10.8 SURFACE INSPECTION

Surface conditions of a workpiece affect the service life, appearance, and function of the workpiece. The surface characteristics with which this section deals are roughness, waviness, and lay. Surface hardness, wear resistance, luster, corrosion, etc. are not dealt with in this section.

The simplest method for measuring surface quality is the visual comparison of the workpiece with an acceptable sample. This sample surface may be a machined surface set aside by someone in authority. The comparison of the sample with the machined workpiece may be visual as well as by running a fingernail first across the sample and then across the workpiece. The workpiece may also be compared with standard samples which may be purchased in sets. One such set is shown in Fig. 10.20a. A magnifier and comparator is shown in Fig. 10.20b. These systems will allow comparisons of from 2 to 500 microinches.

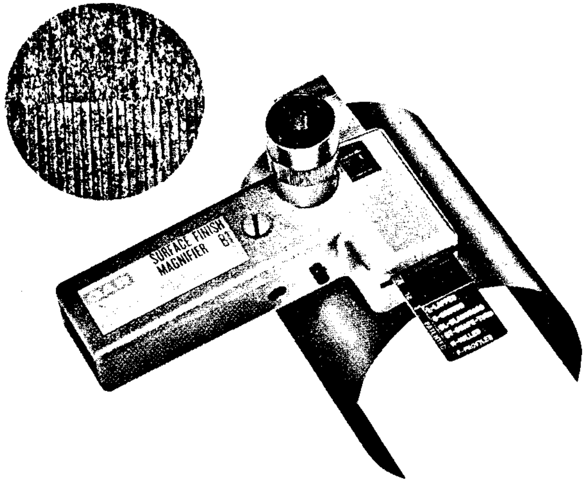
(a)

Figure 10.20a

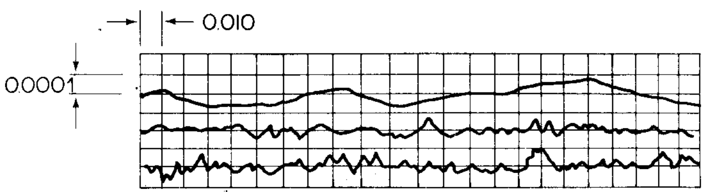
Surface may also be visually examined after being recorded on a transparent film which is placed on the surface to be inspected. This film, when partially hardened, may be stripped off the workpiece. The hardened film records the surface of the workpiece which then may be studied.

Profilometers, which use a very finely pointed diamond tracer, are used to read surface irregularities. They produce readouts as arithmetic or rms (root mean square) averages. With a diamond tracer which has a tip radius of 0.0005 in. and a 90° cone angle very finely finished surfaces may be averaged. The tracer may be operated manually or mechanically.

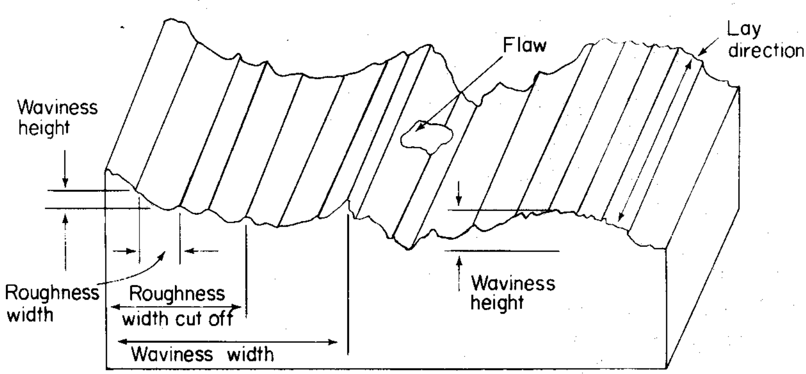
Figure 10.20c shows a trace where the variation in depth is read to 0.0001 inches and the length of trace is 0.010 inches. The lower trace is a trace of the



(b)



(c)



(d)

Figure 10.20 (b, c, d)

surface of the workpiece in terms of roughness, waviness, and flaws such as scratches. The *middle trace* shows fine irregularities of roughness in the work surface. The averages of the irregularities are shown by this trace. When the roughness is spaced out it is called a wave. These waves are recorded by the upper trace. Recent experiments with electrical condenser plates, very fine air jets and light beams, seem to hold some hope for their use as tracers.

Commonly used terms are shown in Fig. 10.20d and defined.

ROUGHNESS. These are the surface irregularities which result from the various fabricating processes. They are the finely spaced irregularities which combine to form the surface texture. The height, width, and general direction of the pattern are included. The *height* is averaged above and below, perpendicular to a mean line, and stated in microinches. The *width* is stated in inches and is the maximum spacing allowed between successive peaks, measured parallel to the mean line.

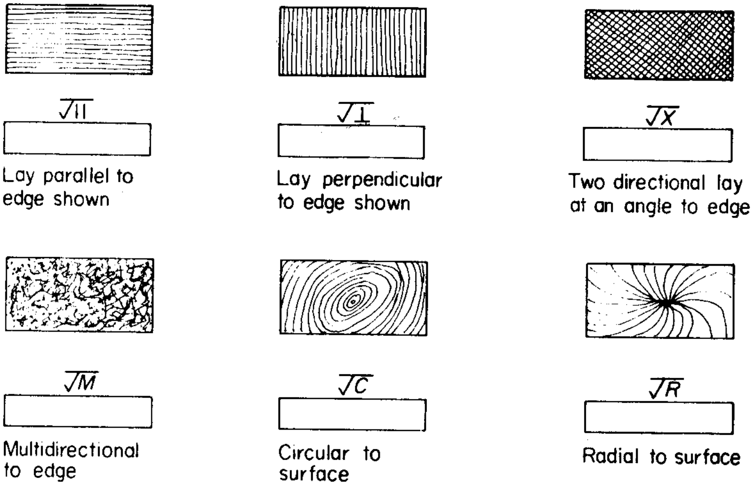
This establishes the *roughness-width cutoff* which must always be greater than the roughness width to establish the rating values for roughness height. These cutoffs may be 0.003, 0.010, 0.030, 0.100, 0.300, and 1.000. Unless another value is used, the preferred value is 0.030. It should be noted that the roughness-width cutoff is a matter of instrument setting rather than surface quality. If the surface of the work has very fine irregularities, then the machine may be set at 0.003 roughness-width cutoff. If the roughness is wide, such as would be the case in machining chatter, the roughness-width cutoff should be chosen to include the major variations in roughness height of the work surface. Thus the higher the number of the roughness-width cutoff, the more inclusive but discriminating are the evaluations. A 0.030 number includes most of the coarse and some of the medium and all the fine irregularities. The 0.003 includes only the fine irregularities.

WAVINESS. This refers to the irregularities which are outside the roughness-width cutoff values. As seen in Fig. 10.20d, the *waviness-width* has the roughness superimposed on it. It results from bending, strain, work deflection, etc. It is measured from one peak to the next peak. It is given in inches. *Waviness height* is the peak-to-valley distance. *Waviness-width cutoff* is also selected as the maximum permitted variation in waviness height. Anything outside this cutoff is said to be an imperfection. It is given in inches.

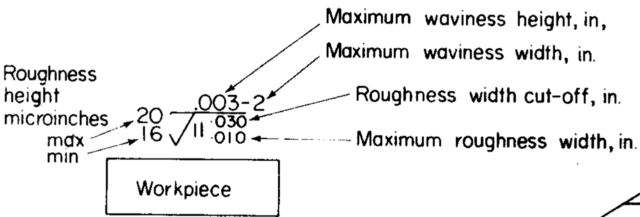
Cracks, scratches and ridges, are called *flaws*. They are not regularly recurring and are imperfections outside the regular pattern of surface texture.

LAY is directional and reflects the machining or fabricating method. The symbol $\sqrt{}$ is used to indicate surface conditions. The notations ||, ⊥, X, M, C, and R are used with the symbol to indicate lay. This is shown in Fig. 10.20e.

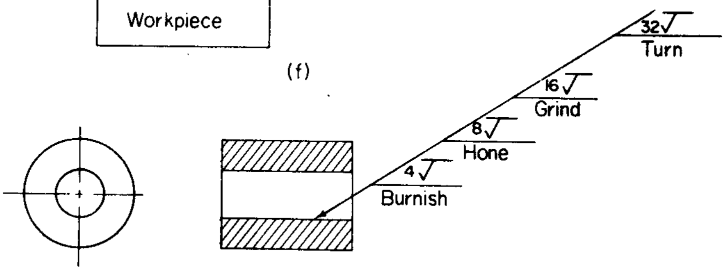
The above terms are shown in the symbol Fig. 10.20f. The symbol is drawn so that it touches the surface line, extension line, or leader line which indicates the surface described. Figure 10.20g shows the finish requirements for four machining operations.



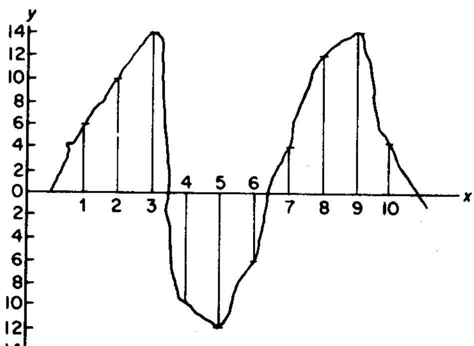
(e)



(f)



(g)



(h)

Figure 10.20 (e, f, g, h)

Surface finishes which can be expected from the various fabricating processes are shown in Table 10.4. These vary with the type of manufacturing company considered.

TABLE 10.4
Surface Finishes Produced by Various Processes

Operation	RMS, 10^{-6} in.	Operation	RMS, 10^{-6} in.
Lapping	2-8	Burnishing	2-4
Honing	2-10	Turning	20-300
Polishing	2-10	Shaping	20-300
Reaming	8-50	Sand Casting	500-1000
Grinding	5-150	Extrusion	10-250
Broaching	15-60	Sawing	250-1000
Drilling	75-200	Blanking	30-100
Milling	20-300	Forging	100-400
		Die Casting	15-100

The rms is obtained by taking the square root of the sum of the squares of the y-measurements divided by the number of y-measurements. The mathematics is

$$\Sigma y_n = y_1 + y_2 + y_3 + \cdots + y_n$$

The arithmetic average is

$$\frac{\Sigma y_n}{n}$$

The root mean square is

$$\text{rms} = \sqrt{\frac{\Sigma y_n^2}{n}}$$

Example 7

Calculate: (a) the arithmetic average and (b) the rms for Fig. 10.20h.

Solution

The y and y^2 values are:

n	y	y^2
1	6	36
2	10	100
3	14	196
4	10	100
5	12	144
6	6	36
7	4	16
8	12	144
9	14	196
10	4	16
	$\Sigma y = 92$	$\Sigma y^2 = 984$

(a) The arithmetic average is

$$\frac{\Sigma y_n}{n} = \frac{92}{10} = 9.2 \text{ microinches.}$$

The root mean square is

$$\text{rms} = \sqrt{\frac{\Sigma y_n^2}{n}} = \sqrt{\frac{984}{10}} = 9.9 \text{ microinches}$$