Metrology, standardization and certification

Theme 8: Rationing of requirements to surface irregularities

Lecture plan:

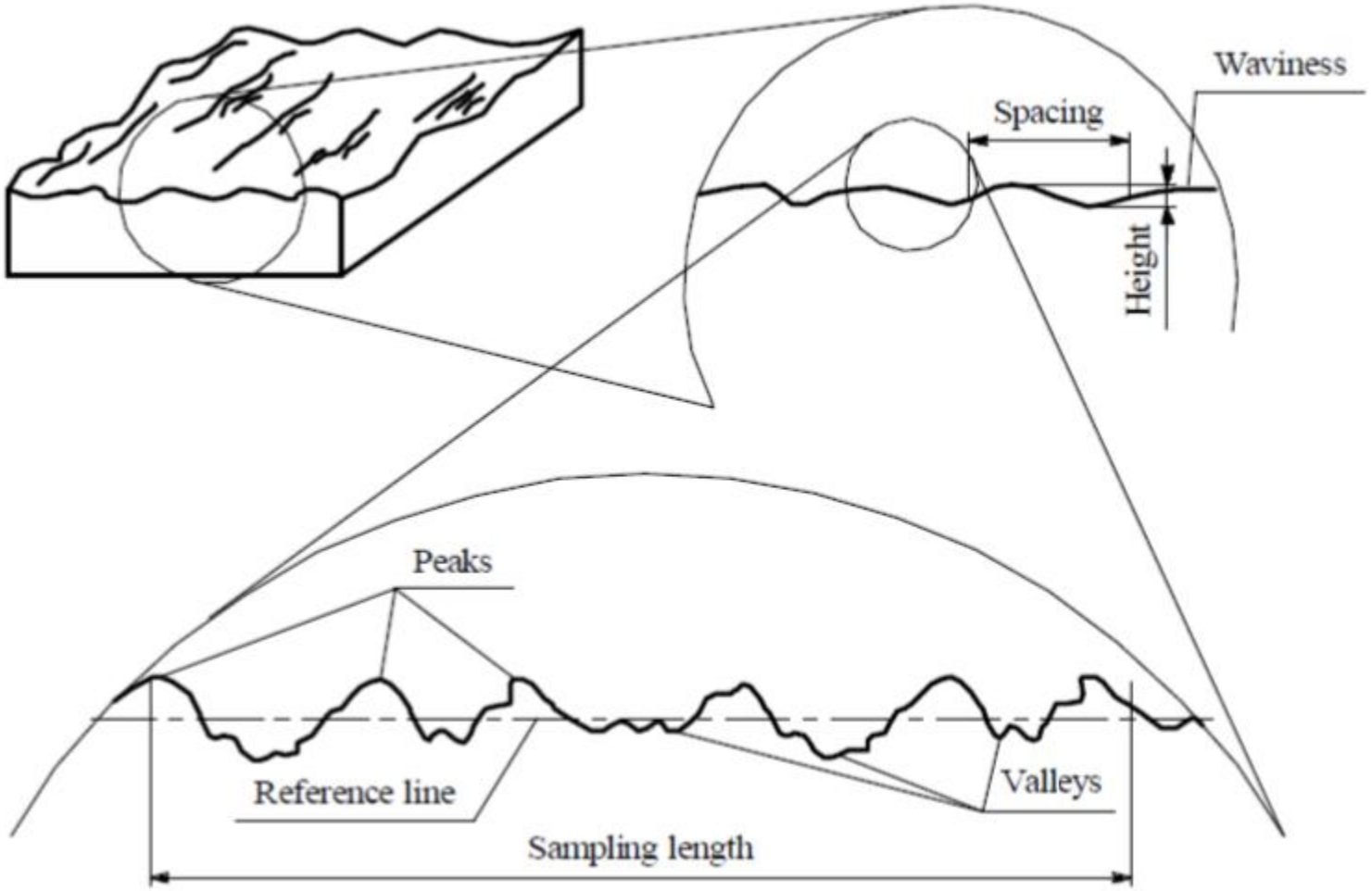
1. Reasons for surface finish control.
2. Surface texture and types of irregularities.
3. Roughness parameters.
4. Designation of roughness parameters in the drawing.

Reasons for surface finish control

The reasons for surface finish control are as follows:

1. **Friction behaviour** can be significantly improved by surface finish. High surface finish reduces friction forces and helps to maintain oil films on the contacting surfaces; consequently, the energy losses are reduced.
2. **Wear characteristics** relate to parameters of surface finish.
3. **Fatigue strength** of heavy loaded components can be affected by sharp irregularities of the surface texture, which act as stress concentrators.
4. **Corrosion resistance** also decreases with surface finish improvment.
5. **Appearance** of car bodies is an example of the cosmetic effect that is provided by high quality surface finish.
6. **Effective contact area** is of great importance for microprocessor industry or when heat conductivity of a surface should be as high as possible, e.g. transistor heatsinks.
7. **Microgeometry** of plastic tubes, for instance, can greatly reduce the damage of blood cells during blood transfusion or hemodialysis.
8. The performance of **sealing** components and devices is defined by surface finish, too.
9. **Noise requirements** are met via proper surface finish control.
10. **Painting and plating** process facilitation.

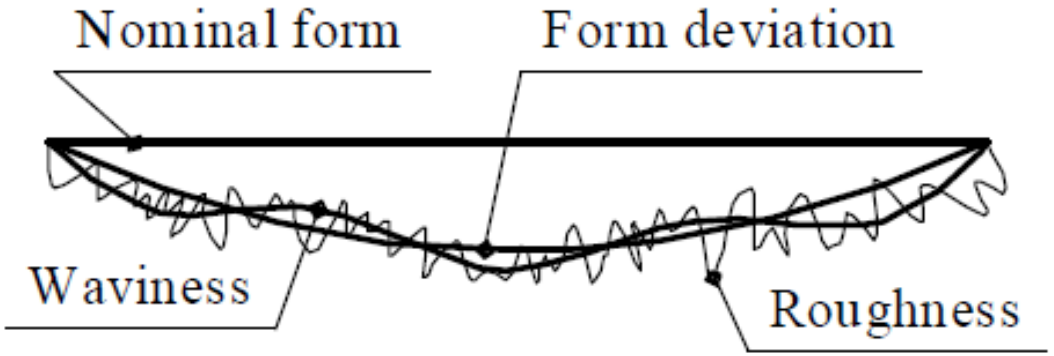
Surface texture

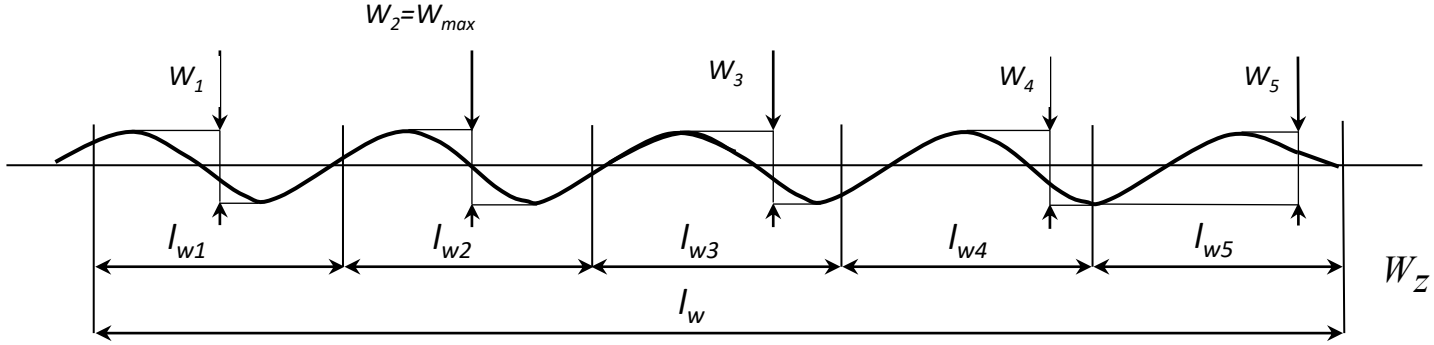


Types of irregularities

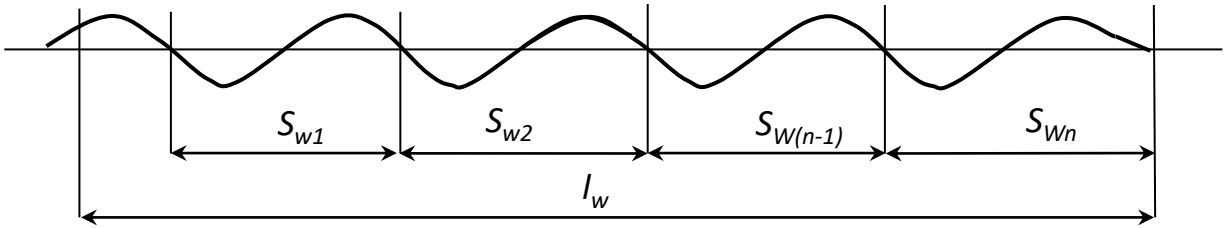
1. Roughness (S_w/W_z)<40
2. Waviness 1000≥(S_w/W_z)≥40
3. Form deviation (S_w/W_z)>1000

S_w - irregularities spacing
W_z - irregularities height





$$W_z = \frac{W_1 + W_2 + W_3 + W_4 + W_5}{5}.$$



$$S_w = \frac{1}{n}\sum_{i=1}^{n} S_w.$$

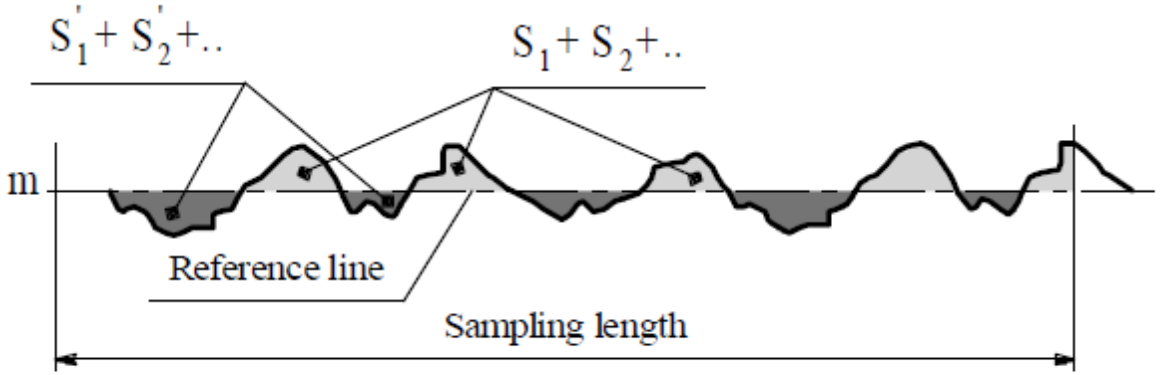
Roughness parameters

According to GOST 2789-73 surface roughness can be assessed by the six parameters, which are grouped with relation to the characteristics of the profile they describe.

1. **Amplitude parameters (vertical direction)**
   - Maximum roughness height, designated as R_{max}
   - Ten-point height, designated as R_z
   - Roughness average, designated as R_a
2. **Spacing parameters (horizontal direction)**
   - Mean spacing of adjacent local peaks, designated as S
   - Roughness peak spacing on the center line, designated as S_m
3. **Bearing parameter**
   - Bearing length ratio, designated as t_p

Roughness parameters

Sampling length is the length over which parameters are measured. The sampling length should be long enough to reveal clearly the surface pattern needed to measure the parameters correctly, but not too long to exclude the influence of waviness (for roughness assessment) or form (for waviness assessment). Actually the sampling length for waviness measurements is usually limited by the profilometer maximum traverse, rather than the form error influence.

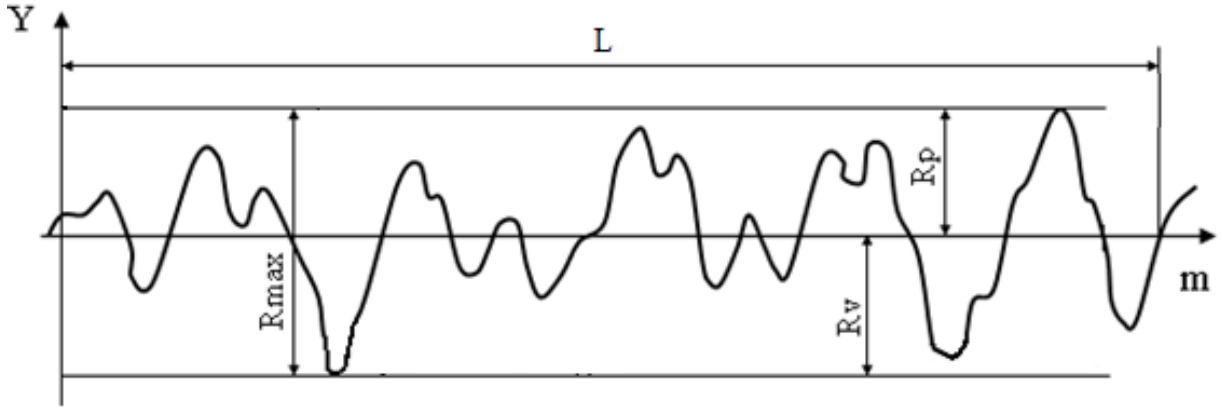


The roughness parameters are measured relative to the **reference line**, which is equidistant to the surface profile and can be represented by either a **center line** or **least squares mean line**. The center line is positioned so that the area above the line ($S_1+S_2+\ldots$) is equal to the area below the line ($S_1'+S_2'+\ldots$). The least squares mean line is a line position so that the sum of square deviations of the profile from the line is a minimum.

Roughness parameters (vertical direction)

Maximum roughness height is defined as the distance between the highest peak, R_p, and the deepest valley, R_V, within the specified length, and measured in μm. R_{max} calculated as:

$$R_{max} = R_P + R_V$$



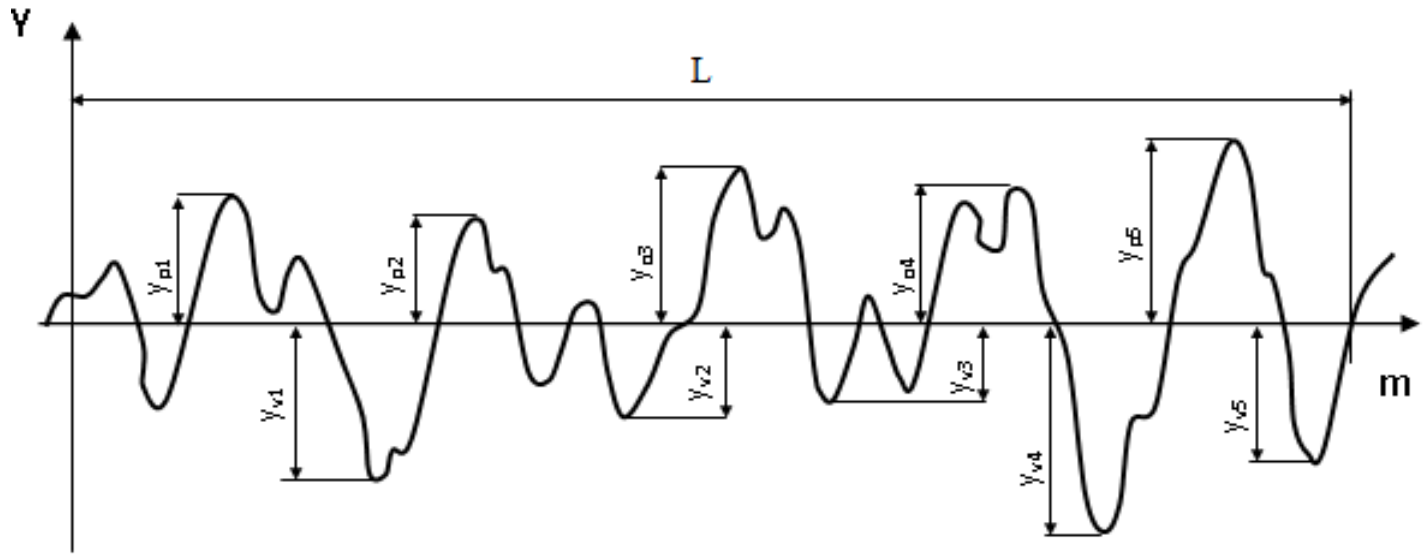
Sampling lengths are divided in three groups (GOST 2789-73):

L= (0.01); (0.03); 0.08 mm – for small height of irregularities,
L= 0.25; 0.8 mm – for meddle height of irregularities,
L = 2.5; 8; (25) mm – for large height of irregularities.

Roughness parameters (vertical direction)

Ten-point height is defined as the mean distance between the five highest peaks, Y_P, and the five deepest valleys, Y_V, within the specified length. The parameter is evaluated with reference to the center line, measured in μm.

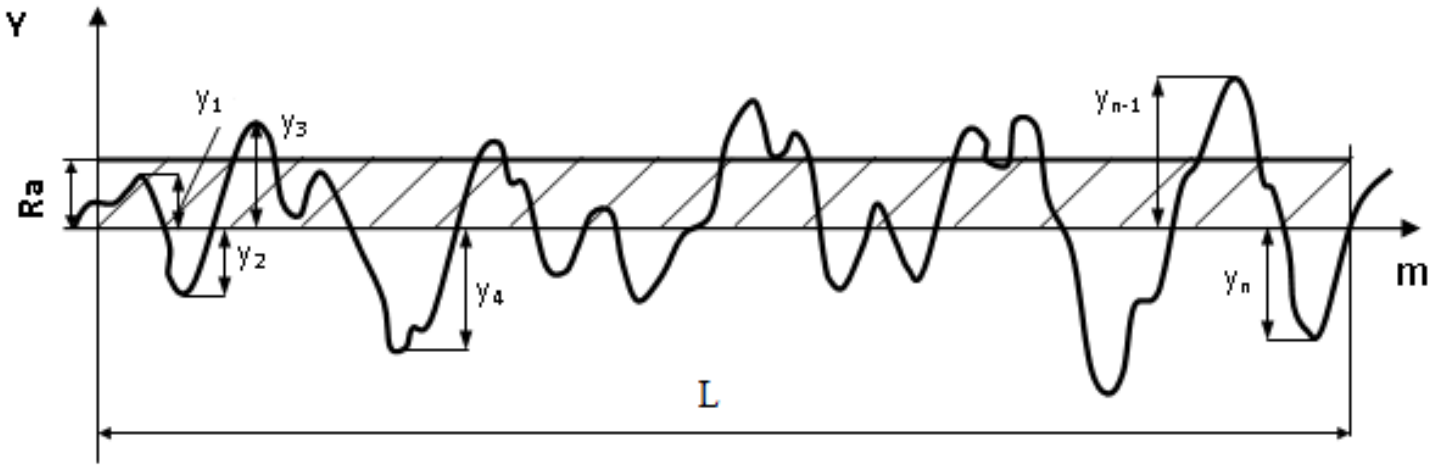
$$R_Z = \frac{1}{5}\left(\sum_{i=1}^{5} |y_{pi}| + \sum_{i=1}^{5} |y_{vi}| \right),$$



Roughness parameters (vertical direction)

Roughness average is defined as the arithmetic average of the absolute values of the profile points departure (y_i) from the center line within the sampling length. The parameter is evaluated with reference to the center line, measured in μm. To calculate the R_a parameter, the following two equations can be used:

$$R_a = \frac{1}{l}\int_0^l |y|dx, \qquad R_a = \frac{1}{n}\sum_{i=1}^{n} |y_i|,$$

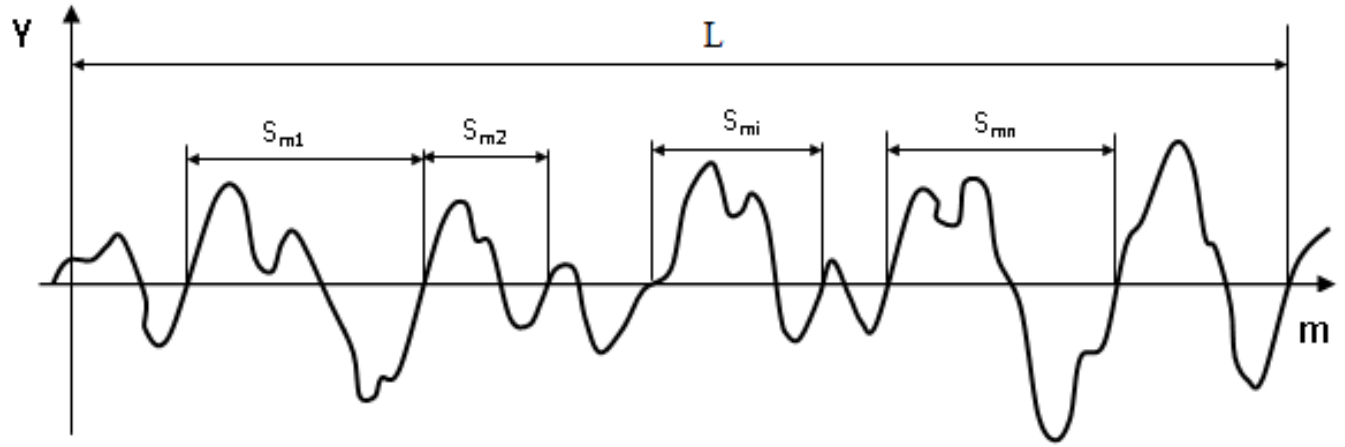


Roughness parameters (horizontal direction)

Roughness peak spacing on the center line is the average spacing, measured on the center line between adjacent crossings (in the same direction) within the sampling length.

The peaks that go into count are the profile peaks that are separated by crossings of the profile line with the center line. This parameter is expressed in mm, and is obtained from:

$$S_m = \frac{1}{n}\sum_{i=1}^{n} S_{mi}.$$

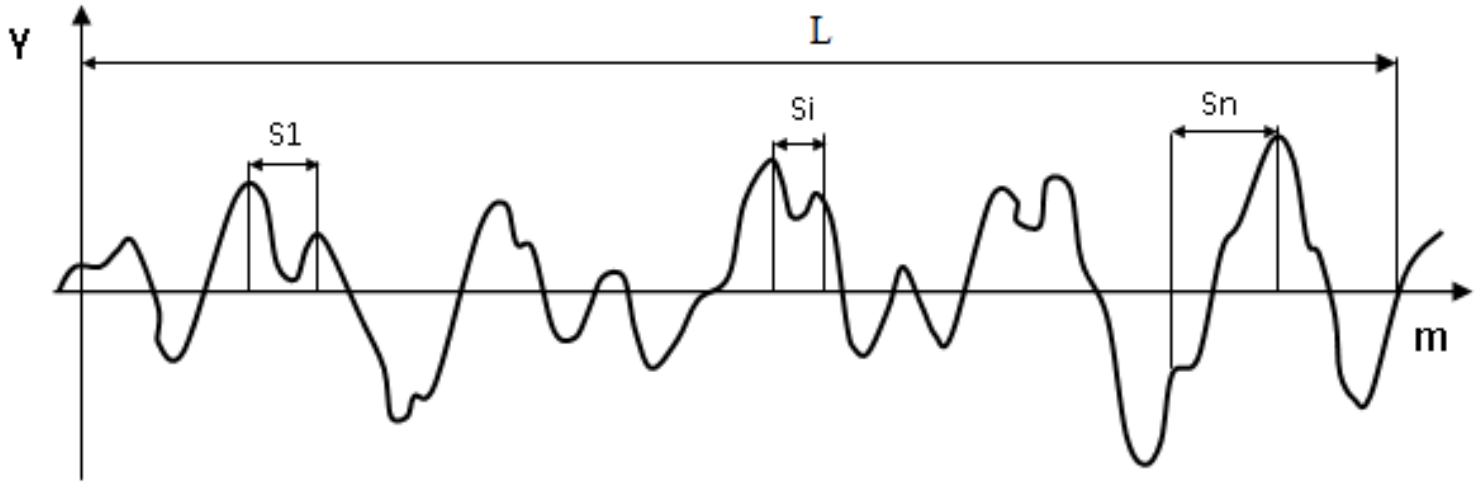


Roughness parameters (horizontal direction)

Mean spacing of the adjacent local peaks is defined as the average spacing, S_i, between the adjacent local peaks measured within the sampling length.

As it is illustrated in by local peaks all the peaks within the sampling length are meant. This parameter is expressed in mm, and can be calculated from the equation:

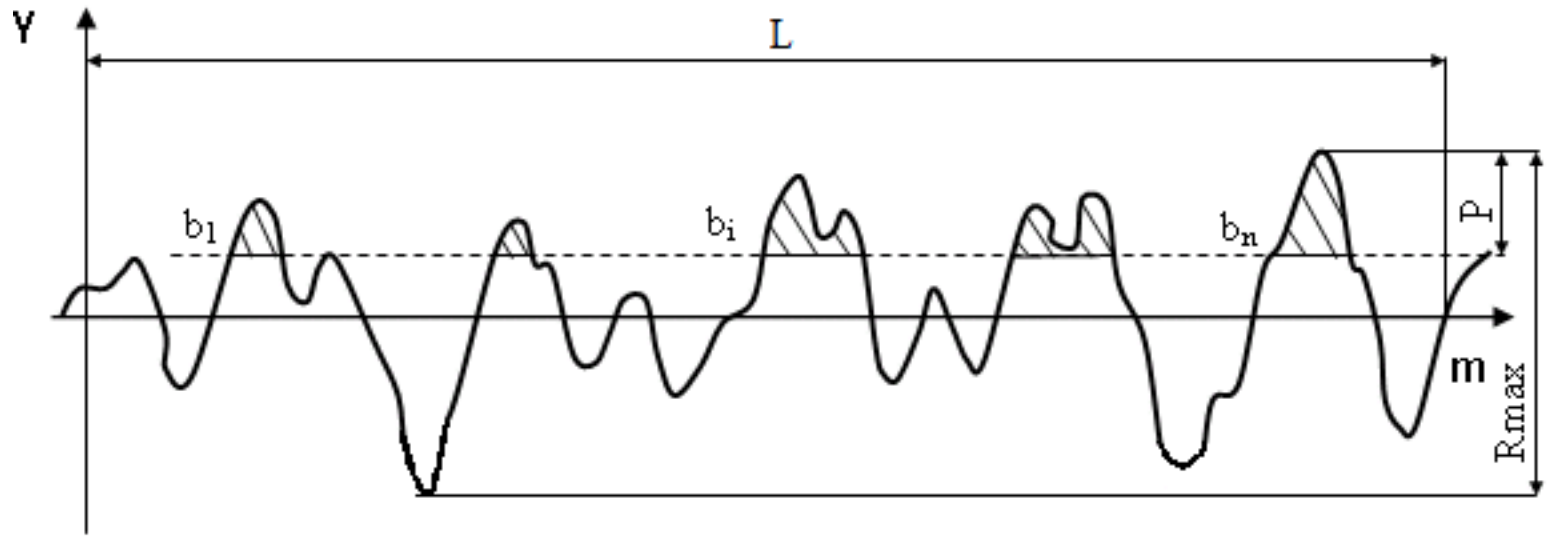
$$S = \frac{1}{n}\sum_{i=1}^{n} S_i .$$



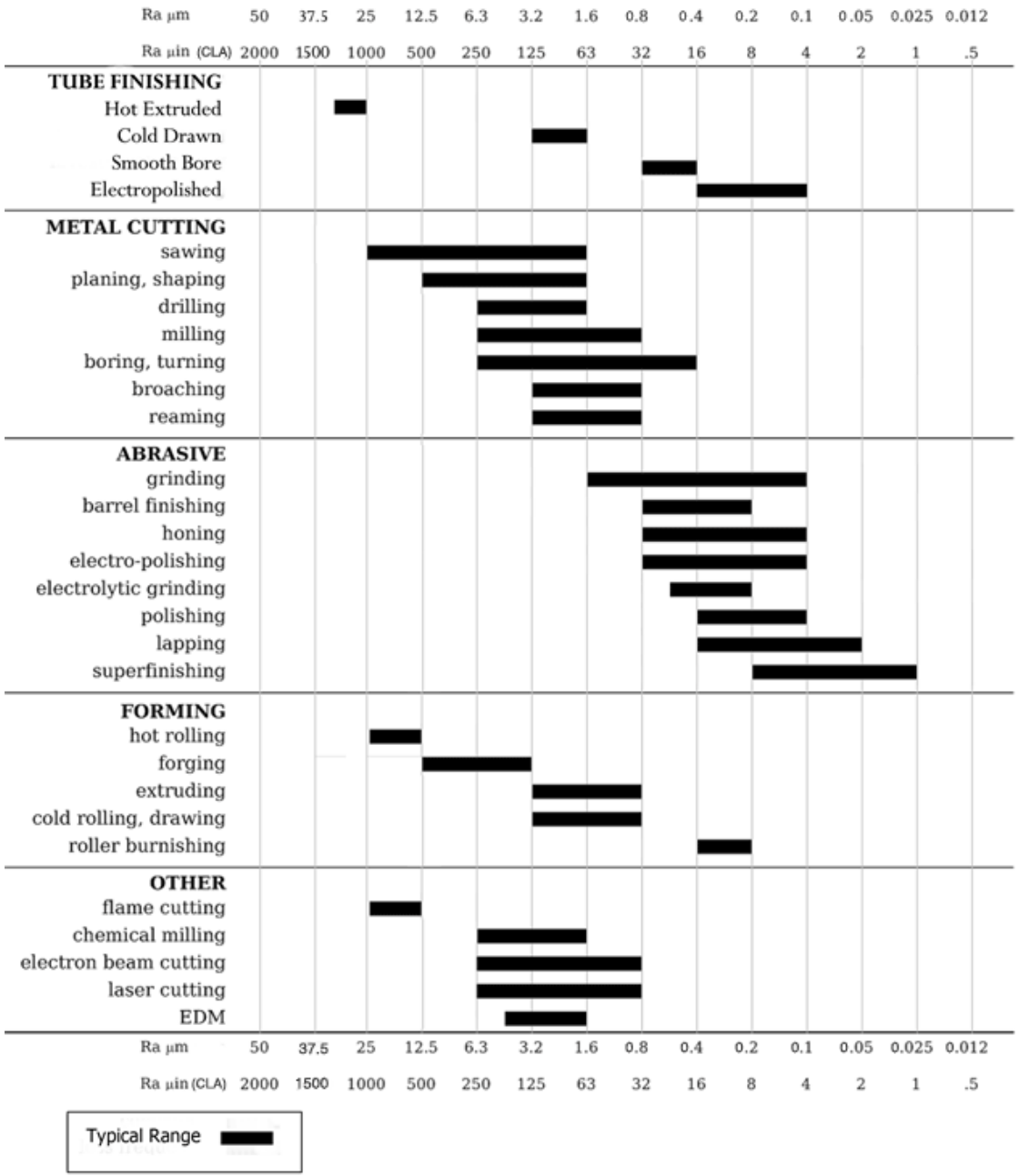
Roughness parameters (bearing parameter)

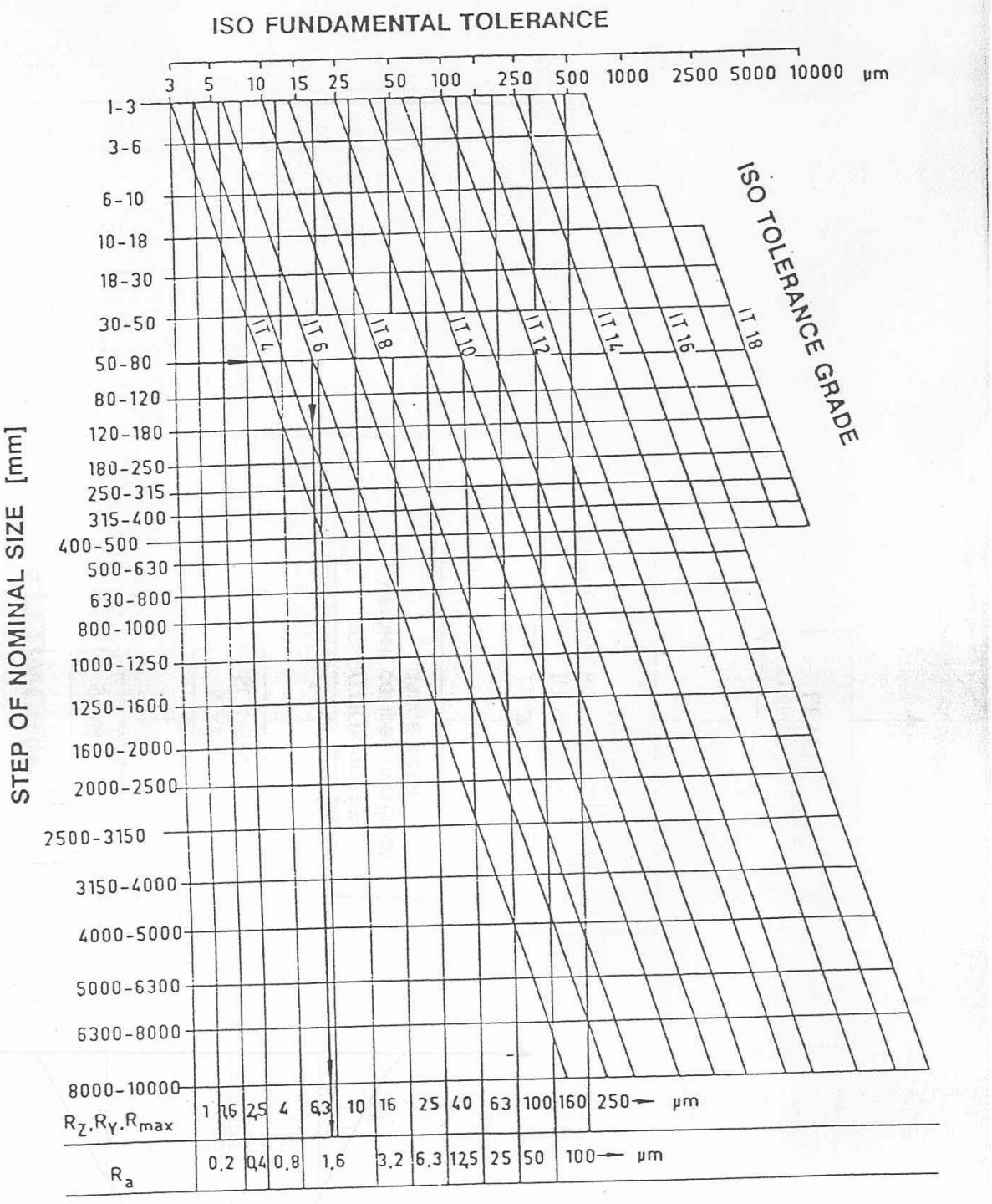
Bearing length ratio is defined as the ratio of the bearing length on the specified level (p) in the profile to the sampling length. The calculation of the parameter is represented by the equation:

$$t_p = \frac{100\%}{L} \sum_{i=1}^{n} b_i,$$

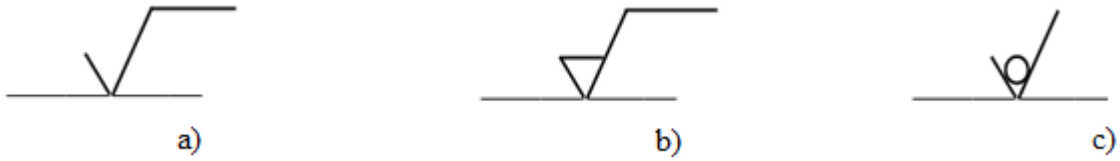


Indicative surface roughness comparisons

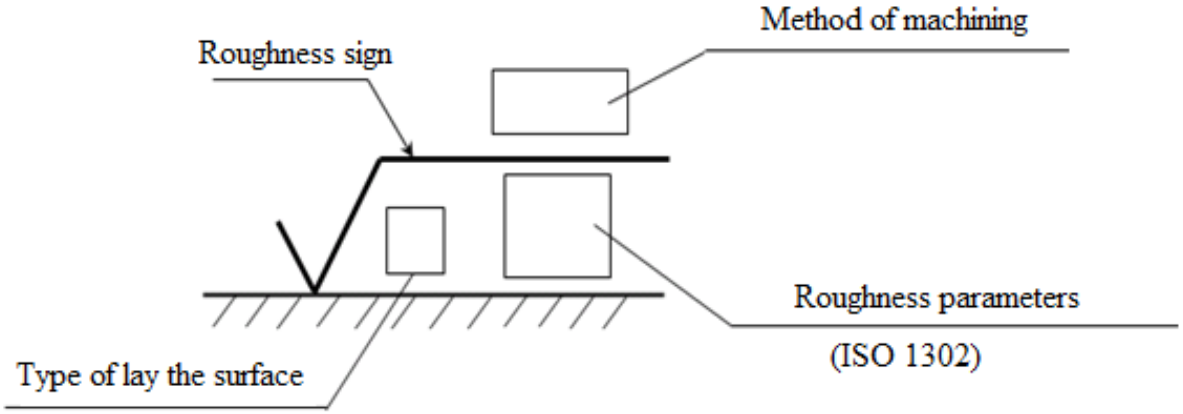


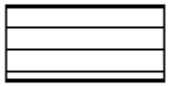
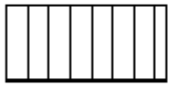
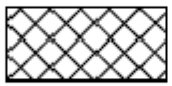
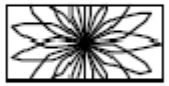
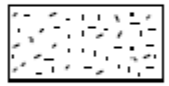

ISO FUNDAMENTAL TOLERANCE
3 5 10 15 25 50 100 250 500 1000 2500 5000 10000 µm
STEP OF NOMINAL SIZE [mm]
1-3
3-6
6-10
10-18
18-30
30-50
50-80
80-120
120-180
180-250
250-315
315-400
400-500
500-630
630-800
800-1000
1000-1250
1250-1600
1600-2000
2000-2500
2500-3150
3150-4000
4000-5000
5000-6300
6300-8000
8000-10000
ISO TOLERANCE GRADE
IT 4
IT 6
IT 8
IT 10
IT 12
IT 14
IT 16
IT 18
R_Z, R_Y, R_{max}
1 1,6 2,5 4 6,3 10 16 25 40 63 100 160 250 µm
R_a
0,2 0,4 0,8 1,6 3,2 6,3 12,5 25 50 100 µm

Designation of roughness parameters



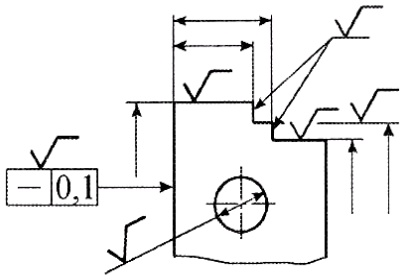
a - surface can be produced by any type of machining;
b – material is removed by machining;
c – surfaces are not to be machined.

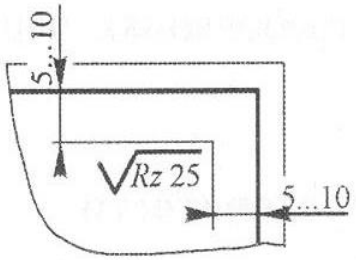


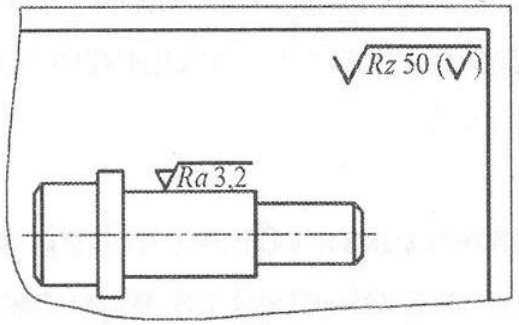
Type	Parallel	Perpen-dicular	Crossed	Multi-directional	Circular	Radial	Particulate
Lay							
Symbol	=	⊥	×	M	C	R	P

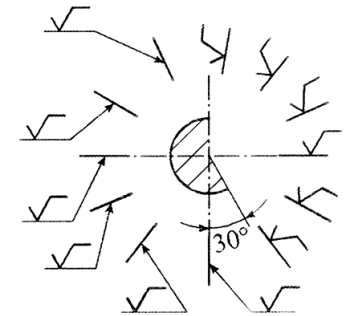
Designation of roughness parameters

Rz 50 ; Ra 0,8 ; polish M0.03/Ra 0.1

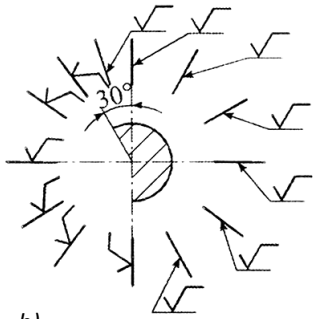




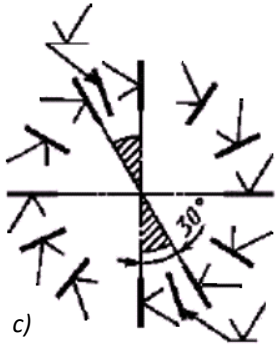




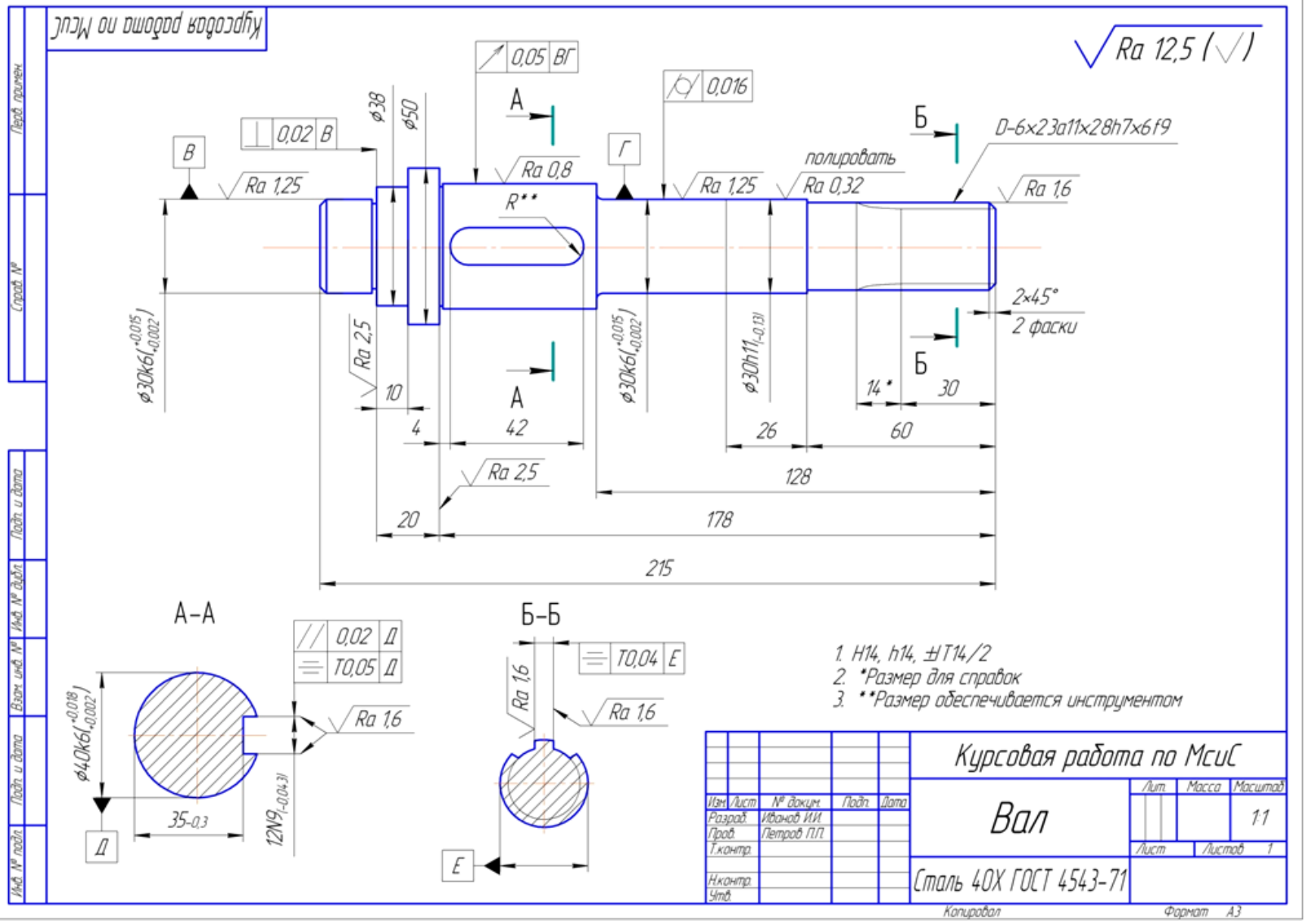
a)



b)



c)


Курсовая работа по МсиС
Ra 12,5
0,05 В Г
0,016
0,02 В
ф38
ф50
А
Ra 0,8
Ra 1,25
R**
Г
Ra 1,25
полировать
Ra 0,32
Б
D-6×23a11×28h7×6f9
Ra 1,6
В
2×45°
2 фаски
ф30К6(+0,015 +0,002)
Ra 2,5
10
4
42
ф30К6(+0,015 +0,002)
ф30h11(-0,13)
14 *
30
26
60
128
Ra 2,5
20
178
215
А-А
0,02 Д
Т0,05 Д
Ra 1,6
ф40К6(+0,018 +0,002)
35-0,3
12N9(-0,043)
Д
Б-Б
Т0,04 Е
Ra 1,6
Ra 1,6
Е
1. H14, h14, ±IT14/2
2. *Размер для справок
3. **Размер обеспечивается инструментом
Курсовая работа по МсиС
Вал
Сталь 40Х ГОСТ 4543-71
Лит.
Масса
Масштаб
1:1
Лист
Листов 1
Изм. Лист № докум. Подп. Дата
Разраб. Иванов И.И.
Пров. Петров П.П.
Т.контр.
Н.контр.
Утв.
Копировал
Формат А3
Перв. примен.
Справ. №
Подп. и дата
Инв. № дубл.
Взам. инв. №
Подп. и дата
Инв. № подл.

Thank you for attention