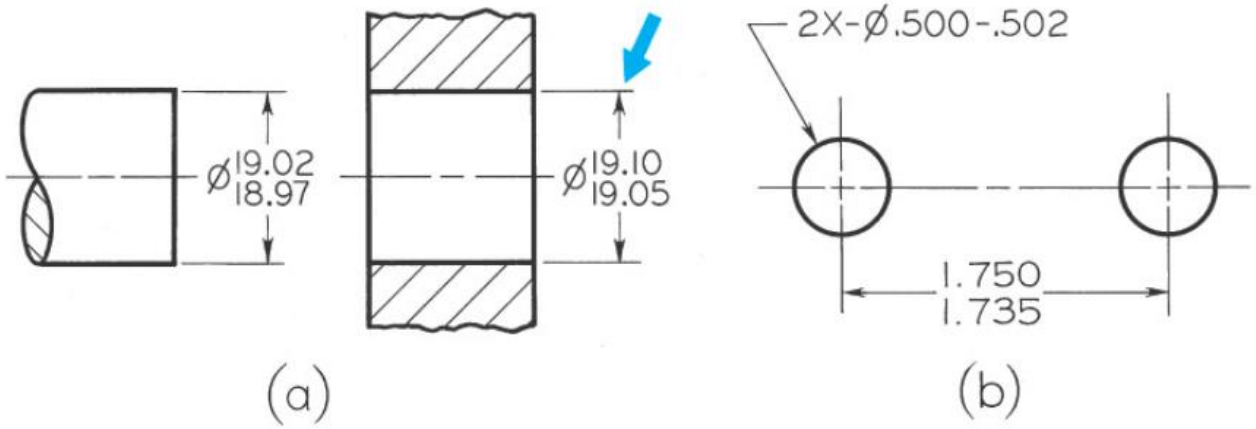
Interference fit, where the internal number is always larger than the external number, requires that the parts be forced together. In Fig. (a), the smallest shaft is 1.2513” and the largest hole is 1.2506”, so the interference of metal between parts amounts to at least .00070”. An inference fit always has a negative allowance.



Transition fit results in either a clearance or interference condition. In Fig. (b), the smallest shaft, 1.2503", will fit into the largest hole, 1.2506". But the largest shaft, 1.2509", will have to be forced into the smallest hole, 1.2500".

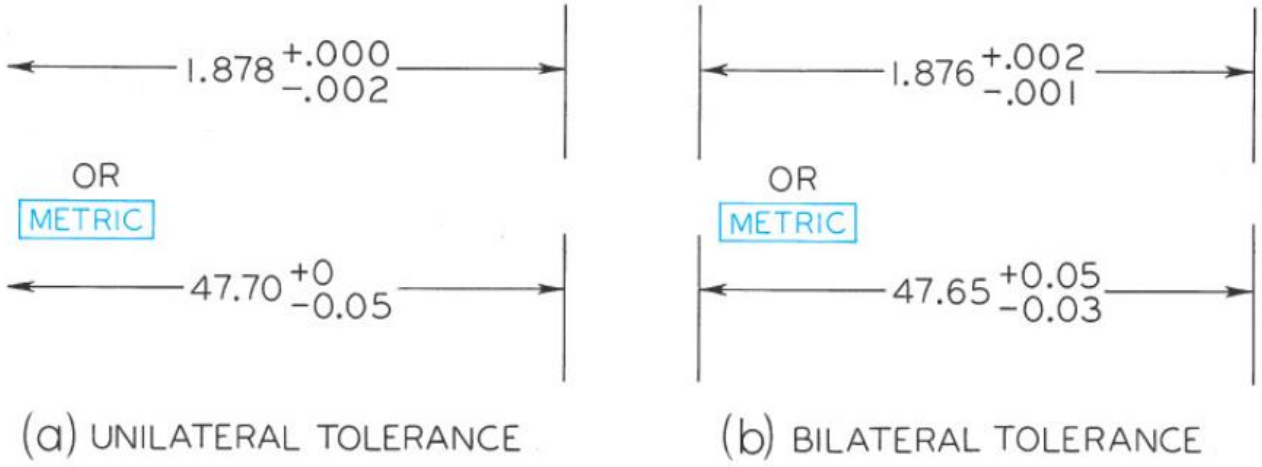
There are several methods of expressing tolerances in dimensions that are approved by ANSI and they are as follows.

Limit dimensioning. In this preferred method, the maximum and minimum limits are specified, as shown below.



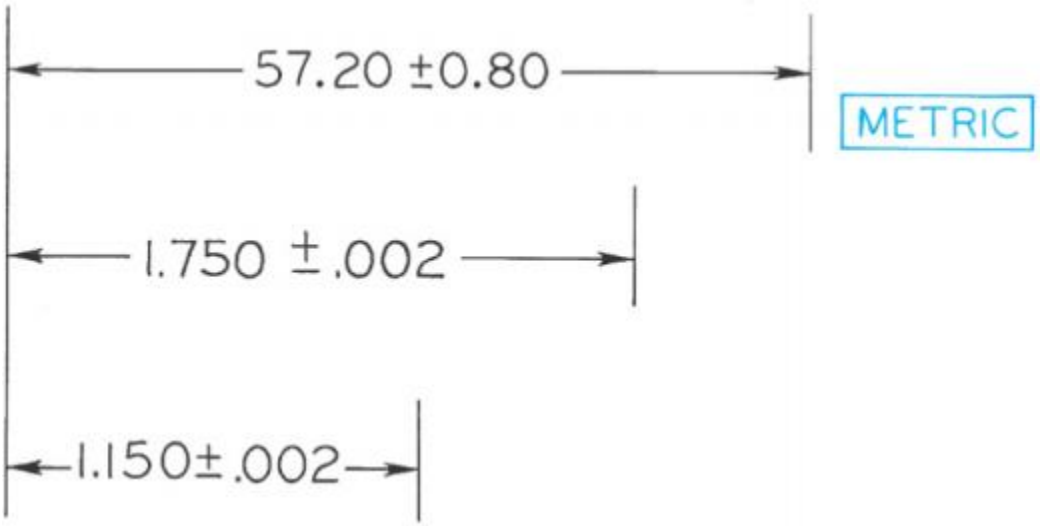
The maximum value is placed above the minimum value as shown in Fig. (a). In the single-line note form, the low limit precedes the high limit separated by a dash, as shown in Fig. (b).

Plus-or-Minus dimensioning. In this method the basic size is followed by a plus-or-minus expression for the tolerance. The result can be either unilateral, where the tolerance only applies in one direction so that one value is zero, or bilateral, where either the same or different values are added and subtracted as show below.



If the plus and minus values are the same, a single value is given, preceded by the plus-or-minus symbol, as shown below.

If the plus and minus values are the same, a single value is given, preceded by the plus-or-minus symbol, as shown below.



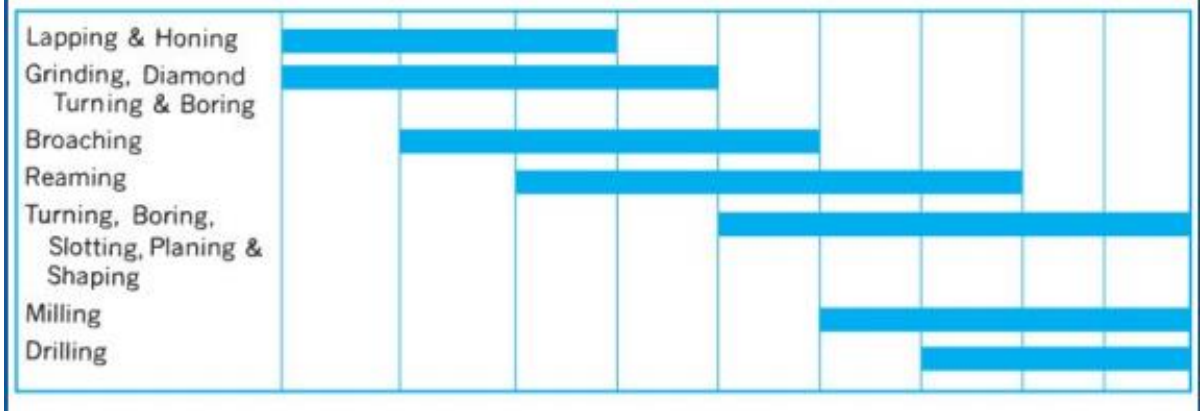
Single-limit dimensioning. It is not necessary to specify both limits. MIN or MAX is often placed after a number to indicate minimum or maximum dimensions desired where other elements of design determine the other unspecified limit.

Angular tolerances are usually bilateral and in terms of degrees, minutes, and seconds.

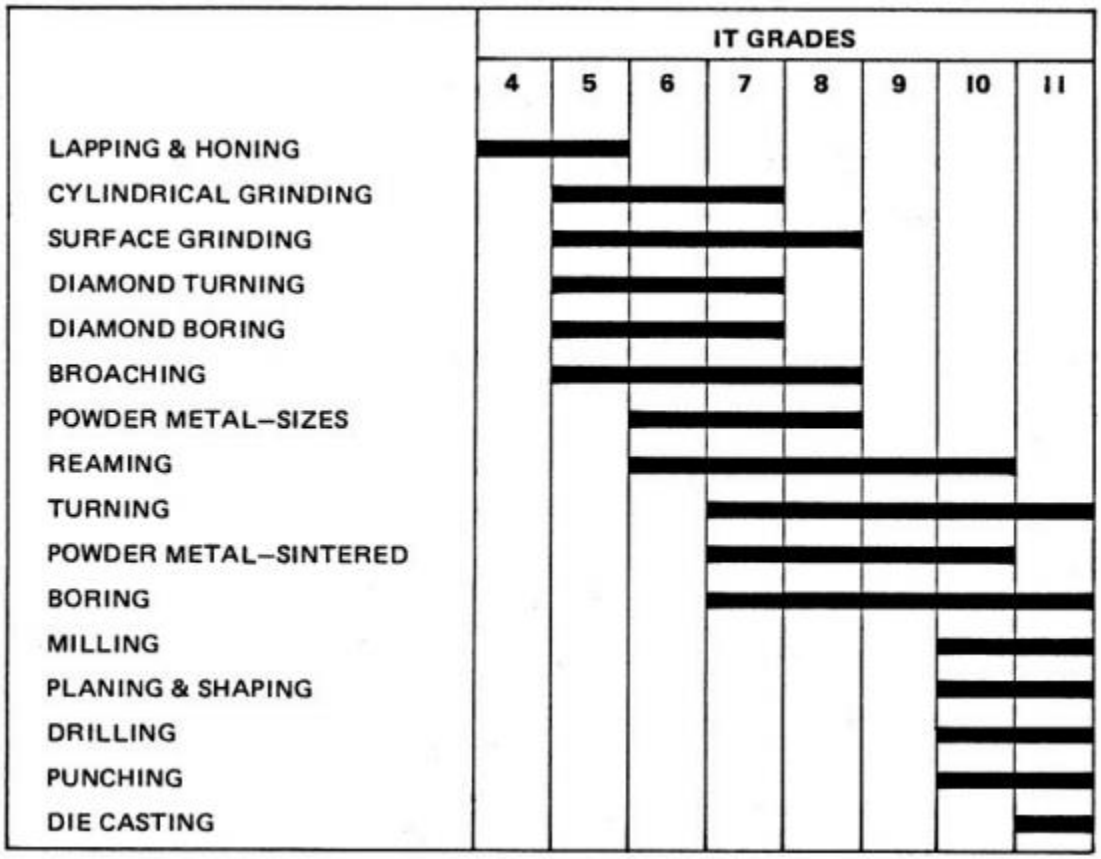
Tolerances and Machining Processes

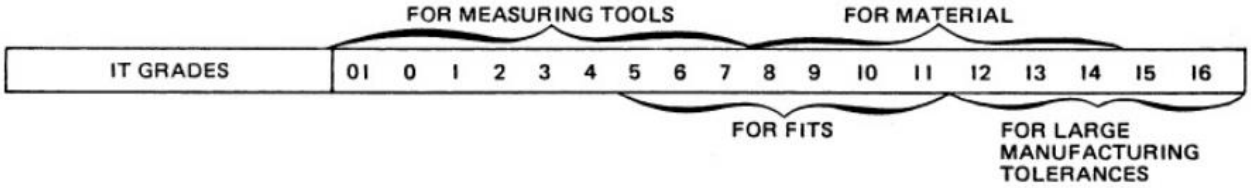
Tolerance should be as generous as possible and still permit satisfactory use of the part. Figure below shows a chart, to be used as a general guide, with the tolerances achievable by the indicated machining process.

Range of Sizes From	To and Including	Tolerances								
.000	.599	.00015	.0002	.0003	.0005	.0008	.0012	.002	.003	.005
.600	.999	.00015	.00025	.0004	.0006	.001	.0015	.0025	.004	.006
1.000	1.499	.0002	.0003	.0005	.0008	.0012	.002	.003	.005	.008
1.500	2.799	.00025	.0004	.0006	.001	.0015	.0025	.004	.006	.010
2.800	4.499	.0003	.0005	.0008	.0012	.002	.003	.005	.008	.012
4.500	7.799	.0004	.0006	.001	.0015	.0025	.004	.006	.010	.015
7.800	13.599	.0005	.0008	.0012	.002	.003	.005	.008	.012	.020
13.600	20.999	.0006	.001	.0015	.0025	.004	.006	.010	.015	.025

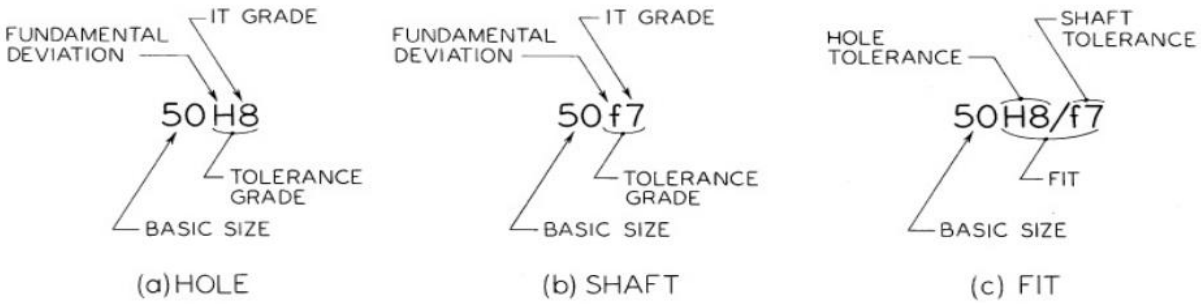


International tolerance grade (IT) is a set of tolerances that varies according to the basic size and provide a uniform level of accuracy within the grade. For example, in dimension 50H8 for a close-running fir, the IT grade is indicated by the number 8. (the letter H indicates that the tolerance is on the hole for the 50-mm dimension.)





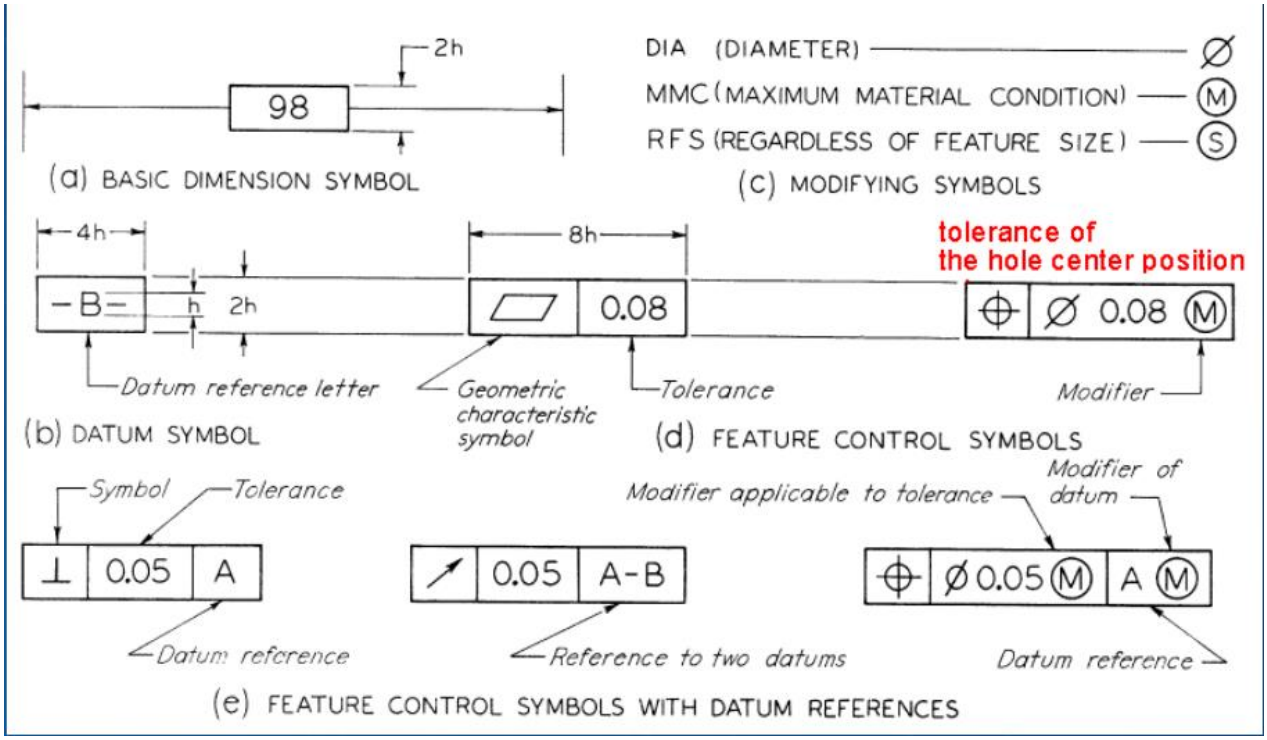
Tolerance zone refers to the relationship of the tolerance to basic size. It is established by a combination of the fundamental deviation indicated by a letter and the IT grade number. In the dimension 50H8, for the close running fit, the H8 specifies the tolerance zone, as shown below.



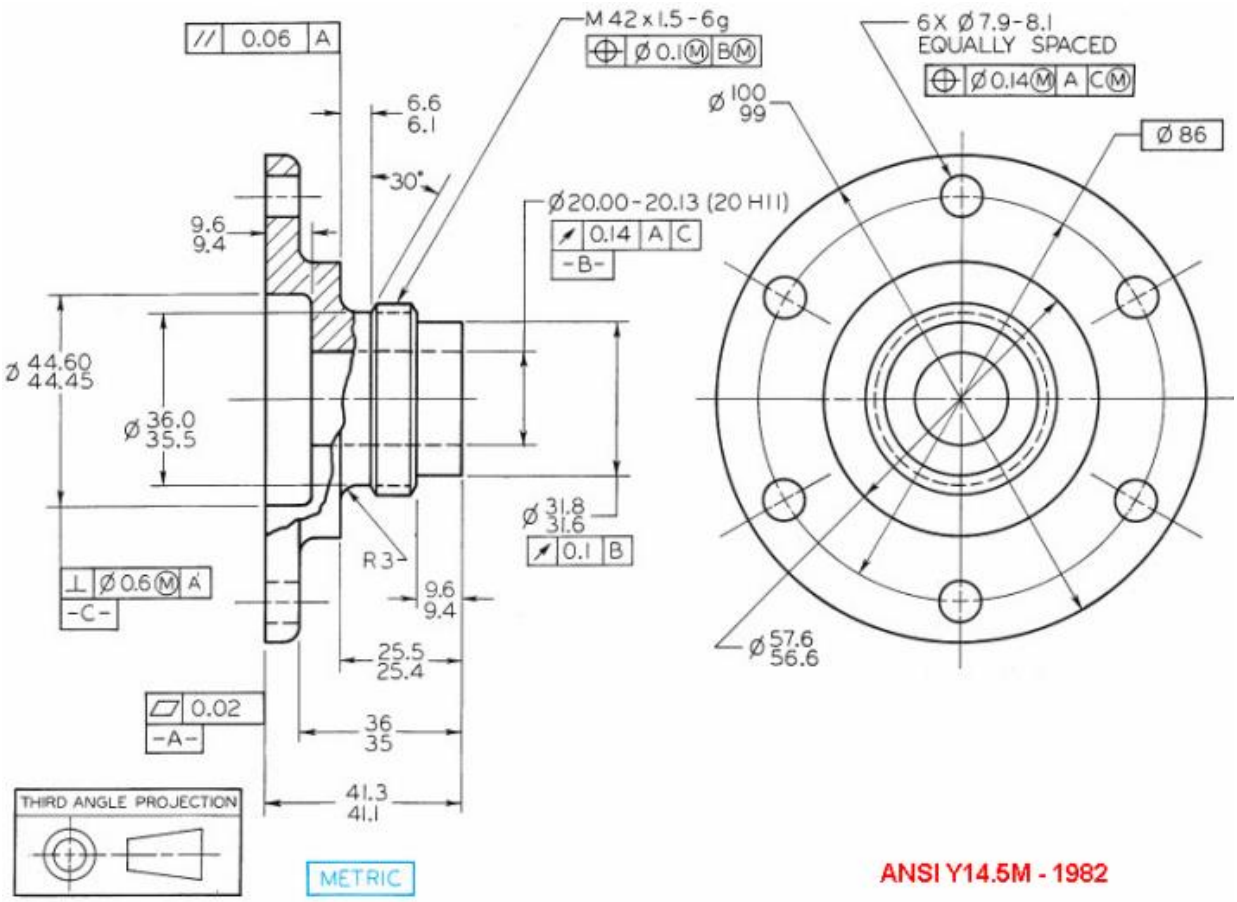
The figure (a) shows the hole-basis system of preferred fits and the figure

(b) shows the shaft-basis system of preferred fits (b).

Combinations of the various symbols and their meanings are given in Figure below.



Application of the symbols to drawing is illustrated in the figure below.



4.2 Component Conformance

Component conformance refers to the extent to which a manufactured component meets the specified requirements, standards, or specifications. It is a measure of how well the component matches the intended design and performance criteria. Conformance is typically assessed through various inspection and testing processes. Here are some key aspects related to component conformance:

- Specifications: Component conformance is evaluated based on the specifications provided for the particular component. These specifications can include dimensions, tolerances, material properties, surface finish, functional requirements, and any other relevant characteristics outlined in the design or engineering documentation.

- Inspection: Inspection involves visually examining the component to verify its conformance to the specified requirements. This can include checking dimensions using measuring instruments, inspecting surface quality, assessing the presence of any defects or damage, and comparing the component against the approved design or reference samples.
- Testing: Testing is performed to validate the functional performance and reliability of the component. Testing methods can vary based on the specific requirements of the component. It may involve mechanical testing (e.g., strength, durability), electrical testing (e.g., conductivity, insulation), chemical analysis, environmental testing (e.g., temperature, humidity), or any other relevant tests to ensure the component meets the desired standards.
- Statistical Process Control (SPC): SPC techniques are often employed to monitor and control the manufacturing process to ensure component conformance. Statistical analysis of process data, such as dimensional measurements or material properties, can help identify any variations or trends that could affect conformance. By monitoring these variations, manufacturers can take corrective actions to maintain conformance and improve process stability.
- Non-Conformance Management: In the event that a component does not meet the specified requirements, non-conformance is identified. Non-conforming components may need to be reworked, repaired, or rejected, depending on the severity of the non-conformance and its impact on the component's functionality and safety. Proper non-conformance management processes are essential to ensure that only conforming components reach the intended customers or applications.
- Component conformance is crucial to ensure the quality, reliability, and safety of the final product. It helps to minimize defects, reduce waste, and maintain consistency in manufacturing processes. Manufacturers often have quality management systems in place, such as ISO 9001, to establish procedures and controls for assessing and ensuring component conformance throughout the production cycle.

Steps Of Checking Components For Conformance

Checking components for conformance involves a systematic process to verify that the components meet the specified requirements or standards. The steps for checking components for conformance may vary depending on the specific requirements and characteristics of the components, but here is a general outline of the process:

- 1.Understand Specifications: Familiarize yourself with the specifications, requirements, or standards provided for the components. This includes dimensions, tolerances, material properties, surface finish, functional requirements, and any other relevant characteristics outlined in the design or engineering documentation.
- Visual Inspection: Perform a visual inspection of the components to identify any obvious defects, damage, or deviations from the required specifications. Check for physical attributes such as shape, size, color, surface finish, and overall appearance. Look for any signs of irregularities, cracks, burrs, or other visual cues that may indicate non-conformance.
- Dimensional Measurement: Use appropriate measuring instruments such as calipers, micrometers, height gauges, or coordinate measuring machines (CMM) to measure critical dimensions of the components. Compare the measured dimensions against the specified tolerances to determine conformance. Pay attention to key features, such as hole diameters, lengths, widths, angles, or any other critical measurements specified in the documentation.
- Functional Testing: Conduct functional tests to verify that the components perform as intended. This may involve applying mechanical forces, testing electrical conductivity, checking for proper fit or operation, or any other specific functional requirements specified for the components. Use appropriate testing equipment and follow the prescribed procedures to assess functional conformance.
- Material Analysis: If required, perform material analysis to ensure that the components are made from the specified materials and meet the required material properties. This can involve techniques such as spectroscopy, hardness testing, or

destructive/non-destructive testing methods to verify material composition, strength, or other relevant material characteristics.

- Statistical Process Control (SPC): Implement statistical process control techniques to monitor and control the manufacturing process. Collect data on relevant process parameters, such as dimensional measurements or material properties, and analyze them for variations or trends. Use control charts, capability analysis, or other statistical tools to assess process stability and conformance.
- Documentation and Record-Keeping: Maintain proper documentation of the inspection and testing results for each component. This includes recording measurements, observations, test results, and any other relevant information. Proper record-keeping helps ensure traceability, identify trends, and facilitates the identification of potential issues or improvements in the manufacturing process.
- Non-Conformance Management: In the event that a component does not meet the specified requirements, identify and document non-conformance. Follow established procedures for handling non-conforming components, including rework, repair, or rejection, depending on the severity of the non-conformance.
- It is important to note that the specific steps and methods for checking components for conformance will depend on the industry, specific requirements, and the complexity of the components being inspected. Manufacturers often establish detailed inspection plans and procedures specific to their components to ensure consistent and accurate assessment of conformance

Self-Check –4.1

Part I - Choose the correct answer from the given alternatives

1. Which one types of testing or testing for conformance of the machined component?

A. Performance B. Surface finish C. Shapes and dimensions D. None

2. Which is one must be included in a non-conformance report?

A. Main reason error B. The solution to prevent the problem

C. Explanation of corrective action to be taken D. All

Part-II: Answer all the questions listed below. Examples may be necessary to aid some explanations/answers.

1. Define the following terms
   a) Tolerance
   b) Actual size
   c) Allowance
   d) Deviations

Operation Sheet 4.1

Operation Title: Checking for conformance of components

Purpose: Quality assure components in conformance to specifications

Safe working area

- ✓ Properly operated tools and equipment
- ✓ Appropriate working cloths fit with the body

Equipment Tools and Materials:

- ✓ Virnir caliper
- ✓ Micro meter
- ✓ Surface plate
- ✓ Dial indicater
- ✓ Revolving-disk wheel balancing
- ✓ Goggles
- ✓ Gauge
- ✓ Protector

Quality Criteria: Assured performing of all the activities according to the procedures

Precautions:

- ✓ Wearing proper clothes, eye glass, glove
- ✓ Make working area hazard free
- ✓ Read and interpret manual which guide you how to use tools and equipment

Steps in doing the task

Step 1 - Establishing Standards and Methods for Measuring Conformance

Step 2 - Measuring the Conformance

Step 3 - Determination of Whether the Conformance Matches the Standard,

Step 4 - Taking Corrective Action

LAP Test

Practical Demonstration

Name: _____ **Date: _____**

Time started: _____ **Time finished: _____**

Instruction: Perform the following tasks

Task 1: **Reported conformance components**

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7.Metal Cutting: Theory and Practice by A. Bhattacharya

Profile of Participants on TTLM Development

No	Name	Qualification (Level)	Field of Study	Organization/ Institution	Mobile No.	E-mail
1	Mohammed Bedri	A	Manufacturing Technology	Robe Poly Technic College	0913175634	Muhammedbedri34@gmail.com
2	Boka Terefa	A	Manufacturing Technology	Anbo Polytechnic College		
3	Mohammed Abdela	A	Manufacturing Technology	DireDawa EthioEtaly Poly Technic College	0907755560	Mahammedabdella49@gmail.
5	Mesrat W/mariyem	A	Manufacturing Technology	Walkite Polytechnic College		