CHAPTER 5

Grinding Process

INTRODUCTION

In grinding process an emery or corundum wheel is used as the cutting tool. Emery and corundum are naturally found abrasives and are impure form of aluminium oxide Al_2O_3. A grinding wheel is made up of thousands of tiny abrasive particles embedded in a matrix called the 'bond' An abrasive is an extremely hard material second in hardness only to diamond. The edges of the abrasive particles project out of the periphery of the grinding wheel, and when grinding wheel rotates, each one of the particles acts like a tiny cutting tool machining away the material from the surface of the work piece. To the naked eye the cut material looks like metal dust mixed with powder from the grinding wheel. However, seen under magnifying lens, the metal dust shows all the characteristics of metal chips produced in other machining processes. The grinding process is truly a chip producing machining process.

The grinding process is capable of producing very accurate sizes, equally accurate geometry like flatness or circularity and extremely good surface finish. The grinding wheel is capable of machining hardened steel and even hardened high speed steel, which cannot be done by other machining processes.

When a grinding wheel is applied to the workpiece, the sharp edges of the abrasive grains which are cutting, will eventually loose their cutting effect and become dull. At that stage, the abrasive grain should either split and form new edges or it should break away from the wheel exposing the next layer of grains to do their work. If the dulled grains stay in the wheel, they simply keep on rubbing on work without actually cutting. This defect is known as 'glazing'. If on the other hand, the abrasive grains break away from the wheel or split prematurely, before becoming dull, it causes reduction in life of grinding wheel.

CHOICE OF ABRASIVES

Emery and corundum, are no longer used in modern grinding wheels. Instead artificially manufactured abrasives are used due to their high purity. These abrasives are (*a*) silicon carbide, and (*b*) aluminious oxide, $Al_2O_3^-$ Silicon carbide is greenish black in colour, whereas aluminous oxide is reddish brown. Silicon carbide is harder and more brittle than alumina. For this reason, it is used for grinding materials of low grinding resistance like cast iron, brass, copper etc. Aluminium oxide abrasive is more suitable for grinding most steels because of its greater toughness to cope with increased grinding resistance offered. The code for silicon carbide is *C* and for Al_2O_3 wheels it is *A*.

Apart from the abrasive, the performance of a grinding wheels also depends upon many other factors. It is important that a suitable grinding wheel is selected for a particular application. The basis of some factors are discussed under the heading ''classification of wheels''.

CLASSIFICATION OF WHEELS

Classification of wheels is based on the following characteristics:

GRIT

Grit indicates, the size of abrasive grain. It is indicated by a number. Higher the number, smaller the size of grains. Abrasives finer than 200, are called ''flours'' designated as *F*, *FF*, and *FFF*. These and finer abrasive 'flours' are used by jewellers. For fine finish of ground surface, smaller grit size abrasive wheels are used. But their metal cutting capacity is limited. With larger size abrasive wheels, finish is rough but metal removal rate is higher.

BOND AND GRADE

Bond refers to the substance of which the matrix of the grinding wheel is made. The degree of hardness possessed by the bond is called the grade of the wheel and indicates the strength of the grip with which the abrasive grains are held in the bond.

The following bonds are generally employed in manufacture of grinding wheels:

1. **Vitrified bond:** It is denoted by letter *V* and about 80% of the wheels used in the industry are of this bond.

2. **Silicate bond:** It is denoted by letter *S* and silicate of soda (commonly known as water glass) is the main constituent of this bond.

3. **Shellac bond:** It is denoted by letter *E* and shellac (a naturally available material) is the main constituent of the bond.

4. **Rubber bond:** Here the abrasive in kneaded in rubber and the wheels are moulded from this material. Denoted by letter *R*.

5. **Resinoid bond:** These wheels are made from bakelite and other resinous material. It is denoted by letter *B*.

The bond hardness or grade is usually represented by the letters of English alphabet. A represents very soft grade, while *Z* is very hard *M* and *N* represent medium grade hardness.

WHEEL STRUCTURE

The proportion of bond material in a wheel varies from about 10% to 30% of its total volume. Structure of wheel depends upon this percentage. If abrasive grains are too tightly packed, the percentage of bond material will be on the lower side. This is called a closed structure. If the abrasive grains are less tightly packed in the same volume, the wheels are said to have an open structure. The structure is indicated by a number varying from 1 (very closed structure) to 15 (very open structure).

On every grinding wheel, the manufacturers are obliged to give the following information, in specified sequence about the

(*a*) Abrasive used (*A* or *C*)

(*b*) Grit number (*e.g.*, 46)

(*c*) Grade (*A* to *Z*)

(*d*) Structure (1 to 15)

(*e*) Bond Type (by specified letters).

In addition, the manufacturer is free to supply some additional information as prefix or suffix to the above information.

WHEEL SHAPES

Grinding wheels are made in a wide variety of shapes to suit the immense range of work and special features of machine tools on which the wheels shall be put to use. Many common shapes are shown in Fig. 5.1.

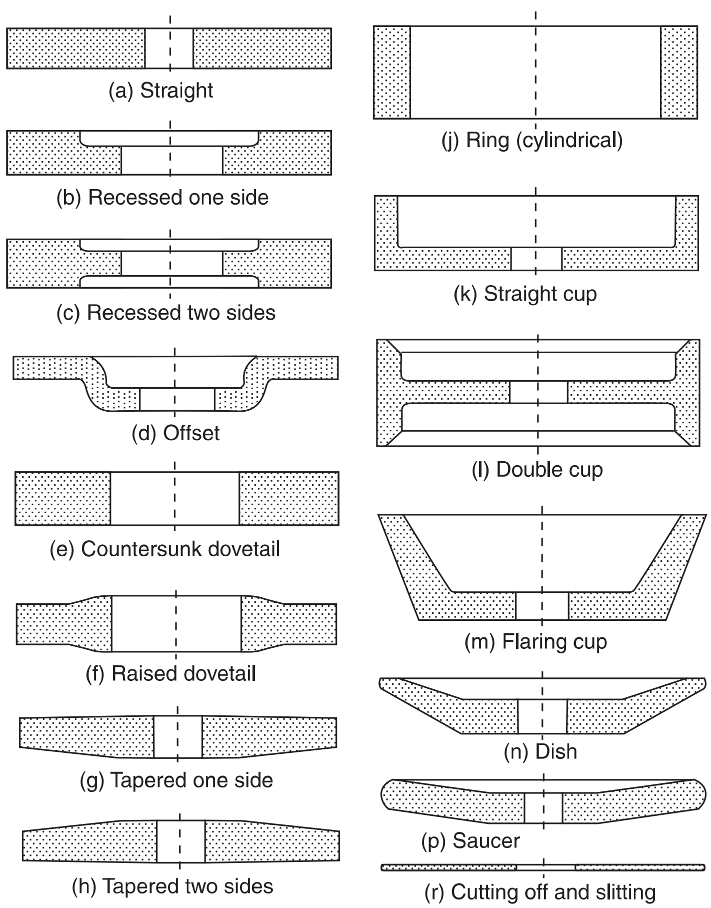

Fig. 5.1 Grinding wheel shapes

Wheels from (*a*) to (*h*) are disc wheels and grinding is to be done on the periphery of the wheel. Wheels (*j*) to (*l*) are mostly used on cup wheel grinders. Wheels (*m*), (*n*) and (*p*) are used for tool and cutters grinding. The thin wheel shown at (*r*) is used on abrasive cutters for slitting and parting off.

Wheel selection: It means choosing the most appropriate wheel for a particular grinding operation. Obviously, wheel selection would depend upon what abrasive is required, and other characteristics of the wheels. But it also depends upon many operating conditions like wheel and workspeed, relative diameters of wheel and jobs, type and condition of machines etc. Therefore it is best to refer to a wheel manufacturer and go by his recommendations. Thumb rule is to use a hard wheel for soft material and soft wheel for hard material. A hard wheel retains the abrasives as they do not get dulled easily on soft material.

MOUNTING A WHEEL ON MACHINE, BALANCING, TRUING AND DRESSING

A grinding wheel is a delicate and fragile tool. Unless it is used properly, it may not give optimum service or may even result in accidents. In this respect correct mounting and balancing is of utmost importance. Balancing is needed as wheels revolve at many thousand r.p.m. and any unbalanced centrifugal forces may crack the wheel or spoil the bearing.

As soon as a fresh wheel has been fitted on a grinding machine spindle, it will be necessary to true its face and perhaps, its sides for a short distance down so that the wheel may become, square to the work piece. Truing or dressing also become necessary after the wheel has been in use for sometime, to correct for non uniform wear on its face or for opening up its face to obtain efficient cutting conditions.

The truing or dressing up of grinding wheels is done by a diamond tool. Being harder, it is able to cut through, the abrasive grains and the bond material.

GRINDING OPERATIONS AND GRINDING MACHINES

The common grinding operations are

(*a*) **Cylindrical grinding:** This operation is carried out on a cylindrical grinding machine which is made in two varieties ‘‘plain’’ and the ‘‘universal’’ type. The fundamental design is the same in both cases, but the universal machine can be adopted for internal grinding operation as well.

In cylindrical grinding operation, the work is mounted between two centres and is rotated. A grinding wheel is mounted on a spindle and revolves at much higher r.p.m. than the work. The work centres are mounted on a table which can traverse at various feeds so that the entire length of the work passes to and fro in front of the wheel. The depth of cut is very small, about 0.015 mm. When the entire length of work has passed infront of the wheel, the wheel advances forward by another 0.015 mm at the end of the traverse and so the cycle of machining goes on, until the desired daimeter of the work piece is reached. The result is a long cylinder of perfectly circular profile with very fine surface finish.

A schematic diagram of the plain cylindrical grinder is given in Fig. 5.2.

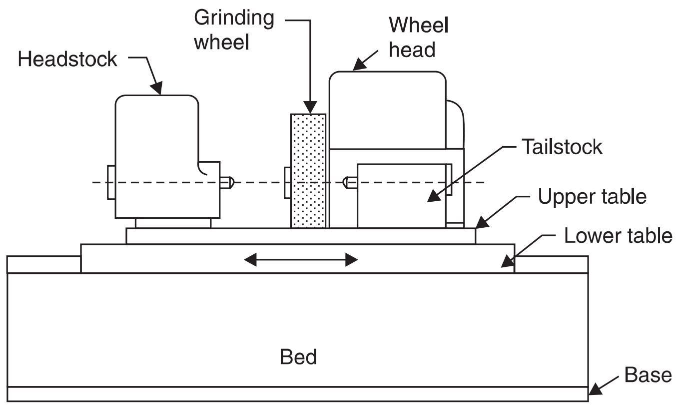

Fig. 5.2 Block diagram of a plain cylindrical grinder

(*b*) **Internal grinding:** Internal grinding operation means, grinding of internal holes or bores. The principle of internal grinding is shown in Fig. 5.3.

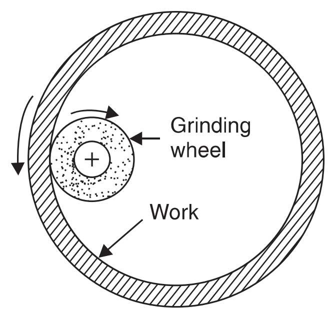

Fig. 5.3 Principle of internal grinding

Internal grinding is designed to grind the surface of bores; whether plain or tapered with the help of a small grinding wheel mounted on a long slender spindle which can enter in the bore. It is capable of giving improved geometry of the hole as well as the surface finish. This operation is performed on specially designed internal grinding machines. For internal grinding, a softer wheel is generally preferred.

(*c*) **Surface grinding:** A flat surface can be ground in many ways with a grinding wheel. Some possible configurations are illustrated in Fig. 5.4.

Recently surface grinding has emerged as a very important operation. Flat surfaces may be ground either by using the periphery of a disc wheel or by grinding with the end of a cup-shaped wheel. These methods can be further sub classified according to the method of feeding the work to the wheel. The method of using disc wheels entails the use of a horizontal spindle grinding machine. The cup wheels may be used in conjunction with either a horizontal or vertical spindle machine.

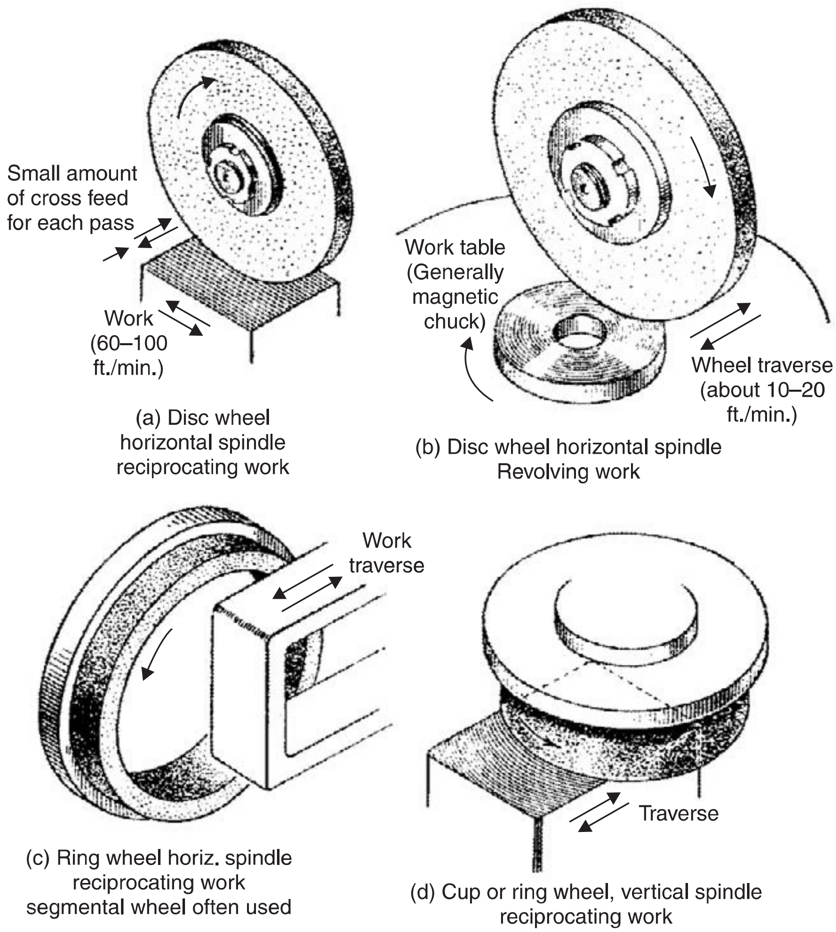

Fig. 5.4 Methods of surface grinding

Wheel speeds: The wheel manufacturer specifies a maximum safe r.p.m. for the wheel. In actual operation, this speed should never be exceeded. Like conventional machining methods, the concept of cutting speeds applies to grinding wheels also. The average recommended wheel speeds in metres per minute for different grinding operations are given below.

Cylindrical grinding	2000 metres/minutes
Internal grinding	700–1000 metres/minutes
Surface grinding	1200–1600 metres/minutes
Cutting off with rubber, shellac and bakelite wheels	3000–4000 metres/minutes.

In cylindrical grinding operation, work is made to rotate at a r.p.m. which works out to about 20-25 metres/minutes speed.

COOLANT

In the grinding operation, lot of heat is generated. This heat must be carried away. Hence an effective coolant is used. The most common coolant for grinding operation is water in which same soda ash has been dissolved. There should be a copious flow of coolant at the work-wheel interface. The coolant also washes away the ground chips and swarf. The coolant must not have lubricant in it, otherwise, it may lead to glazing of wheels.

QUESTIONS

1. What do you understand by grit, grade, bond and structure of a grinding wheel?
2. Justify the popular adage that hard wheels should be used for soft material and vice-versa.
3. Describe the cylindrical grinding operation. Give an idea of the grinding wheel and work speeds recommended for this operation.
4. Describe the surface grinding operations with disc as well as cup type wheel.