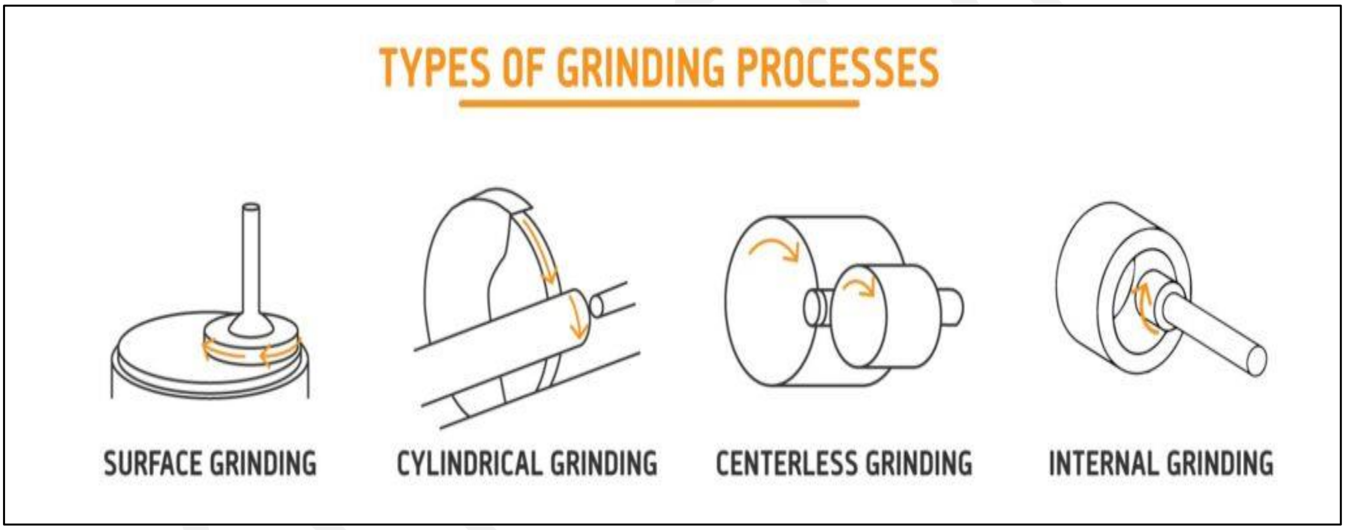
Unit 5.1
Grinder and Its Purpose

A **Grinder** is a machine tool that uses a rotating abrasive wheel to remove material from the surface of a workpiece. It is commonly used for precision machining and finishing processes such as shaping, cutting, and surface finishing. Grinding provides high accuracy, excellent surface finish, and close tolerances.

Types of Grinders:

1. **Surface Grinder**: For flat surfaces.
2. **Cylindrical Grinder**: For cylindrical shapes.
3. **Centerless Grinder**: Used for workpieces without centers.
4. **Internal Grinder**: For inside diameters of objects.
5. **Tool and Cutter Grinder**: For sharpening tools.

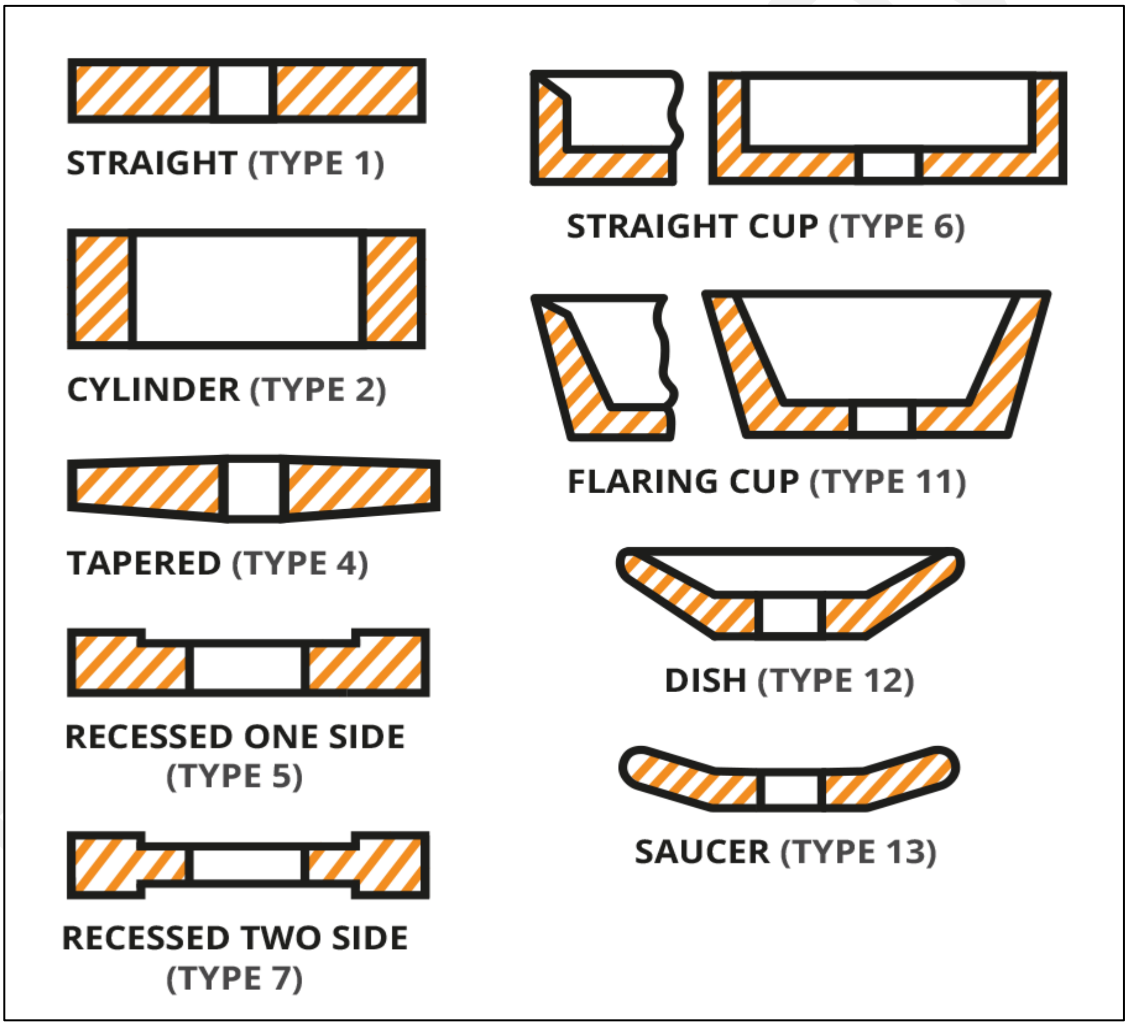


Types of Grinding Wheels

Grinding wheels are cutting tools formed by abrasive grains bonded together. They come in different types, designed for specific tasks:

1. **Straight Grinding Wheel**:
   - Commonly used for cylindrical, surface, and centerless grinding.
   - Straight edges allow versatile applications.
2. **Cylinder or Wheel Ring**:
   - Large wheels with no center mounting support.
   - Used for vertical or horizontal spindle machines.

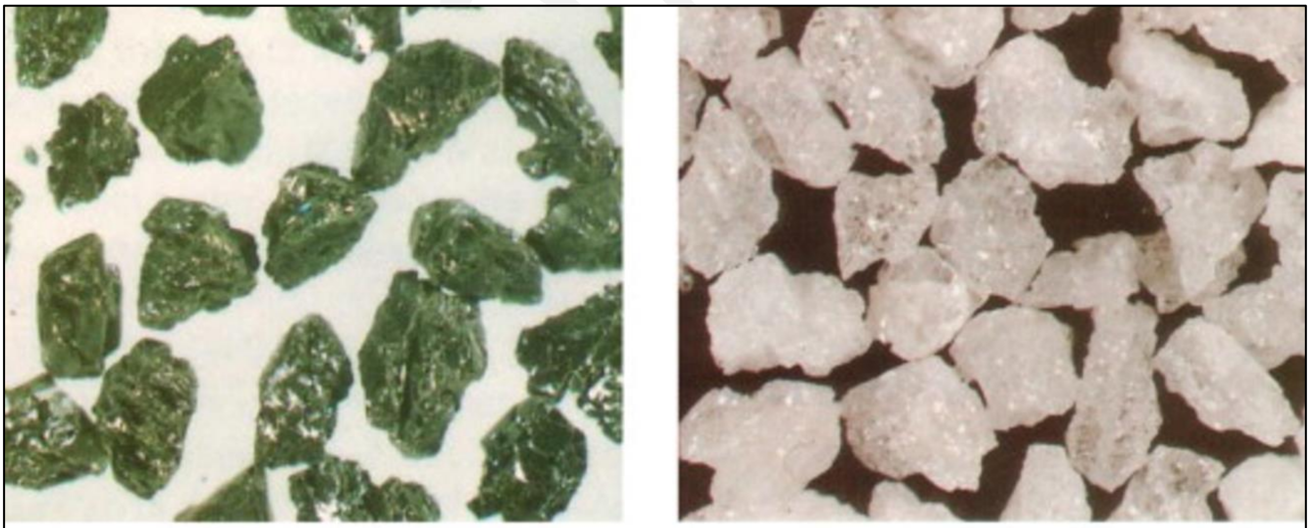
3. **Tapered Grinding Wheel**:
    - Useful for grinding threads, gear teeth, or contours.
4. **Cut-off Wheel**:
    - Thin wheels used for cutting metal or other materials.
5. **Mounted Points**:
    - Small wheels mounted on spindles, ideal for internal grinding.
6. **Segmented Wheel**:
    - Composed of abrasive segments assembled into a circular frame for heavy-duty work.



<u>Types of Abrasive Materials and Their Properties</u>

1. **Aluminum Oxide (Al_2O_3)**:
    - Tough, durable, and versatile.
    - Used for grinding ferrous metals such as steel.

2. **Silicon Carbide (SiC)**:
    - Harder but more brittle than aluminum oxide.
    - Ideal for grinding non-ferrous metals, glass, and ceramics.
3. **Diamond**:
    - The hardest known abrasive.
    - Used for cutting and grinding hard materials like ceramics and carbide.
4. **Cubic Boron Nitride (CBN)**:
    - Second only to diamond in hardness.
    - Preferred for high-speed grinding of steel and superalloys.
5. **Emery**:
    - A mix of aluminum oxide and iron oxide.
    - Common in finishing and polishing applications.
6. **Garnet**:
    - Softer and less durable.
    - Suitable for light-duty grinding.



(a) Green silicon carbide (b) White aluminium oxide

Bonding Materials

Bonding materials hold abrasive grains together and determine the grinding wheel's structure and performance.

1. **Vitrified Bond**:
    - Made from clay and ceramic materials.
    - Provides rigidity and precision but is brittle.

2. **Resinoid Bond**:
   - Flexible and resilient.
   - Used in cutting wheels and heavy-duty grinding.
3. **Rubber Bond**:
   - Flexible, soft, and ideal for thin wheels.
4. **Metal Bond**:
   - Strong and durable.
   - Commonly used in diamond wheels for hard materials.
5. **Shellac Bond**:
   - Smooth and soft.
   - Used for fine surface finishing.
6. **Electroplated Bond**:
   - Single-layer bonding, used for specific applications like diamond tools.

Grinding Wheel Classification

Grinding wheels are classified based on several parameters:

1. **Shape**: Straight, tapered, or cylindrical. We will choose the shape of the wheel according to the shape of the workpiece to be grinded.
2. **Abrasive material**: Aluminum oxide, silicon carbide, diamond, CBN, Boron Carbide etc. Al_2O_3 is used for grinding soft materials while for hard materials CBN and diamond can be used for hard material but only downside being that the **Glazing of the wheel** will be taking place. To remove glazing, we will turn the grinding wheel using cutting tool so that the layer below the glazed one will become the grinding layer. This process is termed as **Dressing of the grinding wheel.Truing** is done to make the wheel geometrically correct or accurate after dressing has been done. This will lead to greater stability of the grinding wheels.
3. **Grain size/ Grit Size**: Ranges from coarse to fine (e.g., 10 for coarse, 800 for very fine). Grit size is calculated as (1/GS). That is if we want to do rough machining, we will choose lower number of grit size i.e. 1/20 or 1/40, while if very fine finish is to be obtained by grinding then we will be choosing grit size of higher values i.e. 1/600 or 1/720 etc.
4. **Grade**: Indicates the hardness of the wheel, from soft to hard A-H, I-P, Q-Z. We will choose the grade according to the workpiece that needs to be grinded for hard workpiece soft grade i.e. A-H range will be chosen, for soft workpiece hard grade will be chosen as suitable.
5. **Structure**: Describes the density of abrasive grains (dense or open). This signifies the average gap between the abrasive particles or their packing density. For dense structure 0-7 range is shown and for open structure 8-16 is chosen. Dense structure is chosen for either rough or fine

machining i.e. for rough machining open structure will be chosen and dense for fine machining. While grinding soft materials using dense structure there arises a problem where chips gets stuck between the abrasives and this results in **Loading/ Clogging of the grinding wheel.** To eliminate loading we will use open structure grinding wheels.

6. **Bond type**: Bond indicates the bonding material used for producing the bond between the abrasive particles. Types of commonly used bonds are Vitrified, Shellac, resinoid, rubber, metal, etc. Vitrified gives glass like finish and is most common type of bond used due to higher bonding, high temperature withstanding and high thermal conductivity. Rubber or Shellac will be used as bonding material for producing flexible grinding / Buffing wheels.

Alphabet	Numeral	Alphabet	Numeral	Alphabet
Type of Abrasives	**Grit Size/ Grain Size**	**Grade**	**Structure**	**Bond**
Al_2O_3 Boron Carbide CBN Diamond SiC	1/10- Coarse grain 1/800- Very fine grain	A-H – Soft I-P – Medium Q-Z - Hard	0-7 – Dense 8-16 – Open	V- Vitrified S- Shellac R- Rubber M- Metal Rs- Resinoid

Conditions for Selecting Grinding Wheels

When selecting a grinding wheel, consider:

1. **Material to be Ground**:
    - Hard materials require soft-grade wheels.
    - Soft materials require hard-grade wheels.
2. **Type of Grinding Operation**:
    - Surface grinding: Straight wheels.
    - Cutting: Thin cut-off wheels.
3. **Wheel Speed**:
    - Higher speeds require stronger bonding materials.
4. **Finish Required**:
    - Fine abrasives for smooth finishes.
    - Coarse abrasives for faster material removal.

5. **Coolant Use**:
   - Wet grinding wheels must resist coolant effects.
6. **Machine Requirements**:
   - Select a wheel compatible with machine spindle speed and power.

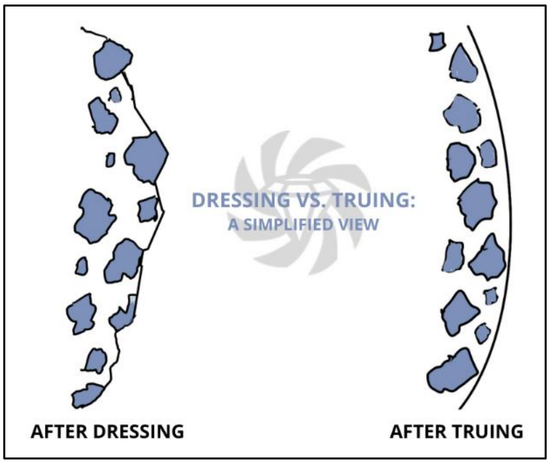
Balancing of Grinding Wheels

Grinding wheel balancing ensures even weight distribution to:

1. Prevent vibrations during operation.
2. Protect the spindle and machine components.
3. Achieve precise and smooth finishes.
4. Prolong the wheel and machine life.

Glazing, Loading, Dressing, and Truing

1. **Glazing**:
   - Occurs when abrasive grains become dull and smooth resulting in Shiny surface.
   - Results in reduced cutting efficiency. Requires Dressing to restore sharpness.
2. **Loading**:
   - Happens when debris fills wheel pores.
   - Decreases cutting performance. To eliminate this open structure is used.
3. **Dressing**:
   - The process of sharpening or cleaning the wheel surface by removing worn grains and debris using single point cutting tool in lathe.
4. **Truing**:
   - Ensures the wheel is concentric with the spindle and has a correct shape.



Designation of Grinding Wheels

Grinding wheels are designated with a standard code to indicate their characteristics:

1. **Abrasive Type**: (e.g., A for Aluminum Oxide, C for Silicon Carbide).
2. **Grain Size**: (e.g., 46 for medium, 60 for fine).
3. **Grade**: (e.g., H for soft, K for hard).
4. **Structure**: (e.g., 5 for dense, 9 for open).
5. **Bond Type**: (e.g., V for Vitrified, B for Resinoid).

Example: *A 60 K 7 V*

- A: Aluminum Oxide.
- 60: Fine grain size.
- K: Medium-hard grade.
- 7: Open structure.
- V: Vitrified bond.

This systematic coding ensures the right wheel is chosen for the job, optimizing performance.

Unit 5.2

Principles of Working of Grinding Machines and Functions of Main Parts

Principles of Working:

Grinding machines operate on the principle of abrasion. The grinding wheel, composed of abrasive grains bonded together, rotates at high speeds and removes material from the surface of a workpiece by shearing small chips. The interaction between the abrasive grains and the workpiece generates friction and removes material to achieve the desired shape and finish.

Functions of Main Parts:

1. **Base**:
   - Supports the machine and ensures stability.
2. **Table**:
   - Holds the workpiece and moves either linearly or rotationally.
3. **Headstock**:
   - Houses the spindle, which rotates the grinding wheel.
4. **Tailstock (for cylindrical grinders)**:
   - Supports the other end of the workpiece.
5. **Wheel Guard**:
   - Encloses the grinding wheel for safety.

6. **Grinding Wheel**:
   - Abrasive tool used to cut or shape the material.
7. **Feed Mechanism**:
   - Controls the depth of cut and movement of the grinding wheel.
8. **Coolant System**:
   - Supplies coolant to prevent overheating and maintain the surface finish.

Types of Grinding Processes

1. **Surface Grinding**:
   - Produces a flat or smooth surface.
   - Workpiece moves linearly while the wheel rotates.
2. **Cylindrical Grinding**:
   - Used for cylindrical parts.
   - Includes external and internal cylindrical grinding.
3. **Centerless Grinding**:
   - Workpiece is supported between a grinding wheel and a regulating wheel.
   - No need for centers or chucks.
4. **Tool and Cutter Grinding**:
   - Sharpens cutting tools such as drills and milling cutters.
5. **Thread Grinding**:
   - Produces precision threads using a specially designed wheel.
6. **Creep-Feed Grinding**:
   - Removes material at very slow feed rates with deeper cuts.

Function of Tool and Work Holding Devices

1. **Tool Holding Devices**:
   - **Collets, Chucks, and Arbors**:
     - Securely hold the grinding wheel or other tools.
   - Ensure concentricity and minimize vibrations.
2. **Work Holding Devices**:

- **Magnetic Chuck**:
  - For holding ferromagnetic workpieces in surface grinding.
- **Centers**:
  - For cylindrical grinding, aligns and supports workpieces.
- **V-Blocks**:
  - For holding cylindrical parts securely during grinding.
- **Clamps and Fixtures**:
  - Custom-designed devices for non-standard workpieces.

Table Drive in Surface and Cylindrical Grinders

1. **Surface Grinders**:
   - **Reciprocating Table Drive**:
     - Moves back and forth linearly.
     - Powered by hydraulics or electric motors.
   - **Rotary Table Drive**:
     - Rotates the workpiece under the grinding wheel.
2. **Cylindrical Grinders**:
   - **Longitudinal Table Drive**:
     - Provides linear movement for external grinding.
   - **Rotational Table Drive**:
     - Rotates workpieces for internal and external grinding.

Types of Lubricants and Coolants Used in Grinding

1. **Types of Coolants**:
   - **Water-Based Coolants**:
     - Contain water and additives to cool and lubricate.
   - **Oil-Based Coolants**:
     - Provide better lubrication but less cooling.
   - **Synthetic Coolants**:
     - Chemically formulated for both cooling and lubrication.

- **Semi-Synthetic Coolants**:
  - Combination of water-based and synthetic properties.

2. **Types of Lubricants**:
   - **Straight Oils**:
     - High lubrication, used for precision work.
   - **Emulsified Oils**:
     - Oil-water mix for cooling and lubrication.
   - **Solid Lubricants**:
     - Graphite or molybdenum disulfide for dry applications.

Grinding Defects, Their Remedy, and Safety Practices

Grinding Defects and Remedies:

1. **Burns**:
   - **Cause**: Excessive heat due to poor coolant flow or too fast grinding.
   - **Remedy**: Improve coolant flow, reduce feed rate.
2. **Chatter Marks**:
   - **Cause**: Vibrations or machine instability.
   - **Remedy**: Balance the wheel, stabilize the setup.
3. **Loading**:
   - **Cause**: Workpiece material sticking to the wheel.
   - **Remedy**: Use proper dressing tools, select the right wheel.
4. **Out-of-Round Workpieces**:
   - **Cause**: Incorrect dressing or misalignment.
   - **Remedy**: Properly dress the wheel, ensure alignment.
5. **Wheel Glazing**:
   - **Cause**: Dull abrasive grains.
   - **Remedy**: Dress the wheel to expose fresh grains.

Safety Practices in Grinding:

1. **Personal Protective Equipment (PPE)**:
   - Wear safety goggles, gloves, and face shields.

2. **Proper Wheel Mounting**:
   - Ensure the wheel is securely mounted and balanced.
3. **Avoid Excessive Speeds**:
   - Do not exceed the recommended speed for the grinding wheel.
4. **Use Wheel Guards**:
   - Protect the operator from fragments in case of wheel failure.
5. **Coolant Management**:
   - Ensure proper coolant flow to prevent burns and thermal damage.
6. **Inspect Wheels**:
   - Check for cracks or defects before use.
7. **Maintain Work Area**:
   - Keep the area clean and free of obstructions.

Unit 5.3

Definition of Finishing Processes

Finishing processes are a set of manufacturing techniques used to improve the surface quality, dimensional accuracy, and physical properties of a workpiece after primary machining operations. These processes remove minimal material and focus on achieving a high-quality surface finish and tight tolerances.

Micro-Finishing

Definition:

Micro-finishing, also known as micro-abrasion or super-abrasion, is a precision surface finishing process that uses fine abrasive films or stones to achieve extremely smooth surfaces.

Equipment Involved:

- Micro-finishing machines with oscillating abrasive tapes.
- Rollers for workpiece rotation.
- Support pads for consistent pressure application.

Materials Used:

- Abrasive films made of aluminum oxide or silicon carbide.
- Flexible backing materials like polyester.

Tolerances Obtained:

- Surface finishes in the range of **0.02 to 0.1 µm Ra**.

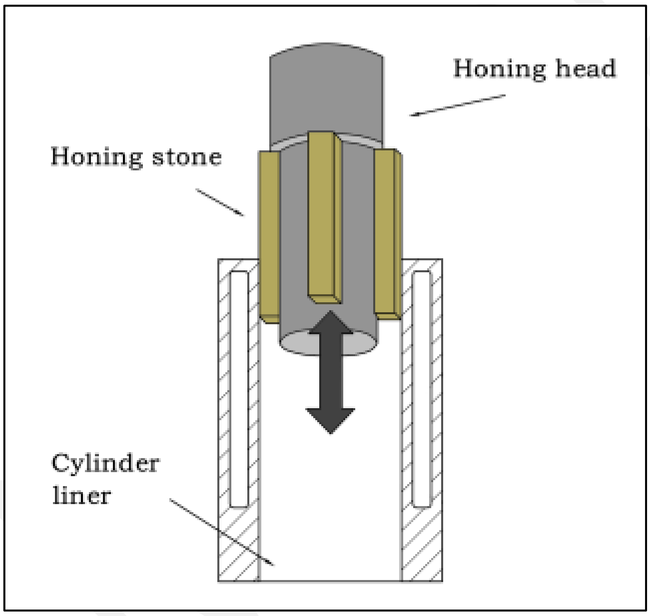
Limitations:

- Limited to small material removal.
- Not suitable for large-scale material removal or rough surfaces.

Applications:

- Automotive components (e.g., crankshafts, camshafts).
- Hydraulic system parts.
- Bearings.

Honing



Definition:

Honing is an abrasive machining process used to improve the geometric form of a surface, typically the internal bore of cylindrical parts. It removes small amounts of material to achieve high accuracy and surface finish.

Equipment Involved:

- Honing machine with a honing head and abrasive stones.
- Spindle for rotating the honing head.
- Work-holding fixtures for alignment.

Materials Used:

- Abrasives such as aluminum oxide, silicon carbide, or diamond.
- Lubricants like honing oil.

Tolerances Obtained:

- Surface finishes up to **0.1 to 0.8 µm Ra**.
- Dimensional accuracy within **±0.005 mm**.

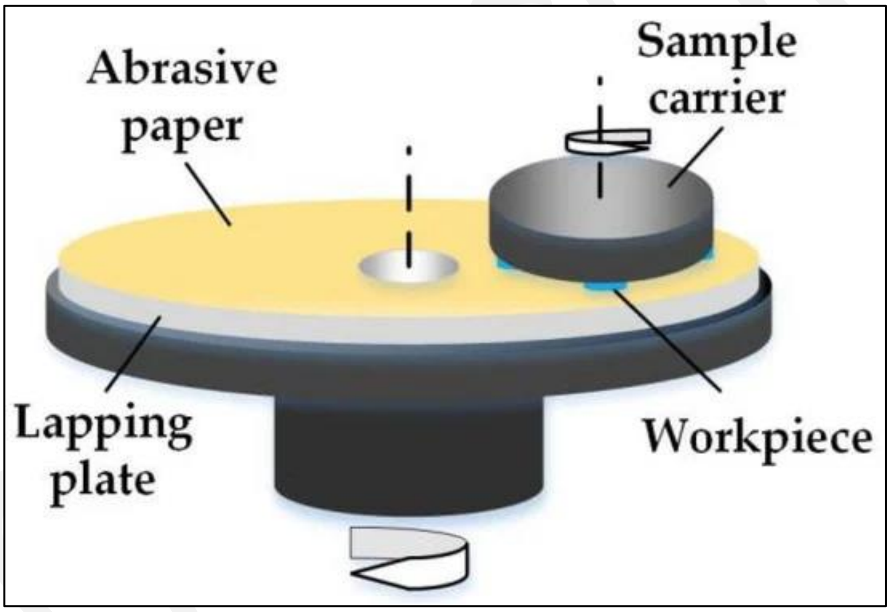
Limitations:

- Restricted to internal surfaces.
- Slow process compared to other methods.

Applications:

- Engine cylinders and hydraulic cylinders.
- Gears and precision bores.

Lapping



Definition:

Lapping is a surface finishing process that involves the rubbing of two surfaces together with an abrasive between them. It produces flat or smooth surfaces with high precision.

Equipment Involved:

- Lapping machine with a rotating plate (lapping plate).
- Fixture for holding the workpiece.
- Abrasive slurry supply system.

Materials Used:

- Abrasive materials like aluminum oxide, silicon carbide, or diamond.

- Lapping fluid (oil or water-based).

Tolerances Obtained:

- Surface finishes as fine as **0.025 to 0.2 µm Ra**.
- Dimensional tolerances of **±0.001 mm**.

Limitations:

- Slow material removal rate.
- Requires skilled operators for consistent results.

Applications:

- Optical components (e.g., lenses).
- Precision gauges and seals.
- Valve seats.

Super-Finishing

Definition:

Super-finishing is a process that uses light pressure and fine abrasives to achieve an ultra-smooth surface finish and improved wear resistance. It involves a combination of oscillatory and rotary motions.

Equipment Involved:

- Super-finishing machine with fine abrasive stones.
- Work-holding devices for alignment.

Materials Used:

- Abrasive stones with aluminum oxide or silicon carbide.
- Lubricants to reduce heat and debris.

Tolerances Obtained:

- Surface finishes in the range of **0.01 to 0.1 µm Ra**.

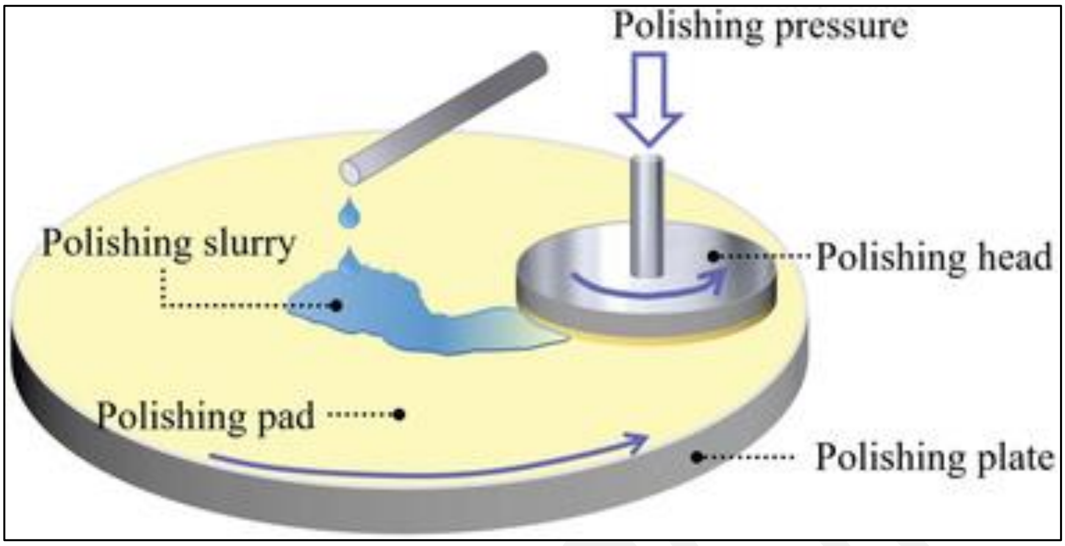
Limitations:

- Limited to small material removal.
- Suitable for specific components only.

Applications:

- Roller bearings and shafts.
- Precision engine parts.

Polishing



Definition:

Polishing is a finishing process that uses abrasive belts, wheels, or pastes to improve the aesthetic and functional properties of a surface. It removes minor imperfections and provides a smooth, reflective finish.

Equipment Involved:

- Polishing wheels (cloth, felt, or leather).
- Rotating spindles and polishing machines.

Materials Used:

- Abrasive compounds like rouge, cerium oxide, or aluminum oxide.
- Polishing pads or wheels.

Tolerances Obtained:

- Surface finishes of **0.2 to 1 µm Ra**.
- No significant dimensional accuracy changes.

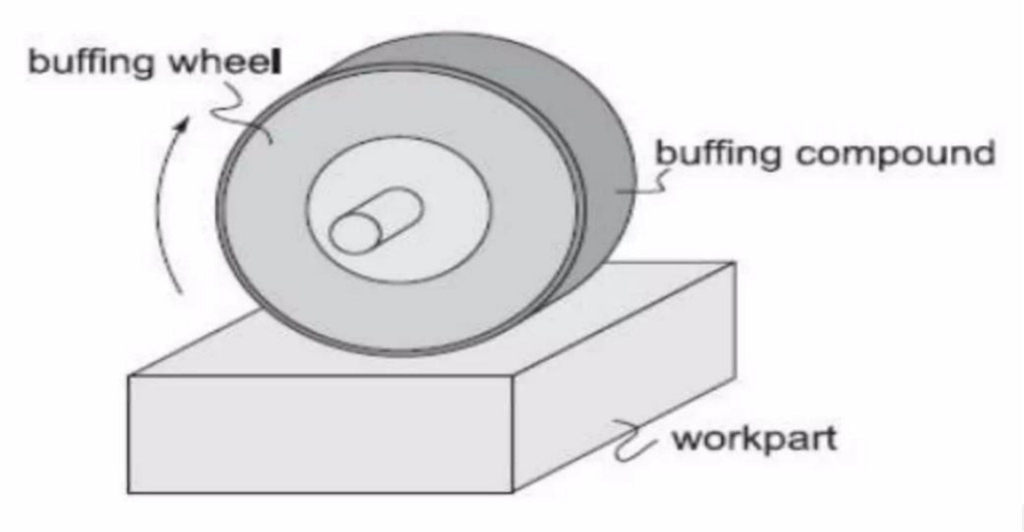
Limitations:

- Time-consuming for large surfaces.
- Generates heat that can distort parts.

Applications:

- Jewelry and decorative parts.
- Automotive and aerospace components.

Buffing



Definition:

Buffing is a process similar to polishing but uses softer materials and compounds to achieve a mirror-like finish. It focuses on aesthetics rather than precision.

Equipment Involved:

- Buffing wheels (soft cloth or felt).
- Buffing machines with high-speed spindles.

Materials Used:

- Buffing compounds (wax-based with fine abrasives).
- Soft buffing pads or wheels.

Tolerances Obtained:

- Surface finishes of **0.2 to 1 µm Ra**.
- Minimal impact on dimensional accuracy.

Limitations:

- Strictly for surface aesthetics.
- Ineffective for rough or unprepared surfaces.

Applications:

- Decorative hardware and appliances.
- Medical instruments.

Comparison of Tolerances Obtained

Process	Surface Finish (µm Ra)	Dimensional Tolerance (mm)
Micro-Finishing	0.02 - 0.1	±0.005
Honing	0.1 - 0.8	±0.005
Lapping	0.025 - 0.2	±0.001
Super-Finishing	0.01 - 0.1	±0.002
Polishing	0.2 - 1	No significant change
Buffing	0.2 - 1	No significant change

Limitations of Finishing Processes

1. Time-consuming and costly for large-scale applications.
2. Limited material removal rates.
3. Requires specialized equipment and skilled operators.
4. May not be suitable for rough or poorly machined surfaces.

Applications of Finishing Processes

1. **Automotive Industry**:
   - Engine parts, shafts, and gears.
2. **Aerospace Industry**:
   - Precision components like turbine blades.
3. **Medical Industry**:
   - Surgical tools and implants.
4. **Optical Industry**:
   - Lenses and mirrors.
5. **Decorative Applications**:
   - Jewellery and aesthetic surfaces.