Manufacturing Science

Metal Grinding

INFO@AMIESTUDYCIRCLE.COM

WHATSAPP/CALL: 9412903929

Metal Grinding

Grinding wheels consist of abrasive particles bonded by some other substance, which may be anything from rubber to a kind of glass. The bond is meant to fail. As a particle becomes worn, the drag on it increases and friction makes it hotter, just as a plane with a dull blade requires more force than one with a sharp blade. The increased drag either fractures the particle, exposing a new cutting edge, or tears the worn particle out of the wheel, exposing fresh abrasive grains with unused cutting edges. The bonding should be such that, under the conditions in which the wheel is meant to be used, worn particles come out and unworn ones don't. The grade of a grinding wheel (hard, soft) refers to the tenacity with which the particles of grit are held, not to the hardness of the abrasive particles themselves.

DIFFERENCE BETWEEN MACHINING AND GRINDING

- Machining is primarily a bulk removal process. It can also semi-finish the surfaces. While the grinding is primarily a surface finishing process. It gives a low **MRR**.
- Machining is dimensional accuracy and tolerance achieved by these processes is not very good. While the Grinding offers better dimensional accuracy and close tolerance
- Each and every cutting edge of the cutter equally participates in cutting action during machining. It is value. While the Grinding only a few among all of the abrasives available at the periphery of the wheel participate in cutting action
- Machining shearing occurs during the process, while the Grinding operation is associated with rubbing, scratching, ploughing, and also shearing
- In Machining every employs a cutting tool for removing material. This cutting tool is commonly made of metal, while the Grinding employs a wheel for removing materials, The wheel is made of tiny sharp abrasives bonded in other mediums
- Machining is a specific energy consumption is comparatively low, while the Grinding is due to high loss of energy because of rubbing, scratching, and the specific energy consumption is very high.
- Machining are hardened material and inherently very brittle and tough materials cannot be smoothy machined by these processes, while the Grinding is hardness, ductility, and toughness of work materials usually posses no problem.

ABRASIVES USED IN GRINDING WHEELS

Aluminium oxide

Aluminium oxide is the most common abrasive used in grinding wheels. It is usually the abrasive chosen for grinding carbon steel, alloy steel, high speed steel, annealed malleable iron, wrought iron, and bronzes and similar metals. There are many different types of aluminium oxide abrasives, each specially made and blended for particular types of grinding jobs. Each abrasive type carries its own designation-usually a combination of a letter and a number. These designations vary by manufacturer.

Zirconia alumina

Zirconia alumina is another family of abrasives, each one made from a different percentage of aluminium oxide and zirconium oxide. The combination results in a tough, durable abrasive that works well in rough grinding applications, such as cut-off operations, on a broad range of steels and steel alloys. As with aluminium oxide, there are several different types of zirconia alumina from which to choose.

Silicon carbide

Silicon carbide is an abrasive used for grinding gray iron, chilled iron, brass, soft bronze and aluminium, as well as stone, rubber and other non-ferrous materials.

Ceramic aluminium

Ceramic aluminium oxide is the newest major development in abrasives. This is a high-purity grain manufactured in a gel sintering process. The result is an abrasive with the ability to fracture at a controlled rate at the sub-micron level, constantly creating thousands of new cutting points. This abrasive is exceptionally hard and strong. It is primarily used for precision grinding in demanding applications on steels and alloys that are the most difficult to grind. The abrasive is normally blended in various percentages with other abrasives to optimize its performance for different applications and materials.

CRITERIA OF ABRASIVES FOR GRINDING OPERATION

This choice of right abrasive is to some extent determined by the type of material only to be ground, which will decide whether the abrasive is Silicon Carbide (SiC) or Aluminium Oxide (Al_2O_3) as these are most commonly used abrasives in different varieties. SiC is the best suited abrasive for brittle and hard materials like grey cast iron castings, chilled iron, tungsten carbide, hard steels, stone, porcelain and other ceramic substances.

SiC is also recommended for low tensile strength material such as non-ferrous metals, bronze, brass, copper, aluminium and plastic materials, $A1_2O_3$ is better for tough materials having high tensile strength like mild steel, alloy steel, high speed annealed malleable iron, tough bronze, wrought iron, etc.

TYPES OF BONDS FOR MAKING GRINDING WHEELS

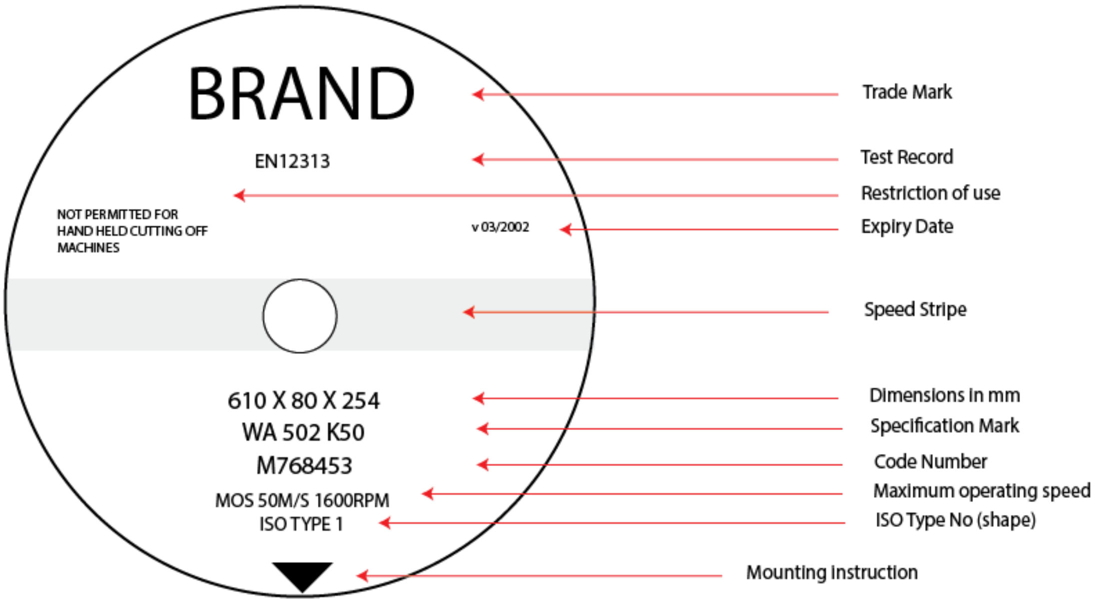
Abrasive grains are held together in a grinding wheel by a bonding material. The bonding material does not cut during grinding operation. Its main function is to hold the grains together with varying degrees of strength. Standard grinding wheel bonds are vitrified, resinoid, silicate, shellac, rubber and metal.

- **Vitrified bond** Vitrified bonds are used on more than 75 percent of all grinding wheels. Vitrified bond material is comprised of finely ground clay and fluxes with which the abrasive is thoroughly mixed. The mixture of bonding agent and abrasive in the form of a wheel is then heated to 1300^0C to fuse the materials. Vitrified wheels are strong and rigid. They retain high strength at elevated temperatures and are practically unaffected by water, oils or acids. One disadvantage is that they exhibit poor shock resistance. Therefore, their application is limited where impact and large temperature differentials occur.

- **Resinoid bond** Resinoid bonded grinding wheels are second in popularity to vitrified wheels. Phenolic resin in powdered or liquid form is mixed with the abrasive grains in a form and cured at about 180^{0}C. Their main use is in rough grinding and cut-off operations.
- **Silicate bond** This bonding material is used when heat generated by grinding must be kept to a minimum. Silicate bonding material releases the abrasive grains more readily than other types of bonding agents. Speed is limited to below 4,500 SFPM.
- **Shellac bond** It's an organic bond used for grinding wheels that produce very smooth finishes on parts such as rolls, cutlery, camshafts and crankpins. Generally, they are not used on heavy-duty grinding operations.
- **Rubber bond** Rubber-bonded wheels are extremely tough and strong. Their principal uses are as thin cut-off wheels and driving wheels in centerless grinding machines. They are used also when extremely fine finishes are required on bearing surfaces.
- **Metal bond** Metal bonds are used primarily as binding agents for diamond abrasives. They are also used in electrolytic grinding where the bond must be electrically conductive.

GRINDING WHEEL SPECIFICATION

All abrasive wheels must conform to the British Standard (BS EN 12413 and BS ISO 525) system for marking. Take a look at the example below which shows each of the essential markings.



The **type** of the wheel is marked as an ISO number and signifies the wheel's shape. For example, ISO Type 52 is a spindle-mounted wheel.

The **size** of the grinding wheel is marked as dimensions in mm. For example, 230 x 3 x 22.2mm. This represents the wheel's diameter x thickness x hole size.

The specification of the grinding wheel is marked as a series of letters and numbers.

Abrasive Material

Two types of material is used for wheel:

- **Natural abrasives:** Natural abrasives include sand stone, diamond, corundum and emery. Diamond abrasive wheels are used sharpening carbide and ceramic cutting tools. They are also used for turning and dressing other types of abrasive wheels. The principal component of corundum and emery is natural aluminium oxide (alumina). Corundum is composed of about 85% aluminium oxide and 75 % iron oxide. Emery contains (10%, aluminium oxide and 40% iron oxide).
- **Artificial abrasives:** They include silicon carbide and aluminium oxide. Silicon carbide is made by heating silica sand, coke, salt and sawdust in an electric furnace at 23000C for hours resulting in a solid mass of silicon carbide. Upon cooling, this mass is removed from the furnace, crushed and graded as per the various sizes obtained. Aluminium oxide abrasive is the crystalline form of aluminium oxide. It is produced in an arc furnace from bauxite, iron filings and coke. The mass of aluminium oxide is obtained which is crushed to the required size and segregated as per size.

Abrasive Grain Size

Abrasive materials are crushed in ball mills and segregated as per size. The selection of size of the abrasive grain required depends upon the following factors:

1. Amount of material to be removed
2. Finish desired
3. Hardness of material being ground

The coarse grit is used for more material removal where as the fine grit is used for small material removal rate. Sizes from 240 to 600 are used for lapping and honing applications.

Bonding

Bonding materials are used to hold the abrasive particles in place. There are six types of bonding material used. They are:

Bonds	Symbol
Vitrified Bonds	V
Resinoid Bonds	B
Shellac Bonds	E
Rubber Bonds	R
Silicate Bonds	S
Oxy-chloride Bonds	O

Vitrified

This is the most commonly used bond. The bond is actually clay mixed with fluxes such as feldspar, which hardens to a glass like substance on firing to a temperature of about 1250°C and develops the strength. This bond is strong, rigid and porous, and not affected by fluids. However, this bond is brittle and hence sensitive to impacts. This bond is also called ceramic bond.

Silicate

This is sodium silicate ($NaSiO_3$) or water glass and hardens when heated. Not as strong as vitrified. This can be used in operations that generate less heat. It is affected by dampness but less sensitive to shocks. Relatively less used.

Grade

This indicates the strength with which the bonding material holds the abrasive grains in the grinding wheel. Different grades in grinding wheels are shown below:

Material	Grade
Soft	A to H
Medium	I to P
Hard	Q to Z

The selection of a grinding wheel depends upon the nature of work, its composition, size and hardness. Hard wheels are used for softer material and vice versa.

Structure

It is the spacing between the abrasive gains or the density of the wheel. The structure of the grinding wheel is designated by a number. The higher the number, the wider is the spacing.

Structure	Symbol
Dense	1 2 3 4 5 6 7 8
Open	9 10 11 12 13 14 15 or more

Example

The grinding wheel is specified as under 300 × 30 × 35W A36 M 55 17

Each element is to be indicated in a fixed order.

First element 300 is wheel diameter.

Second element is thickness.

Third element is diameter.

Forth element is manufacturer’s symbol.

Fifth element is abrasive used.

Sixth element is grain size.

Seventh element is Grade.

Eighth element is structure.

Ninth element is type of bond.

Tenth element is optional for manufacturer.

Example

WA 60 K 7 V. This represents the type of abrasive material, the grit size, the grade, the structure and the bond type. A general guide to specification marking can be seen in the table here:

Example	Marking	Marking code
WA	Abrasive Material	A – regular aluminium oxide WA – white aluminium oxide 19A – mixture of A and WA SD – synthetic diamond ASD – synthetic diamond, metal coating FA – semi-friable aluminium oxide PA – pink aluminium oxide SA (HA) – single crystal aluminium oxide 23A – mixture of A and SA AZ – zirconium oxide C – black silicon carbide GC – green silicon carbide RC – mixture of C and GC
60	Grit size	(Coarse) 10, 12, 14, 16, 20 etc. to 600, 800, 100, 1200 (Fine)
K	Grade	(Soft) A, B, C, D, E etc. through to V, W, X, Y, X (Hard)
7	Structure	(Dense) 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14 (Open)
V	Bond type	V – vitrified B – resinoid R – rubber O – MgO E – epoxy M – metal EP – electroplated

GRINDING OPERATIONS

There are five major types of grinding operations :

- Cylindrical (centre or center less)
- Internal or hole grinding
- Surface grinding
- Tool and cutter grinding, and
- Abrasive belt grinding

Cylindrical Grinding

Cylindrical grinding can be done by grinding from **centre holes**, or it can be **centreless**.

Center type cylindrical grinding

In the center type cylindrical grinding the work revolves while being held between center points. While this is the most efficient method for grinding some kinds of work, it has certain disadvantages as compared with the centerless method.

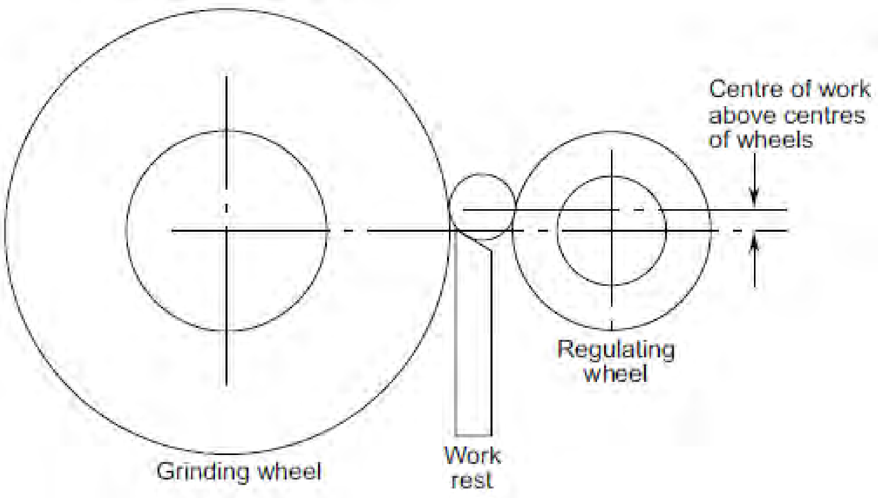
When there is grinding between centres, time is required to drill center holes in the work, true the center points and properly locate them, and check the adjustments of the steady rests.

In center line grinding, machine is similar to a heavy duty lathe except that both centres are fixed so that the workpiece cannot run out at the head stock. To permit easy access of operating to the work area, the wheel is located behind the workpiece and is made large in relation to the workpiece diameter so that the wheel wear in one operation is small as compared to the stock removed from the workpiece, Typically a grinding wheel for such a machine is 60 to 90 cm in diameter and has face width of 2.5 cm to 7.5 cm. Centreline grinding is a rapid, economical production operation for finishing shafts, ball bearings, bearing races and similar products to precise tolerances and good finish.

Centerless grinding

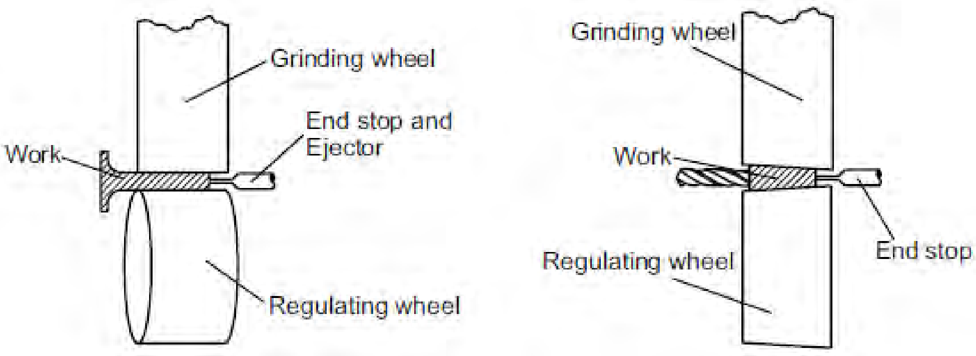
In centerless grinding, the preliminary work is dispensed with because no center point are used. Unlike center grinding, however, centerless grinders must be set up for each job, i.e. set up time is comparatively more.

In centreless grinding, the work is supported by three machine elements the grinding wheel the regulating wheel, and the work rest blade which is bevelled to push the workpiece toward the regulating wheel **(see figure)**. The rubber bonded regulating wheel controls the rotational speed of the workpiece, and its rate of feed is determined by the angle of the horizontal axis of the regulating wheel with respect to that of the grinding wheel, Note that the faces of both wheels are still parallel.



A through feed grinding process

There are two types of centreless grinding: through feed and infeed **(see figure)**.



(a) in feed and (b) end feed grinding process

In **through feed** grinding the workpiece passes completely through the grinding zone and exists on the opposite side. Infeed grinding is similar to a plunge cut when grinding on centres, In this case, the length of the section to be ground is limited by the width of the grinding wheel.

The **infeed method** in centreless grinding differs from through feed in the way the workpiece is handled. The in feed method is used for grinding parts with several diameters or heads or shoulders which would prevent complete passage through the machine.

End-feed grinding, specifically, is a method that is good for shaping a piece of metal so that one end is larger than the other.

In many cases special tooling makes centreless grinding a versatile process, but it is often less expensive to design and build new tools. Unless an economic analysis gives a strong indication that centerless grinding will be worthwhile, it is to stay with conventional grinding. In same cases it may be3 economical to centreless grind as few as 25 or 100 parts, and in others as many as 5000 pieces must be ground before centreless grinding is justified.

Advantages of centerless grinding

- In through feed grinding, the cutting time approaches 100% of the operating time because the grinding action is almost continuous, with little loading and unloading time.
- Since the workpiece is fully supported by the work rest table and regulating wheel;, heavy cuts can be taken with minimum danger of distortion or overheating.
- Centering errors do not exist; therefore workpiece is rounded up with a minimum of excess stock allowance.
- Relatively unskilled personal can be used as machine operators.

Limitations of centerless grinding

- This operation is not so easy to handle at different working diameters.
- This type of operations is not useful at less production.
- Changing the tool of grinding wheels takes a long time.
- This cannot be highly useful to long Flat and key ways.

Internal Grinding

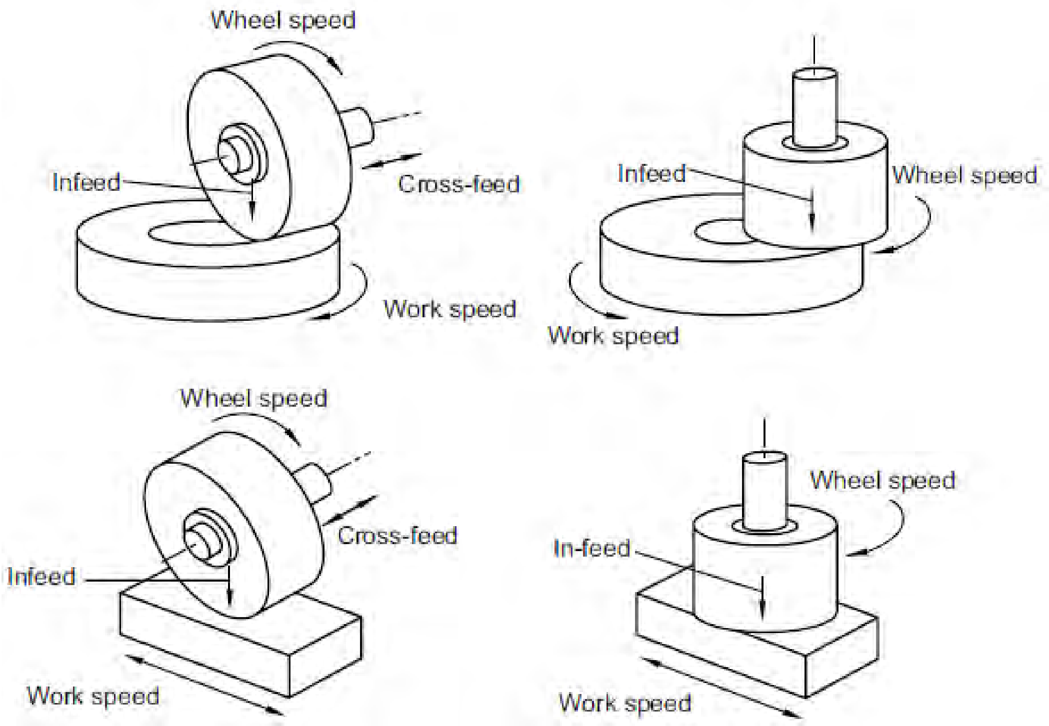
There are three types of internal grinding machines.

- Machines in which the workpiece rotates slowly and the wheel spindles and reciprocates the length of the hole.
- Machines in which the work rotates and reciprocates while the wheel spindle rotates only.
- Machines in which the wheel spindle rotates and has a planetary motion while the workpiece rotates.

Wheel wear is rapid because of the small wheel size and the use of soft grade permit the wheel to break down under light cutting forces. Thus accurate hole sizing is difficult to obtain if tolerances are close. To meet this need, production machines can be fitted with automatic gauging and feedback which assure accurate control of hole size. The grinding wheel keeps cutting until the hole is 0.001 in from the proper size and a special cam control is engaged to provide the fine feed which is continued until the hole is finished to the required tolerance.

Surface Grinding

Surface grinding is primarily concerned with producing plane and frequently parallel surfaces on steel parts. For this reason, magnetic chucks are standard equipment. The grinding wheel may have a vertical or horizontal axis and it may be considered to be equivalent to a face milling cutter when the axis is vertical and to a plain milling cutter when the axis is horizontal. Surface grinders with rotary tables are particularly capable of grinding a number of small pieces simultaneously and at low cost, and they leave a characteristic crisscross pattern on the flat surfaces. **(Refer figure)**



Surface grinding operations

Abrasive Belt Grinding

With the advent of the flexible plastic bond for applying abrasives to belts, the use of abrasive belt grinding has increased because a coolant can be used and the bond is strong. Close dimensions can be held and a minimum of material is allowed for machining. The surface finish produced by belt grinding is better than machining. Simple fixtures, or merely holding the part against the belt, are all that are required for cleaning up surfaces, but water must be used to cool the workpiece.

Abrasive cut off is accomplished by a thin disk-grinding wheel usually made with a rubber bond. The disk principally cuts on its edge although slightly on the sides too. It gives a smooth surface and a very little burr is produced.

The process is as fast as sawing at the part requires no further machining operations when cut off.

Any material that can be cut off by sawing, shearing or flame cutting can also be cut off with an abrasive wheel properly selected for the purpose, Furthermore, band and hack saws are slower and more easily dulled.

ADVANTAGE OF GRINDING PROCESS

There are following advantage of grinding process as mentioned here.

- Investment is less
- Working principle and operation is simple
- It does not require additional skills

- Surface finishing will be approximate 10 times better as compared to milling and turning process of machining.
- Dimensional accuracy will be quite good
- Grinding process could be performed on hardened and unhardened workpiece also.

WHEEL BALANCING

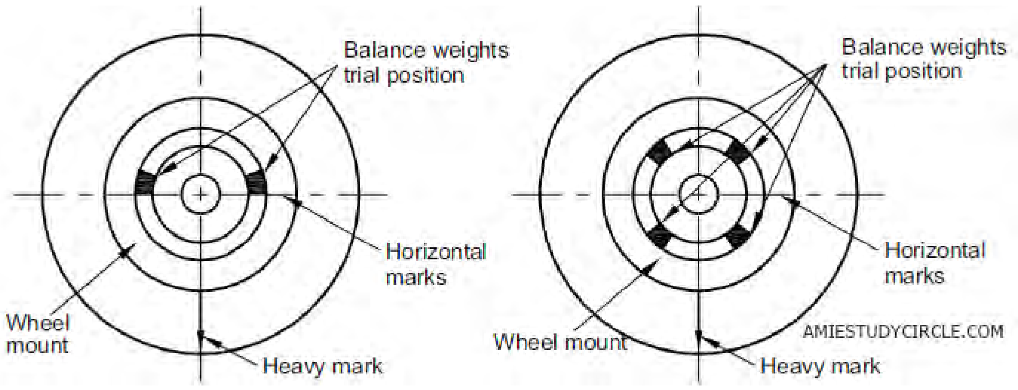
New grinding wheels when used should be properly balanced. Balance of a grinding wheel also depends upon the machine spindle as well as the condition of tightening which will have to be properly taken care of.

In view of the high rotational speeds used, any residual unbalance left would be harmful for the machine part and also produce poor surface finish. Such wheels are provided with movable balance weights for adjusting the balance mass location.

The balancing operation can be carried in two ways:

- Static balancing
- Dynamic balancing

In **static balancing** the grinding wheel is rotated on an arbour and the balance weights adjusted until the wheel no longer stops its rotation in any one specific position. To do this the balance weights are removed and the wheel is kept on the balancing ways. The wheel is allowed to rotate such that the heavier portion of the wheel settles at rest. Place a chalk mark at the heavier portion (bottom most point). Try to rotate the wheel slightly and see where the wheel is resting. The chalk mark should always point to the bottom, which confirms that the heaviest portion is identified. Two weights are now inserted such that they are equidistant from the heavy mark and slightly above the horizontal mark in that position as shown in Fig. (a).



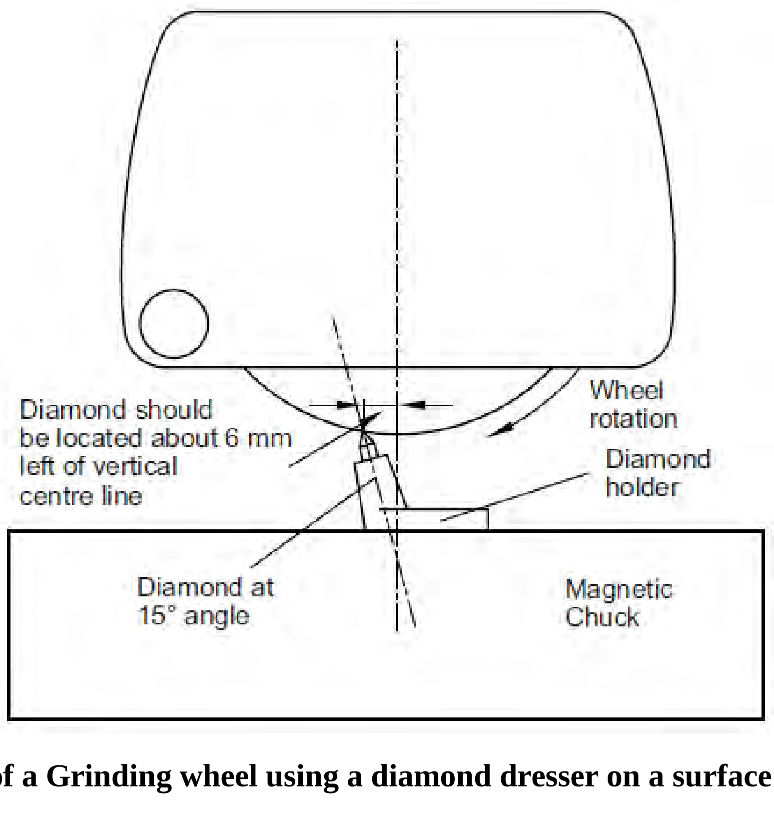
If the wheel stops again at the same point, then move the weights closer. If the wheel stops in the opposite direction, move the weights further apart. It should be possible to find a point of proper balance by repeating this process. If it is not possible by any combination to find a balance, then add more balance weights as shown in Fig. (b).

DRESSING AND TRUING

With continuous use a grinding wheel becomes dull with the sharp abrasive grains becoming rounded. This condition of dull grinding wheel with worn out grains is termed as *glazing*. Further, some grinding chips get lodged into the spaces between the grit with the resulting condition known as loaded wheel. Loading is generally caused during the grinding of soft and ductile materials. A loaded grinding wheel cannot cut properly. Such a grinding wheel can be cleaned and sharpened by means of a process called **dressing**.

A simple dressing is done by means of small steel disks, which are free to rotate at the end of a stick. When these disks contact the grinding wheel face they sharpen the wheel by removing a small portion of the face of wheel. Though the dressing is simple, it will not produce a true concentric surface because it is done manually.

A **true surface** of the grind wheel in terms of either the form or concentricity can be achieved with the help of a diamond dressing tool. A diamond used for truing is set in a closely fitting hole at the end of a short steel bar and is brazed as shown in given figure.



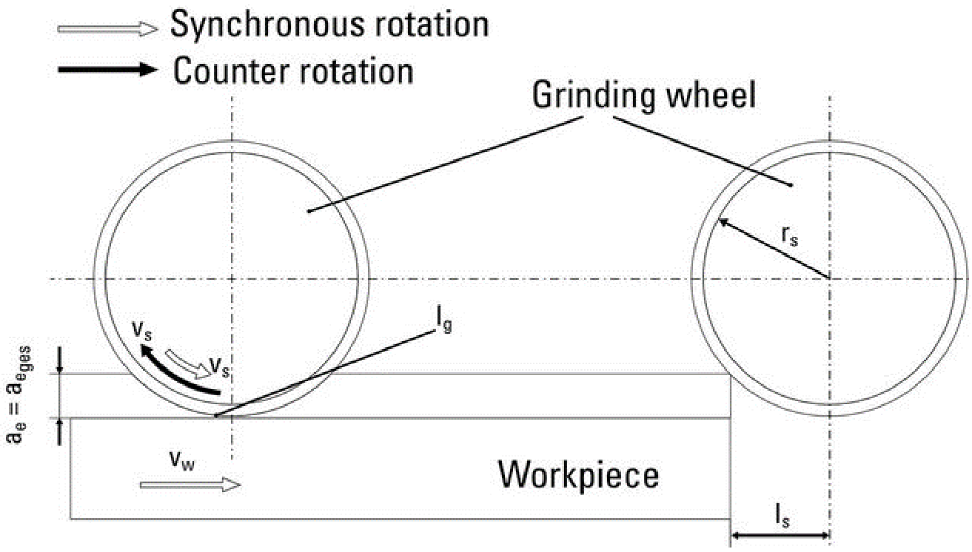
Truing of a Grinding wheel using a diamond dresser on a surface grinder

CREEP FEED GRINDING

The chip thickness and therefore the cutting force on the single grain are lower with creep feed grinding than with conventional traverse grinding. There are no recurring impact loads on the grinding wheel so that the abrasive grains can be held by the bond matrix longer before the grains break out. On the other hand, the thermal load and the total cutting forces are higher.

In creep feed grinding, the higher cutting forces require significantly higher static and dynamic rigidity and higher drive performance of the grinding machine than in conventional traverse grinding. The high thermal load during creep feed grinding not only represents a high load on the tool and grinding machine, but it can also damage the workpiece material and can lead to cracks and structural changes. Such structural changes do not occur, or only occur to a limited degree during conventional traverse grinding and are removed by the subsequent pass.

During conventional traverse grinding, the contact surface of the tool and the workpiece can be easily supplied with cooling lubricant due to the short length of the contact area. Creep-feed grinding requires the cooling of a much larger contact surface and the dissipation of more heat due to the higher friction. Therefore, the cooling lubricant must be supplied at high pressure and high flow rates through nozzles and supply lines with defined shapes.



- Creep feed grinding is characterized by lower workpiece speeds and higher depths of cut resulting in a larger arc length of contact between the grinding wheel and workpiece when compared with reciprocating or pendulum grinding.
- Creep feed grinding achieves significantly higher productivity in mass production compared to reciprocating grinding.
- With today's conventional, highly porous grinding wheels, very high material removal rates are achieved with creep feed grinding.
- The wheel wear is typically lower than in reciprocating grinding.
- The surface quality is typically better than in reciprocating grinding.
- Creep feed grinding operations require rigid and robust machines to ensure the quality of the workpieces given the higher grinding forces.
- Grinding wheels with vitrified bonds are usually dressed with profile rollers that correspond to the finished workpiece profile.

- Materials that are difficult to machine, such as nickel-based superalloys like those used in aerospace jet engines, can today be economically processed with electroplated or vitrified CBN grinding wheels.

GRINDING WEAR

During the grinding process, the state of the working surface of the grinding wheel is constantly changed due to the wear of the grinding wheel itself. With the extension of the grinding time, the cutting ability of the grinding wheel decreases, so that the grinding process cannot be continued. At this time, the grinding wheel must be trimmed to restore the normal grinding state. So, what are the common causes of grinding wheel wear?

Common causes of grinding wheel wear

Abrasive wear

When the abrasives are severely worn, the grinding wheel surface will be become flat when the abrasives have a significant wear surface on the top surface. At this time, the total wear area of the cutting edge increases, and the friction increases so that make it difficult to cut into the workpiece surface. However, the hardness of the grinding wheel is too high, so that the abrasive particles cannot be broken and fall off in time. Such wear generally occurs when the hardness of the abrasive is low, the hardness of the grinding wheel is high, the grain size of the abrasive is too fine, and the tensile strength of the workpiece material is high.

Oxidation wear

Common abrasives are oxides, carbides and nitrides. Oxide abrasives are stable in the air, and the surface of other abrasives will be oxidized at high temperatures and gradually consumed.

Plastic wear

Under the high temperature, the abrasive particles will wear due to *plastic deformation*. Plastic wear depends mainly on the thermal hardness of the workpiece material. During grinding, if the thermal hardness of the cutting edge of the grinding wheel on the front surface of the abrasive grain is greater than the thermal hardness of the abrasive grain contact area, the abrasive grain will plastically wear.

Diffusion wear

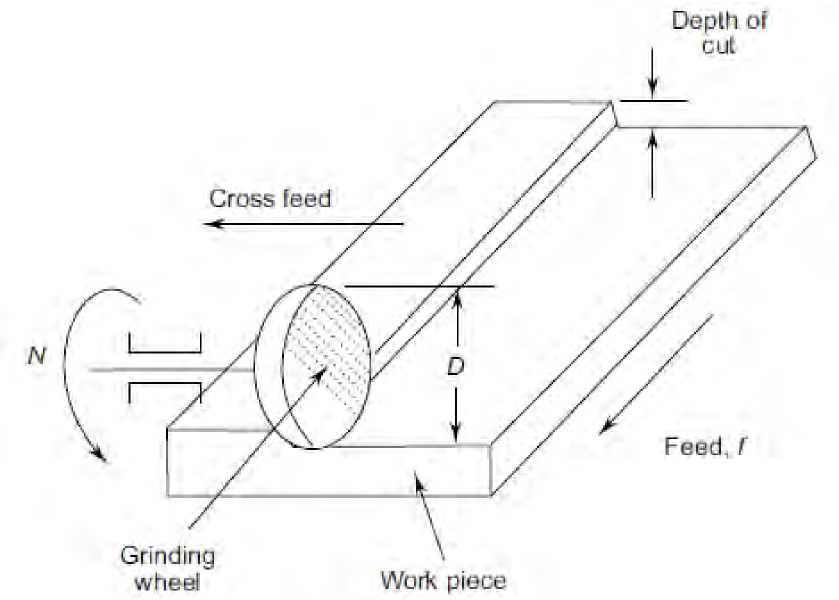
Diffusion wear refers to the wear caused by the weakening of the abrasive surface layer when the abrasive grains and the material being contacted at high temperatures, the elements of the diamond grinding wheel mutually diffuse. The interdiffusion of elements between two materials is closely related to the chemical composition of the material. Because the ability of carbon elements in diamond abrasives to diffuse and dissolve in iron is greater than the ability of elements in boron nitride abrasives to diffuse and dissolve in iron, diamond wheels are not suitable for grinding steel.

Thermal stress damage

During the grinding process, the working surface of the abrasives instantly rises to high temperature, and the grinding wheel is rapidly cooled by the grinding fluid. The frequency of the cold and hot cycles is the same as the rotational speed of the grinding wheel, so that a large alternation is formed on the surface of the abrasives. Thermal stress will crack and break the surface of the abrasive particles. The order of thermal conductivity of various abrasives is diamond, cubic boron nitride, silicon carbide, and corundum.

GRINDING TIME ESTIMATION

Schematically the surface grinding operation with a **horizontal axis grinding machine** is shown in figure.



The grinding wheel will have to traverse beyond the actual work piece by a distance termed as the approach allowance, A which is given by

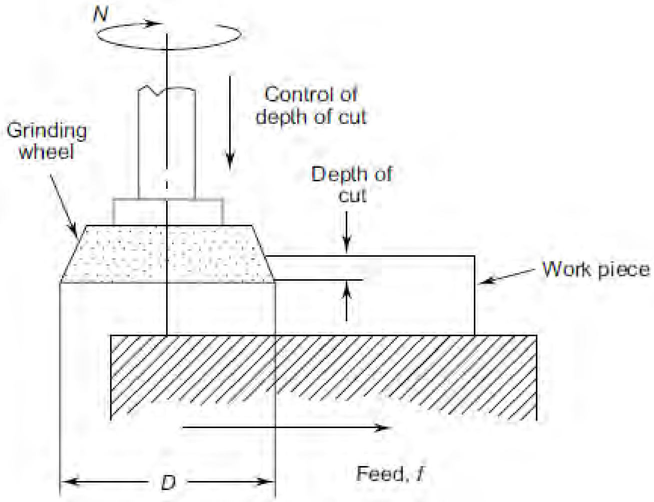
$$A = \sqrt{\left(\frac{D}{2}\right)^2 - \left(\frac{D}{2} - d\right)^2} = \sqrt{d(D-d)}$$

This value is very small since the depth of cut, d is very small in grinding. However, to allow for the table reversal at each end of the table stroke, the radius of the grinding wheel is assumed as the approach allowance. Thus

Time for one pass = (length + diameter)/table feed rate

Number of passes required = width/infeed rate

Following figure shows the situation of a surface grinding operation using a **vertical axis machine**.



Approach distance for this case is given as

$$A = D/2 \qquad \text{for W = D/2 upto D}$$

and $$A = \sqrt{W(D-W)} \qquad \text{for W < D/2}$$

where W is width of cut.

Example (AMIE S19, 8 marks)

Using a horizontal axis surface grinder, a flat surface of C65 steel of size 100 mm x 250 mm is to be ground. A grinding wheel with 250 mm diameter and 20 mm thickness is used. calculate the grinding time required. Assume a table speed of 10 m/min and wheel speed 20 m/sec.

Solution

Approach time = 125 mm

Time for one pass = (250 + 250)/(10 x 1000) = 0.05 min

Assuming an infeed rate of 5 mm/pass number of passes required = 100/5 = 20

Total grinding time = 20 x 0.05 = 1 min

Example

For the above example, if vertical axis surface grinder is to be used, calculate the grinding time. The wheel to be used is 200 mm in diameter with a wheel thickness of 20 mm.

Solution

Given, W = 100 mm, and D = 200 mm

Approach distance, A = 100 mm

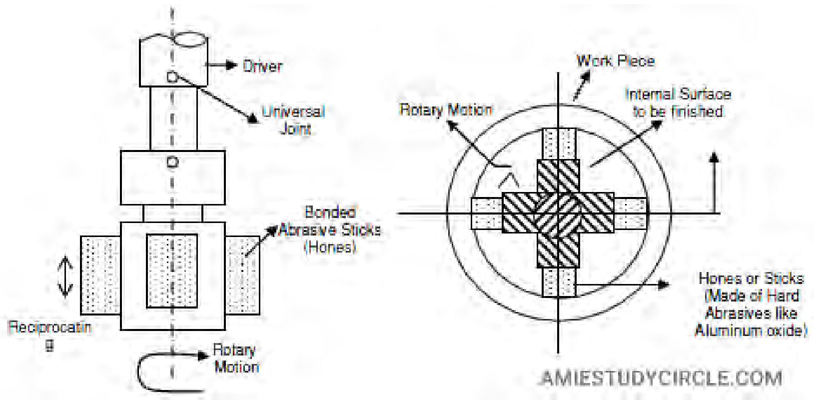
Total machining time = (250 + 200)/(10 x 1000) = 0.045 min

HONING

Honing is a controlled, low-velocity, abrasive machining process that is most often applied to inside diameters or bores. One or more abrasive stones and one or more non abrasive shoes (to equalize force throughout the workpiece) are mounted on an expanding (or contracting) mandrel. The tool is inserted in the bore and adjusted to bear against the walls. A combination of motions gives the stones a figure eight travel path. This motion causes the forces acting on the stones to be continually changing their direction, equalizing wear.

As with lapping very little heat is generated; hence there is no sub microscopic damage to the workpiece surface. Tolerances can be easily maintained to within 0.003 mm on production basis. The surface finish produced can be very smooth and part geometry can be corrected by honing process.

The honing tool consists of a set of bonded abrasive sticks. The number of sticks mounted on a tool depends on its circumferential area. Number of sticks may be more than a dozen.



The motion of a honing tool a combination of rotation and reciprocation (linear).

The motion is managed in such a way that a given point on the abrasive stick does not trace the same path repeatedly.

The process of honing is always supported by flow of coolants. It flashes away the small chips and maintains a low and uniform temperature of tool and work.

BUFFING

Many types of contact wheels have been developed for polishing and buffing surfaces. finishes can be varied from that of textured satin to a high lustre.

Buffing is used to produce a high lustre or bright appearance. To achieve this, the abrading action is reduced to a minimum. A lubricant blended with the abrasive promotes a flowing rather than a gouging action.

The abrasive used are extremely fine powders of aluminium oxide, tripoli (porous form of silica), crushed flint or quartz, silicon carbide and red rouge (iron oxide). The degree of ductility of the metal determines the type of abrasive to use. Soft metals, for example, do not require a cutting abrasive, but a flow or blending as achieved by red rouge.

Buffing wheels are normally made of muslin. Stitched wheels are usually used for cut down fudging. A newer type made of non-woven nylon web material has been developed to produce a satin finish without sacrificing accuracy.

Abrasive compound is applied to the buffs by either spraying on in liquid form or is automatically applied in stick form.

ASSIGNMENT

Q.1. (AMIE S15, 5 marks): How is the grinding wheel selected for a particular job? What is meant by truing and dressing of grinding wheel?

Hint: After the abrasive material and wheel shape, main factors for wheel selection are grit size, bond type and bond hardness.

Q.2. (AMIE W18, 6 marks): Enlist the grinding parameters and briefly explain their effect on grinding force and surface roughness of the work piece.

Hint: The grinding wheel speed, grinding wheel grade, depth of cut, grinding wheel material and feed rate are the important parameters that affect the surface finish, which in turn affects the productivity and cost of the component.

Q.3. (AMIE W15, 19, 5 marks): Explain how grinding is different from other machining operations.

Q.4. (AMIE W15, 5 marks): Discuss the selection criteria of abrasives for grinding operation.

Q.5. (AMIE S16, 8 marks): Explain the alphanumeric system of specification of grinding wheels. From the point of grindability, discuss the importance of each of the factors mentioned in the specification.

Q.6. (AMIE S20, 8 marks): Explain ISO designation of grinding wheel.

Q.7. (AMIE S16, 4 marks): What are the materials commonly used as bonding agent in grinding wheels? Why is CBN superior to silicon carbide as an abrasive in some applications.

Q.8. (AMIE S16, 4 marks): What is purpose of low stress grinding? How is low stress grinding done?

Answer: Low stress grinding (LSG) uses wheel speeds of about 20 m s^{-1} and can usually be done on conventional grinding machines in any of the grinding modes. First the surface of the work piece is pretreated to make the desired surface roughness. Then the work piece is powder blasted to further decrease the surface roughness and to obtain certain residual stress. Finally the aim of low stress grinding is achieved by using a precision grinding method controlling the grinding technique parameters.

Q.9. (AMIE S16, 4 marks): Explain the centerless grinding process with a neat sketch. How are centerless grinders so popular in industry compared to center type grinder?

Q.10. (AMIE S18, 4 marks): What are the advantages and limitations of using centerless grinding.

Q.11. (AMIE S19, 8 marks): Explain the principle of centreless grinding. Explain "through feed", "infeed" and "end feed" methods of centreless grinding.

Q.12. (AMIE S16, 6 marks): What is honing? How do honing stone differ from grinding wheel?

Hint: A honing stone is similar to a grinding wheel in many ways, but honing stones are usually more friable, so that they conform to the shape of the workpiece as they wear in. To counteract their friability, honing stones may be treated with wax or sulfur to improve life; wax is usually preferred for environmental reasons.

Q.13. (AMIE W16, 4 marks): What factors could contribute to chatter in grinding?

Hint: Grinding cut too heavy, wheel too hard, dress feeds disturbance, grinding fluid, slender work unsupported and machine Vibration

Q.14. (AMIE W16, 4 marks): Generally, it is recommended that, in grinding hardened steels, the grinding by wheel of a relatively soft grade. Explain.

Answer: To avoid a phenomena called “glazing" caused by rubbing of hard abrasive particles against a hard work material, no material removal takes place, instead the hard work material gets shiny. Softer abrasive particles are dislodged easily from the grinding wheel matrix thereby repeatedly exposing fresh abrasives, causing efficient material removal whilst avoiding “glazing".

Q.15. (AMIE W16, 4 marks): Describe the methods and importance of dressing of grinding wheels.

Q.16. (AMIE S17, 5 marks): The specific energy in grinding has been found to be higher than that for single point tool machining operation. Explain why.

Answer: The reason behind higher specific energy requirement in grinding than machining process are following:

- Machining is process of giving desired shapes to specimen but grinding is process is done to provide good surface finish to already machined part which requires higher specific energy.
- Machining process uses single point cutting tool in which whole energy is used for shearing the material while removing it but in grinding abrasives are used as cutting tool. Such abrasives have negative rake angles which leads to increase in cutting force thus requires more specific energy.
- The material removal rate (MRR) for grinding is much lesser than that achieved in machining. Rubbing and Ploughing also consumes energy without removing material.

Q.17. (AMIE S18, 8 marks): Describe briefly about creep feed grinding. Mention the method alongwith the application and the precautions to be taken during its operation.

Q.18. (AMIE S18, 19, W19, 8 marks): Describe the dressing and balancing requirement in grinding.

Q.19. (AMIE W18, 4 marks): Explain cutting action of abrasive grits of disc type grinding wheel on a work piece.

Q.20. (AMIE W18, 10 marks): Define grinding ratio. Why the work piece center is usually kept higher than the grinding wheel and control wheel centres? Also, how grinding wheel wear takes place?

Answer: The wheel wear is generally measured with a parameter called ‘Grinding Ratio’ which is defined as the ratio of volume of metal removed to the volume of metal worn from the grinding wheel.