CHAPTER 1.(contd)- Introduction to Grindng

LEARNING OBJECTIVES

- To list the basic uses of grinding
- To understand elements of Grinding system
- To list abrasive materials, Bond, Grade and Structure
- Marking system of Grinding wheel
- Grinding wheel selection.

BASIC USES OF GRINDING.

Grinding is a key technology for production of advanced products and surfaces in a wide range of Industries. Grinding is usually employed when one or more of the following factors apply.

- **High accuracy required**: Grinding process are mostly used to produce high quality parts to high accuracy and to close tolerances. Examples range from very large parts, such as machine to slide ways to small parts, such as contact lenses, needles, electronic components, silicon wafers, and rolling bearings.

- **High Metal removal rate required**: Grinding process are also used for high removal rate. A typical example is high removal rate grinding for flues of high hardened twist drills. The flutes are ground into solid round bars in one fast operation. Twist drills are produced in large quantities at high speed explaining why grinding is a key process for low costs, high production rates, and high quality.

- **Machining of hard material**: While accuracy and surface texture requirements are common reasons for selecting abrasive processes, there is another reason, Abrasive processes are the natural choices for machining and finishing very hard materials and hardened surfaces. In many cases, grinding is the only practical way of machining some hard materials. The ability to machine hard material has become more and more important with the increasing application of brittle ceramics and other hard material such as those used in aerospace engines.

BASIC ELEMENTS OF GRINDING SYSTEM

The basic grinding process: The six basic elements are involved


Figure 1 illustrates a surface grinding process.
Figure 1: Elements of Grinding

ABRASIVE MATERIALS

Material used as the cutting grains are of two types

a) Natural Abrasives
b) Artificial or Manufactured abrasives

**Natural Abrasives:** They include sand stone, diamond, corundum and emery. The principal component of corundum and emery is natural aluminum oxide (alumina). Corundum is composed of about 85% aluminum oxide and 15% Iron oxide. Emery contains 60% aluminum oxide and 40% Iron oxide. The relative abrasive action of each substance depends upon the properties of aluminum oxide. Diamond abrasive wheels are used extensively for sharpening carbide and ceramic cutting tools. Diamonds are also used for truing and dressing other types of abrasive wheels. Because of their high cost, diamonds are used only when other cheaper abrasives will not produce the desired result.

**Artificial Abrasives:** They include silicon carbide (SiC) and aluminum oxide (Al$_2$O$_3$). Silicon carbide is made by charging an electrical furnace with silica sand, coke, salt and saw dust. A temperature of over 2500 deg and heavy current is maintained for several hours. After that furnace is cooled and solid mass of crystal is taken from furnace. It is crushed, graded to various sizes. Silicon carbide is very hard (but less harder than boron carbide). It has high heat resistance and excellent cutting properties. There are two types of silicon carbide tools are available, namely black and green. The black silicon carbide is of lower quality and contains about 95% SiC. Green silicon carbide is somewhat harder and has a high grinding capacity and contains at least 97% SiC.
Green silicon carbide is mainly used for sharpening carbide tipped cutting tools.

Aluminum oxide abrasive is crystalline form of aluminum oxide. It is produced in arc furnace from bauxite, iron filling and small amount of coke. The mass of aluminum that is formed is crushed and the particles are graded to size. It is softer than silicon carbide but is considerably tougher and is more general purpose abrasive. Common trade name for aluminum oxide abrasives are ALUNDUM and ALOXITE.

The physical properties of the material to be cut dictate the kind of abrasive to be selected. As a general guide silicon carbide is used for grinding brittle material and materials of low tensile strength such as cemented carbide, cast iron and ceramics and low tensile strength metals including brass, soft bronze, and copper.

Aluminum oxide having less brittle grains is used for tougher and high strength material such as steel, wrought iron, hardened steel; alloy steel and hard brass and bronze.

In general the physical property of aluminum oxide compared with silicon carbide is as follows:

- Silicon carbide is harder than aluminum oxide.
- Aluminum oxide can withstand greater stresses than silicon carbide
- Aluminum oxide is more tougher than silicon carbide
- Aluminum oxide wheels are generally used for grinding high tensile strength and tough materials whereas silicon carbide wheels are used to grind low tensile strength and non metallic material.

ABRASIVE GRAIN SIZE

Abrasive materials are crushed in ball mills and screened for classification into different sizes. The size of abrasive grain required in a grinding wheel depends on the following factors

- Amount of material to be removed
- Finish desired
- Hardness of the material being ground

The grit or grain size of an abrasive is denoted by a number representing the number of meshes per inch of the screen through which the grains of crushed abrasives are passed for grinding. The standard grain sizes for grinding wheel are represented in Table 1.0.
Table 1: Standard Grain Sizes.

<table>
<thead>
<tr>
<th>Grit Designation</th>
<th>Grain size or Grit Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Course</td>
<td>10  12  14  16  20  24</td>
</tr>
<tr>
<td>Medium</td>
<td>30  36  46  54  60</td>
</tr>
<tr>
<td>Fine</td>
<td>80  100 120 150 180</td>
</tr>
<tr>
<td>Very Fine</td>
<td>220 240 280 320 400 500 600</td>
</tr>
</tbody>
</table>

The coarser grit will remove the stock at a faster rate and finer finish will require a finer grit.

Sizes from 240 to 600 are designated as four sizes. These are primarily used for lapping and honing stones.

BONDS

Bonding material are used as binders to hold the abrasive particle in place. The firmness with which the grains are held in wheel and the strength of wheel itself in which large centrifugal forces are developed in rotation depend on the bonding material. The bonding material determines the force that is required to dislodge an abrasive particle from the wheel which plays a major role in cutting action.

Six types of bonding materials are commonly used.

Vitrified bond: Vitrified bond is made of clay and water. The abrasive grains and clay are thoroughly mixed together with sufficient water to make the mixture uniform. The material is formed into wheel usually by pressing and then these wheels are dried. They then are fired in kiln which results in the bonding material becoming hard and strong. Vitrified bonds are used most extensively. Vitrified abrasive wheels have a high production capacity and are moisture proof.

About 75% of grinding wheels are vitrified bonds.

Resinoid Bond: Resinoid bonding is produced by mixing abrasive grains with synthetic resins. Resinoid bonded wheels are strong, elastic and permit high peripheral speeds but are destroyed by alkaline cooling fluids. This can be avoided by impregnating the wheel with paraffin. These wheels normally operate at surface speeds in the region of 300 m/min. They are particularly suitable for use in grinding steel, cast iron and malleable iron castings.

Shellac Bond: Shellac bond wheels are made by mixing the abrasive grains with shellac in mixer. After the mixture has been rolled or pressed into desired wheel shapes they are then hardened by baking for several hours at about 160 deg. Thin wheels that are strong but possess some elasticity have shellac bond. They can produce high polish and are used in grinding such parts as camshaft and mill rolls.
Rubber Bond: A rubber bond is essentially a mixture of rubber softened by gasoline and sulphur (30%). A rubber bonded wheels have high strength and elasticity and is moisture proof. They are commonly used for snagging work in foundries and for thin cut off wheels.

Silicate Bond: This bond is produced by mixing abrasive grains with silicate of soda (water glass). The mixture is given the desired wheel shape and baked at about 260 deg for a day or more. The silicate bonded wheels are soft, comparatively weak and have low production capacity. Such wheels has limited application,

Oxy chloride Bond: This bond is produced by mixing abrasive grains with oxide and chloride of magnesium.

Different types of bond used in grinding are represented by different symbols as shown in Table 2.

Table 2: Symbols for different bonds.

<table>
<thead>
<tr>
<th>Types of Bond</th>
<th>Symbol</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vitrified Bond</td>
<td>V</td>
</tr>
<tr>
<td>Resinoid Bond</td>
<td>B</td>
</tr>
<tr>
<td>Shellac Bond</td>
<td>E</td>
</tr>
<tr>
<td>Rubber Bond</td>
<td>R</td>
</tr>
<tr>
<td>Silicate Bond</td>
<td>S</td>
</tr>
<tr>
<td>Oxy chloride Bond</td>
<td>O</td>
</tr>
</tbody>
</table>

GRADE

Grade or hardness indicates the strength, with which the bonding material holds the abrasive grains in the grinding wheel. The easier a grain is torn out of the bond, softer the wheel and vice versa. The degree of hardness is specified by use of letters of the alphabet. Different grades of grinding wheels are shown in Table 3.

Table 3: Different grades

<table>
<thead>
<tr>
<th>Grade</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>H</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soft</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Medium</td>
<td>I</td>
<td>J</td>
<td>K</td>
<td>L</td>
<td>M</td>
<td>N</td>
<td>O</td>
<td>P</td>
</tr>
<tr>
<td>Hard</td>
<td>Q</td>
<td>R</td>
<td>S</td>
<td>T</td>
<td>U</td>
<td>V</td>
<td>W</td>
<td>X</td>
</tr>
</tbody>
</table>

The grinding wheel of required grade should be selected for each grinding Job. The selection of a particular grade of wheel is largely governed by the nature of work, its composition, size, and hardness. **Hard wheels are used for softer material and vice versa.**
STRUCTURE

It indicates the spacing between the abrasive grains or in other words density of wheel. Structure of grinding wheel is designated by a number. The higher the number, wider the spacing. It is observed that the tendency for burns is less for open structure. Figure 2 indicates the open and close structures and Table 4 shows the symbols.

![Open and Dense Structures in grinding wheel](image1)

Table 4: Symbols for Structures of grinding wheel,

<table>
<thead>
<tr>
<th>STRUCTURE</th>
<th>SYMBOL</th>
</tr>
</thead>
<tbody>
<tr>
<td>DENSE</td>
<td>1,2,3,4,5,6,7,8</td>
</tr>
<tr>
<td>OPNE</td>
<td>9,10,11,12,13,14,15 or more</td>
</tr>
</tbody>
</table>

MARKING SYSTEM OF GRINDING WHEEL

The Indian Standard: The Indian standard Institution (IS 551-1954) has specified a standard system of marking the grinding wheels. According to this system the following elements are represented in a definite order.

- Abrasive
- Grain Size or grit
- Grade
- Structure
- Bond

In addition to this manufacturer may add some symbols to indicate the abrasive used.

For example: Grind wheel marked 300x30x35 W A 36 M 5 S 17

- **300mm** – wheel diameter
- **30mm** – wheel thickness
- **35mm** – bore diameter
- **W** – manufacture’s symbols for abrasive used (Optional)
- **A** – abrasive (\(\text{Al}_2\text{O}_3\))
36 – abrasive grain size
M – Grade
5 – structure S- Bond(silicate),
17 – manufacture’s symbols for type of grinding wheel (optional)

The ISO Standard: Table 5 shows the marking system of grinding wheels. Grinding wheel code consists of several alphanumeric symbols referring to type of abrasive, nature of abrasives, grain size, wheel grade (relative hardness), structure, nature of bond, and finally a manufacturer’s record. In general the following guidelines can be used for the selection of a grinding wheel:

- Choose aluminum oxide for steel and silicon carbide for carbides and non ferrous metals.
- Choose hard grade wheel for soft materials and a soft grade wheel for hard materials
- Choose a large grit for soft and ductile materials and a small grit for hard and brittle material
- Choose a small grit for a good finish and a large grit for a maximum MRR
- Choose a resinoid, rubber or shellac bond for good finish and a vitrified bond for a maximum MRR
- For a surface speeds greater than 32 m/s do not choose a vitrified bond

Table 5: Marking system for Grinding wheels (ISO)

<table>
<thead>
<tr>
<th>Sequence</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type of abrasive</td>
<td>Nature of abrasive</td>
<td>Grain size</td>
<td>Grade</td>
<td>Structure</td>
<td>Nature of bond</td>
<td>Manufacturer’s record</td>
</tr>
<tr>
<td>51</td>
<td>A</td>
<td>36</td>
<td>L</td>
<td>5</td>
<td>V</td>
<td>23</td>
</tr>
<tr>
<td>Aluminum oxide—A</td>
<td>Silicon carbide—C</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Very fine</td>
<td>Dense to open</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coarse</td>
<td>Medium</td>
<td>Fine</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>30</td>
<td>70</td>
<td>220</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>36</td>
<td>80</td>
<td>240</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>46</td>
<td>90</td>
<td>280</td>
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<tr>
<td>16</td>
<td>64</td>
<td>100</td>
<td>320</td>
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<tr>
<td>20</td>
<td>60</td>
<td>120</td>
<td>400</td>
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<tr>
<td>24</td>
<td>150</td>
<td>500</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>180</td>
<td>600</td>
<td></td>
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<td></td>
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<td></td>
</tr>
</tbody>
</table>

Grade scale

- Soft
- Medium
- Hard

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

Complied by: Jagdeesha T, Assistant Professor, Mech Engg Dept., National Institute of Technology, Calicut
SHAPES OF GRINDING WHEEL

Grinding wheels are manufactured in various standard shapes. Different shapes of grinding wheel are as shown in Figure 3. Straight, recessed on one side and recessed both sides wheels are used primarily for grinding external or internal cylindrical surface and for plain surface grinding. The cylinder shaped wheel is used for producing flat surfaces the grinding being done with the end face of the wheel. Straight cup wheel is used for grinding flat surfaces by traversing the work fast the end or face of the wheel. Flaring up wheel is used for tool sharpening. Grinding wheels tapered on two sides are used for grinding the gear teeth and threads. Dish type is used for grinding tools saws. Straight grinding wheels can be obtained with a variety of standard faces. Some of these are shown in Figure 3:

Figure 3 – Standard grinding wheel shapes.