CMM and Surface Roughness Measurement

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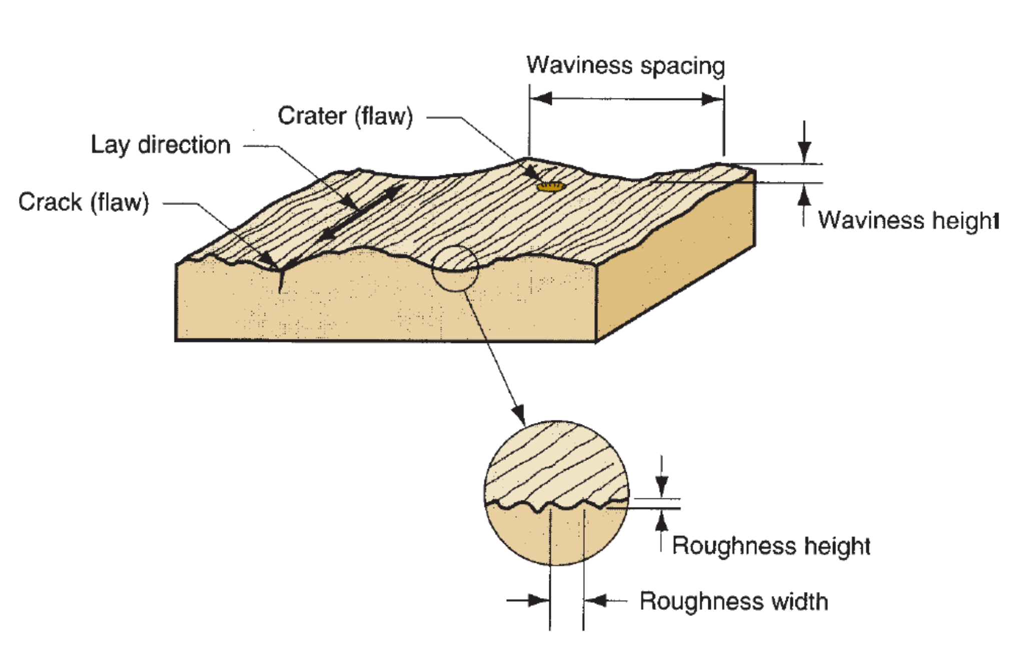


Learning Objective

- Introduction to CMM
- Introduction to Surface Measurement

Coordinate Measuring Machine

- A classic, bridge-style coordinate Measuring Machine (CMM) accurately measures the geometry of an object along X, Y and Z axes using a touch-trigger, scanning or vision probe to take a series of precise points on the surface of an object.

Coordinate Measuring Machine

- CMMs can be made from a wide variety of materials, however a combination of granite and aluminium has been widely adopted by the industry due to its stiffness to weight ratio and allowing the constructed materials to be thermally dynamic.
- Changes in ambient temperatures and thus expansion or contractions of the machine's materials are monitored and compensated for in the user software.

Coordinate Measuring Machine

- The probes position can be manually controlled or, automatically (CNC) through the use of a computer.
- The position is defined using a reference sphere in the X-Y-Z coordinate system.
- CMMs also allow the probe angle to be controlled to enable the measurement of complex surfaces that may otherwise be unreachable.
- The most common use of a CMM is to test the accuracy of a manufactured part against its original design to ensure stringent quality requirements are met and adhered to.

The utility of a CMM

- Traditional handheld inspection methods have their limitations and rely heavily on the skill of the personnel inspecting the parts. Incorrectly manufactured parts can go undetected and supplied to customers.
- In addition, as manufacturing design becomes more refined, parts are made more complex meaning some features can only be accurately measured with a CMM.
- With the need to speed-up and streamline inspection processes, this is where CMM inspection offers accurate, repeatable results in a fraction of the time, all the while meeting ever-increasing customer demands.

Zeiss Spectrum CMM

Surface

- A surface is what one touches when holding an object such as a manufactured part.
- The designer specifies the part dimensions, relating the various surfaces to each other.
- These ***nominal surfaces***, representing the intended surface contour of the part, are defined by lines in the engineering drawing.

Surface

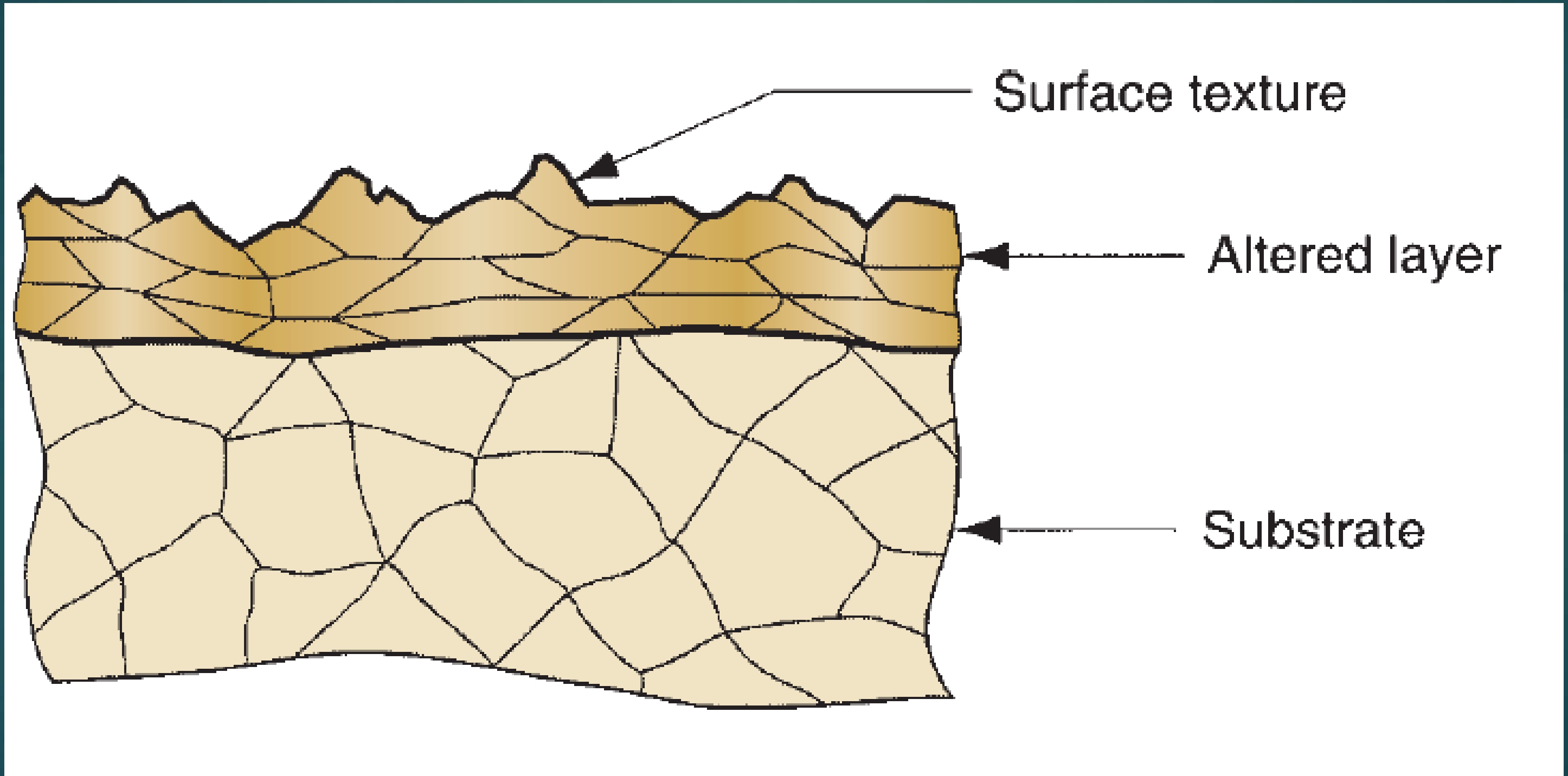
- The nominal surfaces appear as absolutely straight lines, ideal circles, round holes, and other edges and surfaces that are geometrically perfect.
- The actual surfaces of a manufactured part are determined by the processes used to make it.
- The variety of processes available in manufacturing result in wide variations in surface characteristics, and it is important for engineers to understand the technology of surfaces.

Surface Technology

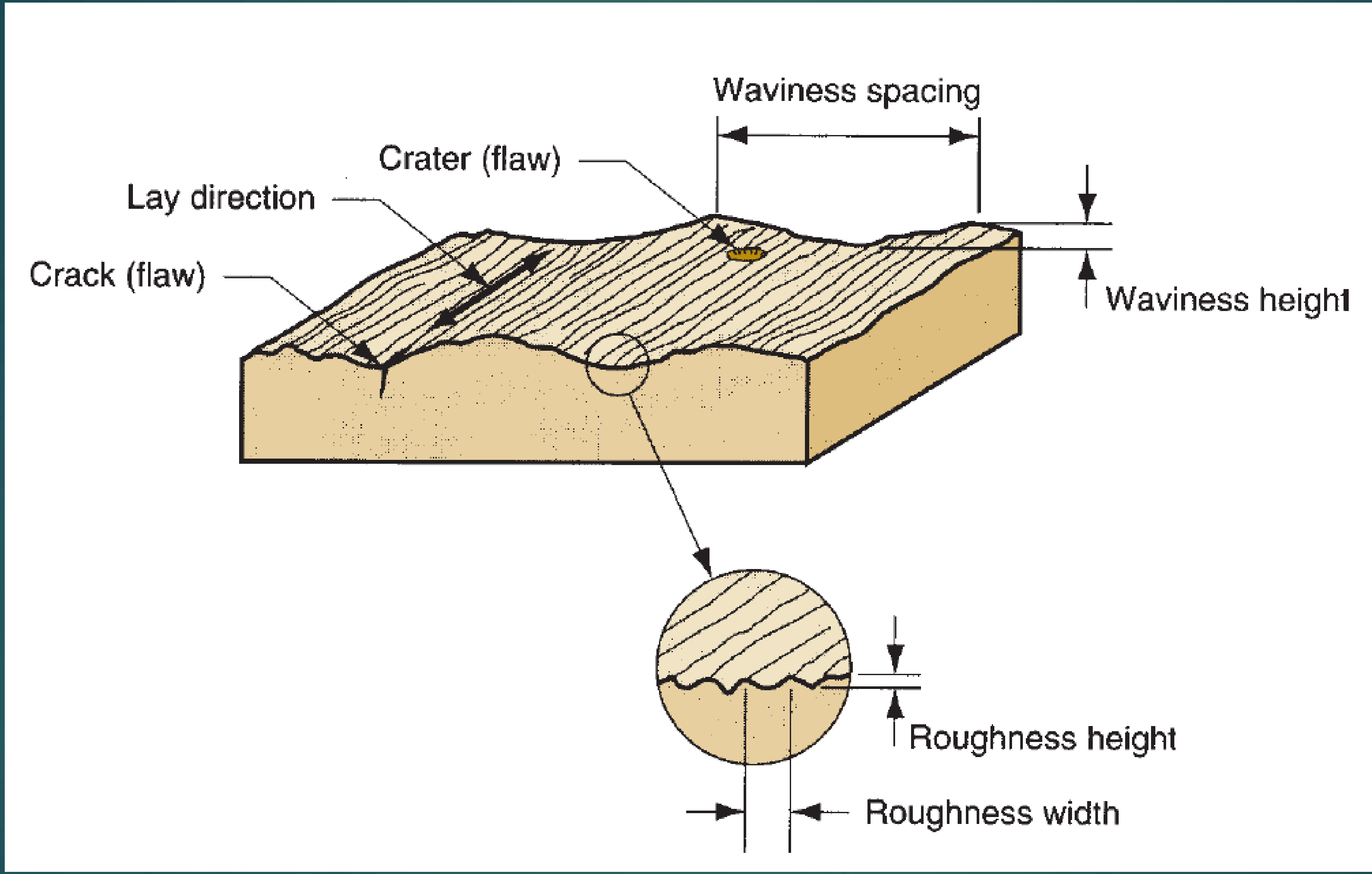
Surface technology is concerned with

- (1) defining the characteristics of a surface,
- (2) surface texture,
- (3) surface integrity,
- and (4) the relationship between manufacturing processes and the characteristics of the resulting surface

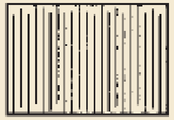
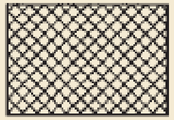
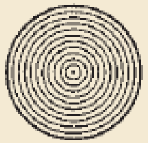
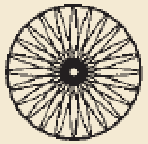
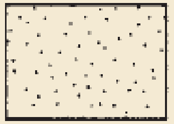
A magnified cross section of a typical metallic part surface



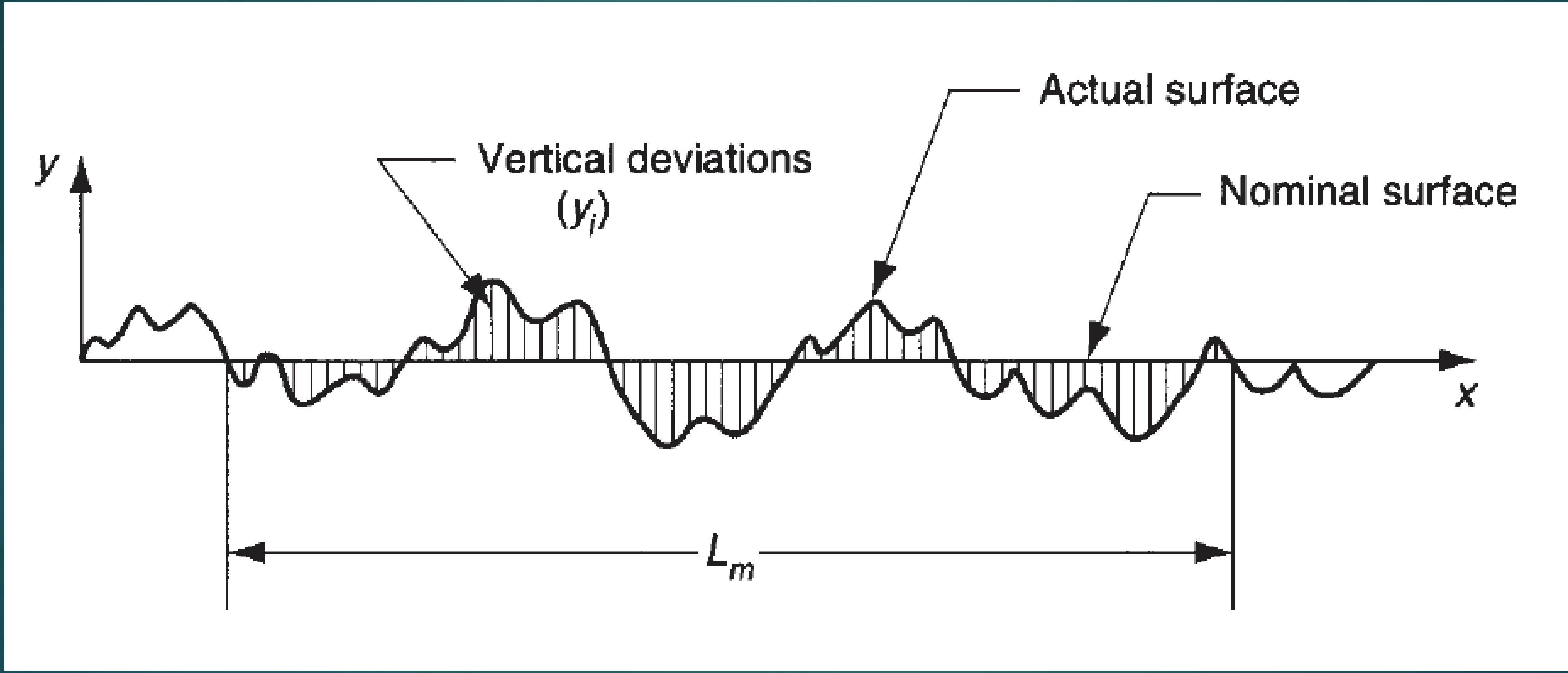
Features of Surface Texture



Possible Lays of Surface

Lay symbol	Surface pattern	Description
=		Lay is parallel to line representing surface to which symbol is applied.
⊥		Lay is perpendicular to line representing surface to which symbol is applied.
X		Lay is angular in both directions to line representing surface to which symbol is applied.
C		Lay is circular relative to center of surface to which symbol is applied.
R		Lay is approximately radial relative to the center of the surface to which symbol is applied.
P		Lay is particulate, nondirectional, or protuberant.

Deviations from nominal surface used in the two definitions of surface roughness.



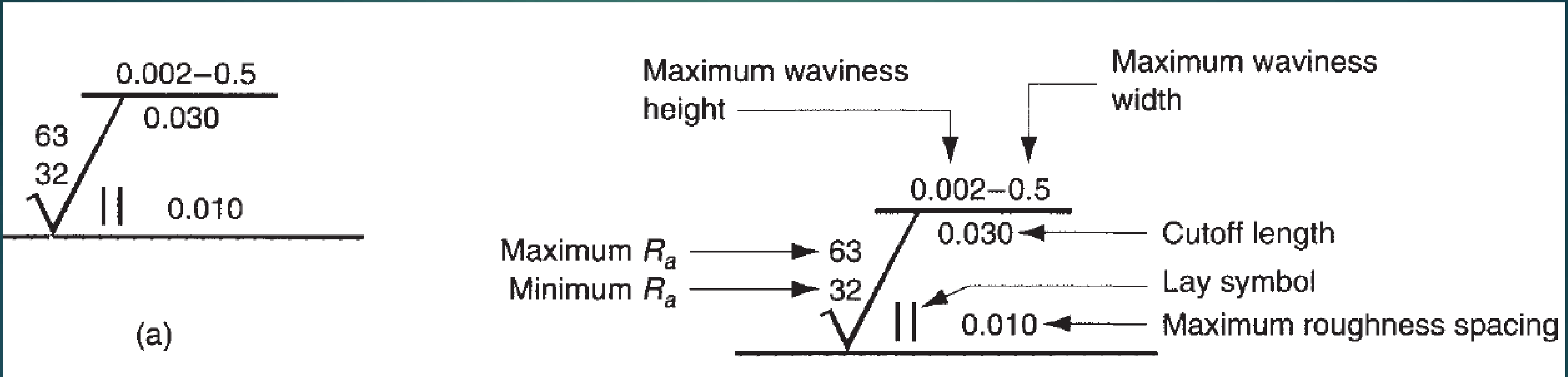
Surface roughness can be defined as the average of the vertical deviations from the nominal surface over a specified surface length. An arithmetic average (AA) is generally used, based on the absolute values of the deviations, and this roughness value is referred to by the name ***average roughness***.

$$R_a = \int_0^{L_m} \frac{|y|}{L_m}\, dx \qquad (5.1)$$

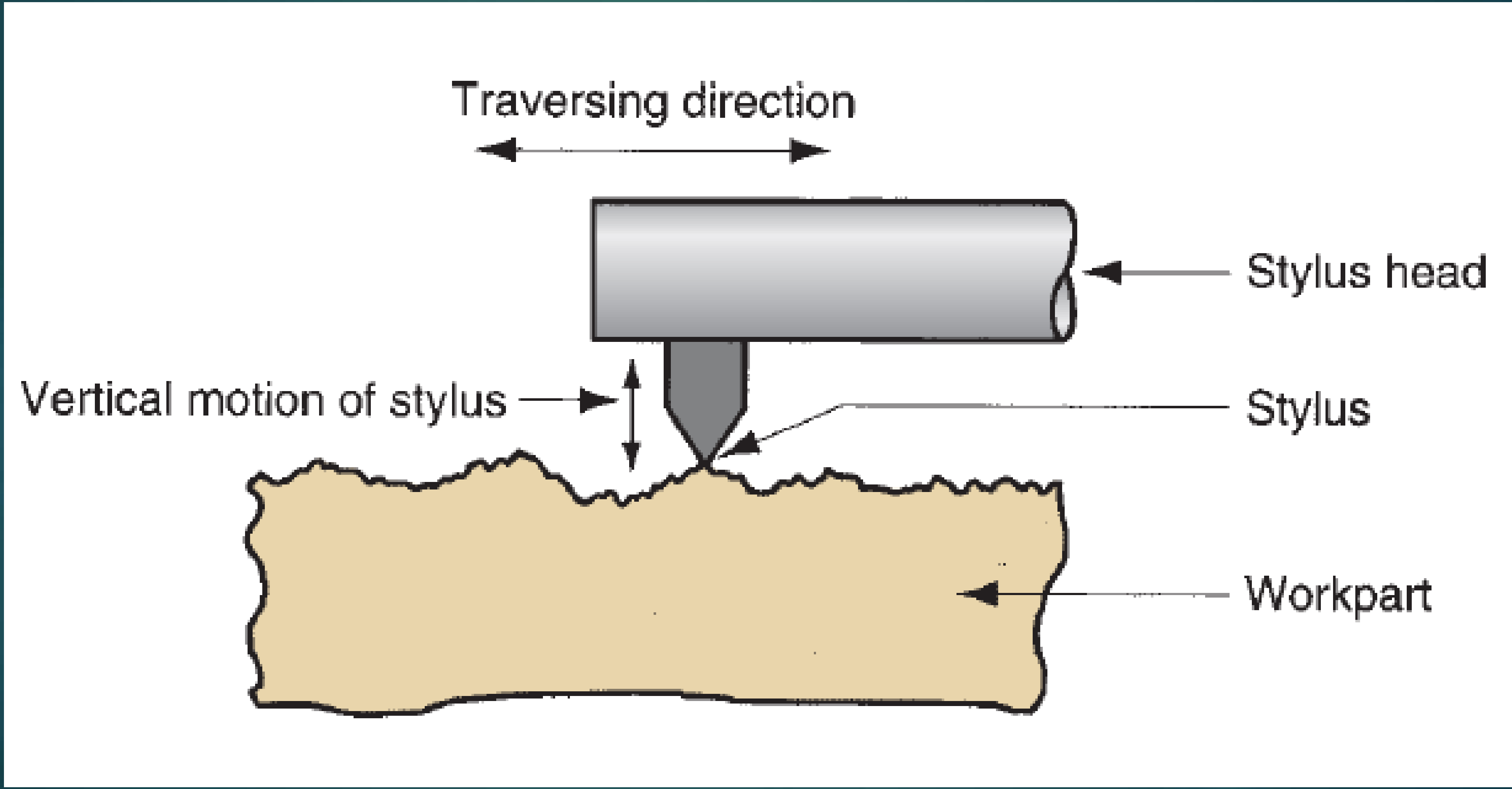
where R_a = arithmetic mean value of roughness, m (in); y = the vertical deviation from nominal surface (converted to absolute value), m (in); and L_m = the specified distance over which the surface deviations are measured. An approximation of Equation (5.1), perhaps easier to comprehend, is given by

$$R_a = \sum_{i=1}^{n} \frac{|y_i|}{n} \qquad (5.2)$$

Surface texture symbols in engineering drawings



Operation of Stylus Type Instrument



Surface Roughness Values produced by various Manufacturing Processes

Process	Typical Finish	Roughness Range [b]	Process	Typical Finish	Roughness Range [b]
Casting:			Abrasive:		
Die casting	Good	1–2 (30–65)	Grinding	Very good	0.1–2 (5–75)
Investment	Good	1.5–3 (50–100)	Honing	Very good	0.1–1 (4–30)
Sand casting	Poor	12–25 (500–1000)	Lapping	Excellent	0.05–0.5 (2–15)
Metal forming:			Polishing	Excellent	0.1–0.5 (5–15)
Cold rolling	Good	1–3 (25–125)	Superfinish	Excellent	0.02–0.3 (1–10)
Sheet metal draw	Good	1–3 (25–125)	Nontraditional:		
Cold extrusion	Good	1–4 (30–150)	Chemical milling	Medium	1.5–5 (50–200)
Hot rolling	Poor	12–25 (500–1000)	Electrochemical	Good	0.2–2 (10–100)
Machining:			Electric discharge	Medium	1.5–15 (50–500)
Boring	Good	0.5–6 (15–250)	Electron beam	Medium	1.5–15 (50–500)
Drilling	Medium	1.5–6 (60–250)	Laser beam	Medium	1.5–15 (50–500)
Milling	Good	1–6 (30–250)	Thermal:		
Reaming	Good	1–3 (30–125)	Arc welding	Poor	5–25 (250–1000)
Shaping and planing	Medium	1.5–12 (60–500)	Flame cutting	Poor	12–25 (500–1000)
Sawing	Poor	3–25 (100–1000)	Plasma arc cutting	Poor	12–25 (500–1000)
Turning	Good	0.5–6 (15–250)			

[a] Compiled from [1], [2], and other sources.

[b] Roughness range values are given, μm (μ-in). Roughness can vary significantly for a given process, depending on process parameters.


Thank you