UNIT 1- GENERAL SAFETY

Objectives:

*Safety rules.

Aim: At the end of the class the trainee will be able to know, about safety to be followed in workshop.

- Always wear shoes in the workshop.
- Do not work alone in the workshop.
- Wear proper workshop dress.
- Do not keep long hair.
- Do not work during ill health
- Wear safety goggles while working in a machine shop.
- Do not play with the machines.
- Always maintain discipline and do not indulge in mischief with co-workers.
- Do not run in the workshop while going for an urgent call.
- Do not walk below the load carried by a crane.

- Do not lift heavy jobs without the uses of cranes.
- Before starting the machine inspect the wheel by knocking method.
- After mounting of the grinding wheel, it should be run idle to a some period.
- Wear the safety goggle during grinding operation
- In pedestal grinding machine, the tool rest must have a distance of 2mm from the grinding wheel.
- Do not touch the grinding wheel while machine is running.
- Use plenty of coolant during grinding.
- During pedestal grinding, the work must be place on the work rest.
- Before mounting of the grinding wheel, it should be balance truly.

Assignments

1. List down 8-10 general safety precautions to be taken when working in the shop floor?
2. List down 8-10 Machine safety precautions to be taken in workshop?

HISTORY OF GRINDING MACHINE

HISTORY OF GRINDING MACHINES

The basis for the modern day cylindrical grinder was first built in the 1830s by two men working independently, Jonathan Bridges and James Wheaton. It took another 40 years before further improvement and refinement of the tool occurred.

Joseph Brown believed that the shaft and needle bars of the sewing machine must be crafted from hardened tool steel. It was this desire that led to their experimentation with building a cylindrical grinder. The first attempt was simply a small lathe with a grinding wheel mounted to it. Subsequent attempts led to the cylindrical grinder displayed at the 1876 Centennial Exposition and the subsequent patent.

A man in Waltham, Massachusetts, Ambrose Webster had created a small grinding machine in 1860 that contained all of the improvements Brown & Sharpe claimed to be their own original invention. Even more so, the emphasis on precision, accuracy, and reliability was championed by

Charles Norton.

Norton was an employee of Brown & Sharpe who quit the company with the desire to further pursue his belief that the cylindrical grinder is not merely a finishing tool but could be a staple of the machine shop. He founded the Norton Grinding Company, where he continued improving the cylindrical grinder to use faster rpm values and more precise grinding tolerances. He was acknowledged for his work on April 18, 1925 when he won The John Scott Medal and Premium for his invention of "accurate grinding devices of high power".

The innovation of the last 70 years can be characterized by three waves of change. The first wave was the creation of numerical control by John T. Parsons in the 1940s. The U.S. Air Force,

Looking for a faster, cheaper, and more efficient means of part and tool production for airplanes, played a large role in developing NC both politically and financially. The first implementation of NC in machine tools occurred in the 1950s and continued through the 1960s.The second wave of innovation, occurring during the 1970s and 1980s, is marked by the massive demand for microcomputers to be used to direct NC. The joining of computers marked the birth of Computer Numerical Control which once again revolutionized the ability of the cylindrical grinder. The third wave of change came in the 1990s with the advent of the Personal Computer. Integrating CNC and the PC into one dynamic system allowed for even further control of the manufacturing process that required little to no human supervision

INTRODUCTION

Grinding is a metal cutting operation like any other process of machining removing metal in comparatively smaller volume. The cutting tool used is a rotating abrasive wheel having many numbers of cutting edges. The machine on which grinding the operation is performed is called a grinding machine.

This process is used to improve geometric accuracy of a work piece i.e. +_0.02 mm and it gives the surface finish up to 0.1microns.

Grinding has three advantages over other metal cutting methods.

- It is the only economical method of cutting hard materials like hardened steel.
- It produces very smooth surfaces up to N4, suitable for bearing surface.

Surface pressure is minimum in grinding. It is Suitable for light work, which will spring away from the cutting tool in the other machining processes

GRINDING IS MAINLY USED FOR FOLLOWING PURPOSES

01. It is used to remove very small amount of material and it gives close Dimension up to 0.000025 mm
02. It is used for re sharpening of the cutting tools.
03. In grinding process, the hardened material can be ground.
04. It is used to obtain mirror surface finish on the work (N4).
05. Smooth surface can be achieved by removing less material i.e. 0.25 to 0.50mm.
06. It is also used to grinding different types of threads.

KINDS OF GRINDING

Grinding may be classified into two groups they are as follows:

01. Rough or non-precision grinding.
02. Precision grinding

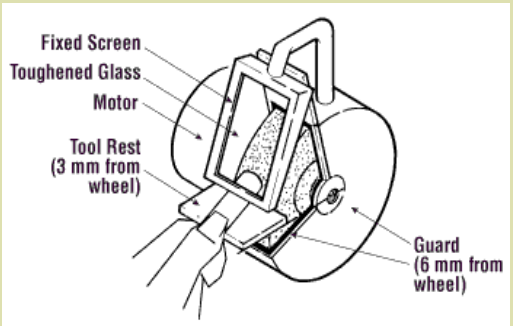
ROUGH OR NON-PRECISION GRINDING

Rough grinding is also called as SNAGGING or OFF HAND or non-precision grinding. In rough grinding the work piece is held by the operator hand. In rough grinding the work piece is pressed hardly against rotating abrasive wheel or vice-versa. In this grinding the accuracy and surface finish cannot be maintained. The snagging operation is done where a large or considerable amount of material is removed. The example for rough grinding burrs left on casting parts, excess material on welding parts, cracks etc.

The main types of rough grinders are:

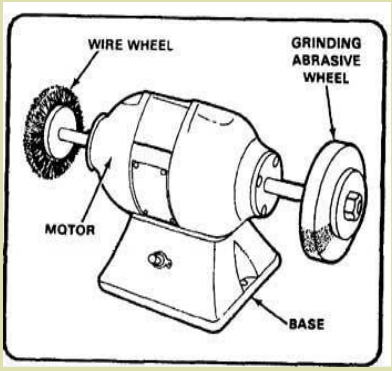
Hand grinding machine, **Bench grinding machine**

Floor stand grinding machine, **Flexible shaft grinding machine.**



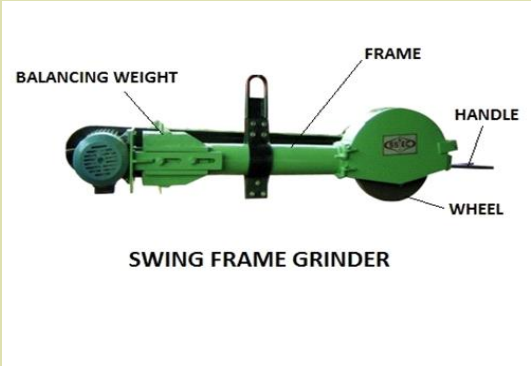
Bench-Type Utility Grinding and Buffing Machine

The bench-type utility grinding and buffing machine is more suitable for miscellaneous grinding, cleaning, and buffing It is not recommended for tool grinding since it contains no tool rests, eye shields, or wheel guards. This machine normally mounts a 4 inch-diameter wire wheel on one end. The wire wheel is used for cleaning and the abrasive wheel is used for general grinding. One of the two wheels can be removed and a buffing wheel mounted in its place for buffing and polishing. The 1/4-HP electric motor revolves at a maximum of 3,450 RPM. The maximum cutting speed of the 4-inch-diameter wheel is approximately 3,600 SFPM.



The portable hand grinding machine is looks like a portable hand drilling machine. It is having a long flexible shaft and it is easily moved in wider area to remove the small amount of material. Heavy and complicated work piece can be ground easily. This is also used in assembly to suit the mating parts.

SWING FRAME GRINDER:



The swing frame grinder has a horizontal frame about 2 to 3 Meters long suspended at its center of gravity. It has to move freely with in the area of operation. The operator applies the force on one end of the work piece to remove the large amount of material and also to cut or slice the work piece accurately. The machine is moved on the work piece with the help of crane.

ABRASIVE BELT GRINDER

The abrasive belt grinders have abrasive cloth of accurate length and breadth. The abrasive end-less belt is fixed on two cylindrical drums driven at a higher speed. The work piece may be press by hand to the open belt to each or various curve and flat surface. This is used to de burr and to smooth the edge of the work piece.

ABRASIVE BELT GRINDER

PRECISION GRINDING

The precision grinding is an operation of producing good surface finish and high degree of accuracy. In precision grinding the wheel or work piece both are guided in precision path as compare to the rough grinding or snagging.

Precision grinding will be classified with the type of surface generated and works done these are classified as follows:

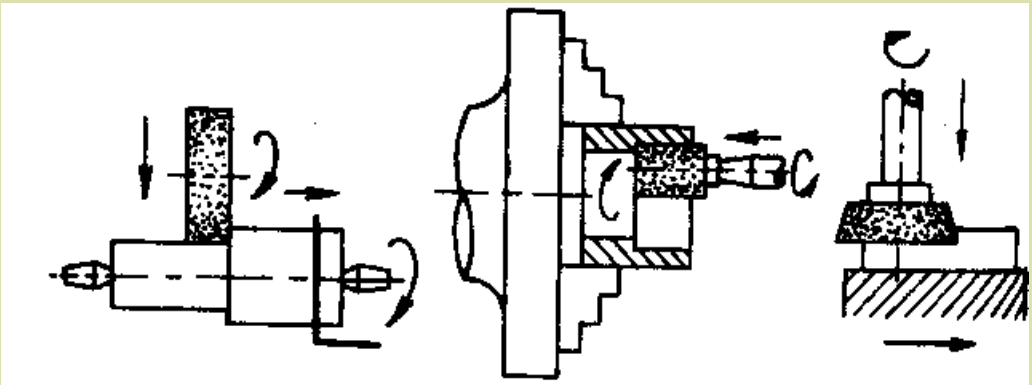


Figure 10.1 Basic kinds of precision grinding

PRECISION GRINDING MACHINES:

Surface grinding machine

1) Reciprocating table.
2) Rotary table.

Reciprocating

1) Horizontal spindle.
2) Vertical spindle.

Rotary table

1) Horizontal spindle.
2) Vertical spindle**.**

Cylindrical grinding machine

1. Center type or plain.
2. Center type or universal.
3. Center less

Internal grinding machine:

1. Chucking.
2. Plain chucking.
3. Universal chucking.
4. Planetary.

Internal center less grinding

Tool and cutter grinder

1) Universal tool and cutter grinder.
2) Special tool and cutter grinder.

Special grinding machine

PRECISION GRINDING:

SURFACE GRINDING: Surface grinding machines are employed to produce flat surfaces. The surface produced by a surface grinder is more economical and more accurate than the surface

obtained by filing or scraping.

They are also capable of grinding irregular, angular, curved, convex & concave surface.

Conventional Surface grinding machine can be broadly classified as follows.

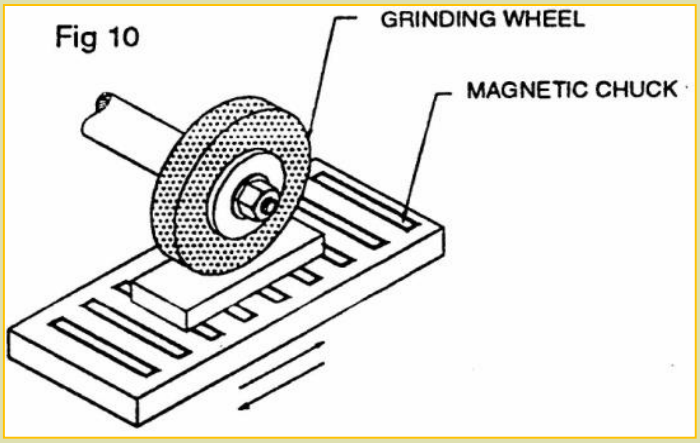
01. Horizontal spindle reciprocating table-grinding machine.
02. Horizontal spindle rotary table grinding machine.
03. Vertical spindle reciprocating table-grinding machine.
04. Vertical spindle rotary table grinding machine.

HORIZONTAL SPINDLE RECIPROCATING TABLE SURFACE GRINDING MACHINE

The majority of surface grinders are of horizontal spindle type. In the horizontal type of the machine, grinding is performed by the abrasives on the periphery of the wheel producing the flat surface. Though the area of contact between the wheel and the work is small, the speed is uniform over the grinding surface and the surface finish is good. The grinding wheel is mounted on a horizontal spindle and the table is reciprocated to perform grinding operation. Peripheral grinding is used in high-precision work on simple flat surfaces; tapers or angled surfaces; slots; flat surfaces next to shoulders; recessed surfaces; and profiles.

These machines are available in wide Varity of sizes and can be used where smooth finish and close tolerance are required. The typical precision of a surface grinder depends on the type and usage; however, ±0.002 mm should be achievable.

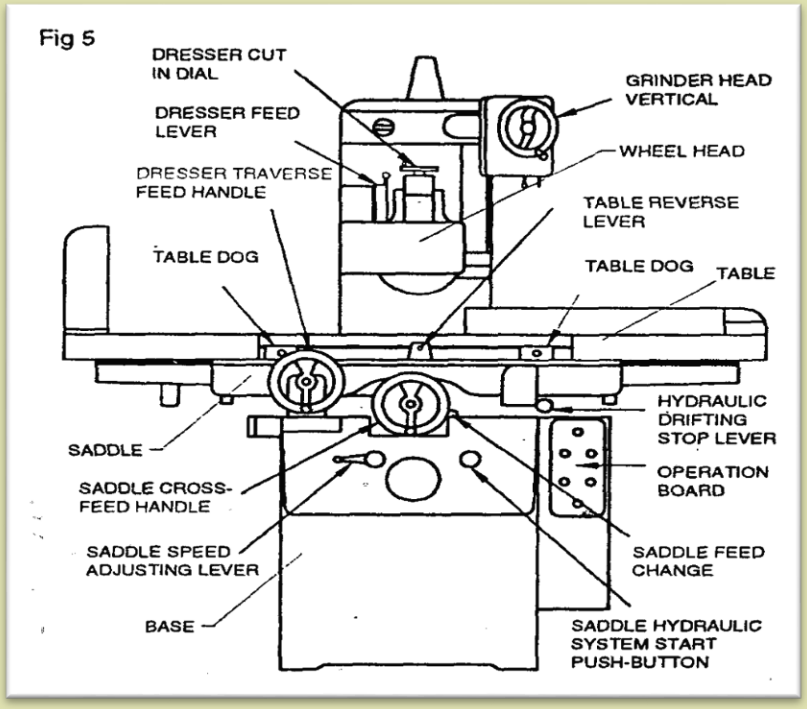
In surface grinding large area of the wheel will be in contact with the work piece, as compared to cylindrical grinding where a relatively small area of contact is present. As a result, the force of each abrasive grain against the work piece is smaller than that applied to each grain in cylindrical grinding. In surface grinding the grinding wheel should be generally softer in grade and wider in structure than for cylindrical grinding.



The surface grinder is composed of an abrasive wheel, a work holding device known as a chuck, and a reciprocating or rotary table. The chuck holds the material in place while it is being worked on. It can do this one of two ways: ferromagnetic pieces are held in place by a magnetic chuck, while non-ferromagnetic and non-metallic pieces are held in place by vacuum or mechanical means.

A machine vise (made from ferromagnetic steel or cast iron) placed on the magnetic chuck can be used to hold non-ferromagnetic work pieces.

PARTS OF HORIZONTAL SURFACE GRINDER



Base

The base is made of cast iron. It is a box like casting which houses all the table drive mechanisms. The column is mounted at the back of the base which has guide ways for the vertical adjustment of the wheel head.

Saddle

Saddle is mounted on the guide ways provided on the top of the base. It can be moved at cross towards or away from the column.

Table

The table is fitted to the carefully machined guide ways of the saddle. It reciprocates along the guide ways to provide the longitudinal feed. The table is provided with 'T'- slots for clamping work pieces directly on the table or for clamping grinding fixtures or magnetic chuck.

The cross feed is provided either on the table or on the wheel head depending on the specific design.

Wheel head

An electric motor is fitted on the wheel head to drive the grinding wheel. The wheel head is mounted on the guide ways of the column, which is secured to the base. It can be raised or lowered with the grinding wheel to accommodate work pieces of different heights and to set the wheel for depth of cut.

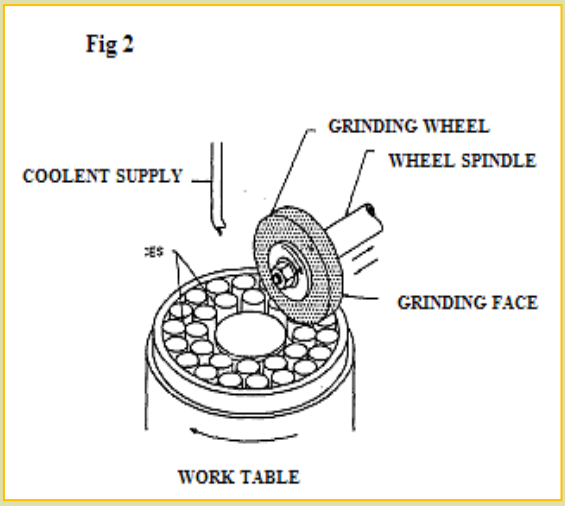
Mounting Work piece for Surface Grinding

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.

Surface Grinder with electromagnetic chuck, inset shows a Manual magnetic chuck

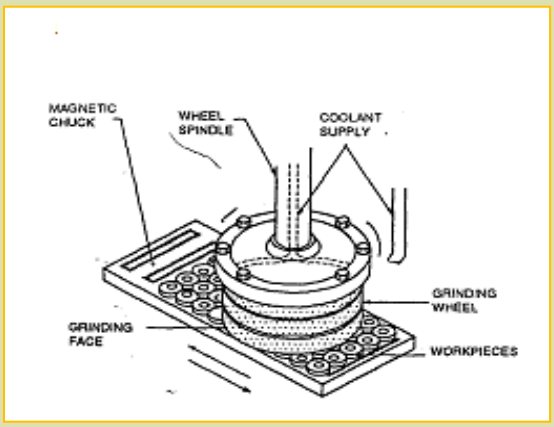
HORIZONTAL SPINDLE ROTARY TABLE GRINDING M/C



This type of machine is generally used for precision grinding and they are not usually considered as a rough grinding machine. Grinding machine spindle is carried on a wheel and can be slide traversed across the work & which is mounted on rotary table.

By swiveling the table can be ground concave or convex and individual parts.

VERTICAL SPINDLE RECIPROCATING TABLE GRINDING MACHINE

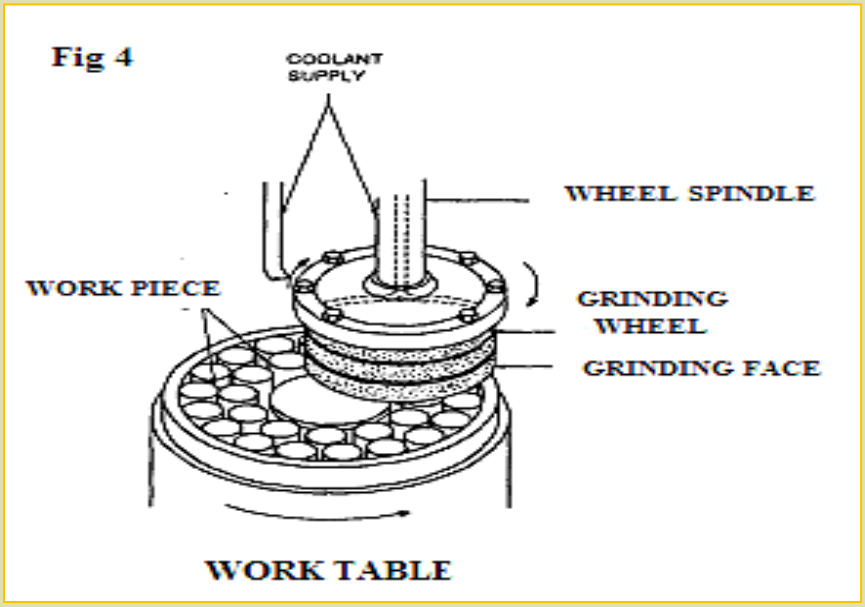


In this type of grinder, the table is mounted on the base on top of which a magnetic chuck is mounted. The table is made to reciprocate or rotate to bring the work surface below the grinding wheel to perform grinding.

A cup, Disk or segmented wheels is mounted on the vertical spindle of the wheel head which slides vertically on the column.

In this type of grinder, the wheel diameter should exceed the width of surface to be machined. The face or sides of the wheel are used for grinding flat surface. The area of contact is large and stock can be removed quickly. But a crisscross pattern of grinding scratches is left on the work surface. The work is held on the table and grinding is done. The base of the machine is a box like casting. The base is very similar to the one of the horizontal spindle type. It houses all the table drive mechanisms. It is primarily used for production type of work but some machines can accomplish high-precision work. The work piece is held on a reciprocating table, which can be varied according to the task, Considering the quality of surface finish obtained, the horizontal spindle type machines are widely used.

VERTICAL SPINDLE ROTARY TABLE GRINDING MACHINE



These machines with rotary table using cup or segmented wheels are widely used in high production work. The machine spindle is supported on a vertical revolving or rotary table, with

continuous or indexed rotation. Indexing allows loading or unloading one station while grinding operations are being performed on another. For finishing work, the wheel axis kept exactly perpendicular to the surface to be ground.

Disc grinders and double-disc grinders

Disc grinding is similar to surface grinding, but with a larger contact area between disc and work piece. Disc grinders are available in both vertical and horizontal spindle types. Double disc grinders work both sides of a work piece simultaneously. Disc grinders are capable of achieving especially fine tolerances.

Types of lay generated in surface grinding process

- Each method will produce a characteristic finish determined by the lay of the surface of the work piece after the grinding operation.
- A straight wheel on a horizontal spindle with reciprocating work will produce fine straight lines on the work surface. (Fig 6)
- A cup wheel with reciprocating work will produce curving lines. (Fig 7)
- A segmental wheel on a vertical spindle will produce radial lines on a rotating work piece. (Fig 8)
- A cup or segmental wheel with rotating work will produce concentric lines on the work surface.(Fig 9)

Fig 6

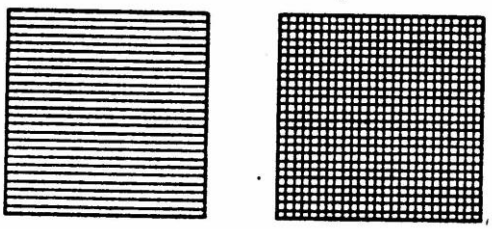


Fig 7

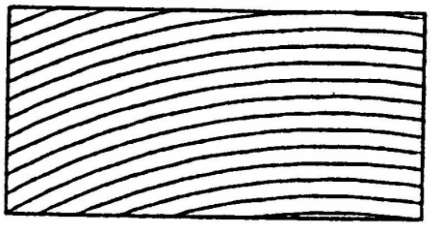


Fig 8

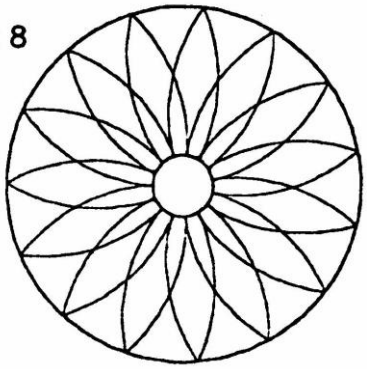
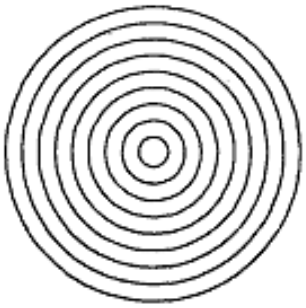


Fig 9



A particular type of finish may be considered unsuitable on certain works. Hence the suitable finish and the convenient method of grinding should be determined.

Surface grinding operations

The grinding wheel is not limited to a cylindrical shape and can have a myriad of options that are useful in transferring different geometries to the object being worked on. Straight wheels can be dressed by the operator to produce custom geometries. 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 reverse image.

The figures given here show the various types of surface grinding operations.

- Grinding flat surface (Fig 10)
- Grinding vertical surface (Fig 11)
- Grinding Slot (Fig 12)
- Grinding angular surfaces (Figs 13 & 14)
- Grinding a Radiou (Figs 15 & 16)
- Cutting off (Fifg 17)

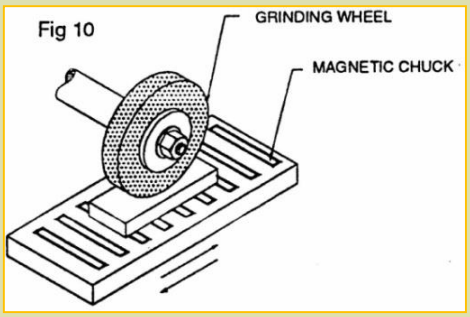


Fig 10
GRINDING WHEEL
MAGNETIC CHUCK

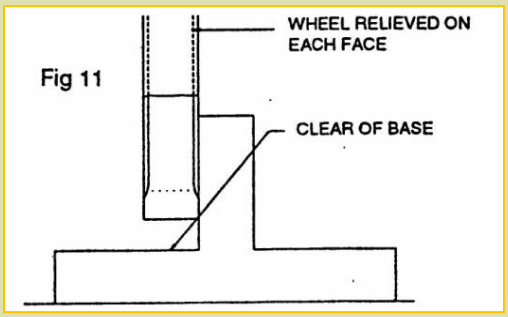


Fig 11
WHEEL RELIEVED ON EACH FACE
CLEAR OF BASE

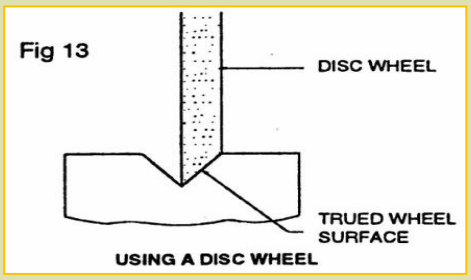


Fig 13
DISC WHEEL
TRUED WHEEL SURFACE
USING A DISC WHEEL

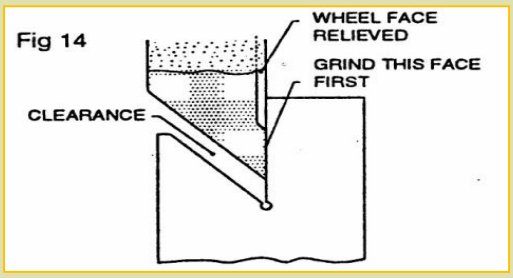


Fig 14
WHEEL FACE RELIEVED
GRIND THIS FACE FIRST
CLEARANCE

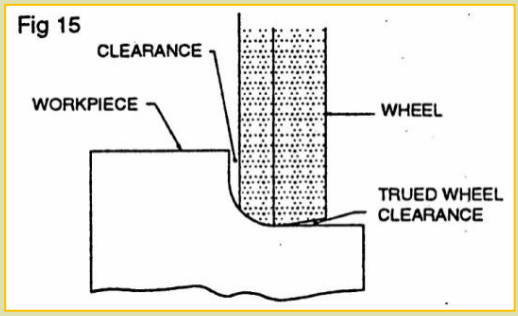
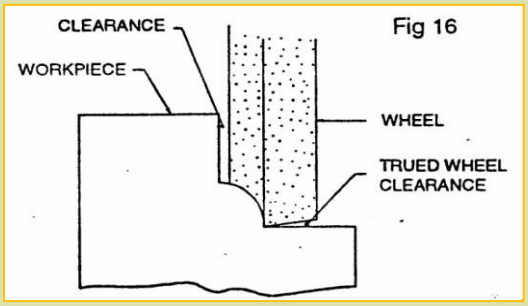


Fig 15
CLEARANCE
WORKPIECE
WHEEL
TRUED WHEEL CLEARANCE


CLEARANCE
Fig 16
WORKPIECE
WHEEL
TRUED WHEEL CLEARANCE

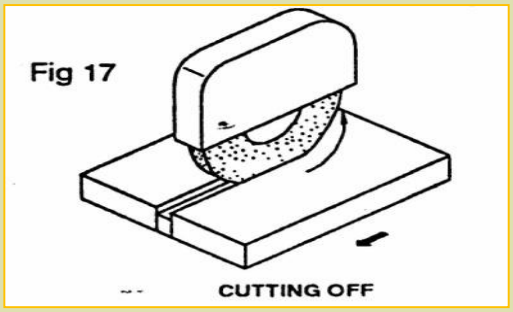
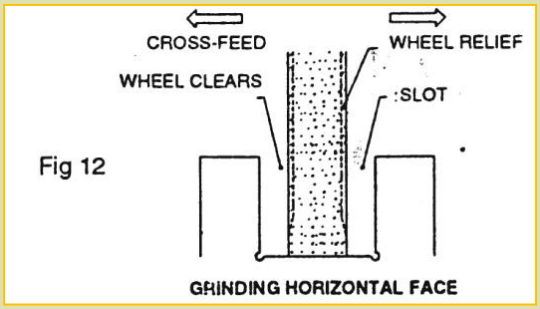


Fig 17
CUTTING OFF


CROSS-FEED
WHEEL RELIEF
WHEEL CLEARS
SLOT
Fig 12
GRINDING HORIZONTAL FACE

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.

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

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

Factors to consider in surface grinding are the material of the grinding wheel and the material of the piece being worked on.

Typical work piece materials include cast iron and mild steel. These two materials don't tend to

clog the grinding wheel while being processed. Other materials are aluminum, stainless steel, brass and some plastics. When grinding at high temperatures, the material tends to become weakened and is more inclined to corrode. This can also result in a loss of magnetism in materials where this is applicable.

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

Grinding wheels for surface grinders

Aluminum oxide, silicon carbide, diamond, and cubic boron nitride (CBN) are four commonly used abrasive materials for the surface of the grinding wheels. Of these materials, aluminum oxide is the most common. Because of cost, diamond and CBN grinding wheels are generally made with a core of less expensive material surrounded by a layer of diamond or CBN.

Diamond and CBN wheels are very hard and are capable of economically grinding materials, such as ceramics and carbides that cannot be ground by aluminum oxide or silicon carbide wheels.

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

Specification of a surface grinder

- The reciprocating table type surface grinders are specified by the table area and the maximum height of the grinding wheel from the table surface.
- The rotary table type surface grinder is specified by the diameter of the chuck or table.
- Maximum dia of the wheel that can be held on the spindle
- Maximum size of the job that can be ground. . (Length x width x height) (150 x 150 x 400)
- The type of drive of the worktable: hydraulic/ electrical

SOME OF THE EXAMPLES ARE GIVEN BELOW

Horizontal Spindle Surface Grinding Machine HMT 200

Salient Features :

- Bed made of high tensile strength cast iron, heavily ribbed for better vibration damping and shock absorption.
- Precision hardened and ground antifriction roller guideways for saddle, table and vertical column.
- Higher powered wheel head.
- Automatic in feed at table reversal.
- Infinitely variable table speed.
- Ideal for components requiring extremely accurate and highly finished flat surfaces, tool room applications. High rates of output can be obtained especially in those cases where the components can be loaded/clamped in batches on the table or on a magnetic chuck.

Specifications : Horizontal Spindle Surface Grinding Machine HMT 200

Table clamping area	**mm**	**600x200**
Max. work height	mm	330
Max. job weight on table	kg	180
Size of magnetic chuck	mm	600x200
Max. height of spindle centre above table	mm	460
Grinding wheel size (ODxWxID)	mm	250x20x76.2
Wheel speed	rpm	3220, 2440
Grinding wheel motor	kW	2.2
Max. Traverse - Long / Cross / Vertical	mm	630 / 230 / 360

Vertical Surface Grinder GVS 30/40

Ideally suited for heavy stock removal with high degree of accuracy combined with

economic method of grinding for engine block, cylinder head, refractory bricks and many other general engineering components.

» Bed is a single piece high tensile strength casting, heavily ribbed for better vibration damping and shock absorption ensuring rigidity to the machine.

» ➢ Precision scraped V & Flat guide ways for table with forced feed continuous lubrication. Truncate lining for GVS 40.

» ➢ Rectangular, box type truncate lined guide ways for wheel head.

» ➢ Rapid movement of wheel head by electric motor for faster setting.

» ➢ Hydraulically operated auto in feed at each table reversal along with inching feed.

» ➢ Built in motor drive to the grinding wheel head.

» ➢ Hollow spindle for better coolant supply to ensure full power utilization.

» ➢ Grinding head tilting facility for hollow grinding.

» ➢ Hydraulic table traverse for infinitely variable speed and smooth reversal.

» ➢ Speed regulation of table in GVS 40 with remote operated proportional valve. Table stroke sensed by limit switches.

» ➢ Built in safety interlocks.

VERTICAL SPINDLE GRINDING MACHINE SPECIFICATIONS

		GVS30	GVS40
Table clamping area	mm	300x1500	400x2000
Max. grinding width	mm	300	400
Max. distance between grinding wheel & table	mm	500	500
Max. table load	kg	400	800
Table speed	m/min	2-16	2-25
Longitudinal travel	mm	2025	2850
Segmental grinding wheel dia.	mm	320	450
Grinding wheel speed	rpm	1440	960
Grinding wheel motor	kW	15	22
Rapid traverse rate	m/min	0.825	0.825
Least count of hand wheel for in feed	mm	0.01	0.01

SURFACE COSMOS

Features	M-7040	M-8040	M-1140	M-1540
CAPACITY				
Grinding area	700x400 mm	800x400 mm	1100x400 mm	1500x400 mm
Longitudinal travel	750 mm	850 mm	1150 mm	1550 mm
Cross travel	425 mm	425 mm	425 mm	425 mm
Distance between table to spindle centre	525 (Opt:650) mm	525 (Opt:650) mm	525 (Opt:650) mm	525 (Opt:650) mm
Maximum load on table	350 kg	400 kg	550 kg	800 kg
SPINDLE & GRINDING WHEEL				
Spindle motor	3.7/4.5 Dual Speed kW	3.7/4.5 Dual Speed kW	3.7/4.5 Dual Speed kW	5 Dual Speed kW
Speed max	1400/2800 rpm	1400/2800 rpm	1400/2800 rpm	1400 rpm
Grinding	305x50x	305x50x	305x50x	355x65x

wheel (OD X W X ID)	76.2 mm	76.2 mm	76.2 mm	127 mm
FEED & TRAVERSE				
Table speed	1 ~28 m/min	1 ~28 m/min	1 ~28 m/min	1 ~28 m/min
Minimum incremental in vertical axis	0.001mm	0.001mm	0.001mm	0.001mm
Cross feed / stroke	1 ~ 65mm stroke	1~65 mm stroke	1~65 mm stroke	1~65 mm stroke
Cross rapid traverse	10~1200 mm/min	10~1200 mm/min	10~1200 mm/min	10~1200 mm/min
OTHERS				
Total power consumption	9 kW	9 kW	9 kW	10 kW
Machine weight	3500 kg	4000 kg	4500 kg	5200 kg

Cylindrical grinding

Cylindrical grinders are used to grind external and internal cylindrical surfaces. The cylindrical surfaces produced may be plain, tapered or stepped.

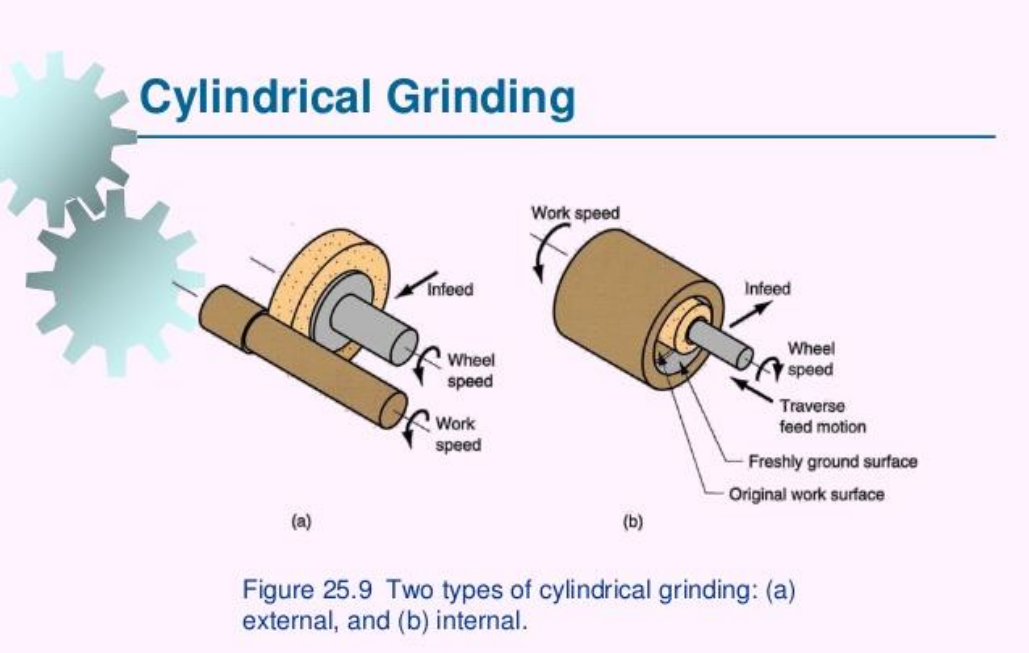


Figure 25.9 Two types of cylindrical grinding: (a) external, and (b) internal.

By cylindrical grinding the diameter of a work piece can be maintained to a close tolerance (up to 0.0025 mm), and a high quality surface finish can be obtained (up to N4).

- External Cylindrical grinding machine.

Plain Center-type

a. Universal Center -type.

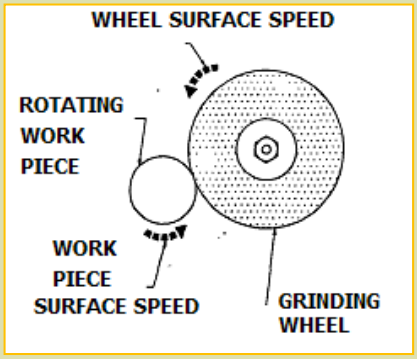
- Internal Cylindrical grinding machine.

a. Chucking.

i. Plain chucking. ii. Universal chucking.

b. Planetary.

EXTERNAL CYLINDRICAL GRINDING

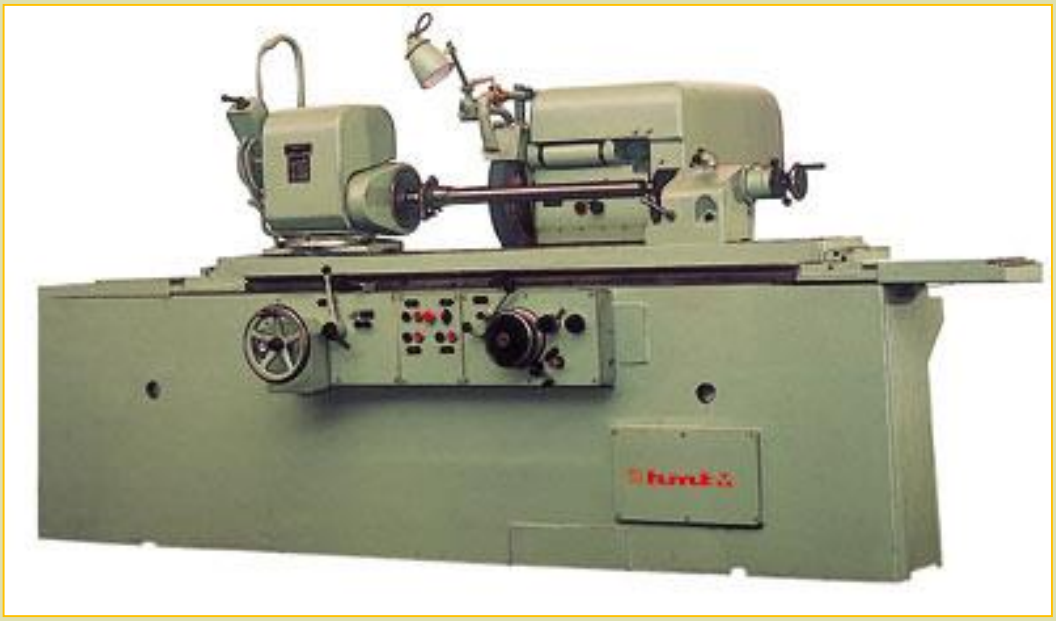


It produces a straight or tapered cylindrical surface. The work piece is rotated about its own axis between centers as it passes lengthwise across the face of a revolving grinding wheel .

.

PLAIN CENTRE TYPE CYLINDRICAL GRINDER (Fig 1)

This machine is usually manual operated machine. It is mainly intended to produce plain, stepped or tapered external cylindrical surfaces also used for grinding countered type cylindrical, fillets and cams etc. The work piece is usually held between dead center and revolving center for removing the stock material.



UNIVERSAL CYLINDRICAL GRINDING MACHINE

This machine is usually manual operated machine and resembles the plain type but. The work head and wheel head can be swiveled to facilitate the taper grinding. An extra accessory makes it possible to do internal grinding and surface grinding operation. The different grinding operation can be performed on universal grinding machine. The work head mounted on a swivel base, which can also be displaced longitudinally along the table. The work head and wheel head can be swiveled to required taper grinding work.

CYLINDRICAL GRINDING:

Cylindrical grinding is the practice of grinding cylindrical or conical workplaces by revolving the work piece in contact with the grinding wheel. Cylindrical grinding is

divided into three general operations: plain cylindrical, conical grinding (taper grinding), and internal grinding. The work piece and wheel are set to rotate in opposite directions at the point of contact (Figure 5-21).

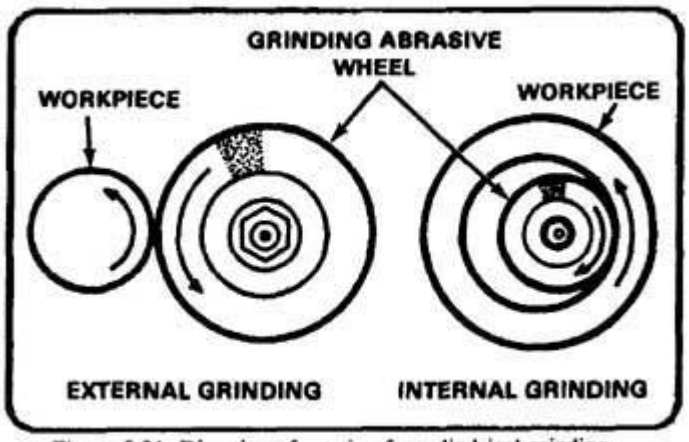


Figure 5-21. Direction of rotation for cylindrical grinding.

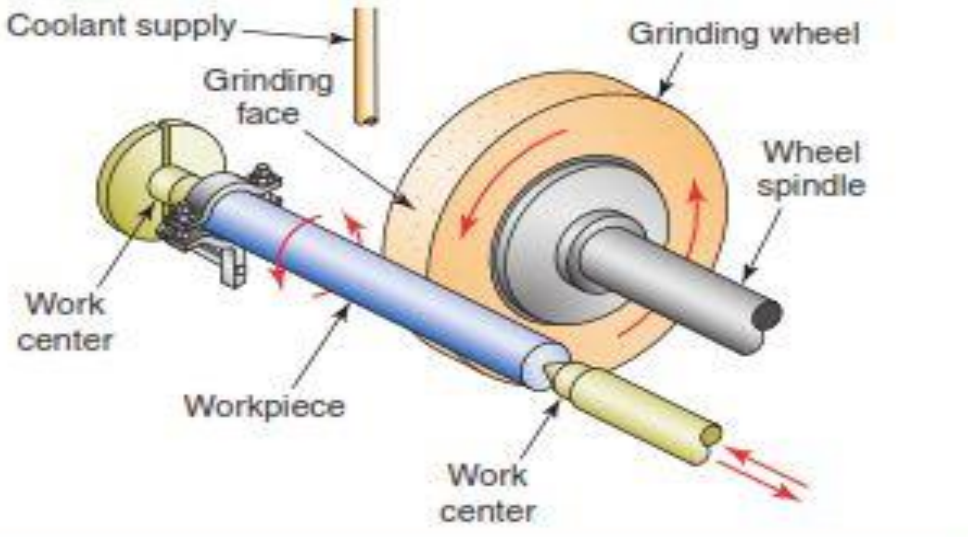


Figure L-110 Sketch of center-type cylindrical grinder set up for traverse grinding. Note particularly the direction of travel of the grinding wheel and the workpiece, and the method of rotating the workpiece.

In center type grinding machine four movements are involved they are as follows.

01. The work must revolve.

02. The wheel must revolve.

03. The work must pass the wheel.

04. The wheel must pass the work.

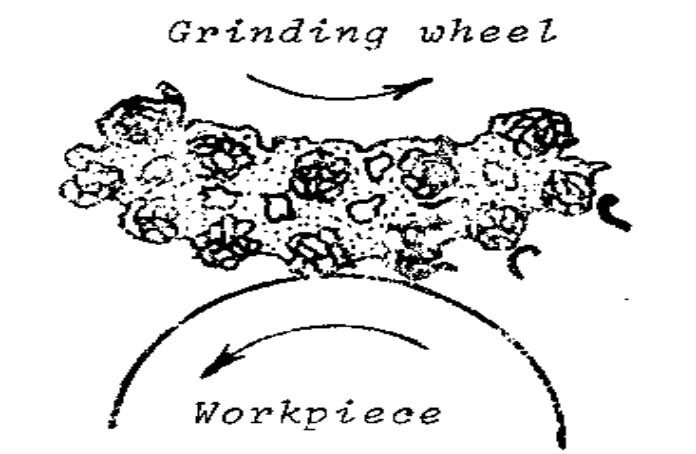


Fig. 5.2

Center type grinding machines are used to grind single and multi-diameter shaft.

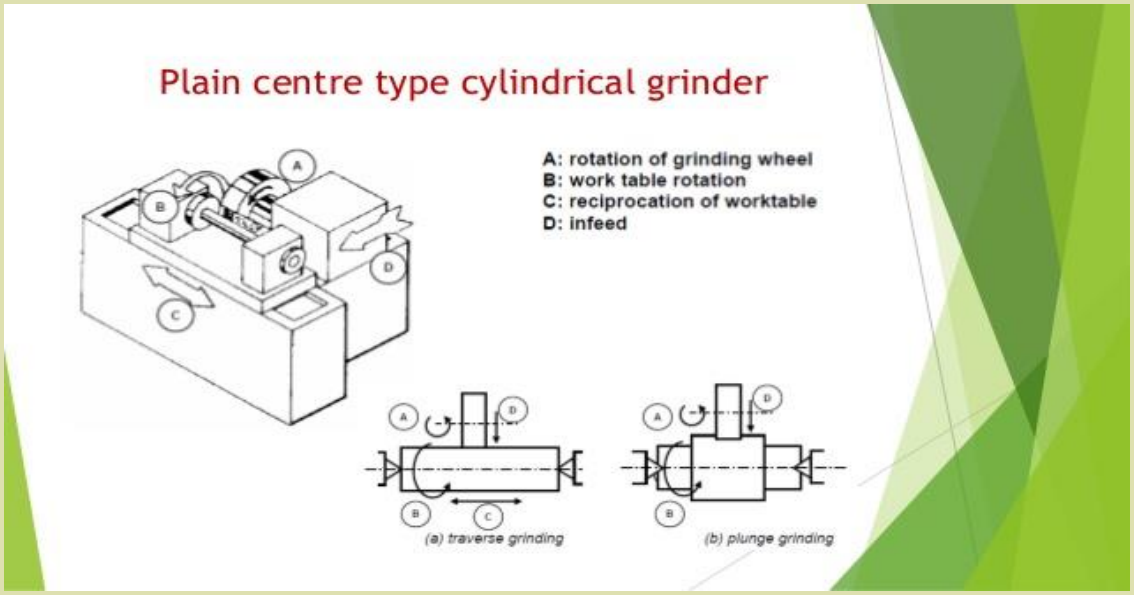
MAIN FEATURES OF CYLINDRICAL GRINDING MACHINE

* In cylindrical grinding there are two types.

01. Plunge grinder.

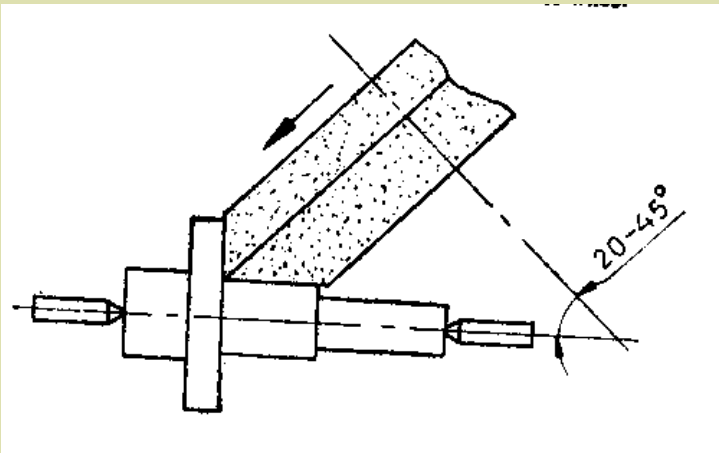
02. Traverse grinder.

OD grinding is grinding occurring on external surface of an object between the centers. The centers are end units with a point that allow the object to be rotated. The grinding wheel is also being rotated in the same direction when it comes in contact with the object. This effectively means the two surfaces will be moving opposite directions when contact is made which allows for a smoother operation and less chance of a jam up.



01. PLUNGE GRINDING:

In plunge grinder the work is rotated in fixed position and wheel feeds to produce cylinders. The length of the work piece is equal or shorter than the width of wheel.

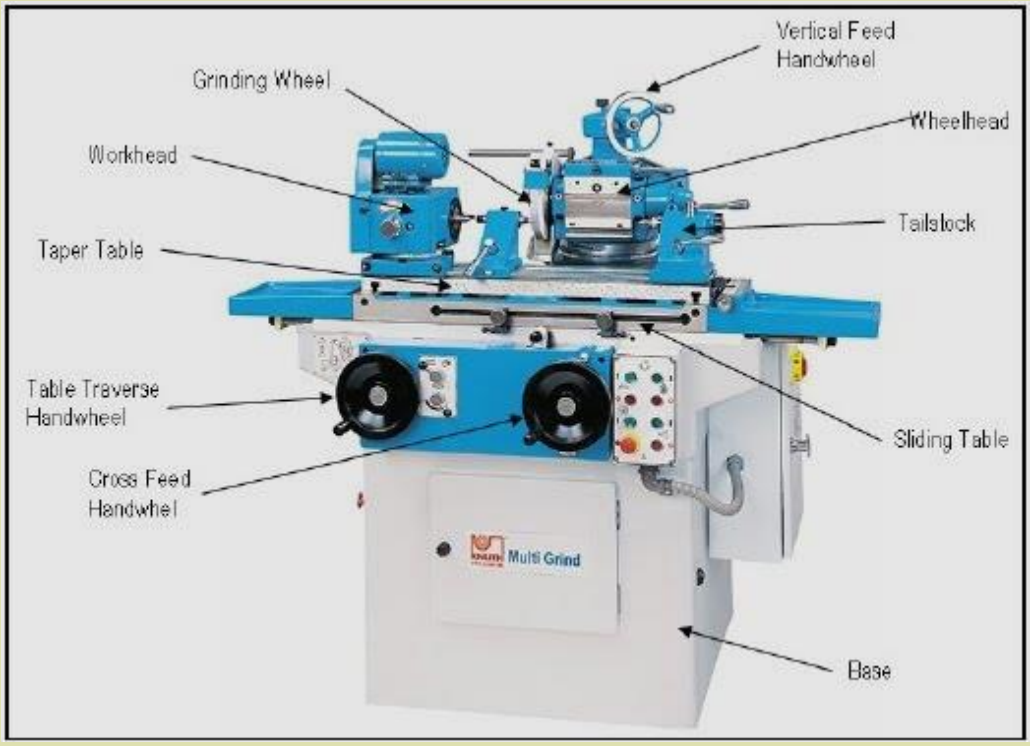


02. TRAVERSE GRINDING:

In transverse grinding the work is reciprocating to produce the cylindrical shape to the grinding wheel. Here the length of the work piece is more than the width of the grinding wheel.

- The work speed for cylindrical grinder is from 20to 30 S.M.P.M (S.M.P.M=Surface Speed in meters per minute).
- For thread grinding 1 to 3 S.M.P.M is required.
- The wheel speed usually ranges from 1500 to 2000 S.M.P.M.

MAIN PARTS OF CYLINDRICAL GRINDER



01. BASE:

The base is made of cast iron, bed is mounted on floor and it supports the all other parts and rests. The base is precision horizontal guide ways and set at right angle for sliding table easily.

02. TABLE:

There are generally two types of tables.

a. Lower table

b. Upper table

It slides on guide ways on the bed provides traverse of the work pass the grinding wheel. It can be moved by hand or power mechanism. The upper table is mounted on the top of the lower table. It is having T-slots for securing or holding

the headstock or tailstock and can be position to the desired length of the work. The upper table can be swiveled to an angle of +10 to produce taper surface.

03. HEAD STOCK:

The head stock supports to the work piece by means of dead centers and revolving center and drives by means of dog or hold in the chuck. Headstock is permanently fixed to the bed.

04. TAILSTOCK:

The tailstock can be moved on the table and clamped to the desire length or work piece length.

05. WHEEL HEAD:

The wheel head caries the grinding wheel. The driving motor mounted on a wheel head at the side of the top and rear or back of the base. The wheel head may be moved perpendicular to the table guide way.

06. CROSS FEED:

The grinding wheel is feed to the work by hand or power as determined by the engage of the cross feed control lever.

CONICAL GRINDING:

Most conical grinding is performed in the same manner as plain cylindrical grinding. Once the grinding machine is set up, the table is swiveled until the correct taper per inch is obtained. Steep conical tapers are normally ground by swiveling the

headstock to the angle of taper. Whichever method is used, the axis of the grinding wheel must be exactly at center height with the axis of the work.

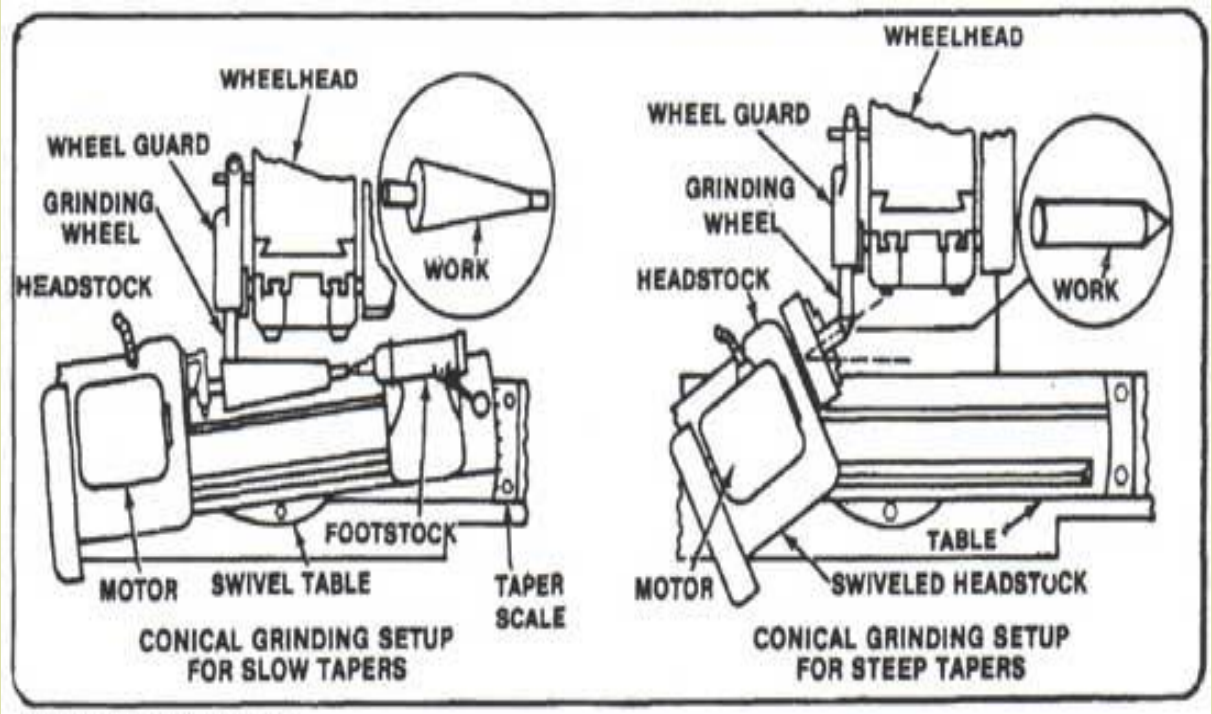
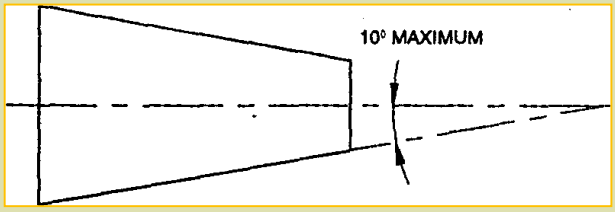


Figure 5-15. Conical grinding setups.

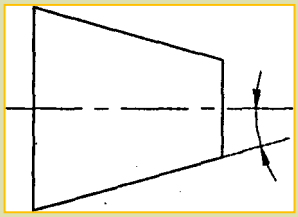
GRINDING TAPERS AND ANGLES

A conical work piece with an angle not more than 10° between its axis and its surface face is known as a taper or slow taper.



TAPER OR SLOW TAPER

If the angle is greater than 10°, the work piece is known as an angle or fast taper.

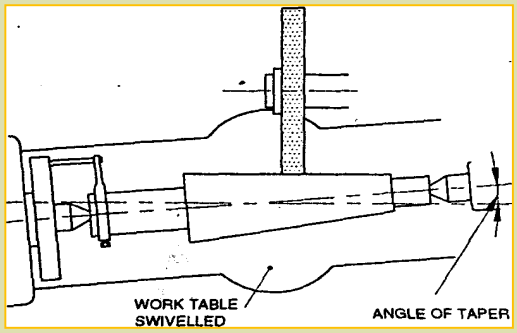


MORE THAN 10°

ANGLE OR FAST TAPER

Tapers

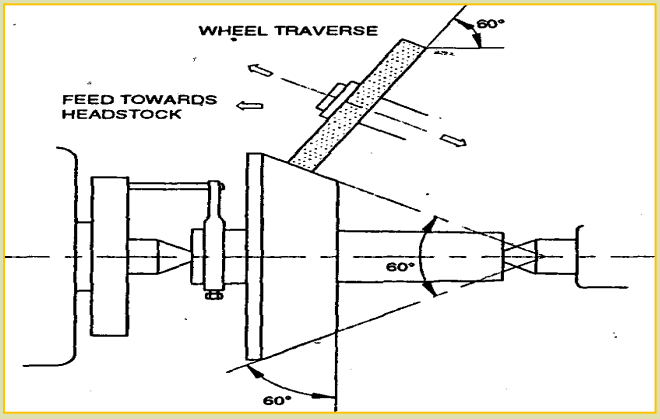
Tapers are usually produced by mounting the work piece between centers. The procedure is the same as for plain cylindrical grinding. The machine work table is swiveled to give the desired angle between the centers and the wheel spindle. (Follow the general grinding rules.)



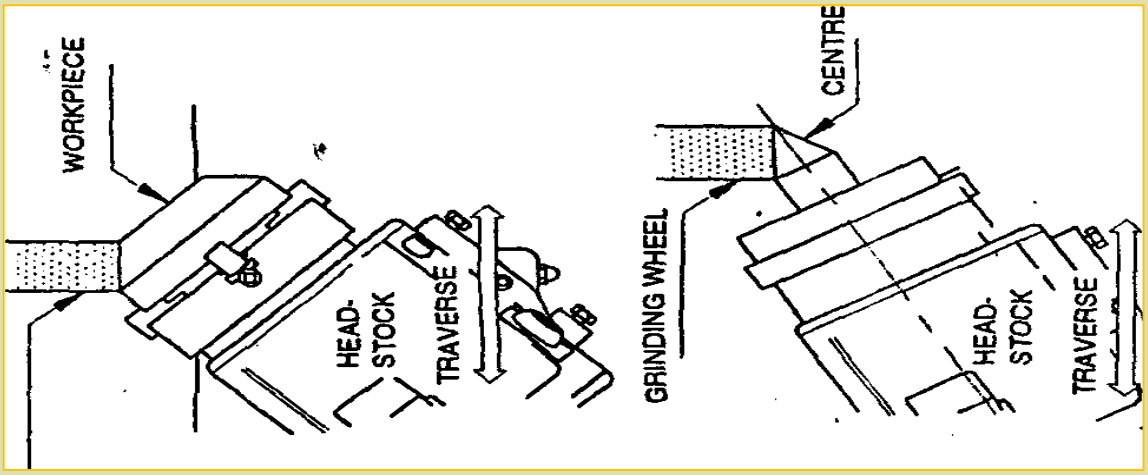
GRINDING A TAPER

Angles

Where the amount of taper to be ground is more than 1 C the work is mounted between centers with the work tab set at zero. The wheel head is swiveled to the desired angle and the work piece traversed by moving the table and feeding the wheel simultaneously. The feed should always be directed towards the headstock. (Follow the general grinding rules.)



GRINDING AN ANGLE WITH WHEEL HEAD SWIVELLED GRINDING WHEEL



The headstock may also be used to hold small work pieces for angle grinding. The headstock is swiveled to the desired angle and the wheel traversed, if required, by longitudinal movement of the work table. This method is used to grind the centers of the universal grinding machine when this becomes necessary.

HEAD STOCK SWIVELLED FOR GRINDING ANGLES

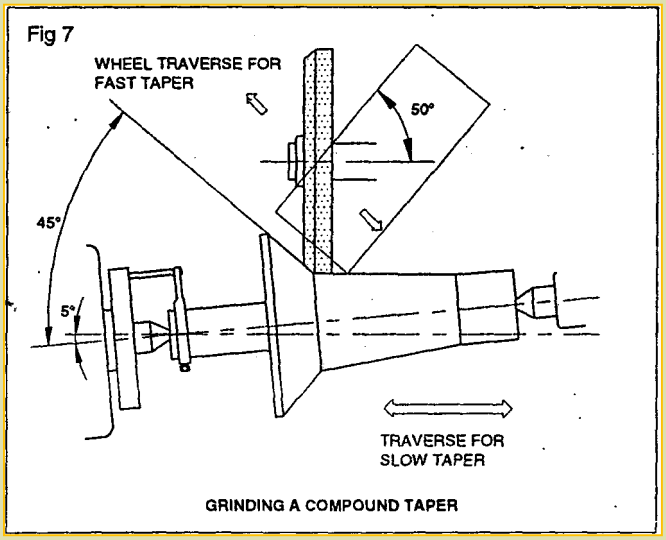
Grinding angles with a dressed grinding wheel

Where a wheel of the appropriate face shape is available, an angle may be ground with the axis of the work piece aligned with the wheel spindle. In some cases it may

be economical to dress a wheel to the required angle. (Fig.6) (Follow the general grinding rules.)

Grinding compound tapers

Work pieces having double or compound tapers may be ground with a single machine settings to do this, one taper must be within the range of the swivel table. The table is set for the small angle and the wheel head is set at a right angle to the longest surface, the wheel is beveled to suit the steeper taper. One part is ground by traversing the table and the other by moving the wheel head. (Fig 7) (Follow the general grinding rules.)



PLAIN CYLINDRICAL GRINDING OPERATION

The step-by-step procedure for grinding a straight shaft is given below. The shaft has been roughly turned prior to grinding.

- Check and grind headstock and tailstock centers if necessary.
- Check drilled centers of work piece for accuracy.
- Place a grinding wheel of the proper grain, grade, structure, and bond on the wheel spindle.
- Place wheel guards in position to cover the wheel adequately.
- Set the proper wheel speed on grinding machine (Table 5-2 in Appendix A).

- Place the diamond dresser and holder on the machine table and true and dress the grinding wheel.
- Mount the headstock and footstock on the table.
- Attach the proper size drive dog on the headstock end of the work piece.
- Mount the work piece between headstock and tailstock centers. Use lubricant (oil and white lead mixture) on tailstock center. Make sure centers fit drill center holes correctly with no play.
- Set the proper rotational work speed on the wheel head. The general range of work speed for cylindrical grinding is 60 to 100 SFPM. Heavy rough grinding is sometimes performed at work speeds as low as 20 or 30 SFPM. Soft metals such as aluminum are sometimes ground at speeds up to 200 SFPM.
- Position the table trip dogs to allow minimum table traverse. The wheel should overlap each end of the work piece not more than one-half the wheel width to assure a uniform straight cut over the length of the work piece.
- Calculate the table traverse feed using this formula.

TT = (WW x FF x WRPM) + 12

Where

TT = Table travel in feet per minute

WW = Width of wheel

FF = Fraction of finish

WRPM = Revolutions per minute of work piece

12 = Constant (inches per foot)

The fraction of finish for annealed steels is 1/2 for rough grinding and 1/6 for

finishing; for hardened steels, the rate is 1/4 for rough grinding and 1/8 for finishing. For example, an l-inch-wide wheel is used to rough grind a hardened steel cylinder with a work RPM of 300.

Table travel = (1 x 1/4 x 300) ÷ 12 = (75) ÷ 12 = 6.25 FPM

After the calculations have been completed, set the machine for the proper traverse rate, turn on the table traverse power feed, and grind the work piece.

- Check the work piece size often during cutting with micrometer calipers.
- Check the tailstock center often and readjust if expansion in the work piece has caused excessive pressure against the drilled center in the work piece.
- The finishing cut should be slight, never greater than 0.001 inch, and taken with a fine feed and a fine grain wheel.

If two or more grinding wheels of different grain size are used during the grinding procedure, each wheel should be dressed and trued as soon as it is mounted in the grinding machine.

INTERNAL GRINDING

Internal cylindrical grinding

It produces internal cylindrical holes straight or taper sided. The work pieces are held in the chuck or collets and rotated precisely about their axis. A revolving grinding wheel, smaller than the diameter of the hole, to be ground is set against the rotation of the work piece and traverses along the surface of the hole.

The following step-by step procedure for grinding the bore of a bushing is outlined below as an example.

- Set up the work piece in an independent chuck and check and adjust its alignment.
- Mount the internal grinding attachment to the wheel head and adjust its position so that the grinding wheel is centered vertically with the mounted work piece.
- True and dress the grinding wheel.
- Set the proper wheel speed on the grinding machine by adjusting the pulleys and belts connecting the wheel spindle to the drive motor shaft.
- Set the proper rotational work feed. The speed should be 60 to 100 SFPM.
- Be sure sufficient clearance is allowed when setting the traversing speed so that the grinding wheel will not strike any part of the work piece or setup when the wheel is fed into and retracted from the work piece.

If two or more grinding wheels are used to complete internal grinding, true each wheel after mounting it to the spindle of the internal grinding attachment.

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.

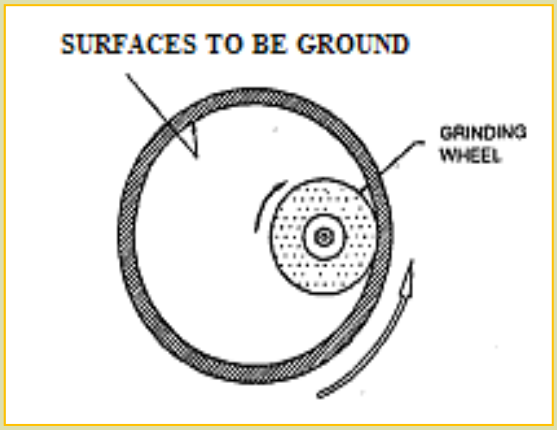
Therefore, it is important to pay particular attention to the condition of the wheel and to use either a coarse grain wheel to provide more chip clearance or a softer grade wheel that will break down more easily.

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.



SPECIFICATION: A cylindrical center type grinder is specified by the maximum diameter and length of the work piece that can be accommodated between centers. The diameter of the work piece should not be more than half of the capacity given

Crankshaft Disc Grinding Machine GCS 500

Proven Grinder for its high rigidity, accuracy & reliability. Now with PLC control, upgraded features and various other options.

Salient Features :

- Bed made of high tensile strength cast iron, heavily ribbed for better vibration damping and shock absorption through stability and high rigidity of machine.
- Precision V & flat guide ways for table with continuous automatic lubrication.
- Dual table arrangement for taper setting and taper grinding facility.
- Hydraulic step less variable table speed with provision for dwell and dampening.
- Grinding wheel with axial movement of 5 mm on either side to an accuracy of 0.01 mm.
- Antifriction roller/truncate lined guide ways for in feed slide, ensuring Micronics response and repeatability.
- Both work head and tailstock spindles are provided with eccentric clamping arrangement with chuck for adjusting according to the eccentricity of the crank pin. The required eccentricity can be set within 0-130 mm with an accuracy of

0.1 mm. alternatively by use of gauges; the eccentricity can be set to finer limits where necessary.

- Grinding wheel spindle has a provision for axial movement of 5 mm on either side to an accuracy of 0.010 mm for shoulder grinding.

Special Executions :

» Machine with 2-Axes CNC control (Fanuc/Siemens).

» Machine with higher GWH power.

» Dynamic wheel balancing apparatus.

» Electronic automatic wheel balancer.

» Table/bed/wheel head mounted in process gauging.

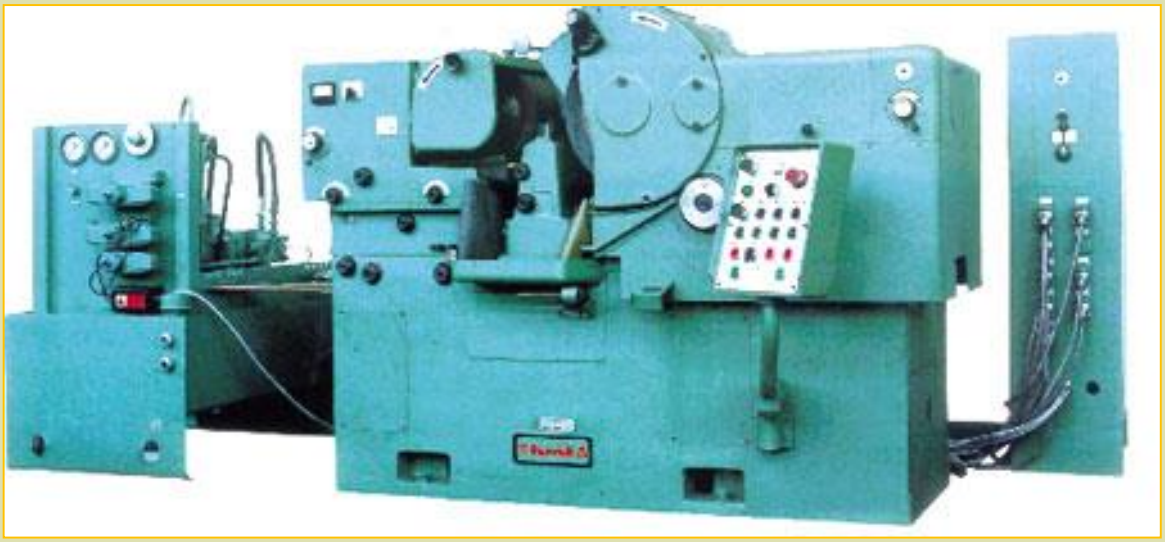
» Simplified manual controlled machine for economical use.

Specifications :

Swing over table	**mm**	**540**
Admit between Centres	mm	1800
Distance between chucks	mm	1600
Max. job wt between centres / chucks	kg	250 / 120
Max. eccentricity of connecting rod pins	mm	130
Grinding wheel (ODxWxBore)	mm	900x50x305
Work head speed range	rpm	34,48,68,96
Peripheral / cutting speed	m/sec	30
Work head motor	kW	0.75/1.1
Wheel head motor	kW	7.5

CRANK SHAFT GRINDER

CENTRE LESS GRINDING

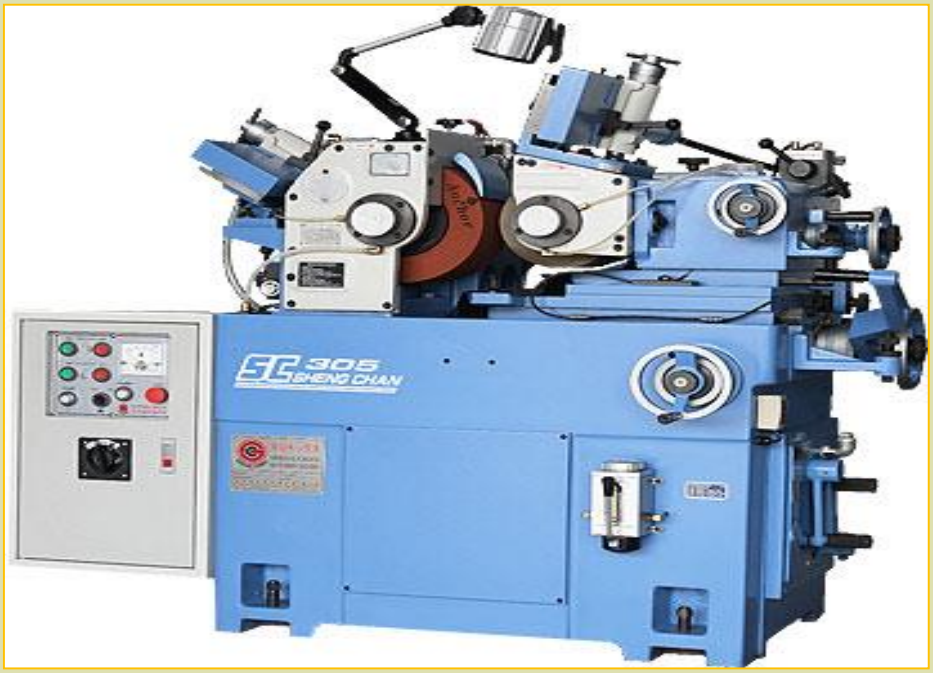


Centre less grinding is a method of grinding external cylindrical, tapered and formed surfaces on work pieces that are not held and rotated between centre's or in chucks.

There are two types of center less grinding and they are

1. External center less grinding 2. Internal center less grinding

CENTRELESS GRINDING



Centre less grinding is a method of grinding external cylindrical, tapered and formed surfaces on work pieces that are not held and rotated between centers or in chucks.

Center less grinding eliminates need for center holes, drives and other fixture required to hold the work piece. This is supported on a work rest and it is backed up against the grinding wheel by regulating wheel which is positioned to apply lateral pressure to the work piece, and usually has either a very rough or rubber-bonded abrasive to trap and control the speed of the work piece and also the rate of feeding.

Grinding wheels are interchangeable, to allow for different grits and shapes. The work blade is angled slightly towards the regulating wheel, with the work piece

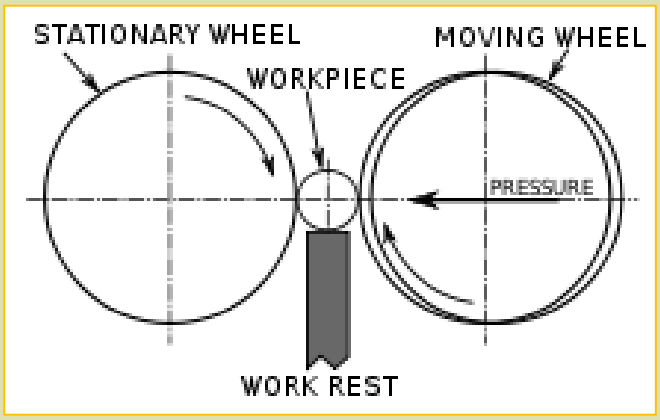
centerline above the centerlines of the regulating and grinding wheel; this means that high spots do not tend to generate corresponding opposite low spots, and hence the roundness of parts can be improved.

The speed of the two wheels relative to each other provides the grinding action and determines the rate at which material is removed from the work piece. During operation the work piece turns with the regulating wheel, with the same linear velocity at the point of contact and (ideally) no slipping. The grinding wheel turns faster, slipping past the surface of the work piece at the point of contact and removing chips of material as it passes.

There are two types of center less grinding and they are

1. External center less grinding 2. Internal center less grinding

EXTERNAL CENTERLESS GRINDING



Two wheels - a grinding and a regulating wheel are used in external center less grinding. Both these wheels are rotated in the same direction. The work is placed upon the work rest and rotated between the wheels. The feed movement of the work along its axis past the grinding wheel is obtained by tilting the regulating wheel at a slight angle from the horizontal. An angular adjustment of 0 to 10 degrees is provided in the machine for this purpose

A schematic of the External center less grinding process.

The original or actual feed can be calculated by formula.

S=3.142 * n * sinα

Where, S- Feed in mm/min.

N- Revolution per min.

D- Diameter of the regulating wheel in mm.

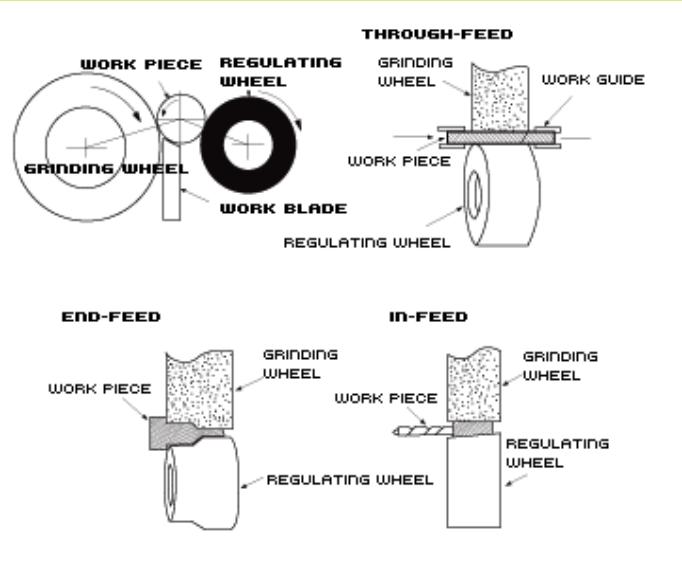
A- Angle in inclination of wheel.

In external center less grinding general elements is as follows.

01. Regulating wheel or back up wheel.
02. Grinding wheel.
03. Work rest.

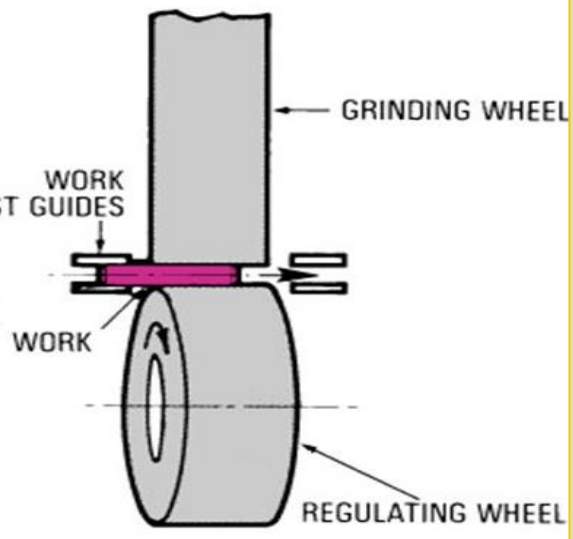
A close-up of the grinding wheel and back-up wheel

Center less grinding may be done in one of the three ways.



Thru-Feed Centerless Grinding

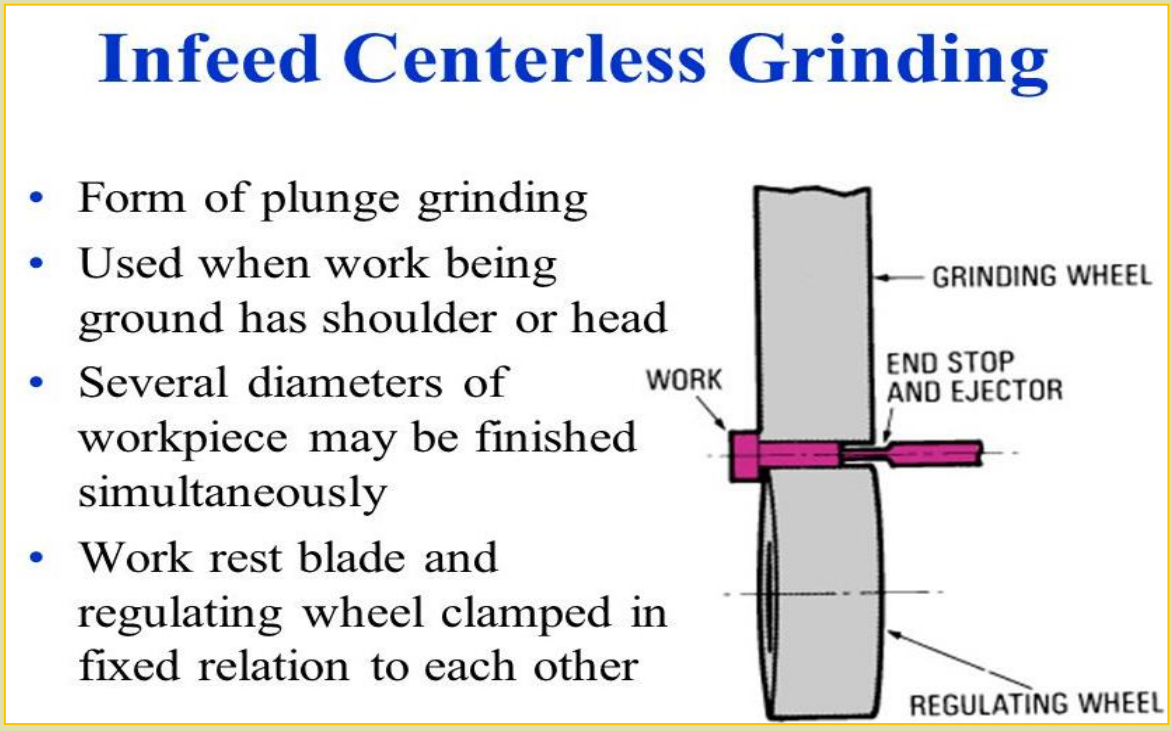
- Consists of feeding work between grinding and regulating wheels
- Work fed by regulating wheel past grinding wheel
- Speed of feeding work controlled by speed and angle of regulating wheel



THROUGH FEED

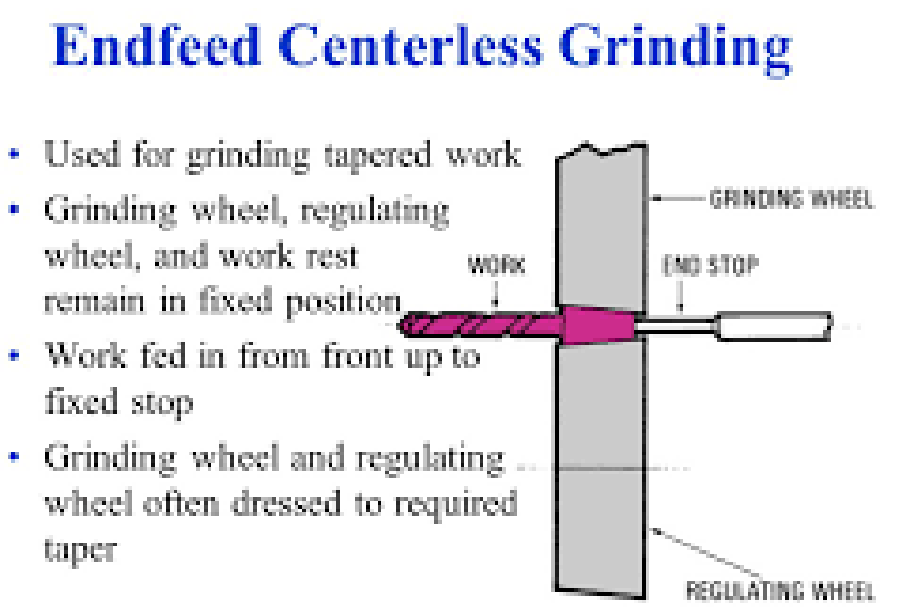
It is adopted for straight cylindrical surface. Bars longer than the grinding wheel can be ground by the through feed method short cylindrical part can be continuously ground several parts being simultaneously engage with the wheels. Higher speed with less inclination is used for finishing grinding operation, the wheel takes the more time to cut the material and longer sparking time to produce the better finish.

Though feed is especially used to grind the round shoulder-less work piece. Through-feed grinding can be very efficient because it does not require a separate feed Mechanism.



IN FEED: In-feed grinding is especially used for grinding the work piece having shoulder or stepped. In-feed grinding is similar to the cylindrical plunge grinding or form grinding and there is no axial movement between the work and grinding wheel.

The length of the grinding portion of the work piece is less than the width of the wheel.



END FEED:

- End feed grinding is mainly used for tapered work.
- The work piece moves up to end stop. Either the grinding wheel or regulating wheel or both should be tapered to obtain the required taper.
- The work piece is fed length wise between the wheels and is ground as it advances until it reaches at the end stop.

ADVANTAGES:

- As a true floating condition exists during the grinding process, less metal to be removed.
- The work piece supported throughout the length, hence no tendency to chatter or deflection of the work.
- This process is continuous and adapted for production work.
- The size of the work is easily controlled.
- The low order of skill is needed in the operation of the machine.

- No center holes, no chucking or mounting of the work on mandrels or other holding devices are not required.

DISADVANTAGES:

* In hollow work the outside diameter will be concentric with the inside diameter.
* In the work piece having multiple diameters it is not easily handled.

INTERNAL GRINDING:

The internal grinding machines are used to finish straight, taper or formed holes to the accurate size.

There are three general types of internal grinding.

01. Chucking.
02. Planetary.
03. Centre less.

CHUCKING:

In chucking grinding the work piece is checked and rotated about its own axis or direction to bring all parts of the other surfaces to be ground in contact with grinding wheel.

The best application of chucking grinding is the works piece itself can be conveniently chucked and rotated.

PLANETARY:

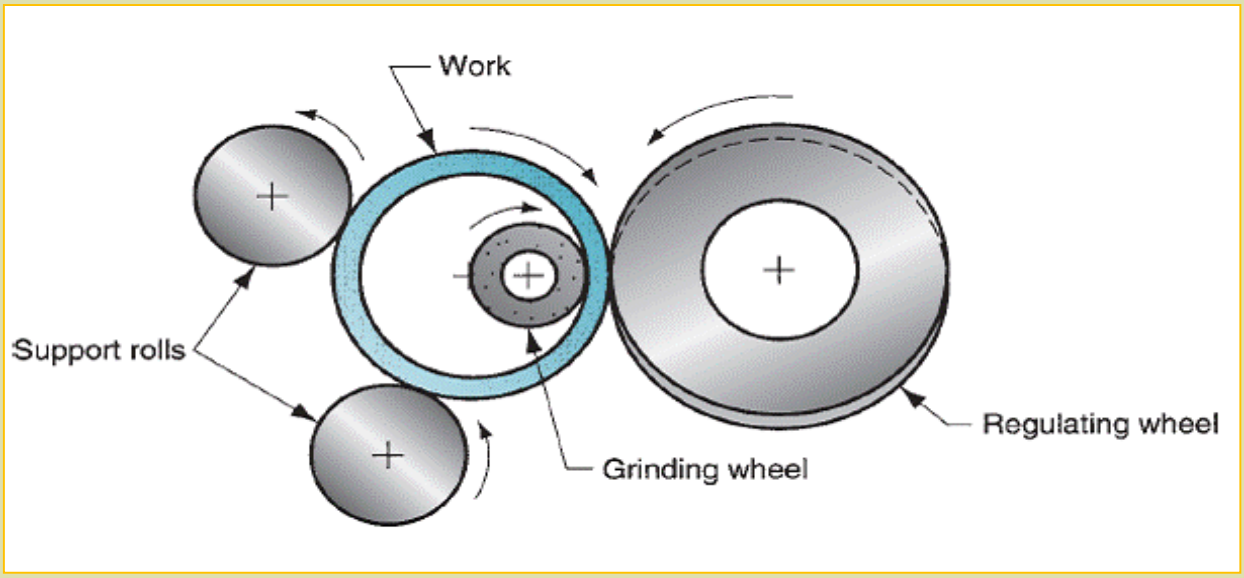
In planetary the work piece is mounted on the reciprocating table and it is not

revolved. Instead of that grinding wheel is giving the rotary and planetary motion to grind cylindrical hole.

In planetary grinding large and awkward work piece cannot be or conveniently rotated by chuck.

INTERNAL CENTRELESS GRINDING

The external center less grinding principle is also applied to the internal center less grinding machine.



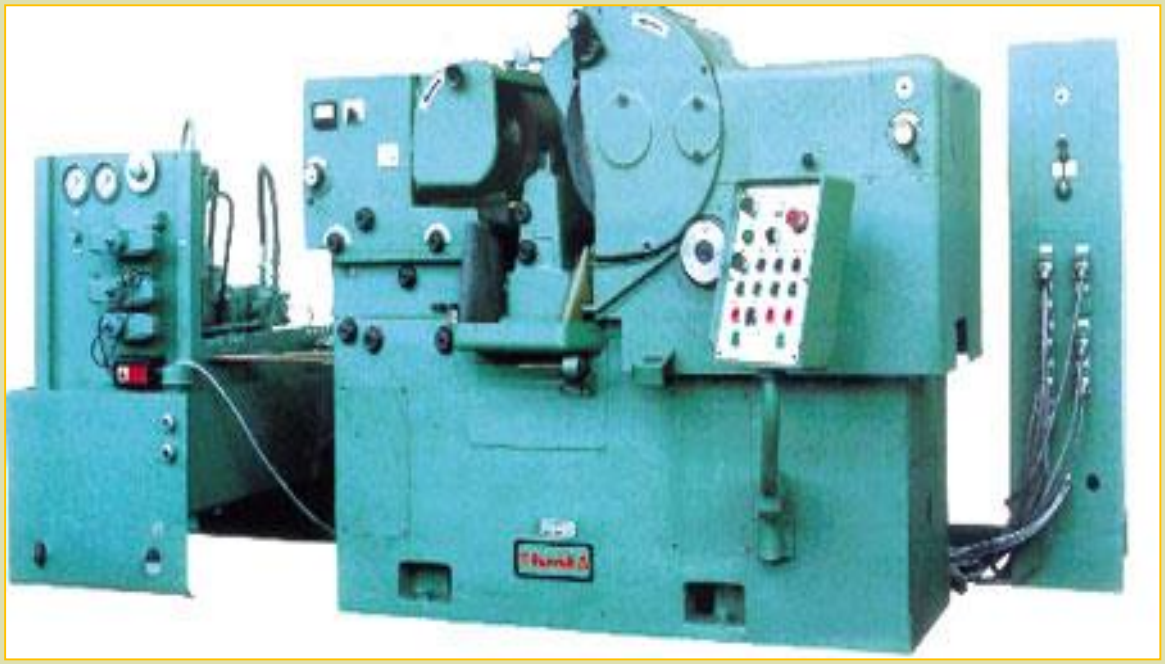
In internal center less grinding the work is supported by four rollers.

01. Regulating wheel.
02. Grinding wheel.
03. Pressure wheel.
04. Support wheel.

Pressure wheel to hold the work piece firmly against the supporting wheel & regulating wheels. The grinding wheel contacts the inside diameter of the work piece directly opposite to the regulating wheel.

The uniform wall thickness can be achieved by the internal center less grinding and also achieve uniform concentricity. Swinging or tilting pressure wheel does loading and unloading of the work piece.

1) The low order of skill is needed in the operation of the machine.
2) No center holes, no chucking or mounting of the work on mandrels or other holding devices are not required.
3) In hollow work the outside diameter will be concentric with the inside diameter.
4) In the work piece having multiple diameters it is not easily handled.



TOOL AND CUTTER GRINDER

- In a machine shop, much of the machining operations are done by single point tools or multi-point tools called milling cutters.
- The cutting tools become blunt due to constant use, and need re-sharpening for continued production.
- Such re-sharpening is done by using TOOL AND CUTTER GRINDER.
- There are many types of Tool and cutter grinders for sharpening a large variety of tools and cutters like Single lip cutters, Milling cutters, Hobs, Reamers, Dies, Punches, Taps and drill etc.

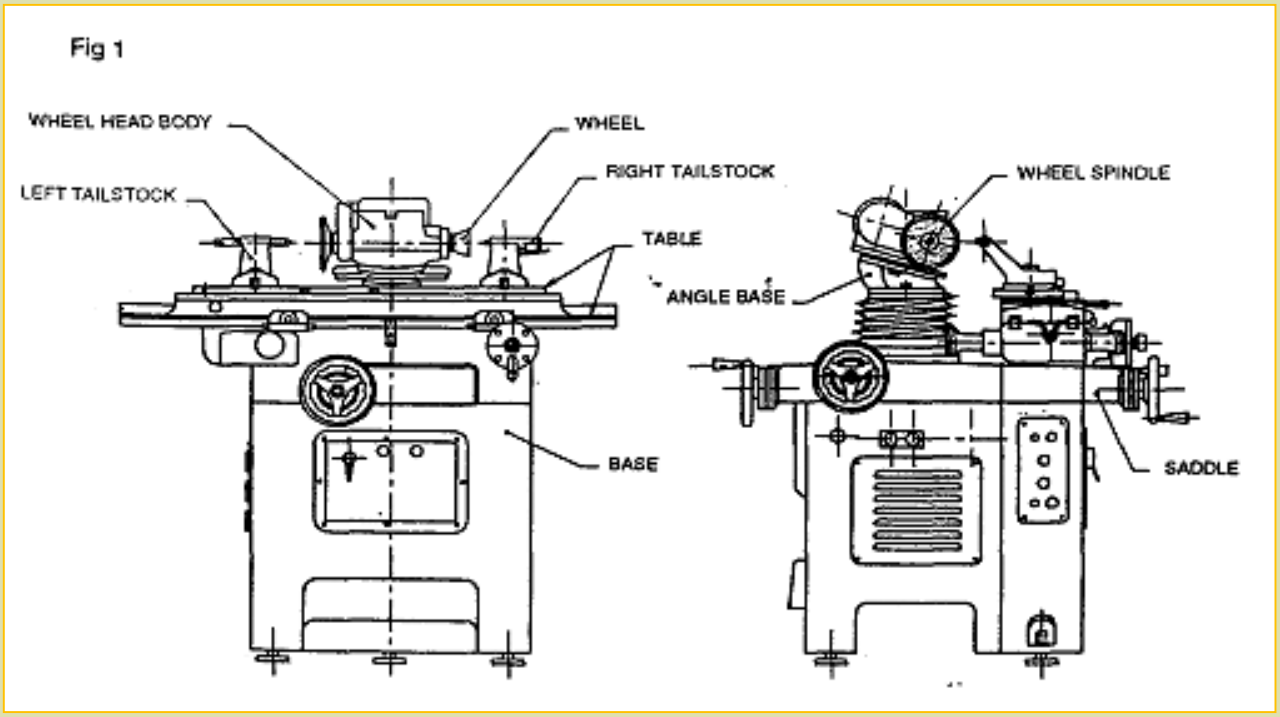
They are classified in to two types:

1. Single purpose tool and cutter grinder.
2. Universal tool and cutter grinder.

- Single purpose tool and cutter grinder are used grinding tool such as drill, cutter, hobs, reamer etc.

- The Universal tool and cutter grinder is the most popular of all the machines because of its versatility and capability. They can be employed for surface grinding, cylindrical grinding and internal grinding by using various attachments and also to sharpen various type of cutting tools.

PARTS AND CONSTRUCTION OF A TOOL AND CUTTER GRINDER



Base

The base of the machine gives rigidity and stability to the machine. It is bolted rigidly to the floor of the shop by bolts and nuts. It supports all the other parts of the machine. It is box type and houses all the mechanisms for the saddle movements.

Saddle

The saddle is mounted directly on the top of the base and slides over it. The column is mounted on the saddle. It can be moved up and down and swiveled to either side.

Table

The table resets and moves on a top base, which is mounted over the saddle. The table has two layers. The worktable is mounted on the sub table which has 'T' slots for mounting the work and attachments used on the machine. The worktable can be swiveled while grinding tapers.

Headstock and tailstock

The headstock and tailstock are mounted on either side of the table. The work pieces are positioned between centers and driven exactly as in a cylindrical grinder.

Wheel head

The wheel head is mounted on a column on the back of the machine. It can be swiveled to the required angle (360°).and positioned in the base for different set-up. It has two grinding wheels on both ends of the spindle a straight wheel and a cup wheel are mounted on either side of the wheel head.

Work head

It is a separate part and is fitted on the table for cylindrical works. It is driven by a separate motor fitted with the work head. It moves along the table and can be swiveled to any angle (180°).

A tailstock is provided for supporting the mandrel between centers.

Attachments

A tool and cutter grinding machine is also used as a surface grinding, cylindrical grinding and internal grinding machine with the help of certain attachments.

Three different types of grinding wheels are used in tool and cutter

- Straight type
- Cup type
- Disc type

Specification of tool and cutter grinder

1. Maximum dia. of the wheel that can be held in the spindle.
2. Maximum height of the job that can be ground.
3. Maximum length of the job that can be ground.
4. Maximum breadth of the job that can be ground.
5. Type of drive
   - Hydraulic
   - Electrical.
6. Type number.

A tool and cutter grinder is specified further by the maximum size of tool that can be sharpened and dressed.

Specifications : Universal Tool & Cutter Grinding Machine GTC 28TM

Centre height	**mm**	**130**
Swing	mm	280
Swing with raising block	mm	370
Admit between tailstock centers	mm	760
Admit between work head & tailstock center	mm	615
Max. job weight for cylindrical grinding	kg	15
Longitudinal travel of table	mm	510
Clamping area	mm	980x140
Cross traverse	mm	250
Tailstock taper		MT2
Total power	kW	3

New modified Tool & Cutter Grinder ideal for sharpening all types of commonly used cutting tools like milling cutters, hobs, gear cutters, and tools with spiral cutting edges.

Salient Features

- Rugged box frame structure.
- Preloaded antifriction, cartridge type spindle for wheel head to run in either sense of rotation.
- Wheel spindle can accommodate grinding wheel/interchangeable arbors on

both sides.

- Tilting of wheel head in both planes for more versatility.
- Dual control of table for easy operation.
- Higher rigidity and consistent accuracies.
- New improved wheel head on inclined plane allows use of diamond and CBN wheels and higher rated motor power, longer spindle can be used in place of arbors for better accuracies.
- Ideally suited for small workshops, tool rooms, assembly section and training institutes.

Special Executions

- Fanuc/Siemens CNC system controlled machine.
- Precision radius grinding attachment.
- DRO for all slides.

CNC TOOL AND CUTTER GRINDER

Modern CNC tool grinders with automatic wheel pack exchanger and tool loading capabilities.

Today's tool and cutter grinder is typically a CNC machine tool, usually 5 axes, which produces end mills, drills, step tools, etc. which are widely used in the metal cutting and woodworking industries.

Modern CNC tool and cutter grinders enhance productivity by typically offering features such as automatic tool loading as well as the ability to support multiple grinding wheels.

High levels of automation, as well as automatic in-machine tool measurement and compensation, allow extended periods of unmanned production. With careful process configuration and appropriate tool support, tolerances less than 5 micrometers (0.0002") can be consistently achieved even on the most complex parts.

Apart from manufacturing, in-machine tool measurement using touch-probe or laser technology allows cutting tools to be reconditioned. During normal use, cutting edges either wear and/or chip. The geometric features of cutting tools can be automatically measured within the CNC tool grinder and the tool ground to return cutting surfaces to optimal condition.

Significant software advancements have allowed CNC tool and cutter grinders to be utilized in a wide range of industries. Advanced CNC grinders feature sophisticated software that allows geometrically complex parts to be designed either parametrically or by using third party CAD/CAM software.

3D simulation of the entire grinding process and the finished part is possible as well as detection of any potential mechanical collisions and calculation of production time. Such features allow parts to be designed and verified, as well as the production process optimized, entirely within the software environment.

Tool and cutter grinders can be adapted to manufacturing precision machine components. The machine, when used for these purposes more likely would be called a CNC Grinding System.

CNC Grinding Systems are widely used to produce parts for aerospace, medical, automotive, and other industries. Extremely hard and exotic materials are generally no problem for today's grinding systems and the multi-axis machines are capable of generating quite complex geometries.

FORM GRINDING

It produces formed surfaces. Here the grinding wheels are formed to required shape & contours as needed &these specially shaped grinding wheels grind the work piece surfaces to the formed surfaces as is the case of grinding gear teeth, threads, splined shafts etc.

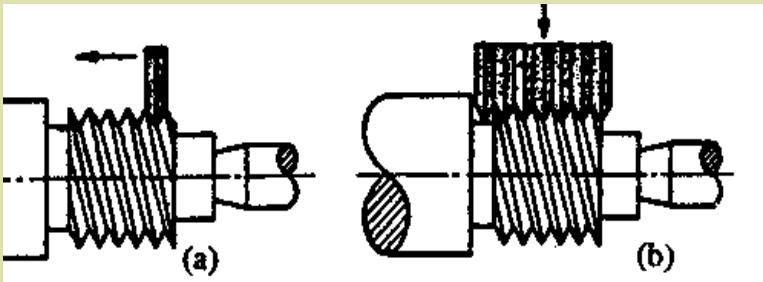


Figure 10.13 Thread grinding
(a). Single wheel grinding, (b). Plunge cut grinding.

SPECIAL OPERATIONS ON GRINDING MACHINES

A wire wheel mounted to a utility grinding machine is used for cleaning operations such as removing rust, paint, or dirt from metal objects. If the utility grinding machine on which the wire wheel is to be mounted is equipped with wheel guards and tool rests, these parts should be removed or swung out of the way so that the objects to be cleaned can be brought against the wheel without interference.

To clean objects with a wire wheel, place the object firmly against the wire wheel. Work the object back and forth across the face of the wheel until all traces of rust, paint, or dirt are removed. Avoid excessive pressure against the face of the wire wheel to prevent spreading the steel wires. Keep the point of contact below the center of the wheel to avoid kickback of the work piece.

UNIT 3 – GRINDING WHEELS

Grinding wheels are composed of selective sized abrasive grains held together by a bonding agent.

The following influences the properties of the grinding wheel.

1) Type of abrasive

2) Grain size

3) Type of bond.

4) Structure of the wheel.

ABRASIVES

Abrasives are used for grinding and polishing operations. It should have uniform physical properties of hardness, toughness and resistance to fracture. Abrasive may be classified into two principal groups.

- Natural abrasives
- Artificial abrasives

NATURAL ABRASIVE

The natural abrasives are obtained from the Earth's crust. Corundum, emery, and diamond, solid quartz (sand) are the most commonly used natural abrasive for grinding wheel.

SAND STONE

Sand stone or solid quartz is one of the natural abrasive stones from which grinding wheel or stone shaped. The quartz-cutting agent is relatively soft so that the materials harder than quartz cannot be abraded or ground rapidly. Sandstone is used as abrasive to grind softer materials only.

EMERY

Emery is a natural aluminum oxide. It contents from 55 to 65 % of alumina and contains iron oxide and impurities. This is having greater hardness.

CORUNDUM

EDWARD. G. ACHESON. Manufactured the first abrasive in the year 1891 set to the task of trying to produce artificial diamond by combining powered of coke and corundum clay at extremely at high temperature and this mixture is called CARBORUNDUM.

It is also natural aluminum oxide. It contains from 75to95% alumina oxide and remaining is impurities. It contains greater percentage of aluminum oxide than emery. Both emery and corundum has higher degree of hardness and better abrasive action than quartz.

DIAMOND

Diamonds are the hardest known materials. Chemists and laboratory technicians tried for 125 years to develop the combination of elements that would produce man – made DIAMOND. In 1955, the general electrical company announced success in producing artificial diamond and which is suitable for industrial use.

The diamond abrasive wheel has become a necessary tool in all production shops. The diamond wheels are used to grinding cemented carbide tools.

ARTIFICIAL ABRASIVE

The well design manufactured abrasive and quality controlled property such as hardness, roughness etc.

Artificial abrasive mainly classified into two types.

01. Aluminum oxide (AL2O3). **02. Silicon carbide (SIC).**

ALUMINIUM OXIDE (AL2O3)

Aluminum oxide is tough and not easily fractured, so it is better adapted to grinding materials of high tensile strength & ferrous alloys such as most steels, carbon steels, high speed steels, and tough bronzes.

This is denoted by the letter 'A'.

The raw material used for producing aluminum oxide is bauxite, titanium oxide, silica etc., mixed with coke and iron borings. It is boiling in electric arc furnace to produce abrasive. This is manufacture under trade name aloxite, alundum, boredom, electric abrasive etc. It is manly used for dry grinding of heat sensitive steel. The pure aluminum oxide is quite friable. It is denoted by latter "A". It consisted of about 95% of aluminum.

SILICON CARBIDE (SIC)

Silicon carbide is next to diamond in the order of hardness. But it is not tough enough as aluminum oxide. Silicon carbide wheels are used for grinding non-ferrous materials or low tensile strength material such as cemented carbides, ceramic materials, grey brass, bronze, copper, lead, aluminum, vulcanized rubber etc. This is manufactured under trade names of carborundum.

It is denoted by the letter 'S'.

The raw materials are silicon dioxide and petroleum. Silicon carbide is manufactured from 56 parts of silica, 34 parts of powdered coke, 2 parts of salt and 12 parts of sawdust in a long rectangular electric furnace of the resistance type that is built of loose brick work.

There are two types of silicon carbide.

01. Silicon **green** grit –It is having 97 % of silicon carbide.
02. Silicon **black** grit –It is having 95 % of silicon carbide.

Pure silicon carbide of green variety is more flexible than the black type. It is also used for grinding dense material where high finish is required.

CUBIC BORON NITRIDE [CBN]

This Grinding Wheels basic foundation is a combination of Boron and Nitrogen. You can grind all magnetic HARDENED HSS, and that includes powered metal and carbon steel.

BOND AND BONDING PROCESS

A bond is an ADHESIVE substance that is employed to hold abrasive grains together in the form of grinding wheels. There are several types of bonds. These bonds are used in either silicon carbide or aluminum oxide. The choice of the bond depends on the accuracy, surface finish and the nature of the grinding operation.

Different grinding wheels are manufactured by mixing hard abrasives with suitable bonds.

The table containing the types of wheels manufactured using different types of bonds and their symbols is given below

Sl.no	Type of bond	Symbol	Grinding wheel
1.	Vitrified	V	Vitrified wheel
2.	Silicate	S	Silicate wheel
3.	Shellac	E	Elastic wheel
4.	Resinoid	B	Resinoid wheel
5.	Rubber	R	Vulcanized wheel
6.	Oxychloride	O	Oxychloride wheel

VITRIFIED BONDING PROCESS

The majority of the grinding wheels are used in engineering industries are VITRIFIED BOND. The clay and abrasive grains are thoroughly mixed together with sufficient water to make the mixture uniformly. The fluid mixture is poured in to the moulds, and allowed to dry. When it is dried to point it can be handled, the material is cut or trimmed to make perfect size and shape.

Vitrified bond gives a good strength as well as porosity to remove high stock material with cool cutting. About 75 % of wheels are manufactured with this bond. Water, acids, or ordinary temperature changes do not affect it, and it is free from hard or soft spots. A Vitrified bonded wheel is denoted by latter "V".

SILICATE BONDING PROCESS

Mixing abrasive grains with silicate of soda or water glass makes silicate wheels. The mixture is packed into the moulds and allowed to dry. The molded shapes are then backed in a furnace at a temperature of 260˚ C for several days.

The silicate wheels are used for grinding edge of the tools such as drill, reamer, milling cutter etc. It is less sensitivity to shock and side loads than the vitrified bond wheels. The silicate wheels are waterproof.

The hardness of the silicate bond wheel is governed by the amount of bond material used, and by the amount of pressing. Silicate bond wheels can be made in large diameter than the vitrified bond wheel.

Silicate bond wheels are denoted by letter "S".

SHELLAC BONDING PROCESS

Shellac bonded wheels are also called as ELASTIC BONDED WHEELS. In this process the abrasive and shellac are mixed in heated containers and then rolled or pressed in heated moulds. Latter the shapes are backed a few hours at temperatures of approximately 150˚C. The elasticity of this bond is greater than in other types of bond. And it is considerable strength. It is intended for heavy duty work. Shellac bond is cool cutting on handed steel and also on thin section. It is used for finishing chilled iron, cast iron and steel rules, and for jobs where a high luster finish is required.

It is denoted by the latter "E".

RESINOID BONDING PROCESS

Resinoid wheels are produced by mixing abrasive grains with synthetic resins and other compounds; the mixture is placed in moulds and heated about 200˚ C at this temperature the resin sets to hold the abrasive grains to form the wheel.

Resinoid bonded wheels are used for rough grinding. The temperature produces during grinding is less than vitrified bond wheels. The wheels bonded with synthetic resins such as Bakelite and reedman are used, which require a strong free high-speed wheels. They can remove the stock material very rapidly. It is denoted by latter "B".

RUBBER BONDING PROCESS

Rubber bonded wheels are prepared by mixing abrasive grains with pure rubber & Sulphur, the mixture is rolled into sheets and wheels are by punched out of the sheet

on a punch press. The rubber-bonded wheels are also called as CUT-OFF wheels. Rubber bonded wheels are more resilient less heat resistance, and denser than resinoid bonded wheels they generate more heat on the job than vitrified bond wheels, if the long wheels are stored long time the strength of the bond decreases. A rubber-bonded wheel is denoted by letter "R".

OXY - CHLORIDE BONDING PROCESS

This process consists of mixing abrasive grains with oxide and chloride of magnesium. The mixing of bond and abrasive is performed in the same way as for vitrified bonded wheels. This type of organic bond is used particularly for disc grinding. They are less brittle and less sensitive to side loads than vitrified bond wheels.

The oxy chloride bonded wheel is denoted by the letter "O".

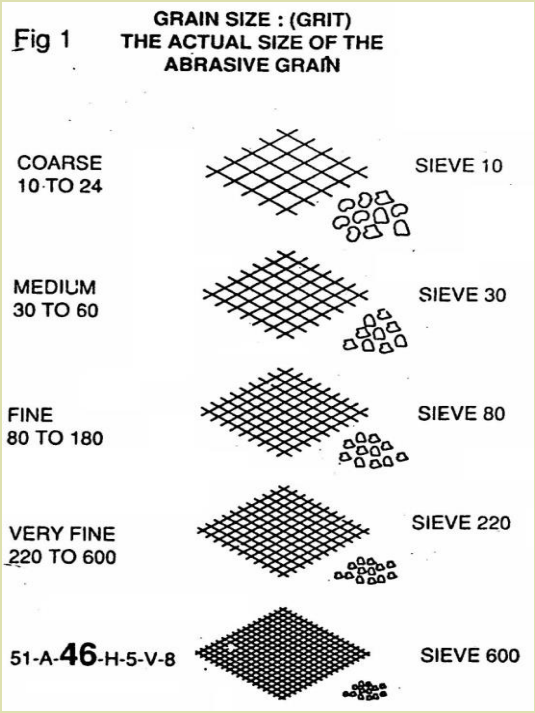
GRAIN SIZE (GRIT)

The grinding wheel is made up of thousands of abrasive grains. The grain size or grit number indicates the size of the abrasive grains used in making a wheel, or the size of the cutting teeth. Grain size is denoted by a number indicating the number of meshes per linear inch of the screen through which the grains pass when they are graded. There are four different groups of the grain size namely coarse, medium, fine and very fine. If the grit number is large, the size of the abrasive is fine and a small grit number indicates a large grain of abrasive.

Very coarse	6	8	10	12	14
Coarse	16	20	24	30	-
Medium	36	46	54	60	-
Fine	80	90	100	120	-
Very fine	150	180	220	240	-
Super fine	250	320	400	500	600

The coarse grit size is used for heavy material removed and less surface finish required and finer grit are used for less material removal and good surface finish recommended grain size for various surface finish.

Grain Size	**Surface finish**
48	0.8 micron
54	0.6 to 0.8
60	0.4 to 0.6
80	0.2 to 0.4
80 to 200 & finer	0.05 to 0.2



GRADE

This is frequently referred to as the hardness of the wheel with which the wheel holds the abrasive grains in place. It does not refer to the hardness of the abrasive grains. The abrasive grains in the grinding wheel are bonded together by the bonding agent. The bond must hold the abrasive grains completely.

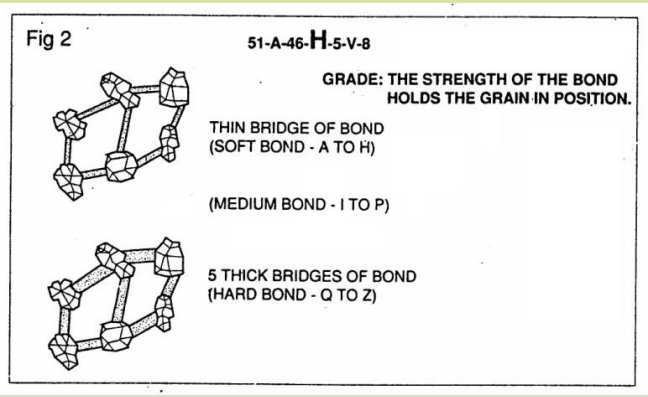
The grains break off by increasing cutting force, the force holds the grain in a place it denotes the hardness of the wheel. The term ‘soft’ or ‘hard’ refers to the resistance a bond offers to disruption of the abrasives. A wheel from which the abrasive grains can easily be dislodged is called soft whereas the one, which holds the grains more securely is called Hard.

Harder grade wheels are used for heavy stock removal and precision grinding. They are also used when the area of contact of the wheel with the work piece is

small. Softer grade wheels are used for hard materials and light stock removal.

The hardness of grinding wheels has been classified as very soft, soft, medium, hard, and very hard. Grade is denoted by alphabets A to Z.

Very soft	A	B	C	D	E	F	G
Soft	H	I	J	K	-	-	-
Medium	L	M	N	O	-	-	-
Hard	P	Q	R	S	-	-	-
Very hard	T	U	V	W	X	Y	Z



STRUCTURE

The relative spacing occupied by the abrasives and the bond is referred to as structure. The structure indicates the density or opens of the abrasive grain spacing, depending up on the structure of the grinding wheels are divided into compact, semi compact & porous groups. Open structured wheels in which there are few grains per unit volume are used for high stock removal, close or dense structured wheels are used for precision work. The structure is represented by number ranging from 0 to

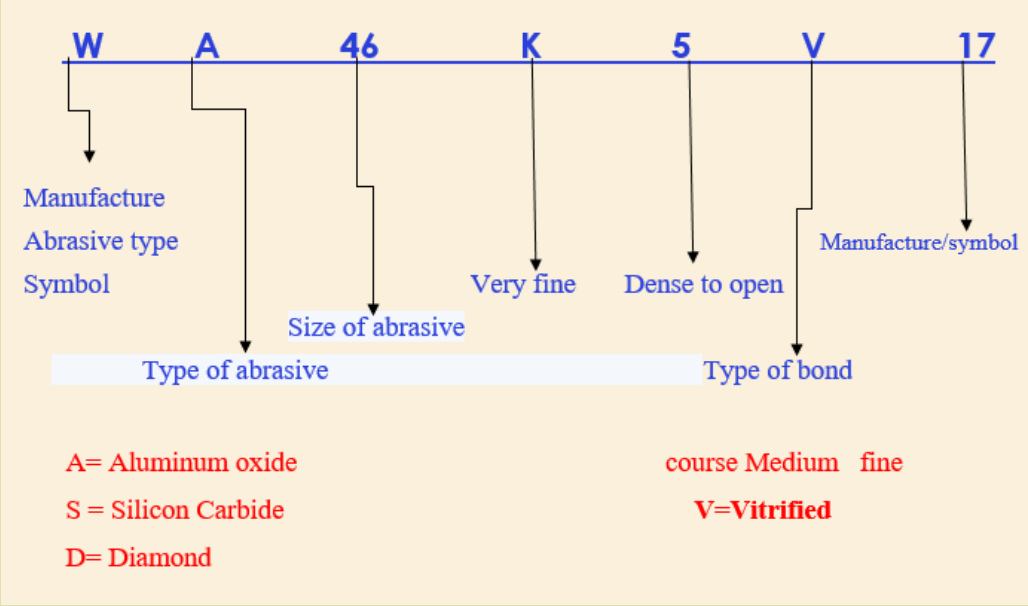
15 the lower number indicating a dense structure &higher numbers an open structure. An open structured wheel will cut more freely. That is, it will remove more metal in a given time and produce less heat. It will not produce such a good finish as a close structured wheel.

DENSE **OPEN**

0 1 2 3 4 5 6 7 8 9 10 12 13 14 15

Standard marking system of grinding wheels

The Indian standard marking system for grinding wheels has been prepared with a view of establishing a uniform system of marking of grinding wheels to designate their various characteristics.



02: Example: 51 A 36 L 8 V 23

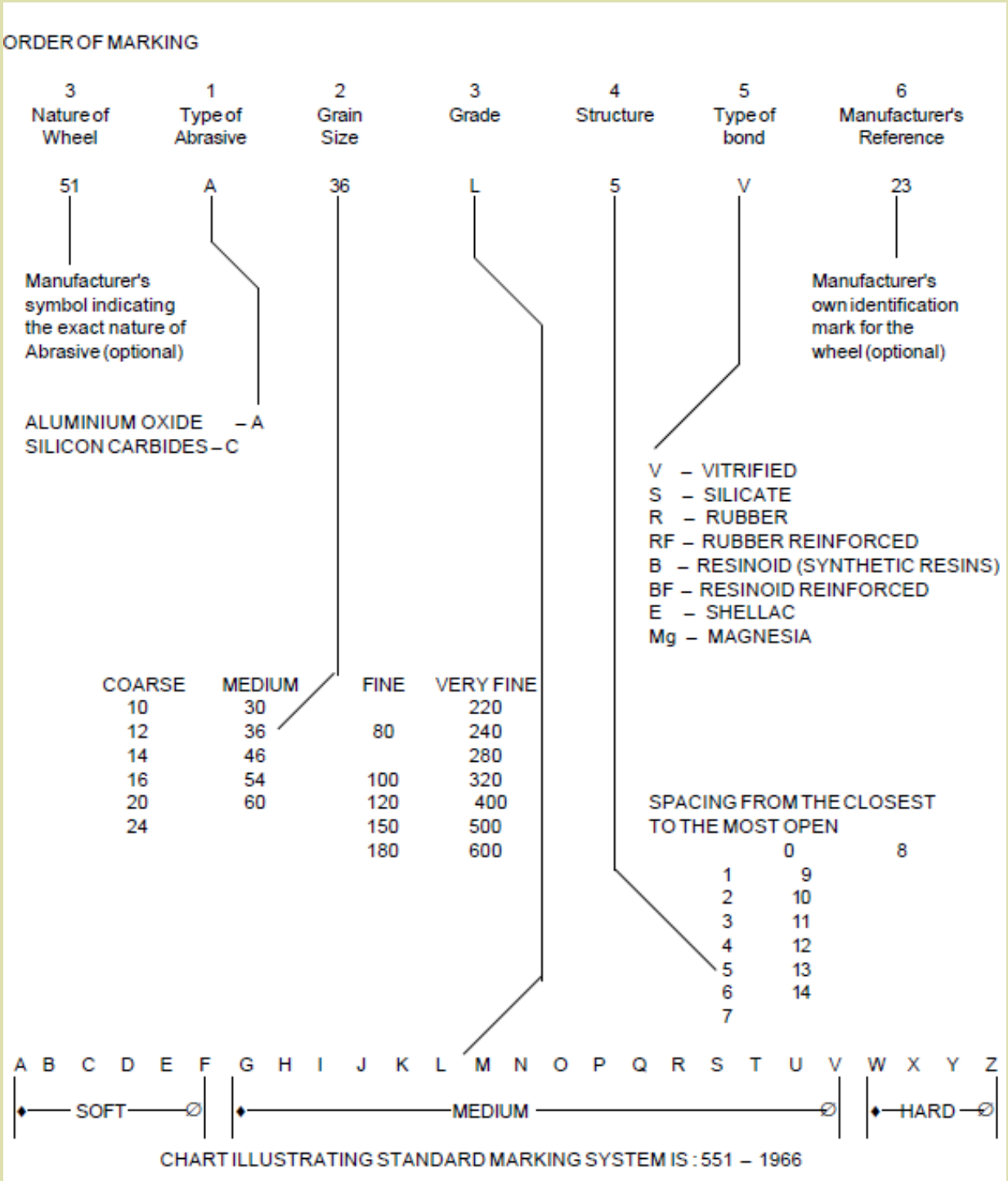


CHART ILLUSTRATING STANDARD MARKING SYSTEM IS : 551 – 1966

Specification of grinding wheels

A grinding wheel is specified by the

- Standard wheel markings
- Diameter of the wheel
- Thickness of the wheel
- Bore diameter of the wheel
- Type (shape) of the wheel.

Example:

32 A46 H8V

250 x 20 x 32

Straight wheel

UNIT 4 - WHEEL SELECTION

Manufactures to provide through their published literature information on the selection and use of grinding wheels but it may not always be possible or convenient for uses to take advantage of such consultative service.

In selecting a grinding wheel there are four constant factor and variable factor as follows.

CONSTANT FACTOR

01. Material to be ground.
02. Amount of stock to be removed.
03. Area of the contact.
04. Type of grinding machine

MATERIAL TO BE GROUND

This influence the selection of Abrasive, Grain size, Grade, Structure, Bond,

- Aluminum oxide abrasive recommended for materials of high tensile strength and silicon carbide for low tensile strength.
- Fine grin is used for hard and brittle material a coarse grain for soft, ductile material.
- Hard wheel is used for soft material grinding.
- Soft wheel is used for hard material grinding.
- Generally close spacing is required for hard and brittle materials.
- Generally wide spacing is required for soft and ductile material.

AMOUNT OF STOCK TO BE REMOVED

This involves accuracy and finish of the work piece. Coarse grain is used for fast cutting & fine grain is used for finishing, wide spacing for rapid removal and close finishing where required.

AREA OF CONTACT

Area of contact influences the selection of grit size, grade size, and structure. Fine grain and close grain spacing are use full where the area of contact is small and coarse grain and spacing is employed where a large area of contact concerned.

TYPE OF GRINDING MACHINE

Heavy rigidly constructed machine are takes softer wheels then the lighter more flexible types.

VARIABLE FACTOR

01. Wheel speed. 02. Work Speed. 03. Condition of the machine. 04. Personal factor.

WHEEL SPEED

The wheel speed influences the selection of grade and bond. The higher wheel speed with relation to work speed, the softer the wheel should be vitrified bond is usually specific speed for up to 2000 S.M.P.M and rubber, shellac and resionoid bond wheel for speed over or above 2000 S.M.P.M.

WORK SPEED

The work speed with relation to the wheel speed determines the hardness of the wheel. The variable work speed is after provided on grinding machine to preserve the proper relative surface speed between the work and wheel, as the wheel diameter decreases because of wear.

CONDITION OF THE GRINDING MACHINE

The condition of grinding machine has a bearing on the grade of the wheel to be selected. The spindle loose in their bearing and insecure or shaky foundations would necessary the use of harder wheels than would be the case if the machine was in better operating condition.

PERSONAL FACTOR

The skill of the worker is another variable factor, which should be considered in selecting the wheel.

UNIT 5- WHEEL SHAPES AND APPLICATIONS

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.

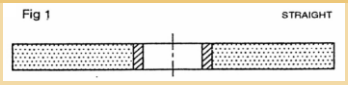
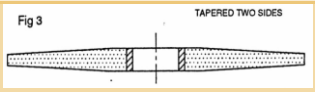
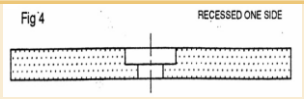
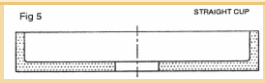
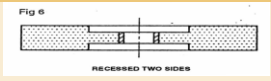
Mounting Work piece for Tool and Cutter Grinding:

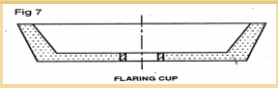
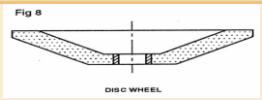
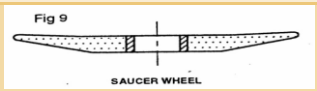
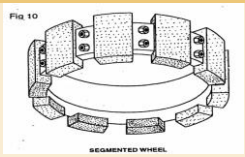
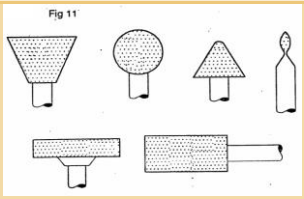
- A work piece for tool and cutter grinding is usually held between centers or on a fixture clamped to the table.
- The work piece is mounted in the same manner as for cylindrical grinding, except the lathe dog if not used
- When a fixture is used, the work piece is placed in the fixture and the fixture is clamped to the table.

GRINDING SHAPES AND SIZES

Grinding wheel is manufactured in various standard shapes. The shape of wheel is standardized so that they can use commonly in production and tool room grinding. The standard grinding shapes and size are as follows.

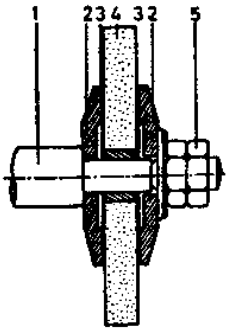
Grinding wheels are made in different shapes and sizes for grinding different jobs and for use in different machines. The size may differ in diameter, face width and bore dia.

SHAPE		APPLICATION
Straight Wheel		This type of wheel is used on cylindrical, surface and center less grinders for grinding cylindrical and flat surfaces. Sometimes this type of wheel is used on rough grinders for offhand grinding.
Cylinder Type		This type of wheel is used on both horizontal and vertical spindle surface grinders for the surface grinding operations
Tapered Two Sides		It is mainly used for rough grinding. The tapered sides reduce the chance of breaking
Recessed one Side		It is used for cylindrical, surface and center less grinding. The recess provides clearance for the flange
Straight cup:		It is used on surface grinders and on tool and cl grinders to grind flat surfaces.
Recessed both sides		Used on cylindrical, surface and center less grinders. T recesses provide clearance for both flanges.

Flaring cup		It is used on tool and cutter grinders mainly to sharps milling cutters and reamers.
Dish Type		Used on tool and cutter grinders to sharpen milling cutters with narrow slots like formed relieved cutters, hobs etc.
Saucer Type		It is used for sharpening circular and hand saws. It is also used for gashing milling cutter teeth.
Segmented wheels		This type of wheels is formed by holding segments of abrasives using a metal holder. This is mainly used on a vertical spindle surface grinder
Mounted wheels		These are wheels with less than 50 mm dia. formed on a steel shank to various shapes. Mounted wheels are mainly used for die grinding, de burring and for finishing operations. Used on pneumatic or electric grinders.

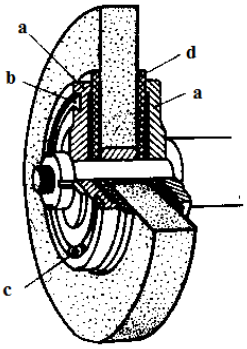
UNIT 6- WHEEL MOUNTING & SAFETY PRECAUTIONS

Great care must be taken in mounting the grinding wheels on the spindle because of high cutting speeds. The following points are important in connection with mounting of grinding wheel.

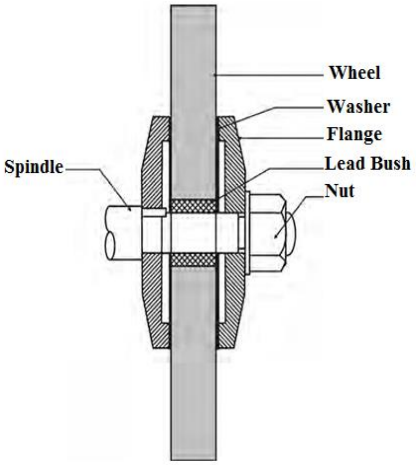


Mounting the Grinding Wheel

1. Spindle, 2. Flange,
3. Intermediate layer,
4. Wheel, 5. Screwed joint



Mounting of the grinding wheel. a) Clamping flange. b) Circular Groove. c) Counter Balance. D) Cardboard Packing felt or Leather.



1. Before mounting the grinding wheel into the spindle of the machine, the grinding wheel must be checked by **RINGING TEST**. The grinding wheel is fix in the arbor; while it is subjected to the slight hammer blows on the grinding wheel. A clear ringing vibrating sound can be heard, and then the grinding wheel is OK. If the ringing sound is dull, the grinding wheel has some cracks.
2. The abrasive wheels should have an easy fit on their spindle. They should not force on it.

3. The hole of grinding wheel mostly lined with lead. The liner bush should not project outside of the wheel.
4. The both flange diameter must be equal to the half of the grinding wheel diameter. Both the flanges should be of the same diameter otherwise the wheel is break down.
5. Both the flanges should be clamped perfectly flat & bear evenly all around the wheel.
6. All flanges must be relived in the center so that the flanges contact the wheel only with the annular clamping area. If they are not properly relived the pressure of the flange is concentrated to the hole side.
7. The nut should be tightened to hold the wheel firmly.
8. The wheel guard should be closed before the machine is started for work.
9. After mounting of the wheel the grinding machines run idle for a period of about 10 to 14 min.
10. The grinding wheel must be dressed and trued.

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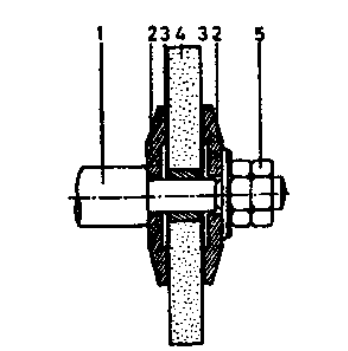
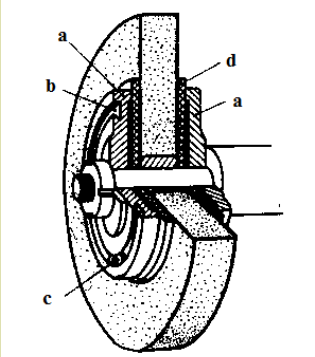
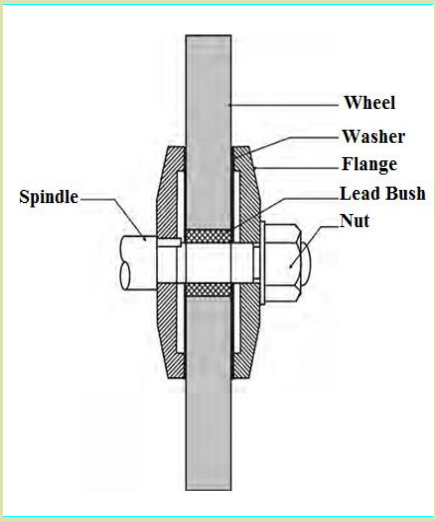


Mounting the Grinding Wheel

1. Spindle, 2. Flange,
3. Intermediate layer,
4. Wheel, 5. Screwed joint



Mounting of the grinding wheel. a) Clamping flange. b) Circular Groove. c) Counter Balance. D) Cardboard Packing felt or Leather.



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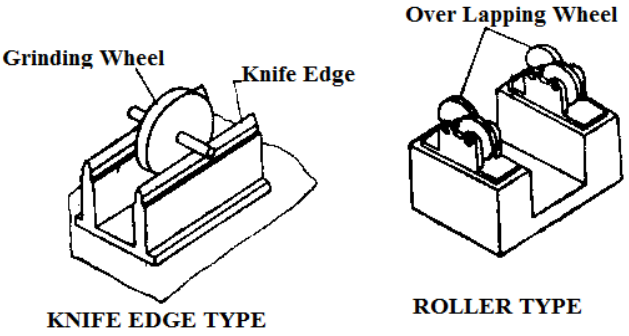
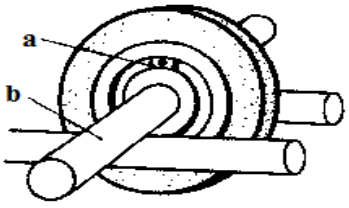
UNIT 8- GRINDING WHEEL BALANCING



WHEEL BALANCING STANDS



Balancing of Grinding Wheel
a) Counter Balance. b) Test Mandrel
The counter balance are shiftable in the circular groove and can be fixed with screws.

Grinding wheel balancing

- Vibration in grinding operation is critical from the point of view of wheel life and surface finish on the job.
- Assuming that the machine is rigid and the bearing are in good condition. Vibrations to a large extent are caused by out of balance.
- Since the grinding wheel speeds are high slight out of balance condition may give rise to large force.
- This may result in excessive vibration, poor surface finish, and faster wheel break down and may be dangerous to the operator.
- Therefore, particular attention should be given or paid to balancing of wheels.
- Generally balancing weights are provided on the flange of the grinding wheels. By mounting the wheel on a static balance stand and it is equipped with two rollers or pairs of over lapping disk the wheel is brought to static balance by moving the weights.

- Then it is mounted on the grinding machine and dressed to concentricity.
- It is once again removed from the machine and rebalanced and checks the concentricity then it can be used for grinding and gets better results. The wheel can be dynamically balanced while it is running on the machine.

Glazing

After regular use the wheel becomes dull or "glazed", glazing which the face or cutting edge takes on a glasslike appearance. This happens the abrasive grains wear away faster than the bond that holds them together.

That is the cutting point of the abrasive have become dull and the worn down to the bond, continued work of the wheel that glazes increases the smoothness of the wheel face and decreases its cutting capacity.

Glazings take place when a wheel is too hard or revolves at too fast or speed. The remedy for glazing is to decrease the speed or to use a softer wheel.

LOADING

The wheel may also become "loaded". The cutting face of the loaded wheel has particles of the metal being ground adhering to it, the operations or pores of the wheel face having filled with metal, thus preventing the wheel from cutting freely, loading may be caused by grinding a soft metal or by using a wheel of too hard a bond and running it to slowly &by not using the right type of coolant.

The remedy for loading is to run the wheel at higher speed or use of the softer wheel.

Truing and dressing

Truing means removal of abrasive metal from the cutting face of the grinding wheel and side of the wheel, so that the wheel runs true with respect to the axis of the rotation. Truing and dressing is done in same tool but not same purpose. The truing feed rate must not exceed 0.02mm otherwise grooves may be cut into the wheel.

Chattering

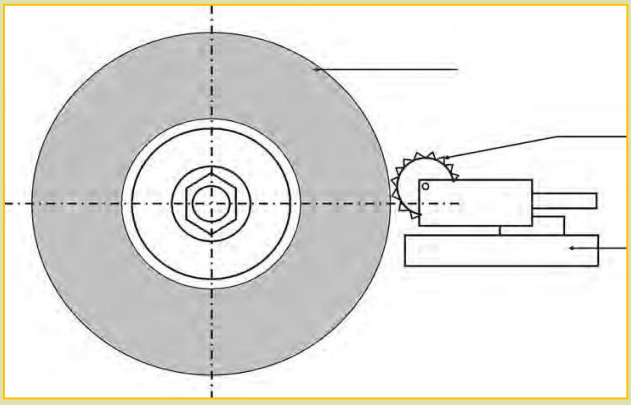
The wavy pattern of crisscross lines is visible on the ground surface some times. This condition is known as chattering. It takes place when the spindle bearings are not fitted correctly and because of the imbalance of the grinding wheel.

UNIT 9- WHEEL DRESSING

Dressing

Dressing involves removing the worn out grains from the surface of the wheel, removing loaded materials from the face of wheel, and restoring the original geometric shape and to form a specific profile and process of breaking away the glazed surface so that sharp particles are again presented to the work. The common types of wheel dressers known as "**Star" -dressers** and **diamond tool dressers** are used for this purpose.

A star dresser consists of a number of hardened steel wheels on its periphery. The dresser is held against the face of the revolving wheel and moved across the face to dress the wheel surface. This type of dresser is used particularly for coarse and rough grinding wheels. Fig. 4.8 shows dressing by a star wheel dresser.

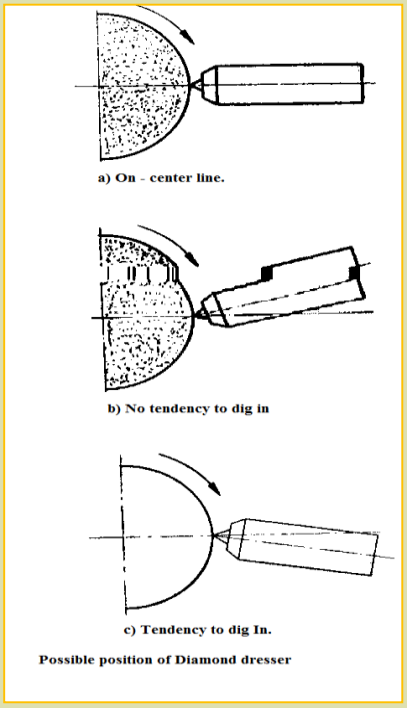


Dressing of a grinding wheel (Star wheel method)

SINGLE POINT DIAMOND DRESSER

This is used to dressing wheels for precision type operation like surface grinding, cylindrical grinding, center less grinding, internal grinding, thread grinding etc. And Small industrial diamond is known as BORT.

The diamond dressing can be done by tilting or slanting the holder down at an angle of 15 degrees and dressed against surface of wheel, A good supply of coolant should be used when dressing with a diamond, as overheating can cause the diamond to fracture it setting. Very light cut is given with diamond dresser normally depth of cut is 0.02 to 0.05 mm is used.



Possible position of Diamond dresser

DEFECTS IN SINGLE POINT DIAMOND DRESSER

01. If traverse feed not more than grain size, then dressing causes lot of wear.

02. Angle at which dresser is held to wheel is dependent upon cutting edge of a

Diamond.

03. Truing can be done in one direction only.

The choice of the dressing method depends on the application.

METAL CRUSHERS: Metal crushers generally used to dress for rough operations.

ABRASIVE STICKS: The abrasive stick dresser comes in two shapes: square for hand use, and round for mechanical use. It is often used instead of the more expensive diamond dresser for dressing shaped and form wheels. It is also used for general grinding wheel dressing.

ABRASIVE WHEELS: The abrasive wheel dresser is a bonded silicon carbide wheel that is fastened to the machine table at a slight angle to the grinding wheel and driven by contact with the wheel. This dresser produces a smooth, clean-cutting face that leaves no dressing marks on the work.

SIX POINT DRESSER: Over comes all the above defects and has long life as compared to single point dresser. The middle diamond acts as roughing tool and the other two for finishing. When above three diamonds wear out then bottom three starts working.

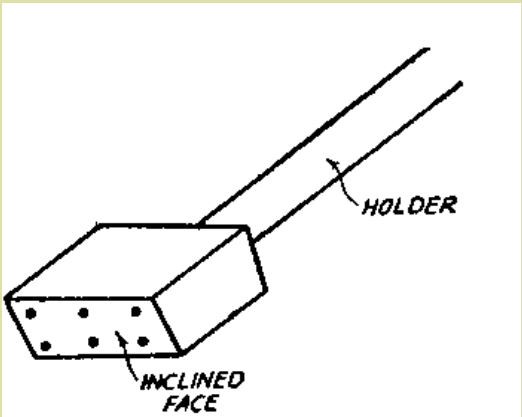


Fig. 20.12

UNIT 10- CUTTING SPEED, FEED & DEPTH OF CUT

CUTTING SPEED:

Cutting speed of a grinding process is the relative speed of the grinding wheel and the work piece. It is expressed in m/sec.

The cutting speed of the wheel is expressed as

Cutting speed (C.S) = $\pi dn/1000$ = _____per sec

Where:

'd'- the diameter of the grinding wheel in mm, and

'n'- the speed of the grinding wheel in r.p.s.

FEED:

Feed in a grinding process is the longitudinal movement of the work mounted on the table per revolution of the grinding wheel. It is expressed in mm per revolution. The longitudinal feed during rough grinding is approximately 0.6 to 0.9 of the width of the wheel and 0.4 to 0.6 of the width of the wheel during finish grinding.

DEPTH OF CUT:

The thickness of the metal layer removed from the work in one pass of the wheel is known as depth of cut. It is expressed in mm. Depth of cut is kept ranging from 0.005 to 0.04mm.

Grinding Operations Work Speed for Cylindrical Grinding

In cylindrical grinding, it is difficult to recommend any work speeds since these are dependent upon whether the material is rigid enough to hold its shape, whether the diameter of the work piece is large or small, and so forth. Listed below are areas to consider when performing cylindrical grinding:

- The larger the diameter of the work piece, the greater is its arc of contact with the wheel.
- The cutting speed suitable for one diameter of work piece might be unsuitable for another.
- The highest work speed that the machine and wheel will stand should be used for roughing.
- Higher work speeds increase the cutting action of the wheel and may ‘indicate that a harder wheel and a smaller depth of cut be used to reduce wheel wear.
- The following cylindrical work speeds are only typical:

  - ✓ Steel shafts, 50 to 55 FPM
  - ✓ Hard steel rolls, 80 to 85 FPM
  - ✓ Chilled iron rolls, 80 to 200 FPM
  - ✓ Cast iron pistons, 150 to 400 FPM
  - ✓ Crankshaft bearings, 45 to 50 FPM
  - ✓ Crankshaft pins, 35 to 40 FPM

Work Speed for Surface Grinding

Surface grinding machines usually have fixed work speeds of approximately 50 SFPM or have variable work speed ranges between 0 and 80 SFPM. As with cylindrical grinding, the higher work speeds mean that more material is being cut per surface foot of wheel rotation and therefore more wear is liable to occur on the wheel.

UNIT 11- CUTTING FLUIDS DURING GRINDING

WET AND DRY GRINDING

In wet grinding a coolant is used over the work and wheel face & sides. This coolant dissipates the heat about 2000˚C generated during grinding to promote long life of wheel, and to wash away burrs.

In dry grinding two undesirable effects will Occur-Discoloration and burring. Discoloration is indication of heat generated during cutting and burring indicates the skin hardening, which affects the machinability. Dry grinding cannot eliminate burring.

USE OF CUTTING FLUIDS DURING GRINDING:

Application of a cutting fluid is very important in a grinding operation. The cutting fluid should be applied in adequate quantity and at very low pressure. The cutting fluid should be directed on the work just above the point where it makes contact with the wheel is. Contact zone.

The sparks (glowing metal chips) flying off while grinding, indicate that the friction between the work piece and grinding wheel creates high temperature. The heat is transmitted to the grinding wheel and the work piece. The wheel may blast by excessive heating. The work piece may warp, hardened pieces may lose hardness. Annealing colors on the work piece are a definite sign of overheating.

In order to dissipate the heat, cooling is necessary. The coolant, which simultaneously washes the grinding chips, must flood the grinding area with a strong

jet. Water with an addition on of 5% soda or grinding emulsion is used as coolant. As a rule, steels are ground wet and cast iron is ground dry.

Advantages of cutting fluid

- It removes the heat generated.
- It improves the surface finish of the work piece.
- It maintains the hardness of the heat-treated works.
- It removes burn marks on the ground surface.
- It washes away the metal chips and discharged abrasive grains.
- It keeps the grinding wheel face clean.
- It acts as a lubricant for the work piece and the moving parts of the machine and prevents rust formation.
- It controls the grinding dust from flying around which may present a health hazard.

Recommended cutting fluids

Soluble mineral oil and pure water are mixed in the ratio of 1:40 or 50 (depending upon the grinding wheel) and is used for grinding the following materials.

- Cast iron or hardened steel
- Soft steel
- Connected carbide tools (using silicon wheel)

In India we use IOC Servo cut oils as cutting fluid.

There is special grade oil manufactured by IOC for grinding alone. It is called Servo cut - clear.

Important points to be noted while using cutting fluids

- Always add pure water to soluble oils.
- Always the coolant should be kept clean. Periodically clean the coolant tank.
- Do not allow soluble oil to mix with other oils.
- Always mix water to the oil in correct proportion and not oil to the water.
- It should be kept cool under normal temperature.
- Use suitable splash guard so that the operator is protected from the splash of the fluid.

Types of lubricants used for grinding based on work piece material

Work piece material	**Lubricant**
Aluminum	Heavy duty oil
Brass	Light duty oil
Cast iron	Heavy duty emulsifiable oil, light duty chemical and synthetic oil
Mild steel	Heavy duty water-soluble oil
Stainless steel	Heavy duty emulsifiable oil, heavy duty chemical and synthetic oil
Plastics	Water-soluble oil, dry, heavy duty emulsifiable oil, light duty chemical and synthetic oil

UNIT 12- ELECTRICAL DISCHARGE MACHINE {E.D.M.}

HISTORY OF EDM MACHINE

Two Russian scientists, B. R. Butinzky and N. I. Lazarenko, were tasked in 1943 to investigate ways of preventing the erosion of tungsten electrical contacts due to sparking. They failed in this task but found that the erosion was more precisely controlled if the electrodes were immersed in a dielectric fluid. This led them to invent an EDM machine used for working difficult-to-machine materials such as tungsten. The Lazarenkos' machine is known as an R-C-type machine, after the resistor–capacitor circuit (RC circuit) used to charge the electrodes.

Simultaneously but independently, an American team, Harold Stark, Victor Harding, and Jack Beaver, developed an EDM machine for removing broken drills and taps from aluminum castings from feeble electric-etching tools,

Electrical Discharge Machining (EDM)

Is the process of machining electrically conductive materials by using precisely controlled sparks that occur between an electrode and a work piece in the presence of a dielectric fluid? The electrode may be considered the cutting tool.

Figure 1-1 illustrates the basic components of the EDM process.

Die-sinking (also known as ram) type EDM machines require the electrode to be machined in the exact opposite shape as the one in the work piece.

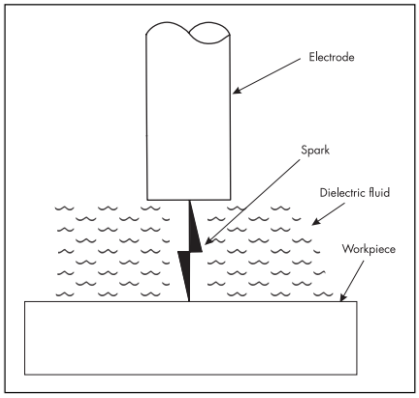


Figure 1-1. Basic components of EDM.

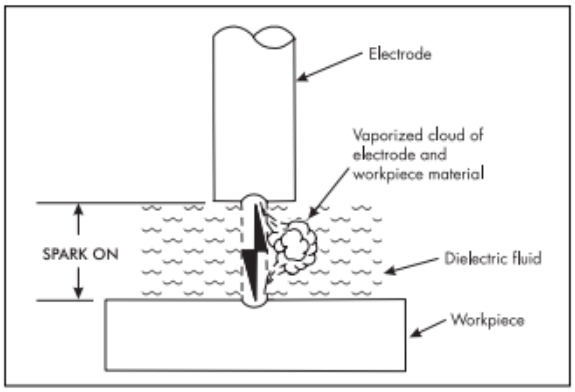


Figure 1-5. Spark ON: electrode and workpiece material vaporized.

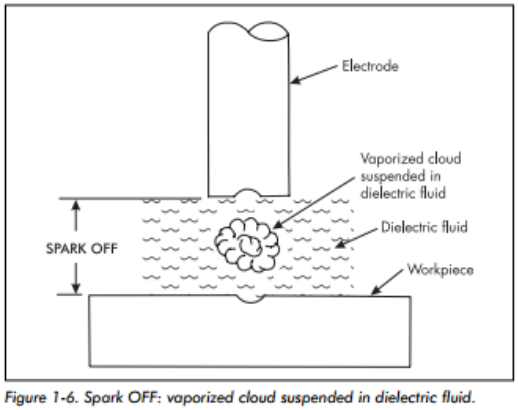


Figure 1-6. Spark OFF: vaporized cloud suspended in dielectric fluid.

WORKING PRINCIPAL OF EDM MACHINE

When the voltage between the two electrodes is increased, the intensity of the electric field in the volume between the electrodes becomes greater than the strength of the dielectric which breaks down, allowing current to flow between the two electrodes. As a result, material is removed from the electrodes. Once the current stops, new liquid

dielectric is usually conveyed into the inter-electrode volume, enabling the solid particles (debris) to be carried away and the insulating properties of the dielectric to be restored. Adding new liquid dielectric in the inter-electrode volume is commonly referred to as "flushing." Also, after a current flow, the difference of potential between the electrodes is restored to what it was before the breakdown, so that a new liquid dielectric breakdown can occur.

ELECTRODES USED IN EDM

1. Complex shapes that would otherwise be difficult to produce with conventional cutting tools.
2. Extremely hard material to very close tolerances.
3. Very small work pieces where conventional cutting tools may damage the part from excess cutting tool pressure.
4. There is no direct contact between tool and work piece. Therefore, delicate sections and weak materials can be machined without perceivable distortion.
5. A good surface finish can be obtained; a very good surface may be obtained by redundant finishing paths.

Disadvantages of EDM include

- The slow rate of material removal.
- Potential fire hazard associated with use of combustible oil based dielectrics.
- The additional time and cost used for creating electrodes for ram/sinker EDM.
- Reproducing sharp corners on the work piece is difficult due to electrode wear.
- Specific power consumption is very high.

- Power consumption is high.
- "Overcut" is formed.
- Excessive tool wear occurs during machining.
- Electrically non-conductive materials can be machined only with specific set-up of the process

Dielectric Fluids

During the EDM process the work piece and the electrode are submerged in the dielectric oil, which is an electrical insulator that helps to control the arc discharge. The dielectric oil, that provides a means of flushing, is pumped through the arc gap. This removes suspended particles of work piece material and electrode from the work cavity.

Flushing

One of the most important factors in a successful EDM operation is the removal of the metal particles (chips) from the working gap. Flushing these particles out of the gap between the work piece to prevent them from forming bridges that cause short circuits.

Flushing Ram Type EDM

- Flushing is the most important function in any electrical discharge machining operation.
- Flushing is the process of introducing clean filtered dielectric fluid into the spark gap.
- Flushing applied incorrectly can result in erratic cutting and poor machining conditions.

There are a number of flushing methods used to remove the metal particles efficiently while assisting in the machining process. Too much fluid pressure will remove the chips before they can assist in the cutting action, resulting in slower metal removal. Too little pressure will not remove the chips quickly enough and may result in short-circuiting the erosion process

Wire EDM Dielectric Fluids

The dielectric fluid must be circulated under constant pressure to flush (wash) away the metal particles and assist in the machining or erosion process. If red sparks occur during the 3cutting operation, the water supply is inadequate. To overcome this problem, increase the flow of water until blue sparks appear.

The Servo Mechanism

Both wire and vertical EDM machines are equipped with a servo control mechanism that automatically maintains a constant gap of about the thickness of a human hair between the electrode and the work piece. It is important for both machine types that there is no physical contact between the electrode and the work piece, otherwise arcing could damage the work piece and break the wire.

The servomechanism advances the electrode into the work piece as the operation progresses and senses the work-wire spacing and controls it to maintain the proper arc gap which is essential to a successful machining operation.

UNIT 13- JIG GRINDING

Jig Grinding is a specialty process that allows us to grind complex geometrical shapes in our tools with extremely high precision and accuracy. Jig boring is a similar specialty machining process that allows toolmakers to produce precision holes on tools and dies with a high degree of positioning and size accuracy.

The machine operates by a high speed air spindle rotating a grinding bit. The air spindles are removable and interchangeable to achieve varying surface speeds. Some spindles are fixed speed (60000 rpm), others are adjustable (30000-50000 rpm), and still others are very high speed (175000 rpm). The machines have a standard X-Y table with the notable exception of knee travel. All axes are indexed to .0001" via a vernier scale on the hand wheels, with higher accuracy available with the use of measuring bars. The machine head has two vertical travels, one rough head adjustment and the

other a precise spindle adjustment. The spindle to which the detachable air spindle mounts also rotates at a variable speed and can typically out feed .100" while running, again with an accuracy of .0001" on the hand wheel or greater, for very precise hole, peg and surface grinding. A well-kept jig grinder will reliably position work to a higher degree of accuracy than is possible with hand wheels alone. These features are all critical in positioning a hole and peg system a precise distance from a reference surface or edge.

The most important factor on a jig grinder is the dual-spindle configuration. The main spindle is roughly positioned with between 1" or 2" of travel for setup, and then the .100" of out feed is used during machine operation to out feed into the work. A spacer bar may be used between the grinder and main spindle, allowing large (9" radius or larger) work to be completed. The main spindle has a wide range of speeds to ensure proper grinder feed rates are maintained.