Safety Hazards
Material Processing Laboratory Room 232

HAZARD: Rotating Equipment / Machine Tools

Be aware of pinch points and possible entanglement

Personal Protective Equipment: Safety Goggles; Standing Shields, Sturdy Shoes
No: Loose clothing; Neck Ties/Scarves; Jewelry (remove);
Long Hair (tie back)

HAZARD: Projectiles / Ejected Parts

Articles in motion may dislodge and become airborne.

Personal Protective Equipment: Safety Goggles; Standing Shields

HAZARD: Heating - Burn

Be aware of hot surfaces

Personal Protective Equipment: Safety Goggles**;** High Temperature Gloves; Welding Apron, Welding Jacket, Boot Gauntlets, Face Shield

HAZARD: Chemical - Burn / Fume

Use Adequate Ventilation and/or Rated Fume Hood. Make note of Safety Shower and Eyewash Station Locations.

Personal Protective Equipment: Safety Goggles; Chemically Rated Gloves; Chemically Rated Apron

HAZARD: Electrical - Burn / Shock

Care with electrical connections, particularly with grounding and not Using frayed electrical cords, can reduce hazard. Use GFCI receptacles near water.

HAZARD: High Pressure Air-Fluid / Gas Cylinders / Vacuum

Inspect before using any pressure / vacuum equipment.
Gas cylinders must be secured at all times.

Personal Protective Equipment: Safety Goggles; Standing Shields

HAZARD: Water / Slip Hazard

Clean any spills immediately.

EXPERIMENT # 5

SURFACE TOPOGRAPHY

Goal: To learn dependence of accuracy on surface finishing.

Objectives: To study variations in the surface finish produced by different manufacturing processes, to learn the standard symbols used to specify the surface roughness during surface measurements, designing, and manufacturing, and to learn different surface measuring tools and comparators.

Equipment & Tools: Surfometer 2A; Profilometer; Bench type plate; Microfinish Comparator.

Specimens: Glass, Shaft-1, Bushing-2, Block-3, Block-4 and other available parts.

Each group of students has to complete one experiment on learning surface topography measuring techniques, study the surface finish of suggested parts, produce the Data Sheet, and give the answers to the Set of Questions.

A report has to be prepared according to the requirements of the General Instruction.

LABORATORY ASSIGNMENT

In carrying out your assignment, follow the sequence given below:

1. Study surface finish standard, Table 5-1;
2. Study the different surface finishes obtained after different machine cutting processes, Table 5-1;
3. Study the influence of surface finish on different engineering applications like:
   a. accuracy of mating parts;
   b. friction and wear resistance of mating parts;
4. Learn different methods of conventional surface roughness measurements;
5. Learn the principles of Profilometer or Profilograph, Fig.5-2,b;
6. Learn to operate the Profilometer;
7. Learn the principles of Surfometer System 2A, Fig.5-2,a;
8. Learn to operate the Surfometer System 2A, use Surfometer manual;
9. Learn to use the Microfinish Comparator;
10. Compare the surface finish of all the suggested specimens with the Microfinish Comparator and determine the roughness height of the surface in microinches;
11. Obtain the profile of the surface of suggested specimens using the Profilometer and calculate Mean Absolute Height (CLA) and Root Mean Square Average (RMS);
12. Measure surface roughness of suggested specimens using Surfometer 2A;
13. Calculate the mean value of the arithmetic average readings (AA);
14. Record all your obtained results in Table 5-2 and compare them, taking Surfometer results as standard;

15. Determine the possible machine cutting process by which this roughness might have been obtained;
16. Learn symbols used for the surface characteristic and standard method to represent them on the drawing;
17. Make the drawings of suggested specimens showing all the surface characteristics you could obtain from the Surfometer (use standard method), see Figure 5-1;
18. Give the answers to the Set of Questions.

HINTS TO THE LABORATORY ASSIGNMENT:

1. Read [1], page 288-295 to complete assignments 1 & 2;
2. Read [2], page 296-311 and use Fig. 5-1 to complete assignments 3, 4 & 6;
3. Learn to operate the Profilometer with help of the Instructor, assignment 5;
4. Learn to operate the Surfometer System 2A using the "Operating Instructions", page 1-4, assignment 7, see Figure 5-2,a;
5. Learn to use the Microfinish Comparator. Read [1], page 295, assignment 9;
6. Compare the surface finish of the specimens given below with the Microfinish Comparator, assignment 10:
   a. Glass
   b. Shaft-1
   c. Bushing-2
   d. Block-3
   e. Block-4
7. Learn the principles of obtaining profiles of the surface of suggested specimens using Profilometer, assignment 11;
8. Calculate Mean Absolute Height and Root Mean Square Average from the obtained profile. Use [1], page 290, assignment 11;
9. Operate the Surfometer and take at least five readings at different patches on each specimen and calculate the mean value, assignments 12 & 13;
10. Use Table 5-2 to record all the results, assignment 14;
11. Use Figure 5-1 and Table 5-1 to fill the last column of Table 5-2;
12. Sketch the suggested specimens on the Data Sheet;
13. Use Fig. 5-1 for assignments 15&16.

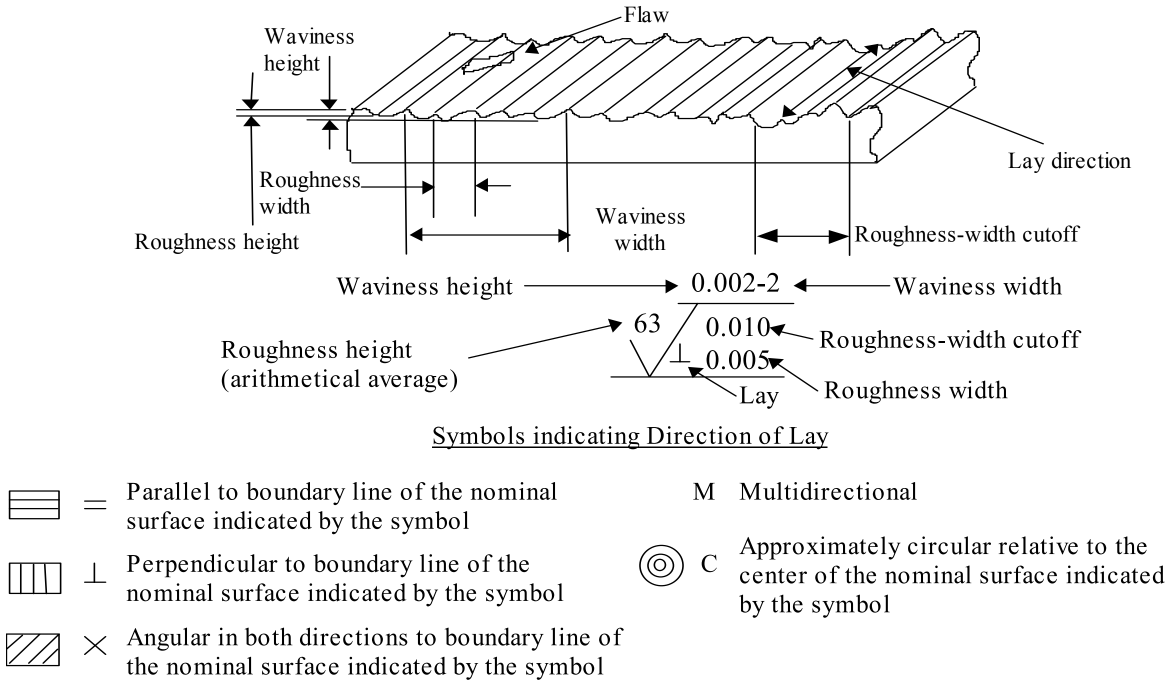


Fig. 5.1 Surface Texture

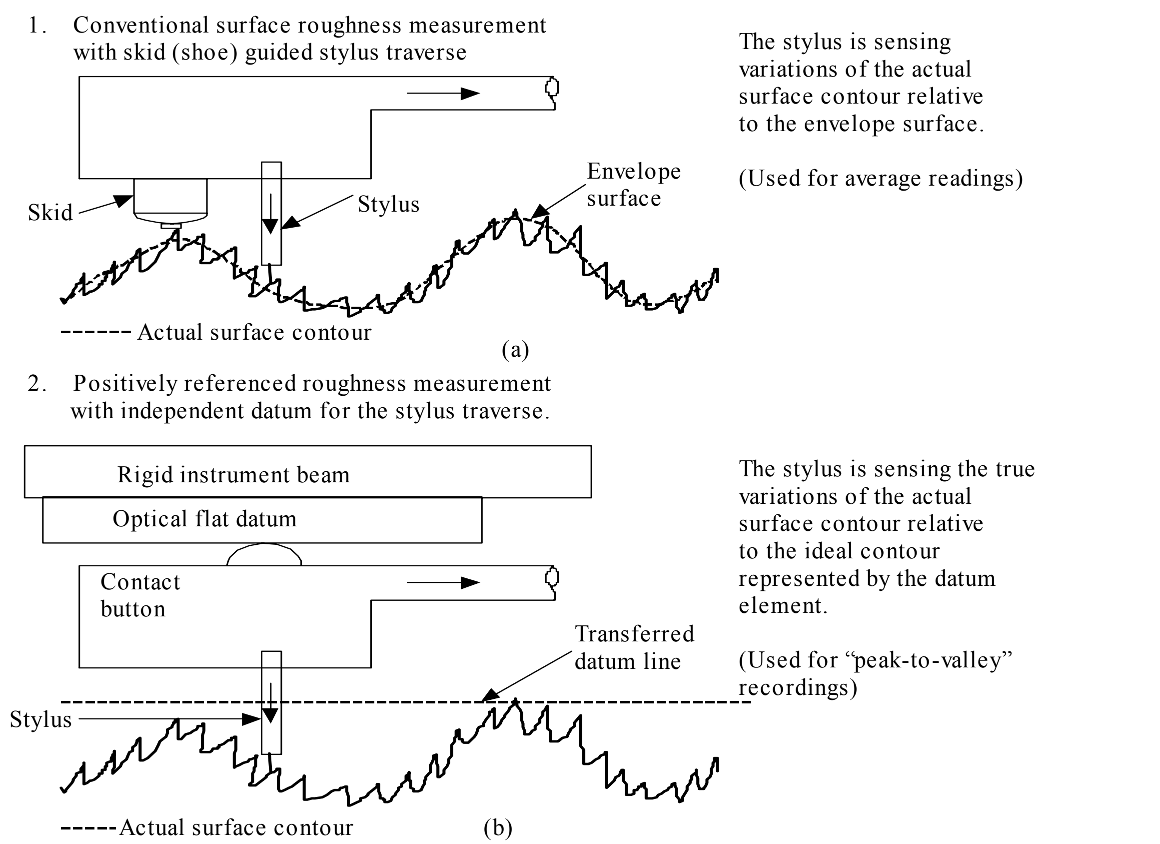
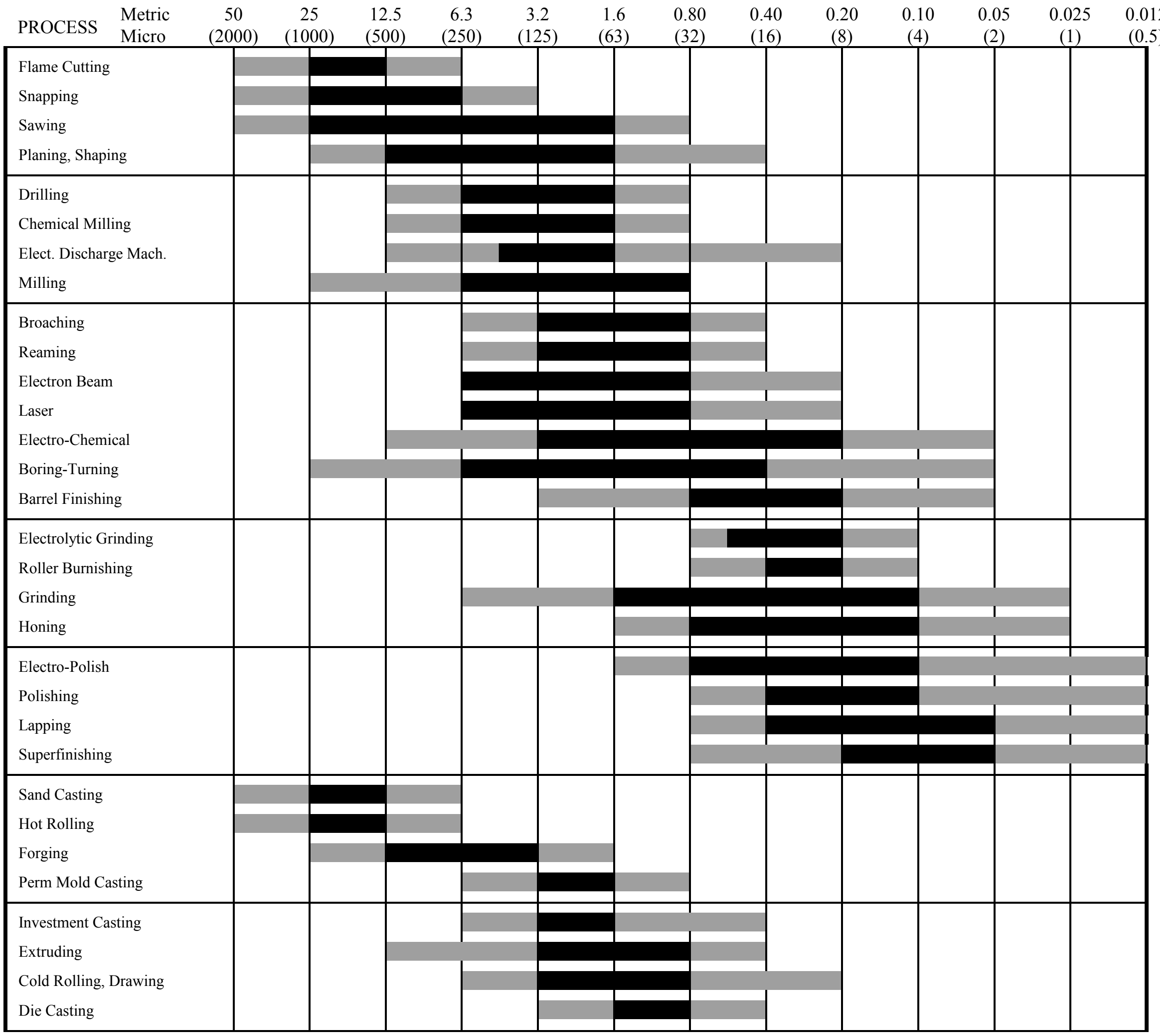


Fig. 5.2 Principle of Surface Measurements a) Surfometer; b) Profilometer or Surfanalyzer

TABLE 5-1.

ROUGHNESS HEIGHT RATING MICROMETER, μm (MICROINCHES μin) AA



The ranges shown above are typical of the process listed.

Higher or lower values may be obtained under special conditions

KEY: Average Application (black); Less Frequent Application (grey)

DATA SHEET FOR EXPERIMENT # 5

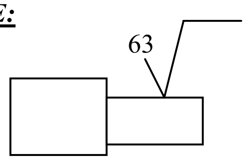
GROUP MEMBERS				GROUP LEADER	GROUP:
1		5		INSTRUCTOR'S APPROVAL:	
2		6			
3		7		DATE:	
4		8			

Table 5-2. SURFACE FINISHING

	Material or Specimen	Microfinish Comparator		Profilometer (mean absolute height) CLA		Surfometer (arithmetic average) AA		Possible Machine Cutting Process
		μin	μm	μin	μm	μin	μm	
1	Glass							
2	Shaft							
3	Bushing							
4	Block –3							
5	Block - 4							

SUGGESTED SPECIMENS.

Make a sketch and specify your investigated surface.

EXAMPLE: Part 1 		

SET OF QUESTIONS

1. What kind of commercial instruments are available for measuring and recording the surface finish?

2. Discuss the effects of grinding and turning on the endurance limit of steel. What is the reason of change in fatigue strength with various surfaces finishes?

3. Explain the principle of measurement by light wave interference?

4. Why is the microfinish comparator often used for specifying surface finish?

5. A designer places the following surface finish specification symbol on a given surface:

   0.003-2
   10 √ 0.030
   10.002

   (a) Is the roughness width cut off consistent with the roughness width?
   (b) What processes would be needed to achieve the surface roughness specified?
   (c) What would the roughness be in metric measurement?
   (d) What may be the cause of the waviness?

6. Is it possible to observe the surface roughness directly through an optical or scanning electron microscope?

7. What does this symbol mean?

   $\underline{\sqrt{X}}$

8. Is it possible to obtain surface roughness R_a=1.6 μm by any of the two manufacturing processes: grinding & boring?

9. List all the available machining processes to obtain the microroughness in a range of 3-5 μm.

10. What is the typical surface roughness requirement for the following engineering components?
    a. gear teeth
    b. bearing seals

SUGGESTED LITERATURE

1. E.P. de Garmo, J.T. Black, R.A. Kosher. Materials & Processes in Manufacturing, 8th Edition, Macmillan, New York, 1997.

2. Precision Measurement in the MetalWorking Industry. International Business Machines Corporation, Syracuse University Press, Syracuse, New York, 1982.

3. S. Kalpakjian. Manufacturing Engineering and Technology, Addison -Wesley Publishing Company, Reading, Massachusetts, 1995.

4. “Operating Instructions” for Surfometer System 2.

5. D.F. Moore. Principles and Applications of Tribology, Pergamon Press, New York, 1975.

6. F.T. Farago. Handbook of Dimensional Measurement, Industrial Press, New York, 1968.

7. R. Dubrovsky. Laboratory Manual. Engineering Materials & Processes. ME Department, NJIT, CAPCO,1998.

Mahr Perthometer Concept

Version 7.1

Basic Operating Instructions

Overview

Mahr's Perthometer Concept is a powerful, modular measuring system for measuring surface roughness, waviness and form measurements.

The Perthometer Concept Roughness and topography measuring station serves for determining all common surface texture parameters according to DIN EN ISO/JIS/ASME.

The efficient program package, running under Windows, controls the measuring station components, the measurements and documents the results according to your requirements.

Features

- All common parameters according to DIN/ISO, ASME, JIS
- Height adjustment range from 25 mm to 410 mm (.984 in to 16.14 in)
- Gaussian filter, RC-filter, and special filter
- Variable setting of tracing length and filter
- All standard characteristic curves and profile types
- Easy operation via mouse or keyboard
- Control via the Perthometer Concept menu

Safety First

Please Note: This measuring system has a motorized height adjustment

USE EXTREME CAUTION WHEN PLACING SAMPLES NEAR THE STYLUS PROBE.

- Familiarize yourself with the Emergency Stop button.
- Always wear safety glasses.
- Always keep your hands and fingers away from the drive unit.
- Do not remove any pick-up (stylus) guards.

Set up and Operation

These are generalized instructions to help you get started taking measurements using the Mahr Perthometer.

Please take the time to read and follow the separate operating instructions for the MFW-250 Pick-up (375 2813) and the PGK Drive Unit (375 2733).

Getting Started:
To start the Mahr Perthometer Concept program double click on the "Concept" desktop icon.

Setting the pick-up (stylus) to Zero:

- On the toolbar click on "View" and then "Meas. Station".
  The 'measuring station' window will open.
  The buttons in this window are used to move and position the drive unit.

- Use the Up button directly below the Calibrate button to move the unit up and out of the way.
  Place the sample to be measured so that the pick up (stylus) will contact the far left of the sample piece.
  (The pick up (stylus) travels from the left to the right of the operator's position.)

- Now use the Down button to CAREFULLY start lowering the drive unit.
  As you are lowering the drive unit, do not look at the sample being measured; look at the meter (pick up signal) on the left of the 'measuring station' window.

Setting the pick-up to Zero (continued):
When the pick-up (stylus) contacts the sample being measured the Arrow that is at the bottom of the meter begins to move upwards and the color of the Arrow will turn from the color Red to Black.

- At this point switch over to the Fine adjustment buttons on the left side of the ‘measuring station’ window. ‘Single click’ on the Fine (down) adjustment button until the Arrow lines up with the Zero on the meter.

- Click the Close button and close the ‘measuring station’ window.

Final setting of the pick-up to Zero:

- On the toolbar click on “Assistants” and then “Measurements”. The ‘Measurements Assistants’ window will open. In this window click on the ‘Set To Zero’ button.

- On the toolbar click on “File” and then “Execute”. The pick-up (stylus) is now set to Zero.

Starting the Measurement:

- On the toolbar click on “View” and then “Form”. (A prompt will appear “The current measuring program was modified? Save program?” Click NO.) The ‘Form’ window will open.

- On the toolbar click on “File” and then “New/Start Measurement”. (A prompt will appear “The settings have been modified! Execute the measurement??” Click OK.)

The Profile Acquisition window will now open and the Perthometer will take the measurement (moving first from left to right and then from right to left). Once the Profile Acquisition window closes (automatically) the measurement is finished and complete.

Getting measurement results:
You can obtain your measurement results a couple of different ways:

- Click on the D P W or R icons (located on the left part of the screen).
- On the toolbar you can also click on “Form Field” and then “Profile Field” and then click on the desired profile.

When multiple profile form results are obtained you will receive an Inquiry [Form View] prompt: Field does not match current page. Create a new page? Click YES and the results will continue down the newly created page.

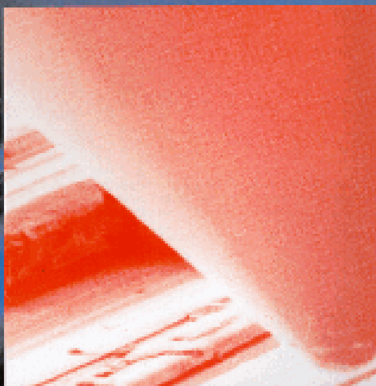
Final Notes:
When you close the Perthometer Program if you do not want to save the measurement results answer NO to all the prompts that pop up.

The Perthometer_Surface Texture Parameters.pdf file (a shortcut is located on the desktop) explains in detail the settings and parameters which can be altered and toggled on and off according to your requirements. (In the Form View click on “Form Field” and then “Parameter Field” to change the settings….)

Once again these are basic instructions to help you get started taking measurements. The program itself has its own very through Help system, which can be used in three operating modes Contents, Search, and Help Mode.

Mahr

Perthometer.
Surface Texture Parameters



New Standards
DIN EN ISO / ASME

MAHR GMBH, Germany - EDITION 09/01/99

Contents

MAHR GMBH, Germany - EDITION 1/09/99

Real surface separates a body from the surrounding medium. (DIN EN ISO 4287)

Stylus instrument enables two-dimensional tracing of a surface. The stylus is traversed normal to the surface at constant speed. (DIN EN ISO 3274)

Traced profile is the enveloping profile of the real surface acquired by means of a stylus instrument. The traced profile consists of form deviations, waviness and roughness components. (DIN EN ISO 3274, DIN 4760)

Parameters usually are defined over the sampling length. An average parameter estimate is calculated by taking the arithmetic mean of the parameter estimates from all the individual sampling lengths. For roughness profile parameters the standard number of sampling lengths is five.
For curves and related parameters (e.g. material ratio) the basis for the calculation of the parameters' values is the evaluation length. (DIN EN ISO 4288)

Geometrical Product Specification (GPS)

ISO/TR 14638, DIN V 32950

Geometrical Product Specification (GPS) implies different kinds of standards dealing with the geometric characteristics of products during product design, manufacture, inspection, quality assurance, etc.

In the **GPS matrix model**, the lines comprise chains of standards dealing with one and the same characteristic such as e.g. size, distance, form features, roughness, waviness, etc. The columns (i.e. the links of the chains) then are:

1. Drawing specifications (DIN EN ISO 1302)
2. Theoretical definitions (DIN EN ISO 4287, 11562, 12085, and 13565)
3. Parameter definitions (DIN EN ISO 4288, 11562, 12085, and 13565)
4. Assessment of deviations (DIN EN ISO 4288 and 12085)
5. Measurement equipment requirements (DIN EN ISO 3274 and 11562)
6. Calibration requirements (DIN EN ISO 5436 and 12179)

The most important standards in the field of **surface texture** are detailed in parentheses ().

BACK NEXT

Traversing length l_t is the overall length traveled by the stylus when acquiring the traced profile. It is the sum of pre-travel, evaluation length l_n, and post-travel.

Cutoff λ_c of a profile filter determines which wavelengths belong to roughness and which ones to waviness.

Sampling length l_r is the reference for roughness evaluation. Its length is equal to the cutoff wavelength λ_c.
The sampling lengths $\mathbf{l_p}$ and $\mathbf{l_w}$, respectively, are the reference lengths for the P-profile and the W-profile evaluation.

Evaluation length l_n is that part of the traversing length l_t over which the values of surface parameters are determined. The standard roughness evaluation length comprises five consecutive sampling lengths.

Pre-travel is the first part of the traversing length l_t.

Post-travel is the last part of the traversing length l_t. Pre-travel and post-travel are required for phase correct filtering.

Profile filter

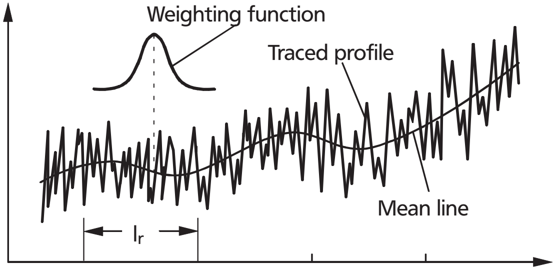
DIN EN ISO 11562, ASME B46.1

Profile filters seperate profiles into long wave and short wave components. The λ_c profile filter separates the roughness profile from long wave components (e.g. waviness).

Mean line is generated by a phase correct filter by calculating the weighted average for each point of the profile.

Weighting function indicates for each point of the profile the assessment factor with which the adjacent profile points enter into averaging (Gaussian curve).

R-profile (roughness profile) represents the deviations of the primary profile from the mean line of the λ_c profile filter. When presenting the roughness profile, the mean line is the zero line.



BACK NEXT

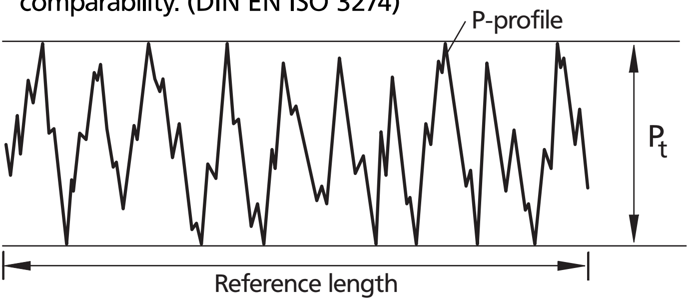
P_t Profile depth

DIN EN ISO 4287

Profile depth P_t (total height of P-profile) is the sum of the largest profile peak height and the largest profile valley depth of the P-profile within the evaluation length l_n (reference length). The reference length has to be stated.

P-profile (primary profile) is computed from the traced profile

- by excluding the nominal form by using the method of best fit least squares of the type indicated in the drawing, e.g. a linear regression line and
- by excluding ultra-short wavelengths from the evaluation by using the λ_s profile filter, which considerably increases comparability. (DIN EN ISO 3274)



BACK NEXT

Selection of cutoff λ_c

DIN EN ISO 4288, ASME B46.1

Periodic profiles	Nonperiodic profiles		Cutoff	Sampl./ Eval. length
R_{sm} (mm)	R_z (µm)	R_a (µm)	λ_c (mm)	l_r / l_n (mm)
over **.013** up to **.04**	up to **.1**	up to **.02**	**.08**	**.08 / .4**
over **.04** up to **.13**	over **.1** up to **.5**	over **.02** up to **.1**	**.25**	**.25 / 1.25**
over **.13** up to **.4**	over **.5** up to **10**	over **.1** up to **2**	**.8**	**.8 / 4**
over **.4** up to **1.3**	over **10** up to **50**	over **2** up to **10**	**2.5**	**2.5 / 12.5**
over **1.3** up to **4**	over **50** up to **200**	over **10** up to **80**	**8**	**8 / 40**

BACK NEXT

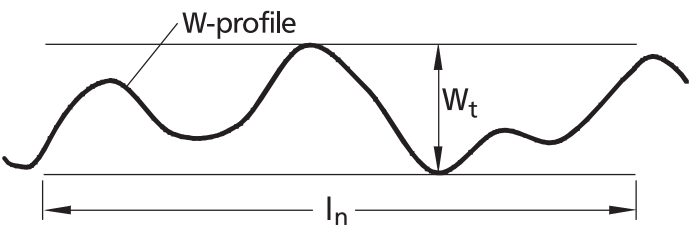
W_t Waviness height

DIN EN ISO 4287, ASME B46.1

Waviness height W_t (total height of W-profile) is the sum of the largest profile peak height and the largest profile valley depth of the W-profile within the evaluation length l_n (reference length).

The evaluation length l_n (reference length) has to be stated.

W-profile (waviness profile) is the mean line generated from the P-profile by the l_c profile filter. The long wave profile components which belong to the form are excluded.



BACK NEXT

R_a, R_q Mean roughness

DIN EN ISO 4287, ASME B46.1

Roughness average R_a is the arithmetic average of the absolute values of the roughness profile ordinates.

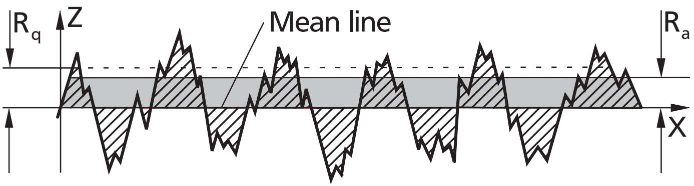
$$R_a = \frac{1}{l}\int_0^l |Z(x)|\,dx$$

Root mean square (RMS) **roughness R_q** is the root mean square average of the roughness profile ordinates.

$$R_q = \sqrt{\frac{1}{l}\int_0^l Z^2(x)\,dx}$$

$Z(x)$ = profile ordinates of the roughness profile.

R_a is also called AA and CLA, R_q also RMS.



BACK NEXT

R_z, R_{max} Roughness depth

DIN EN ISO 4287, ASME B46.1

Single roughness depth R_{zi} is the vertical distance between the highest peak and the deepest valley within a sampling length.

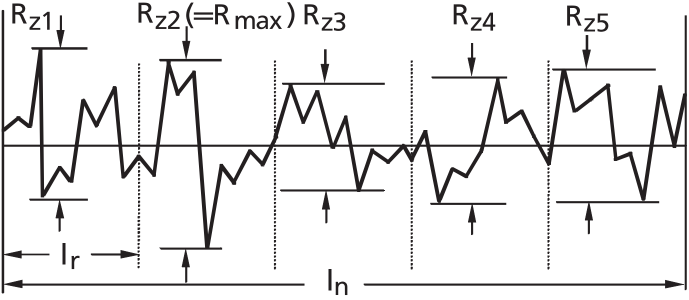
Mean roughness depth R_z is the arithmetic mean value of the single roughness depths **R_{zi}** of consecutive sampling lengths:

$$R_z = \frac{1}{n}(R_{z1} + R_{z2} + \ldots + R_{zn})$$

The R_z definition is identical to the definition in DIN 4768:1990. The ten point height R_z as well as the parameter symbol R_y of ISO 4287:1984 have been canceled.

Maximum roughness depth R_{max} is the largest single roughness depth within the evaluation length.

(cf. DIN EN ISO 4288; R_{max} is also called R_{z1max})

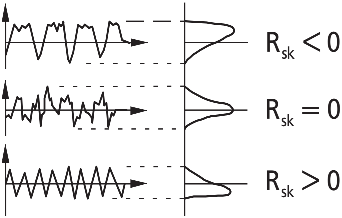


R_{sk}, R_{ku}

DIN EN ISO 4287, ASME B46.1

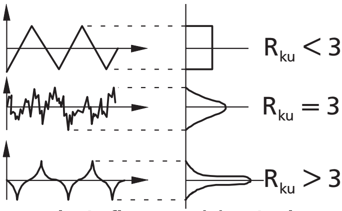
Skewness R_{sk} is a measure of the asymmetry of the amplitude density curve. A negative skewness value indicates a surface with good bearing properties.

$$R_{sk} = \frac{1}{R_q^{\,3}} \frac{1}{l} \int_0^l \left| Z^3(x) \right| \, dx$$



Kurtosis R_{ku} is a measure of the peakedness of the amplitude density curve. For a profile with a Gaussian amplitude density curve R_{ku} is 3.

$$R_{ku} = \frac{1}{R_q^{\,4}} \frac{1}{l} \int_0^l \left| Z^4(x) \right| \, dx$$



Skewness and Kurtosis are strongly influenced by isolated peaks and valleys, fact which reduces their practical importance.

BACK NEXT

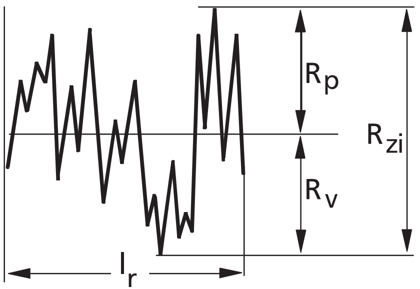
R_p Peak height, R_v

DIN EN ISO 4287, ASME B46.1

R_p is the height of the highest profile peak of the roughness profile within one sampling length.
According to ASME, the R_p mean value (average calculated over the evaluation length) is called R_{pm}.

R_v is the depth of the deepest profile valley of the roughness profile within one sampling length. So far, the parameter symbol R_m was used in place of R_v.

The sum of R_p + R_v is the single roughness depth R_{zi}.



BACK NEXT

R_{3z} Base roughness depth

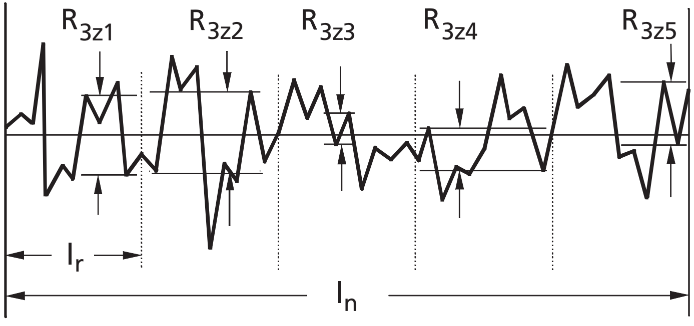
Daimler Benz Standard 31007 (1983)

Single roughness depth R_{3zi} is the vertical distance of the third highest peak to the third deepest valley of the roughness profile within a sampling length l_r.

Base roughness depth R_{3z} is the mean value of the single roughness depths R_{3zi} of five consecutive sampling lengths l_r:

$$R_{3z} = \frac{1}{5}(R_{3z1} + R_{3z2} + R_{3z3} + R_{3z4} + R_{3z5})$$

Profile peak and profile valley must exceed certain vertical and horizontal minimum values.



BACK NEXT

R_{mr}, t_p Material ratio

DIN EN ISO 4287, ASME B46.1

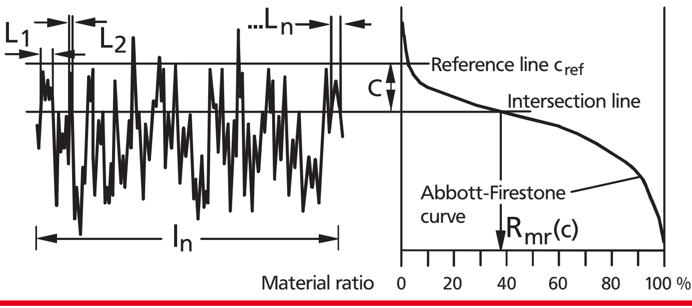
Material ratio R_{mr} (ASME: bearing length ratio t_p) is the ratio expressed in percent of the material-filled length to the evaluation length l_n at the profile section level c.

$$R_{mr} = \frac{1}{l_n}(L_1 + L_2 + ... + L_n)\ 100\ [\%]$$

The profile section level c is the distance between the evaluated intersection line and the specified reference line c_{ref}.

Material ratio curve (Abbott-Firestone curve) shows the material ratio R_{mr} as a function of the profile section level c.

The material ratio can also be evaluated on the P- or the W-profile (P_{mr} or W_{mr}).



BACK NEXT

R_k, R_{pk}, R_{vk}, M_{r1}, M_{r2}

DIN EN ISO 13565-1 and -2

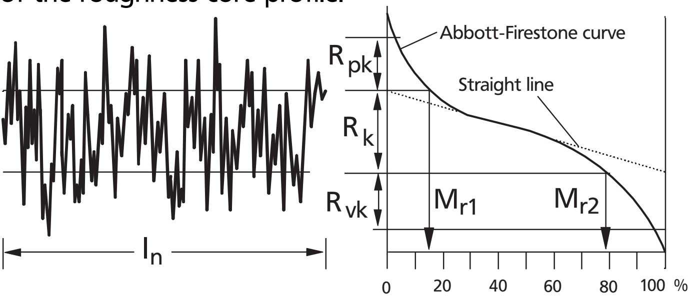
The roughness profile as per 13565-1 is generated by a special filtering technique minimizing profile distortions due to deep valleys in plateau profiles. A straight line divides the Abbott-Firestone curve into three areas from which the parameters are then computed as per 13565-2:

Core roughness depth R_k is the depth of the roughness core profile.

Reduced peak height R_{pk} is the mean height of the peaks protruding from the roughness core profile.

Reduced valley depth R_{vk} is the mean depth of the valleys protruding from the roughness core profile.

M_{r1} and **M_{r2}** are the smallest and the highest material ratios of the roughness core profile.



BACK NEXT

R_{sm}, $R_{\Delta q}$

DIN EN ISO 4287, ASME B46.1

Mean width of profile elements R_{sm} is the arithmetic mean value of the widths of profile elements of the roughness profile.

$$R_{sm} = \frac{1}{n}\sum_{i=1}^{n} S_{mi}$$

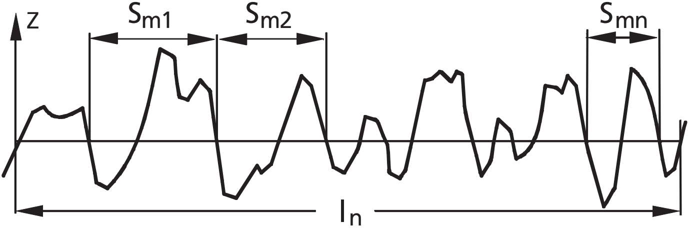
A profile element consists of a profile peak and an adjacent profile valley.

A_r is an older designation for R_{sm}.

Root mean square slope $R_{\Delta q}$ is the root mean square average of all local profile slopes.

$$R_{\Delta q} = \sqrt{\frac{1}{l}\int_0^l \left(\frac{dz}{dx}\right)^2 dx}$$

The local profile slope is computed via a leveling function in order to reduce the influence of noise.



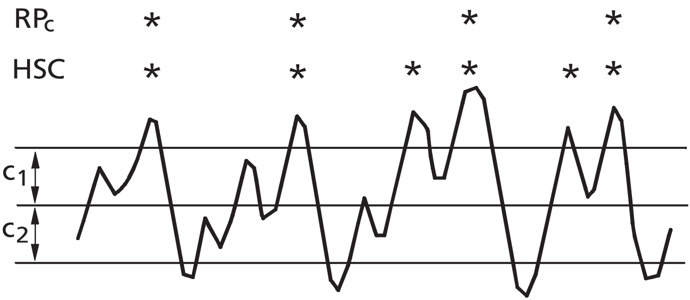
BACK NEXT

RP_c, HSC Peak count

prEN 10049, ASME B46.1

Peak count RP_c is the number of roughness profile elements (see R_{sm}) per cm which consecutively intersect the specified upper profile section level c_1 and the lower profile section level c_2.

High spot count HSC is the number of roughness profile peaks per cm exceeding the specified upper profile section level c_1.



BACK NEXT

Mahr GmbH
Göttingen

Postfach 1853
D-37008 Göttingen
Brauweg 38
D-37073 Göttingen
Phone + 551-70730
Fax + 551-71021
e-mail: info@mahr.de

Hand measuring instruments, length measuring and controlling instruments, gage calibration systems & software, form and gear measuring instruments, 3D multisensor technology, surface texture and contour measuring instruments,, spinning pumps, rotary stroke bearings, calibration services (DKD)

http://www.din.de

http://www.beuth.de

Mahr

http://www.mahr.com

MAHR GMBH, Germany - EDITION 1/09/99