CHAPTER 1- INTRODUCTION TO GRINDING

LEARNING OBJECTIVES

- Introduction to Grinding, advantages and applications
- Grinding wheel and work piece interaction
- Interaction of the grit with the workpiece
- Stages of grinding
- Determination of grit spacing and grit protrusion

CUTTING ACTION IN GRINDING WHEEL.

Since the last two decades, there has been an increased interest in the investigation of grinding processes. Grinding is the most common form of abrasive machining. It is a material cutting process which engages an abrasive tool whose cutting elements are grains of abrasive material known as grit. These grits are characterized by sharp cutting points, **high hot hardness, and chemical stability and wear resistance**. The grits are held together by a suitable bonding material to give shape of an abrasive tool.

A Grinding wheel essentially consists of a large number of abrasive particles, called **grains**, held together by a suitable agent called the **bond**. It may be regarded as a multipoint cutting tool with a cutting action similar to that of a milling cutter except that the cutting points are irregularly shaped and randomly distributed over the active face of the wheel. Those grains at the surface of the wheel that actually perform the cutting operation are called **active grains**. In peripheral grinding, each active grain remove a short chip of gradually increasing thickness in a way that is similar to the action of a tooth on a slab milling cutter. Because of irregular shape of the grains, however, there is considerable interface or **plowing action**, between each active grains and the new work surface. This plowing action results in **progressive wear**, causing the formation of worn areas on the active grains. As grinding proceeds, the number and size of these worn areas increases, thus increasing the interference or friction, resulting in increase in the force acting on the grain. Eventually this force becomes large enough either to tear worn grains from the bond of the wheel and thus expose a new unworn grain or to fracture the worn grain to produce new cutting edges. Thus a grinding wheel has a self sharpening characteristic, and the force a grain can withstand before being torn from the wheel or fractured is a most important factor when grinding wheel performance is considered.

A wheel consists of relatively tough grains strongly bonded together will only exhibit the self sharpening characteristics to a small degree and will quickly develop a glazed
appearance during grinding. This glazed appearance is caused by the relatively large worn areas that develop on the active grains. These worn areas result in excessive friction and the consequent overheating of the workpiece. Grinding under this condition is inefficient and will necessitate dressing of wheel at frequent intervals to remove the worn grains from wheel surface. **Dressing** is usually carried out by passing a diamond tipped dressing tool across the wheel surface while the wheel rotates. Dressing with a diamond tipped tool removes or fractures the worn grains at the wheel periphery, thus generating a new and sharpened cutting surface. The need for frequent dressing to remove worn grains characterizes a **hard wheel**.

![Figure 1: Cutting action of abrasive grains.](image)

**Advantages of grinding**

- Grinding gives good dimensional accuracy
- It gives good surface finish
- It gives good form and locational accuracy
- Grinding is applicable to both hardened and unhardened material

**Applications**

- surface finishing
- slitting and parting
- descaling and deburring
- stock removal (abrasive milling) finishing of flat as well as cylindrical surface
- Grinding of tools and cutters and resharpening of the same.

Generally, grinding is used as finishing process to get the desired surface finish, correct size and accurate shape of the product. However recent researchers have shown that
grinding can also be used economically for bulk removal of unwanted material just like turning, milling, etc. Two variants of process have come out clearly for bulk removal:

- Very high speed grinding
- Creep feed grinding

Advent of advanced grinding machines and grinding wheels has elevated the status of grinding to abrasive machining where high accuracy and surface finish as well as high material removal rate can be achieved even on an unhardened material.

The bulk grinding wheel – workpiece interaction as given in Figure 2 can be divided into the following:

- Grit workpiece (forming chip)
- Chip bond
- Chip workpiece
- Bond workpiece

**Grit workpiece interaction - produce chip and desirable**, the remaining three increases the total grinding force and power requirement and therefore undesirable.

![Figure 2: Grinding wheel and workpiece interaction](image)

**Interaction of the grit with the workpiece**

The importance of the grit shape can be easily realized because it determines the grit geometry. For example rake and clearance angle as given in Figure. It appears that the grits do not have definite geometry unlike a cutting tool & the grit rake angle may vary from $+45^\circ$ to $-60^\circ$ or more.
Grit with favourable geometry can produce chip in shear mode. However, grits having large negative rake angle or rounded cutting edge do not form chips but may ruin leading to lateral flow of the workpiece material as illustrated in Figure 4.

Effect of grinding velocity and rake angle of grit on grinding force.

Figure 5 shows the role of rake angle on cutting force. A negative rake angle always leads to higher cutting force than what is produced with a cutting point having positive rake angle. The figure further illustrates that at low grinding velocity this difference in grinding force is more pronounced. It is interesting to note that the difference is narrowed at a high grinding velocity and the grinding force became virtually independent of the rake angle. This is one of the reasons of conducting grinding at a very high velocity in order to minimize the influence of negative rake angle.

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Figure 3: Variation in rake angle with grits of different shape

Figure 4: Grits engage shearing, ploughing and rubbing
Figure 5: Variation of grinding force with grinding velocity and rake angle of grit.

Various stages of grinding with grit depth of cut

Grinding is a combination of rubbing, ploughing and cutting (actual chip formation with contribution of each being highly governed by grit geometry, work material characteristics, grinding loop stiffness and the grinding velocity)

The various stages of grinding and grinding force with grit depth of cut is shown in Figure 6. At a small grit penetration only sliding of the grit occurs against the workpiece. In this zone rise of force with increase of grit penetration is quite high. With further increase of grit penetration, grit starts ploughing causing plastic flow of the material also associated with high grinding force.

Figure 6: Various stages of Grinding and grinding force.