

# Surface Roughness

It is not possible to achieve in practice, a geometrically ideal surface of a component and hence, production drawings of components must also contain information about the permissible surface conditions.

Machine components which have undergone machining operation, when inspected under magnification, will have some minute irregularities. The actual surface condition will depend upon the finishing process adopted.

The properties and performance of machine components are affected by the degree of roughness of the various surfaces. The higher the smoothness of the surface, the better is the fatigue strength and corrosion resistance. Friction between mating parts is also reduced due to better surface finish.

The geometrical characteristics of a surface include,

1. Macro-deviations,
2. Surface waviness, and
3. Micro-irregularities.

The surface roughness is evaluated by the height,  $R_t$  and mean roughness index  $R_a$  of

the micro-irregularities Following indicated in Fig. 1:

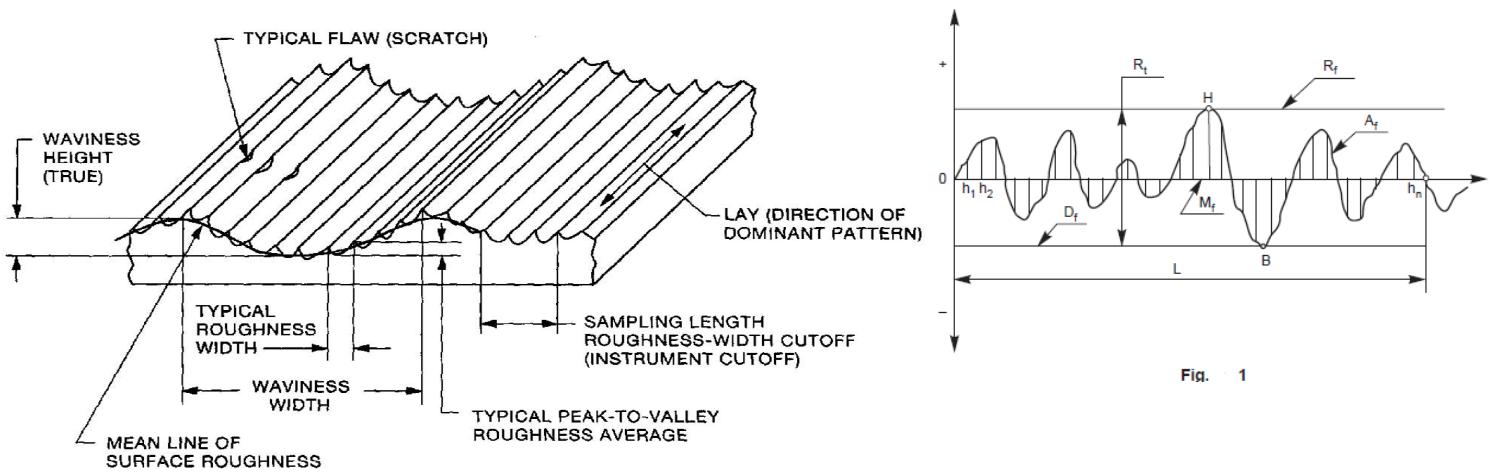


Fig. 1

## Mean Roughness index $R_a$

It is the arithmetic mean of the absolute values of the heights  $h_i$  between the actual and mean profiles. It is given by,

$$R_a = 1/L \int_{x=0}^{x=L} |h_i| dx, \text{ where } L \text{ is the sampling length}$$

The surface roughness number represents the average departure of the surface from perfection over a prescribed sampling length, usually selected as 0.8 mm and is expressed in microns. The measurements are usually made along a line, running at right angle to the general direction of tool marks on the surface. Surface roughness values are usually expressed as the  $R_a$  value in microns, which are determined from (Fig.1),

$$R_a = \frac{h_1 + h_2 + h_3 + \dots + h_n}{n}$$

The surface roughness may be measured, using any one of the following :

1. Straight edge
2. Surface guage
3. Optical flat
4. Tool maker's microscope
5. Profilometer
6. Profilograph
7. Talysurf

Table 1 shows the surface roughness expected from various manufacturing processes.

**Table 1 Surface roughness expected from various manufacturing processes**

Sl. No.	Manufacturing Process	$R_a$ in $\mu\text{m}$													
		0.012	0.025	0.050	0.10	0.20	0.40	0.80	1.6	3.2	6.3	12.5	25	50	100
1	Sand casting									5	12.5	50			
2	Permanent mould casting						0.8	1.6	3.2	6.3					
3	Die casting						0.8	1.6	3.2						
4	High pressure casting					0.32	0.63	1.2							
5	Hot rolling							2.5	5	12.5	50				
6	Forging							1.6	3.2	6.3	28				
7	Extrusion			0.16				0.32	0.63	1.2	2.5				
8	Flame cutting, sawing & Chipping								6.3	12.5	50	100			
9	Radial cut-off sawing							1	2.5	6.3					
10	Hand grinding								6.3	12.5	25				
11	Disc grinding							1.6	3.2	6.3	25				
12	Filing				0.25				0.32	0.63	1.2	2.5			
13	Planing							1.6	3.2	6.3	50				
14	Shaping							1.6	3.2	6.3	25				
15	Drilling							1.6	3.2	6.3	20				
16	Turning & Milling					0.32		0.63	1.2	2.5	5	25			
17	Boring						0.4	0.8	1.6	3.2	6.3				
18	Reaming						0.4	0.8	1.6	3.2					
19	Broaching						0.4	0.8	1.6	3.2					
20	Hobbing						0.4	0.8	1.6	3.2					
21	Surface grinding			0.063				0.125	0.25	0.5					
22	Cylindrical grinding			0.063				0.125	0.25	0.5					
23	Honing		0.025					0.05	0.1	0.4					
24	Lapping	0.012						0.025	0.05	0.1	0.16				
25	Polishing				0.04			0.08	0.16						
26	Burnishing				0.04			0.08	0.16	0.32					
27	Super finishing	0.016						0.032	0.063	0.125	0.32				

## Machining sample

This article deals with the symbols and other additional indications of surface texture, to be indicated on production drawings.

The basic symbol consists of two legs of unequal length, inclined at approximately  $60^\circ$  to the line, representing the surface considered (Fig.2a). This symbol may be used where it is necessary to indicate that the surface is machined, without indicating the grade of roughness or the process to be used.

If the removal of material is not permitted, a circle is added to the basic symbol, as shown in Fig.2b. This symbol may also be used in a drawing, relating to a production process, to indicate that a surface is to be left in the state, resulting from a preceding manufacturing process, whether this state was achieved by removal of material or otherwise. If the removal of material by machining is required, a bar is added to the basic symbol, as shown in Fig. 2c. When special surface characteristics have to be indicated, a line is added to the longer arm of the basic symbol, as shown in Fig.2d.

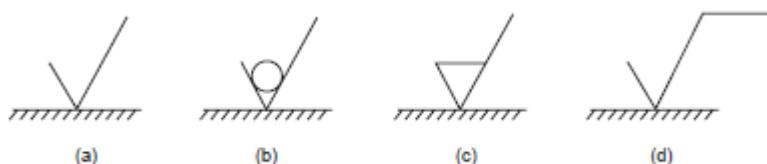


Fig. 2

## Indication of Surface Roughness

The value or values, defining the principal criterion of roughness, are added to the symbol as shown in Fig.3.

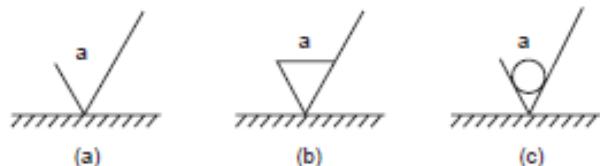


Fig. 3

A surface texture specified,

as in Fig.3a, may be obtained by any production method.

as in Fig.3b, must be obtained by removal of material by machining.

as in Fig.3c, must be obtained without removal of material.

When only one value is specified to indicate surface roughness, it represents the maximum permissible value. If it is necessary to impose maximum and minimum limits of surface roughness, both the values should be shown, with the maximum limit,  $a1$ , above the minimum limit,  $a2$  (Fig.4a).

FIGURE 13

**4.5 Position of the specifications of surface texture in the symbol**

The specifications of surface texture shall be placed relative to the symbol as shown in figure 14.

a = Roughness value  $R_a$  in micrometres or microinches

or

Roughness grade number N1 to N12

b = Production method, treatment or coating

c = Sampling length

d = Direction of lay

e = Machining allowance

f = Other roughness values (in brackets)

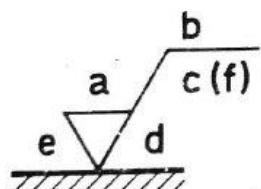


FIGURE 14

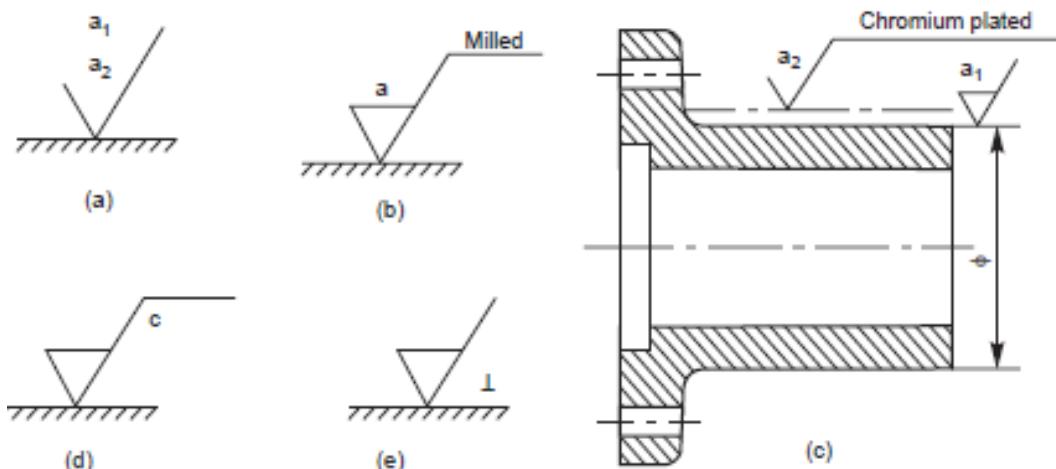


Fig. 4

The principal criterion of surface roughness,  $R_a$  may be indicated by the corresponding roughness grade number, as shown in Table 12.

Table 2 Equivalent surface roughness symbols

Roughness values $R_a \mu\text{m}$	Roughness grade number	Roughness grade symbol
50	N12	$\sim$
25	N11	
12.5	N10	
6.3	N9	
3.2	N8	
1.6	N7	
0.8	N6	
0.4	N5	
0.2	N4	
0.1	N3	
0.05	N2	
0.025	N1	

In certain circumstances, for functional reasons, it may be necessary to specify additional special requirements, concerning surface roughness.

If it is required that the final surface texture be produced by one particular production method, this method should be indicated on an extension of the longer arm of the symbol as shown in Fig. 4b. Also, any indications relating to treatment or coating may be given on the extension of the longer arm of the symbol.

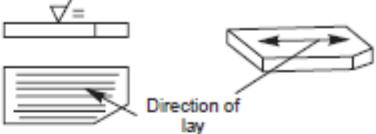
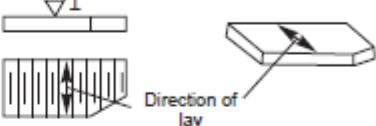
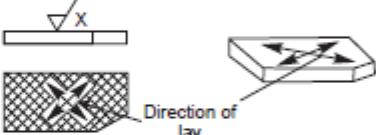
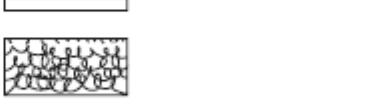
Unless otherwise stated, the numerical value of the roughness, applies to the surface roughness after treatment or coating. If it is necessary to define surface texture, both before and after treatment, this should be explained by a suitable note or as shown in Fig.4c.

If it is necessary to indicate the sampling length, it should be selected from the series given in ISO/R 468 and be stated adjacent to the symbol, as shown in Fig.4d. If it is necessary to control the direction of lay, it is specified by a symbol added to the surface roughness symbol, as shown in Fig.4e.

**NOTE** The direction of lay is the direction of the predominant surface pattern, ordinarily determined by the production method employed.

Table 3 shows the symbols which specify the common directions of lay.

Table 16.8 Symbols specifying the directions of lay

Symbol	Interpretation
$\equiv$	<p>Parallel to the plane of projection of the view in which the symbol is used</p> 
$\perp$	<p>Perpendicular to the plane of projection of the view in which the symbol is used</p> 
$\times$	<p>Crossed in two slant directions relative to the plane of projection of the view in which the symbol is used</p> 
$M$	<p>Multi-directional</p> 
$C$	<p>Approximately circular, relative to the centre of the surface to which the symbol is applied</p> 
$R$	<p>Approximately radial, relative to the centre of the surface to which the symbol is applied</p> 

جدول 3 . 9 درجات الخشونة وقيمها بالمايكرونات  $\mu$  (  $\mu = 1 / 1000 \text{ mm}$  )

درجة الفحصنة	قيمة الخشونة ( $\mu$ )	طريقة الانتاج	تطبيقات
N1	0 . 025	سطح ناعم جدا	تنفيذ هذا السطح يكلف مبالغ كبيرة وهو نادر الاستعمال ، يستعمل في الاجهزه الدقيقه والحساسه جدا .
	0 . 05	ادق انواع مكائن المسفل ( Lapping ) والشحد ( Honing )	
N3	0 . 1	سطح ذو نوعية عاليه صقل ، شحد ، تلميع ( Buffing )	تنفيذ مكلف يستعمل في الاجهزه الدقيقه ، الاسطوانات الهايدروليكيه ، الاعدمهه والكراسي ذات السرع العاليه جدا .
	0 . 2	سطح ناعم شحد ، تلميع	
N5	0 . 4	سطح ذو نوعية جيدة تجليل ، تلميع بواسطه السنفه ، صقل او شحد خشن	عندما تكون النوعه ذات اهميه لوظيفه الجزء مثل الاعدمهه والكراسي السريعه .
	0 . 8	انهاء جيد جدا بالماكينة	
N7	1 . 6	انهاء جيد بالماكينة خراطة ، تفريز باستعمال الات قطع حادة مع تلميع ناعم وسرعه قطع عاليه	يستعمل حيثما تتطلب الحالة توافق دقيق . ولا يناسب الاجزاء المتحركة بسرعه عاليه .
	3 . 2	انهاء متوسط بالماكينة خراطة ، تفريز ، سباكه بالقوالب ، بثق ، تتشيط	
N9	6 . 3	انهاء خشن تجليل خشن ، براده ، خراطة ، تفريز ، تقطيب	يستعمل في المكائن ذات الكلفة الواطنه والاعدمهه والكراسي ذات السرع الواطنه وتحت احمال خفيفه او غير دائميه .
	12 . 5	انهاء خشن نوعيه واطنه تفريز ، خراطة ، تتشيط مع تلميع خشن . براده خشن ، سباكه بالرمل ، حداشه خشن	
N11	25	سطح ذو خشونة عاليه	للسطوح المعرضه الى الهواء لفرض تحسين المظهر العام
	50	سباكه بالرمل ، قطع بالمنشار ، تاجين ( Chipping )	

### Indication of machining allowance

When it is necessary to specify the value of the machining allowance, this should be indicated on the left of the symbol, as shown in Fig. 5a. This value is expressed normally in millimetres. Figure 5b shows the various specifications of surface roughness, placed relative to the symbol.

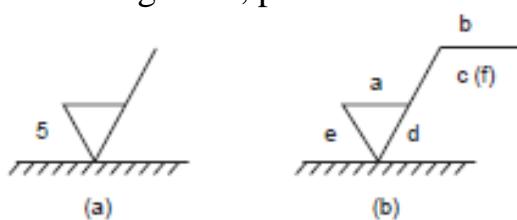
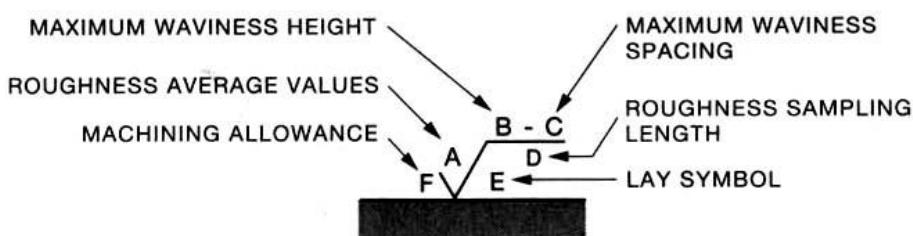


Fig. . 5



EXAMPLE

63 .002-4  
32 √ .05

BASIC SURFACE TEXTURE SYMBOL	✓	MAXIMUM WAVINESS SPACING RATING (C). SPECIFY IN INCHES OR MILLIMETERS. HORIZONTAL BAR ADDED TO BASIC SYMBOL.
ROUGHNESS AVERAGE VALUES (A). SPECIFY IN MICROINCHES, MICROMETERS, OR ROUGHNESS GRADE NUMBERS.	63 ✓ N7 ✓	LAY SYMBOL (E)
MAXIMUM AND MINIMUM ROUGHNESS AVERAGE VALUES (A), SPECIFY IN MICROINCHES, MICROMETERS, OR ROUGHNESS GRADE NUMBERS.	63 ✓ 32 ✓ N7 ✓ N6 ✓	ROUGHNESS SAMPLING LENGTH OR CUTOFF RATING (D). WHEN NO VALUE IS SHOWN USE .03 INCH (0.8 MILLIMETERS).
MAXIMUM WAVINESS HEIGHT RATING (B) SPECIFY IN INCHES OR MILLIMETERS. HORIZONTAL BAR ADDED TO BASIC SYMBOL.	✓ .002	MACHINING ALLOWANCE (F). SPECIFY IN INCHES OR MILLIMETERS.

NOTE: WAVINESS IS NOT USED IN ISO STANDARDS.

### Indication of surface Roughness Symbols on Drawing

The symbol and the inscriptions should be so oriented, that they may be read from the bottom or the right hand side of the drawing (Fig. 16.6a). If it is not practicable to adopt this general rule, the symbol may be drawn in any position (Fig. 16.6b), provided that it does not carry any indications of special surface texture characteristics.

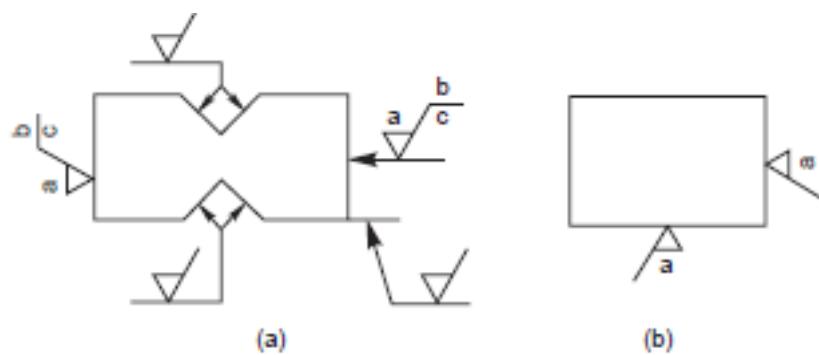


Fig. 6

The symbol may be connected to the surface by a leader line, terminating in an arrow. The symbol or the arrow should point from outside the material of the piece, either to the line representing the surface, or to an extension of it (Fig.6a)

In accordance with the general principles of dimensioning, the symbol is only used once for a given surface and, if possible, on the view which carries the dimension, defining the size or position of the surface (Fig.7).

If the same surface roughness is required on all the surfaces of a part, it is specified, either by a note near a view of the part (Fig. 16.8), near the title block, or in the space devoted to general notes, or following the part number on the drawing.

If the same surface roughness is required on the majority of the surfaces of a part, it is specified with the addition of, the notation, except where otherwise stated (Fig. 9a), or a basic symbol (in brackets) without any other indication (Fig. 16.9b), or the symbol or symbols (in brackets) of the special surface roughness or roughnesses (Fig.9c).

To avoid the necessity of repeating a complicated specification a number of times, or where space is limited, a simplified specification may be used on the surface, provided that its meaning is explained near the drawing of the part, near the title block or in the space devoted to general notes (Fig.10).

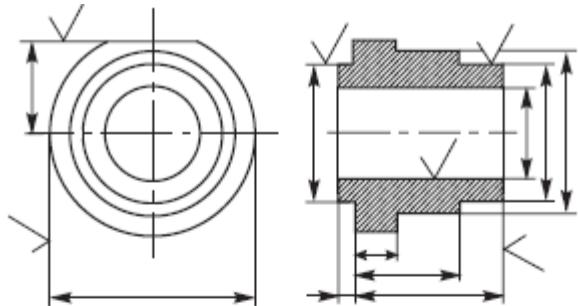


Fig. 7

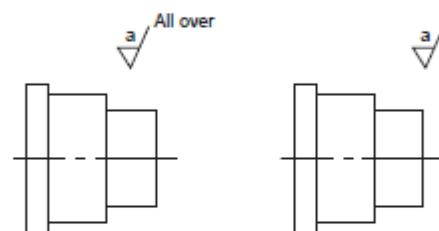


Fig. 8

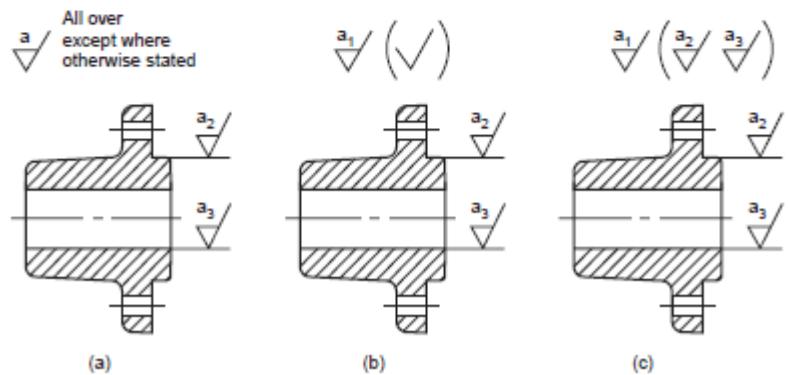


Fig. 9

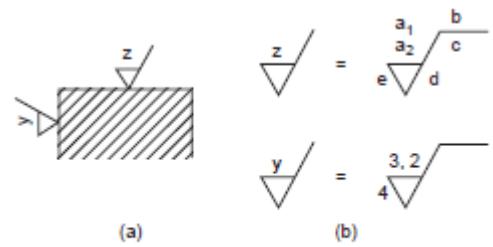
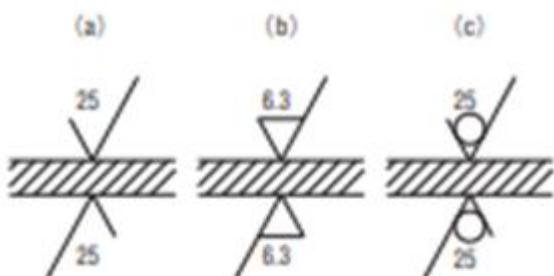


Fig. 10

Examples of indicating the Ra upper limit



Example of indicating grain direction



Examples of indicating Ra upper limit and lower limit



Examples of indicating the machining method



## Important Notes

- 1- Only gave indications of the roughness , method of production or machining allowance in so far as this is necessary to ensure fitness for purpose only for use surfaces which require it
- 2- The specifications of surface texture is unnecessary wherever the ordinary manufacturing processes by themselves ensure an acceptable surface finish

خطا	صع	امثلة في طريقة استعمال رموز التشغيل
		يلامس رأس الرمز خط الرسم دون وجود فاصلة.
		يكون اتجاه الخط الطويل نحو اليمين.
		يوضع الرمز وكذلك البيانات الأخرى بحيث تقرأ من أسفل أو يمين الرسم كما هو متبع في وضع الأبعاد.
		في بعض الحالات يمكن وضع الرمز باتجاه آخر شرط أن تكتب قيمة التسخنة باتجاه مطابق لطريقة وضع الأبعاد.
		عند الضرورة يمكن ربط الرمز مع السطح بواسطة خط دليل ينتهي بسهم.
		يوضع السهم من خارج المادة ، أي بالاتجاه الذي يتم فيه تشغيل السطح بواسطة آلة الفحص.

خطا	صح	امثلة في طريقة استعمال رموز التشغيل
		يوضع الرمز ، حسب الامكان ، على المسنة الذي يحمل ابعاد المسطح .
		إذا كان نفس التشغيل مطلوب على معظم سطح الجسم يوضع الرمز قرب الرسم مع اضافة مابلي :

# Home work

Explain each symbol of surface finish in figures below

