Lecture – 07: Surface Finish and Integrity

Manufacturing Engineering Technology in SI Units, 7th Edition

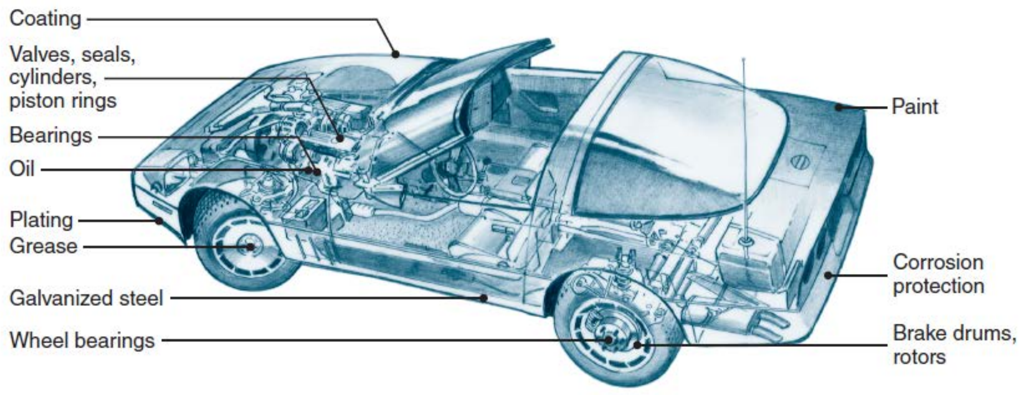
Chapter 21 and 33:

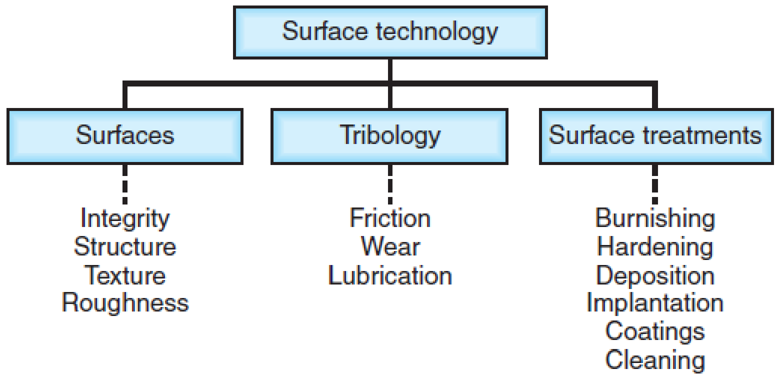
Lecture Outline

1. **Introduction**
2. **Surface texture and roughness**
3. **Surface integrity**
4. **Machinability**

Introduction

- First visual or tactile contact with the objects is through their *surfaces*
- We can feel surface roughness, waviness, reflectivity, scratches, cracks and discoloration





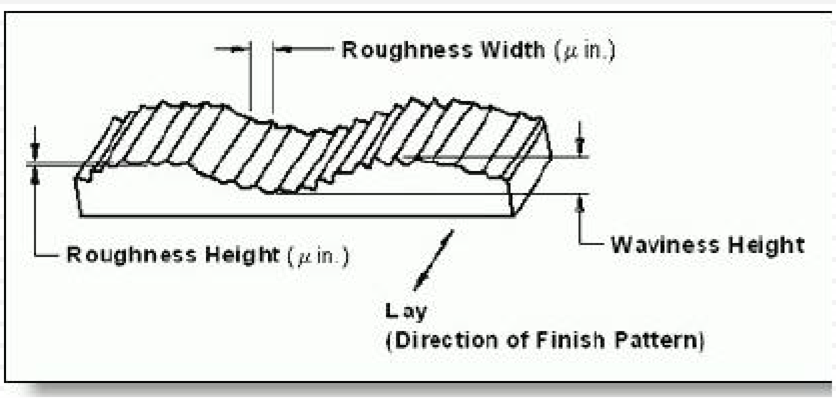
Introduction

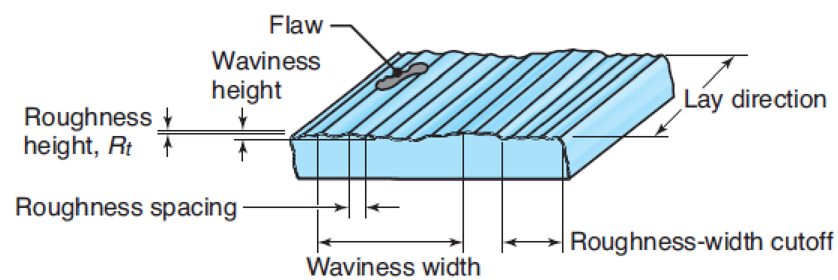
- A specific texture and several defects can exist on a surface depending on how the surface was generated
- Defects and surface textures have major influence on the surface integrity of workpieces, tools, and dies

Surface Texture and Roughness

- Regardless of method of production, all surfaces have their own characteristics referred to as *surface texture*
- The most commonly used measurable quantities for **surface texture** for machined surfaces are:

1. **Roughness (closely spaced, irregular deviations on a small scale expressed in termed of height, width and distance along the surface)**
2. **Waviness (the recurrent deviation of a flat surface, repeating crests and valleys along the surface. Measured as distance between adjacent crests of the waves)**





Surface Texture and Roughness

- **Surface roughness** is characterized

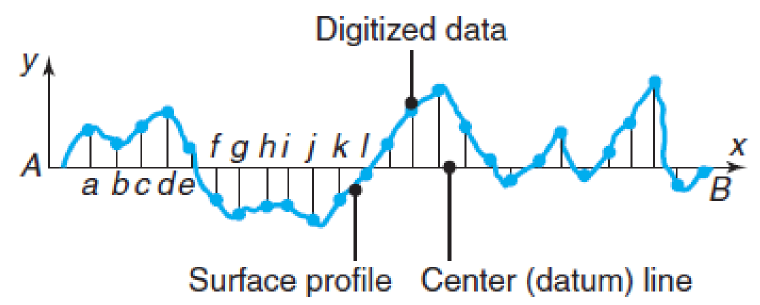
1. **Arithmetic mean value** is

$$R_a = \frac{a+b+c+d+\cdots}{n}$$

a, b, c = absolute values
n = number of readings

2. **Root-mean-square roughness** is

$$R_q = \sqrt{\frac{a^2+b^2+c^2+d^2+\cdots}{n}}$$

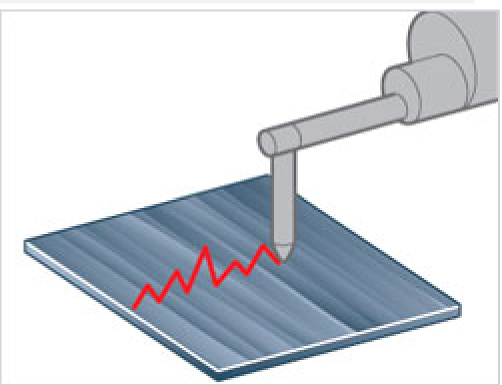


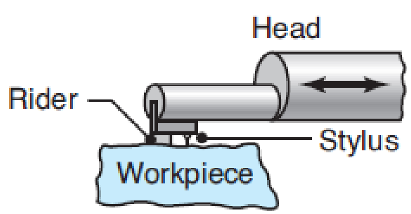
http://www.olympus-ims.com/en/knowledge/metrology/roughness/2d_parameter/

Surface Texture and Roughness

Measuring Surface Roughness

- **Surface profilometers** are used to measure and record surface roughness
- It has a *diamond stylus* that travels along a straight line over the surface





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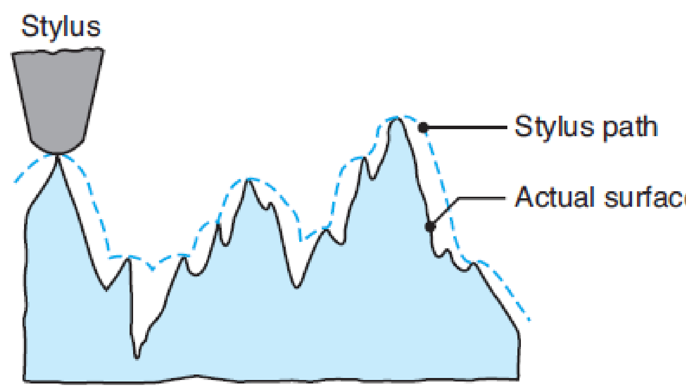
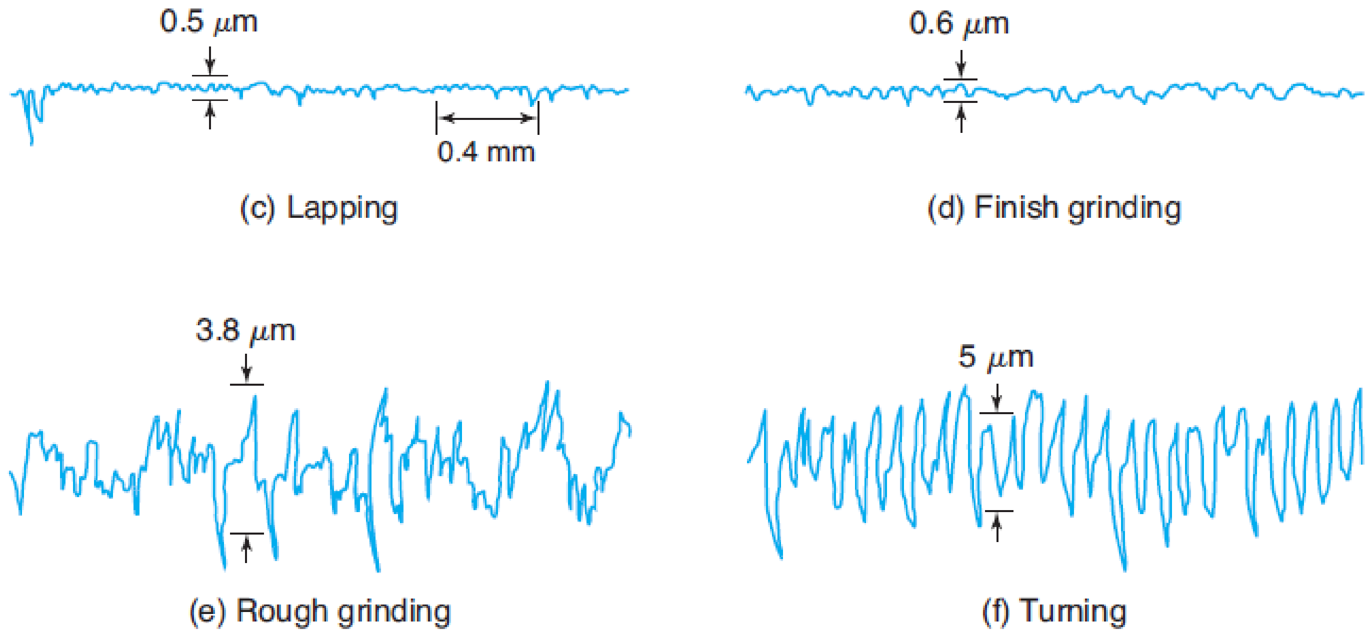


(b)

https://www.youtube.com/watch?v=w-kvPXE05AQ

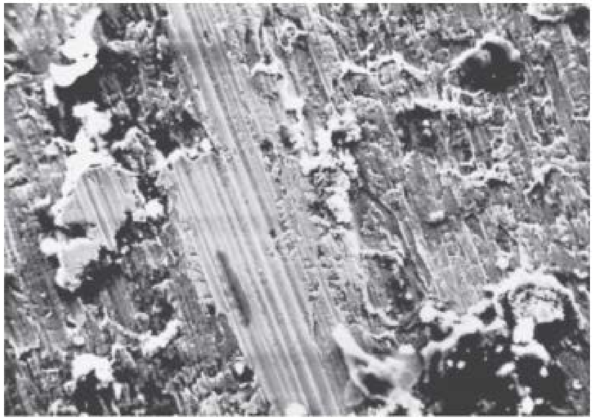
Surface Texture and Roughness

Measuring Surface Roughness



Surface Texture and Roughness

- Surface finish influences the dimensional accuracy of machined parts, properties and performance in service
- *Surface finish* describes the geometric features of a surface while *surface integrity* pertains to material properties
- The *built-up edge* has the greatest influence on surface finish



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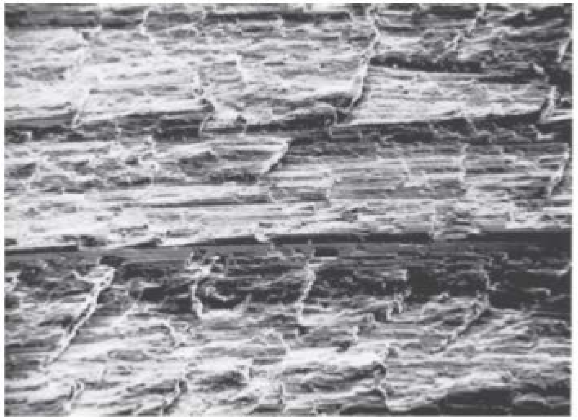
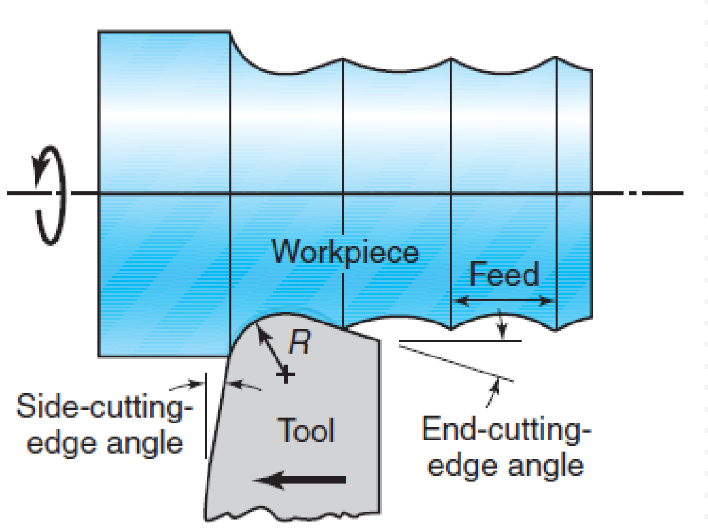


(b)

Surface Texture and Roughness

- A *dull* tool has a large radius along its edges
- In a turning operation, the tool leaves a spiral profile (**feed marks**) on the machined surface as it moves across the workpiece
- The required surface finish is generated in the final passes of the tool.



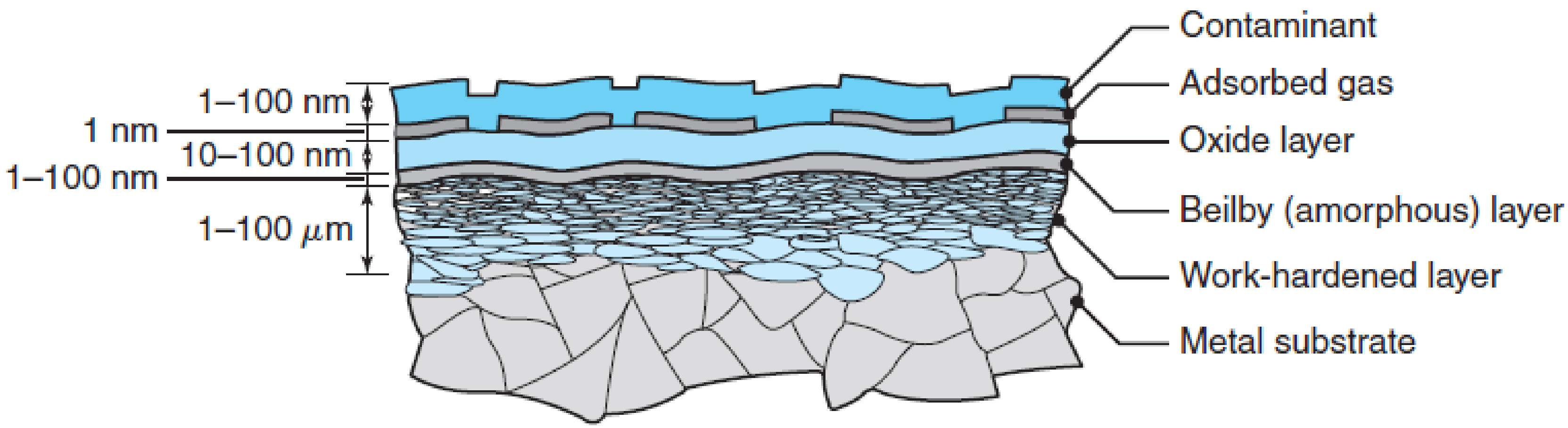
Surface Integrity

Surface Integrity

- *Surface integrity* describes the topological (geometric) features of surfaces such as physical, chemical, mechanical and metallurgical properties and characteristics
- It will influence the fatigue strength, resistance to corrosion and service life

Surface Integrity

- A cross section of the surface structure of a metal:



Surface Integrity

Surface Integrity

- *Surface defects* are caused by:

1. Defects in the original material
2. Machining process by which the surface is produced
3. Improper control of the machining process parameters

Surface Integrity

Surface Integrity

Major **surface defects** after machining are:

1. External or internal cracks
2. Craters and pits
3. Heat-affected zone and Recast layers
4. Laps, folds, and seams (e.g. overlapping of material)
5. Metallurgical transformations (change of micro-structure)
6. Residual stresses
7. Surface plastic deformation

Surface Integrity

- Factors influencing *surface integrity* are:

1. Temperatures generated
2. Surface residual stresses
3. Plastic deformation and strain hardening of the machined surfaces, tearing and cracking

- One of the solutions to overcome the surface defects is to use rough machining only in the beginning to remove a large amount of material and then apply finish machining that lower values of feed rate, depth of cut and moderate cutting speeds at the end of the machining process.

Machinability

- *Machinability* is defined in terms of four factors:

    1. Surface finish and surface integrity
    2. Tool life
    3. Force and power required
    4. The level of difficulty in chip control

- Good machinability indicates good surface finish and surface integrity, a long tool life, and low force and power requirements

Machinability: Machinability of Ferrous Metals

Steels

- If a carbon steel is too ductile, chip formation can produce built-up edge, leading to poor surface finish
- If too hard, it can cause abrasive wear of the tool because of the presence of carbides in the steel
- In **leaded steels**, a high percentage of lead solidifies at the tips of manganese sulfide inclusions
- **Calcium-deoxidized steels** contain oxide flakes of calcium silicates (CaSO) that reduce the strength of the secondary shear zone and decrease tool–chip interface friction and wear

Machinability: Machinability of Ferrous Metals

Effects of Various Elements in Steels

- Presence of *aluminum* and *silicon* is harmful, as it combine with oxygen to form aluminum oxide and silicates, which are hard and abrasive
- Thus tool wear increases and machinability reduce

Stainless Steels

- Austenitic (300 series) steels are difficult to machine
- Ferritic stainless steels (also 300 series) have good machinability
- Martensitic (400 series) steels are abrasive

Machinability:
Machinability of Nonferrous Metals

- **Aluminum** is very easy to machine
- **Beryllium** requires machining in a controlled environment
- **Cobalt-based alloys** require sharp, abrasion-resistant tool materials and low feeds and speeds
- **Copper** can be difficult to machine because of builtup edge formation
- **Magnesium** is very easy to machine, with good surface finish and prolonged tool life
- **Titanium** and its alloys have very poor thermal conductivity
- **Tungsten** is brittle, strong, and very abrasive

Machinability:
Machinability of Miscellaneous Materials

- Machining **thermoplastics** requires sharp tools with positive rake angles, large relief angles, small depths of cut and feed and high speeds
- **Polymer-matrix composites** are difficult to machine
- **Metal-matrix and ceramic-matrix composites** can be difficult to machine, depending on the properties of the matrix material and the reinforcing fibers
- The type of chips and the surfaces produced also vary significantly, depending on the type of **wood** and its condition

ISO CLASSIFICATION WORKPIECE MATERIALS

P	Non-alloy steel and cast steel Low-alloy steel and cast steel High-alloy steel and cast steel Stainless steel and cast steel (ferritic/martensitic)
M	Stainless steel (austenitic)
K	Gey cast iron Ductile cast iron Nodular cast iron (ferritic/perlitic)
N	Non-ferrous metals Aluminium and aluminium alloys
S	Superalloys Titanium and titanium alloys
H	Hard cast iron Hardened steel