Indication of surface roughness measurement properties in technical documents

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Bachelor's thesis

Mechanical Engineering

Autumn 2022

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Tiivistelmä
Vuosi 2022

Työn nimi Pinnankarheuden mittausominaisuuksien merkintä teknisissä asiakirjoissa

Ohjaaja Timo Kärppä

Opinnäytetyön tarkoituksena on tunnistaa erot kahden standardin, uuden pinnan karheusstandardin (SFS-EN ISO 21920-1:2022) ja kumotun pinnan karheusstandardin (SFS-EN EN ISO 1302:2002), välillä.

Molemmat standardit kuvaavat tuotteen teknisessä dokumentaatiossa vaadittuja sääntöjä, kun pintatekstuuri ilmaistaan graafisilla symboleilla koneenrakennuspiirustuksessa.

Lisäksi mukana on lyhyt kuvaus pinnan karheusstandardista (SFS-EN ISO 25178-2:2022), jota on mukautettu uudella standardilla (SFS-EN ISO 21920-1:2022) muokkaamalla muun muassa ominaisuusparametreja ja parametrien nimiä sekä tekemällä muita parannuksia.

Lisäksi kaikki sekä uusia että kumottuja standardeja koskevat pinnankarheusmittausstandardien ominaisuudet on kuvattu yksityiskohtaisesti tämän opinnäytetyössä.

Opinnäytetyö sisältää myös asiaankuuluvat standardimitat ja -määritykset, jotka sisältyvät kuviin, kaavioihin ja suunnittelupiirustuksiin, jotka puolestaan on saatu hyväksytyistä pintarakennestandardien teknisistä asiakirjoista.

Avainsanat pinnankarheus standardi, pinnankarheus, mittaus, SFS-EN ISO, ominaisuudet.
Sivut 49

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Abstract
Year 2022

Subject Indication of surface roughness measurement properties in technical documents

Supervisors Timo Kärppä

The research method of this thesis is a literature review of relevant sources.The purpose of this thesis is to identify the differences between two standards, the new surface roughness standard (SFS-EN ISO 21920-1:2022) and the withdrawn surface roughness standard (SFS-EN EN ISO 1302:2002). The research method of this thesis is a literature review of relevant sources.

Both of these standards describe the rules required in technical product documentation when indicating surface texture using graphical symbols in a mechanical engineering drawing.

In addition, a brief description of the surface roughness standard (SFS- EN ISO 25178-2:2022) is included, which was adapted by the new standard (SFS-EN ISO 21920-1:2022) through improvements to feature parameters, parameter name, and other improvements.

Furthermore, all properties of surface roughness measurement standards are described in details for both the new as well as the withdrawn standards.

The thesis also includes relevant standards measurements and definitions, which are included within figures, diagrams and engineering drawings, which are obtained from the approved technical documents of surface structure texture standards.

Keywords surface roughness standard, texture, measurement, SFS-EN ISO, properties.
Pages 49

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1 Introduction

In the development of a new product, scientists and engineers follow specific method in the process of development. These methods need to be according to ISO standards, which contain different measurements and criterias created by many experts in the field to follow. Such standards contain dimensions, materials to be used, as well as geometrical symbols.

In this thesis, the surface roughness texture, which is considered part of the geometrical symbols within two standards, which will be compared against eachother. These standards are the new surface roughness texture standard SFS-EN ISO 21920-1: 2022 and the withdrawn surface roughness texture standard EN ISO 1302: 2002.

Furthermore, the benefits and importance of the changes between the two standards are documented in details based on the contents of these standards. In addition, the differences of the properties of surface roughness material are documented within this thesis.

Within the new standards, some changes were made compared to the old withdrawn standards. These changes were adopted by many industries within scientific activities, mechanical design, as well as other technical fields. These changes in the new standard helped bring about technical advancement of the manifacturing and mechanical design.

In addition, another new standard SFS- EN ISO 25178-2: 2022 is introduced in this thesis, which includes some methods and points, which are included in the following chapters from another obsolete withdrawn standard SFS- EN ISO 25178-2: 2012. The reason for this is to make this standard (SFS- EN ISO 25178-2: 2022) compatible with the new standard SFS-EN ISO 21920-1: 2022.

2 Surface roughness theory

2.1 History

A series of depressions (bottoms) and zigzag rises (peaks) within familiar distances towards a normal vector of the surface of its clear shape and this is known as surface roughness as shown in fig.1 (Zhuzhou Meetyou Carbide, 2019).

Figure 1. Surface roughness texture (Elder, 2021)

When the surface is smooth, this indicates that these deviations are small, and when the surface is rough, this indicates that these deviations are large (Zhuzhou Meetyou Carbide, 2019).

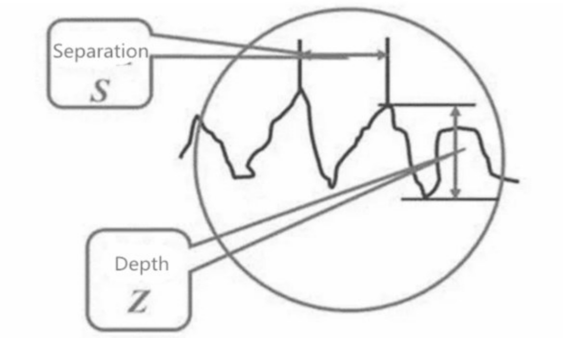
In surface measurement, the roughness is usually expressed as a high-frequency and short-wave component of a measured surface, so the necessary knowledge of frequency and amplitude is of paramount importance, and this happens through the practical application (Zhuzhou Meetyou Carbide, 2019).

The microstructure of the surface is a basic concept, so a surface roughness texture can be described as a series of jagged valleys with peaks between them. The texture of surface roughness is also described by the following:

The length range (S) is considered between peaks, which is between peaks or troughs is usually less than (1 mm). Scale (S) is the main characteristic by which the difference between surface states can be known. As for the depth, which is determined by the range (Z) from top to bottom as shown in Fig. 2, $S < 1$ mm. Afterglow as evidence of surface roughness, $1 \le S \le$

10 mm. Ripple, and S ＞ 10 mm. On geometric unevenness, (Zhuzhou Meetyou Carbide, 2019).

Figure 2. Surface roughness and definition (Zhuzhou Meetyou Carbide,2019)



As for the interaction of a real body with its environment, which determines the surface roughness factor, as smooth surfaces have lower friction coefficients than rough surfaces, and rough surfaces wear out more quickly than other smooth surfaces, so cracks or corrosion may form in the sites of rough surfaces, which gives a good mechanical performance advantage (Zhuzhou Meetyou Carbide, 2019).

The increase in manufacturing costs is a result of the effects of surface roughness reduction processes (Zhuzhou Meetyou Carbide, 2019).

To measure the surface roughness, this can be done using 3-dimensional (3D) microscopic devices as shown in fig. 3 or by manual touch. As for measuring the surface profile, this is done using a profilometer (Zhuzhou Meetyou Carbide, 2019).

Figure 3. (3D) microscopic device (BriCut Tools Oy, 2022)

2.2 Surface theory

The maximum depth of the valley (Ry), the average arithmetic deviation of contour (Ra), and the average height of unevenness (Rz) are the 3 Indexes by unit: mm that measure surface roughness used in China (Zhuzhou Meetyou Carbide, 2019).

The index (Ry) which is used in Japan and referred to as (Rmax) is also considered (Zhuzhou Meetyou Carbide, 2019).

VDI 3400 (which is known as Surface Finish (VDI), which can be processed by Electrical Discharge Machining (EDM). Verein Deutscher Ingenieure (VDI) is the association that developed the (VDI 3400) which refers to surface texture standard), which is used in the European region (Plastopia, 2021).

Therefore, in most actual production activities, the index (Ra) is often applied, as shown in Table. 1 (Zhuzhou Meetyou Carbide, 2019).

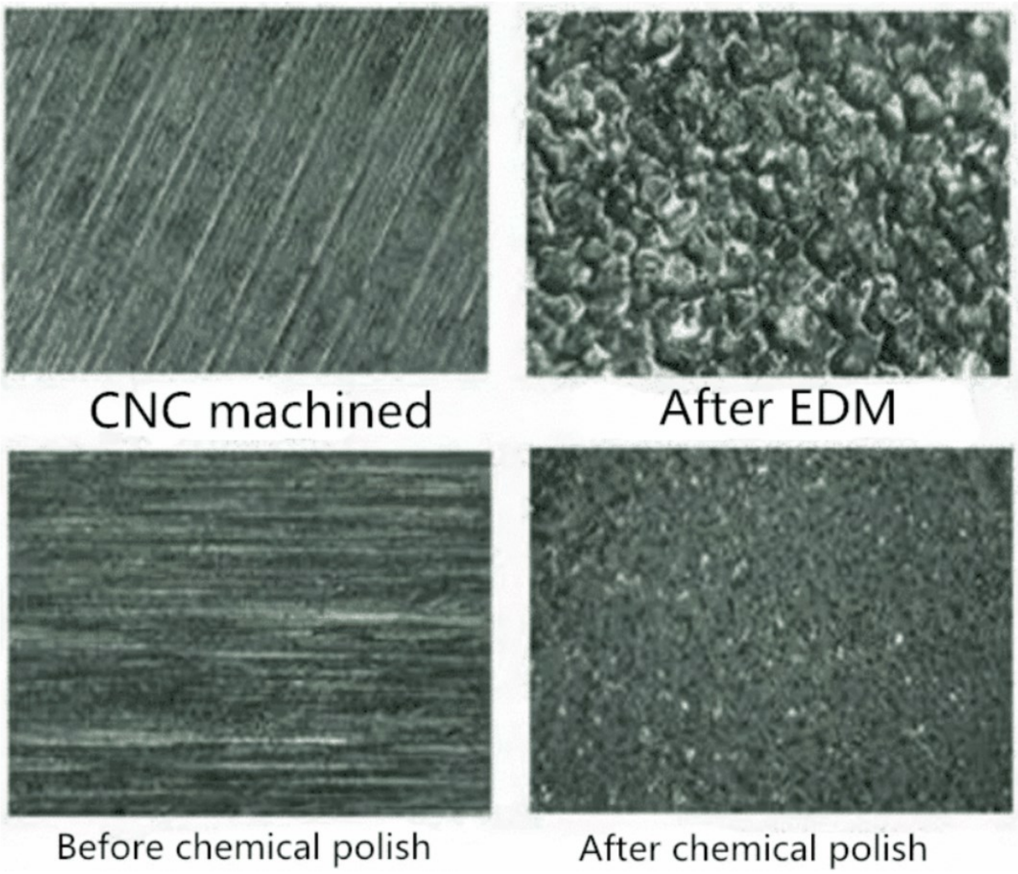
Table 1. Table of the comparison of uses (Zhuzhou Meetyou Carbide, 2019)

VDI3400	Ra (μm)	Rmax (μm)
0	0.1	0.4
6	0.2	0.8
12	0.4	1.5
15	0.56	2.4
18	0.8	3.3
21	1.12	4.7
24	1.6	6.5
27	2.2	10.5
30	3.2	12.5
33	4.5	17.5
36	6.3	24

The surface roughness generally consists of processing methods, as for the friction between the tool in the centre of the part, the plastic deformation of the surface metal when separating the chips, high-frequency vibration, the process system, vacuum drilling for electric machines, etc. are other additional factors (Zhuzhou Meetyou Carbide, 2019).

Due to the difference in the processing method and the material of the workpiece there are differences in the depth, density, shape, and texture of the traces left on the formed surface, as shown in fig. 4 (Zhuzhou Meetyou Carbide, 2019).

Figure 4. Factors causing surface roughness (Zhuzhou Meetyou Carbide, 2019)



The main effect of surface roughness on parts which affects wear resistance, (Zhuzhou Meetyou Carbide, 2019).

When effective contact area between two surfaces is small, this indicates that the roughness of the surface is high. In addition, when the friction resistance is great, this indicates that the pressure is great, this also leads to fast wear of the material (Zhuzhou Meetyou Carbide, 2019).

The coordination stability is affected by different conditions, for example, the clearance fit in which two moving assembled-together parts can get tear and wear easily when the surface between these parts is rough. This will also cause gradual increase in the clearance (Zhuzhou Meetyou Carbide, 2019).

To accommodate the interference, there will be a reduction in the actual effective interference and the contact strength will be reduced due to the extrusion of the fine convex peaks during assembly (Zhuzhou Meetyou Carbide, 2019).

Affected by fatigue strength: the presence of large troughs on the surface of rough parts such as cracks and sharp cracks, it is a sensitive presence of stress concentration, which affects the stress strength of parts (Zhuzhou Meetyou Carbide, 2019).

Effect on corrosion resistance: In the surface of the rough parts, there is ease in making gases or liquids through the surface of the small valley, where they begin to infiltrate the inner metal layer, which leads to surface corrosion, (Zhuzhou Meetyou Carbide, 2019).

Effect on sealing: Rough, surfaces do not fit tightly, so gases or liquids will seep through the cracks between the contact surfaces, (Zhuzhou Meetyou Carbide, 2019).

Affected by contact hardness: contact hardening is the ability of parts to resist contact deformation under external force, and machine hardness depends largely on the contact hardness of parts, (Zhuzhou Meetyou Carbide, 2019).

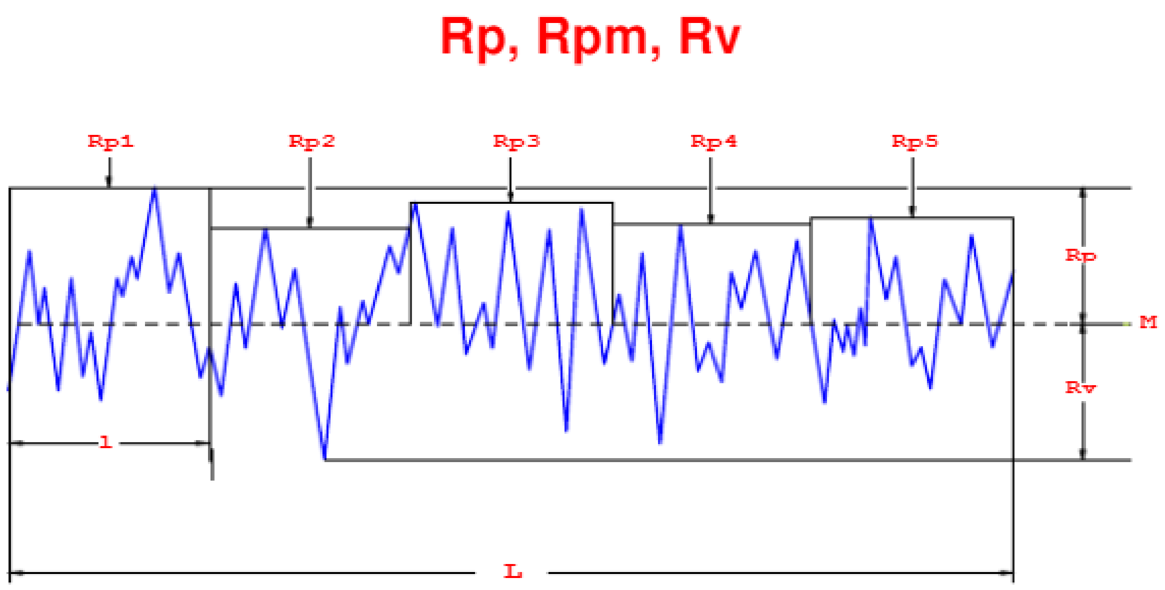
Measurement accuracy is affected: the surface roughness of the measured parts and measuring instruments directly affects the measurement accuracy, especially in the precise measurement, (Zhuzhou Meetyou Carbide, 2019).

2.3 Terminology of surface roughness

Mean Line (M) it is a reference line around which profile deviations are measured, evaluation Length (L) it is the values of the surface parameters are evaluated, and sampling Length (I) also known as cut-off or cut-off length it is the wavelength used to separate the roughness from the wave, (Chandigarh University, 2020).

Profile Valley is the point of maximum depth on the part of a profile located below the midline and between two intersections of the profile with the midline, profile Irregularity is the variation due to the height of the profile and the depth of the adjacent profile, and profile Peak is the point of maximum elevation on a segment of a profile located above the mean e and between two intersections of the profile with the median line, (Chandigarh University, 2020). The explanation of terminology of surface roughness as shown in fig. 5, (Chandigarh University, 2020).

Figure 5. Explanation of terminology of surface roughness (Chandigarh University, 2020)

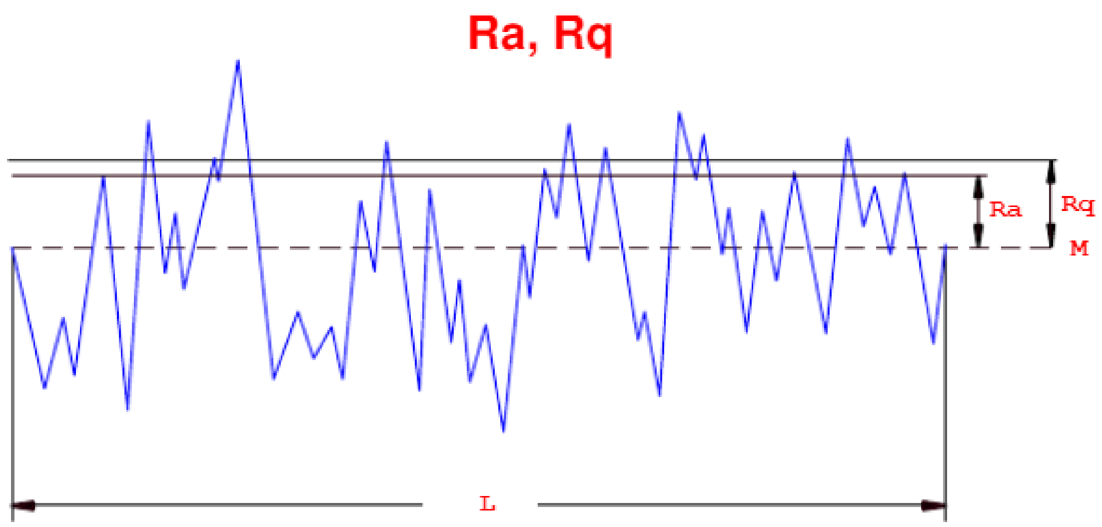


2.3.1 Parameters of surface roughness

(Ra) average roughness the arithmetic means of the absolute values of the profile heights along the rating line (Chandigarh University, 2020), therefore, when a sample is taken from the standard-length section on the roughness diagram from the mean line (so that the median line works in the direction of the (X) axis, and on the direction of the (Y) axis, where the magnification is formed on the Cartesian coordinate system) (Rösler, 2016).

(Rq), (RMS Roughness) is the (RMS) of profile heights along the rating line. (Chandigarh University, 2020), when the (Rq) parameter is compatible with the (Ra) parameter, they will be used together in the predictive calculations of gear life, and this depends on their historical relationship more than their accuracy in classifying the surfaces of gears. Therefore, there is a need to evaluate alternative measures of surface roughness due to the different surface properties (Bell, 2016).

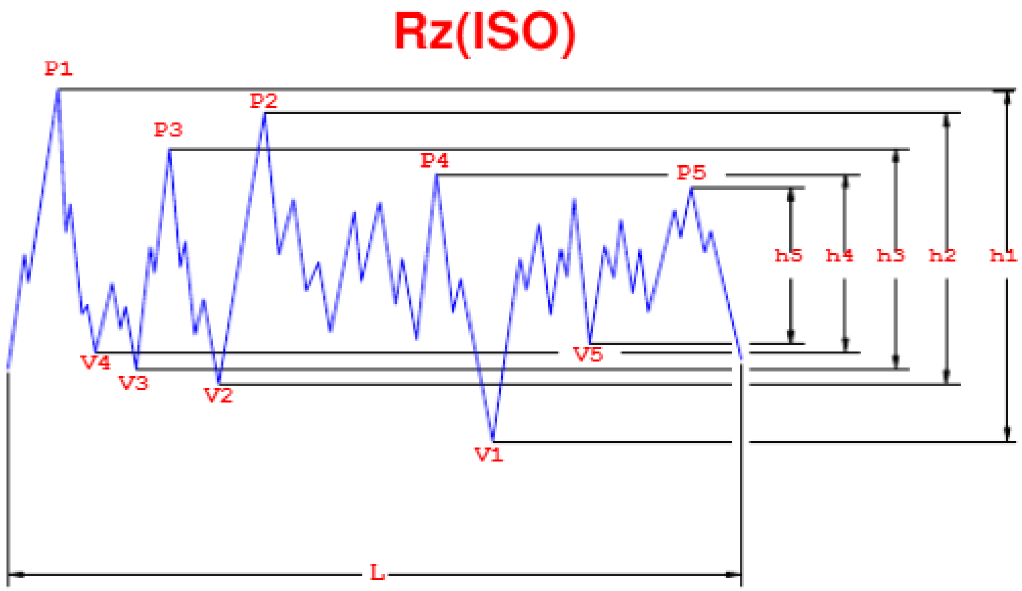
Figure 6. Ra and Rq average roughness (Chandigarh University, 2020)



(Rz) (ISO) ,(Height of Ten Points of Violation) is the average of the absolute values of the heights of the five highest peaks and the depths of the five deep valleys within the evaluation length, as shown in fig. 7, when a sample of the standard-length section is taken on the roughness plot from the mean line (so that in the direction of the (y) axis the distances between the peaks and valleys of the sample line are measured) (Chandigarh University, 2020).

Therefore, among the top 5 peaks, (Yp) which is known as the average peak can be obtained. As for obtaining the average valley (Yv), it is possible between 5 valleys as a minimum. It also expresses all values in micrometers (Rösler, 2016).

Figure 7. Rz (ISO) High of ten points of violation (Chandigarh University, 2020)

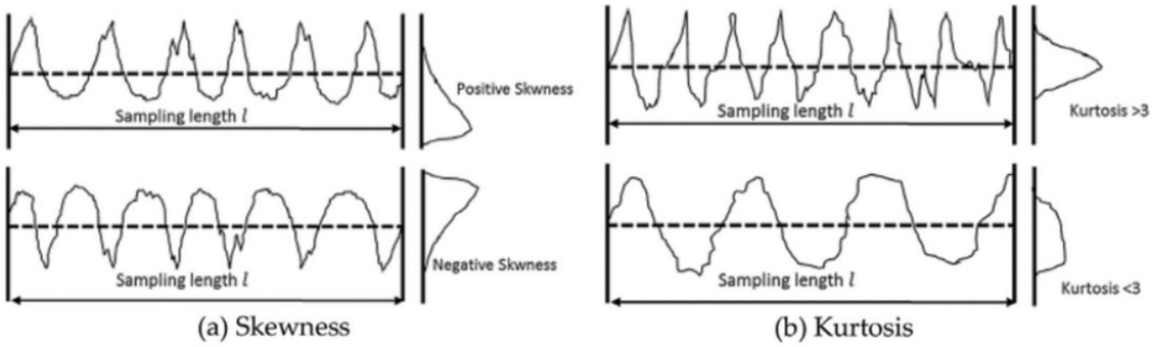


2.4 Surface roughness 2D definition

(R sk) is the deviation of the profile of the surface to be evaluated, also a measure of the asymmetry of the profile around the midline (Zeng & Qin & Chang & Luo, 2018).

(R sk) is negative when most valleys are steeper and peaks are rounded, while (R sk) is positive when the surface has steeper peaks and more rounded valleys, (Zeng & Qin & Chang & Luo, 2018). 2D surface roughness as shown in fig. 8 (Zeng & Qin & Chang & Luo, 2018).

Figure 8. Surface roughness 2D (Zeng & Qin & Chang & Luo, 2018)



2.5 Surface roughness 3D definition

(Sa) is the area equivalent and is 3-dimensional for 2-dimensional Ra, (Sa) is the mean area roughness or average height of all measured points in the measurement area, while (S) surface measurements, (Michigan Metrology, 2022).

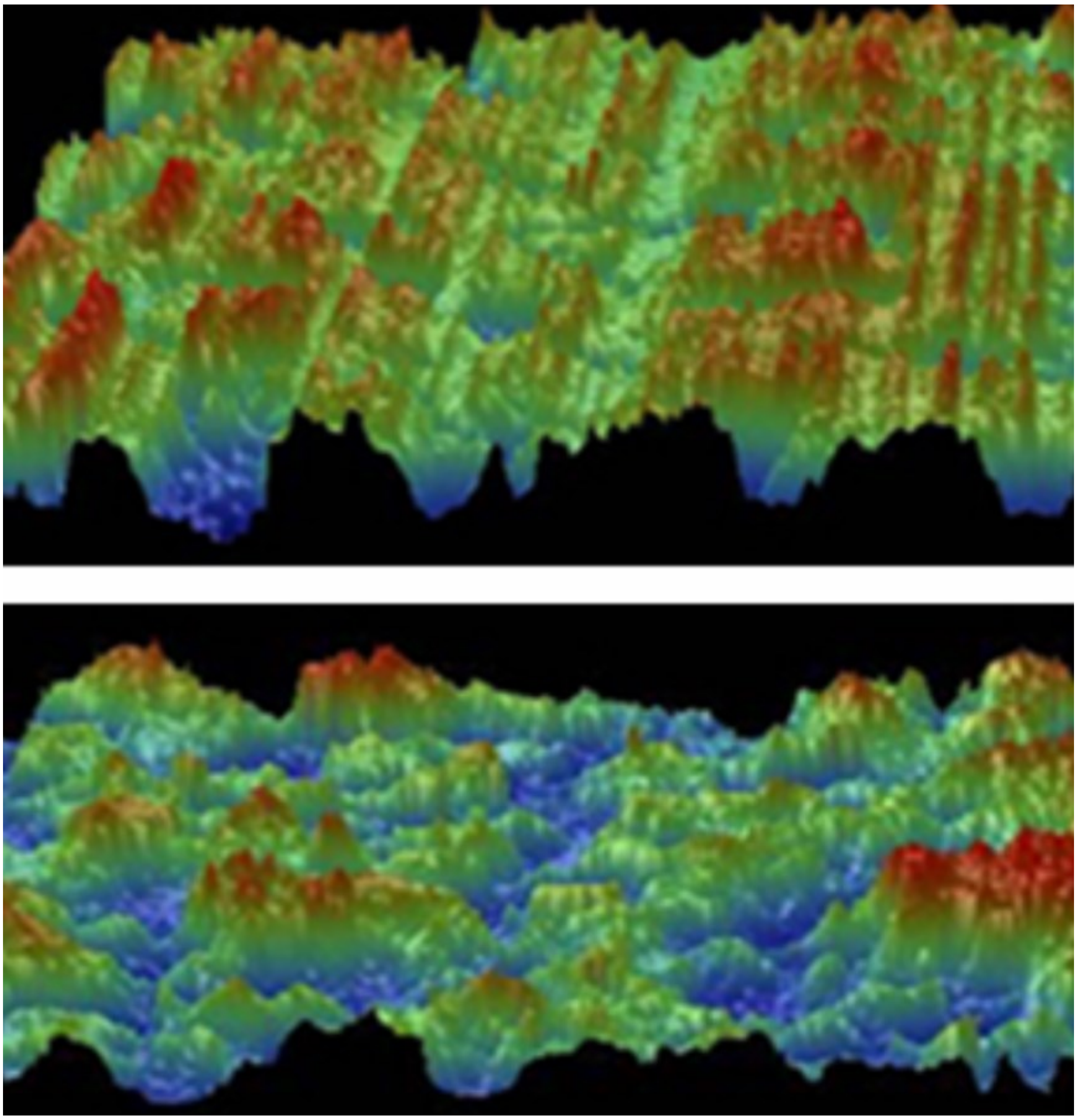
(R), which can be calculated from the roughness profile and divided into three categories, (Michigan Metrology, 2022). These categoris are amplitude, spatial parameters, and hybrid parameters.

Amplitude depends on the total height as it includes the rms of the height deviation distribution (the degree of asymmetry of the surface height distribution) and the mean of the highest, lowest, and highest degrees of the surface height distribution, (Michigan Metrology, 2022).

Spatial parameters depend on feature frequencies and include surface texture orientation, head density, and aspect ratio, (BRUKER, 2022).

Hybrid parameters depend on the average peak curvature and rms surface slopes and the developed surface area ratios, (BRUKER, 2022). Functional parameters, which define the applicability of certain functions, 3D surface roughness as shown in fig. 9, (BRUKER, 2022).

Figure 9. Surface roughness 3D (BRUKER, 2022)



2.6 Filtering

Filter methods can be evaluated by ISO for (S-filter) and (L-filter) since the International Organization for Standardization (ISO) is still working on the revision of filter standards, (Blateyron, 2015).

Gaussian filter (Carl Gauss) which is known as a smoothing filter which suppresses noise as applied in surface roughness measurements in JIS B 0632: 2001, ISO 11562: 1996 and ISO 16610-21: 2011, (Blateyron, 2015).

A (Spline) filter is used to obtain a smooth profile by interpolating segments between effective adjacent points. It is also applied to surface roughness measurements in ISO/TS 16610-22:2006, (Blateyron, 2015).

2.7 Principles and definitions

Standards are specifications for the manufacture or testing of agreed products, they are also publications of requirements or recommendations, (Finnish standard association SFS, 2020).

Standards help facilitate knowledge in living a safer way. Therefore, by defining a standard, requirements and specifications for a product, system, or service can be specified. The standard may also be a digital or print publication, (Finnish standard association SFS, 2020).

As for measured editing, it is considered as a development of best practices and a conclusion of positive solutions in addition to the requirements, methods, and procedures common to them (Finnish standard association SFS, 2020).

2.8 Standards

Essentially, standards are well-established agreements that help provide optimal solutions, however, it is difficult to proceed without the backing up of the guarantees that can be obtained through these standards, (Finnish standard association SFS, 2020).

There are several organizations that work on defining standards according to the interest and the necessity of market requirements, as well as helping participation by individuals and innovators to develop standards, (Finnish standard association SFS, 2020).

The (SFS), which is also the national standards body in Finland, has an important role in the main areas of standardization and these bodies have a key role in writing the standard in various industries, (Finnish standard association SFS, 2020).

Therefore, through (SFS) and other standards writing bodies, standardization work can be carried out in all standardization groups through which comments and participation in the draft standards are allowed, (Finnish standard association SFS, 2020).

As for the other groups that have an additional role to develop standardization standards, but in their work, it is stipulated that the standardization groups follow the international standards (ISO), and the standardization groups follow the European standards (CEN), (Finnish standard association SFS, 2020).

2.9 Filtering using in roughness definition

Filtering for several purposes is one of the most important obligations in the surface texture analysis process, and the use of morphological filters to correct the effects of the tip of the pen with raw data, where these morphological filters are commonly used, (Blateyron, 2015).

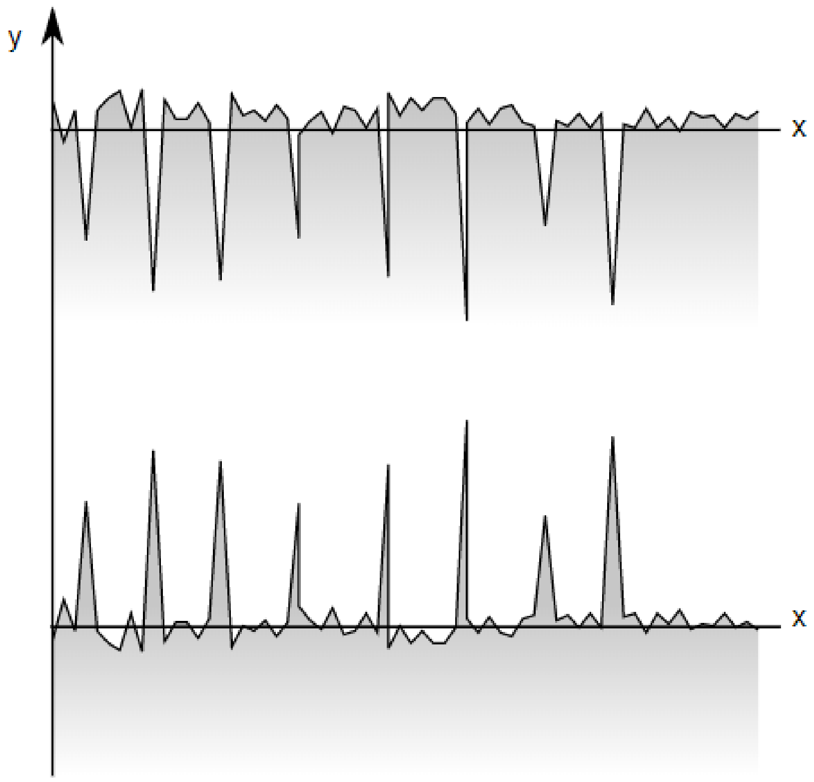
There is a need to use a filter to remove outliers in order, to clean up the measured data via the optical probe and a smoothing filter such as (λs or S-Filter) which contains different instrument methods which are used to compare the measured data (Blateyron, 2015).

The process of separating the ripple from the roughness (in the sense of separating the short-range components from the long-range components while calculating the parameters according to specifications) in the surface all occur because of the use of the filter (Blateyron, 2015).

2.10 Abbott-Firestone curve

It is the curve that describes the texture of a surface that can be found by tracing the profile by drawing lines parallel to the reference to the linear portion measurement inside the profile, as shown in fig. 10 (Kubátová & Melichar, 2019, pp.2-3).

Figure 10. Curve of Abbott-Firestone (Elifieldsteel, 2018)



Parameters (Rk, Rpk, Rvk, Rmr1 and Rmr2) can be evaluated using the (Abbott-Firestone) curve, and those parameters can be obtained through the filter surface which can be evaluated as a graphical representation, as shown in fig. 11-12 (Kubátová & Melichar, 2019, pp.2-3).

Figure 11. Profile Roughness (Kubátová & Melichar, 2019, pp.2-3)

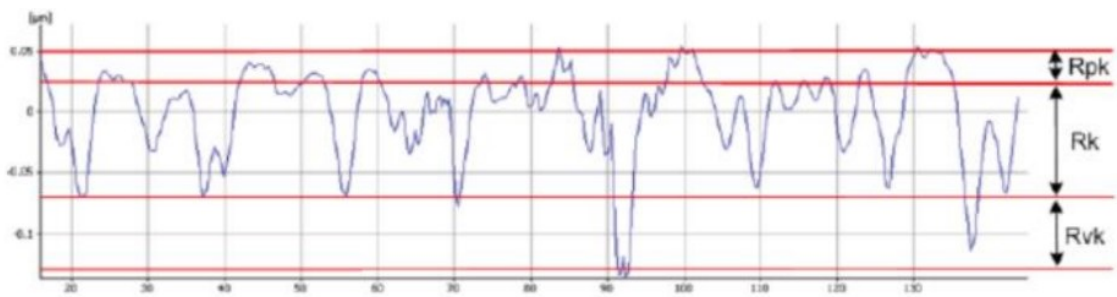
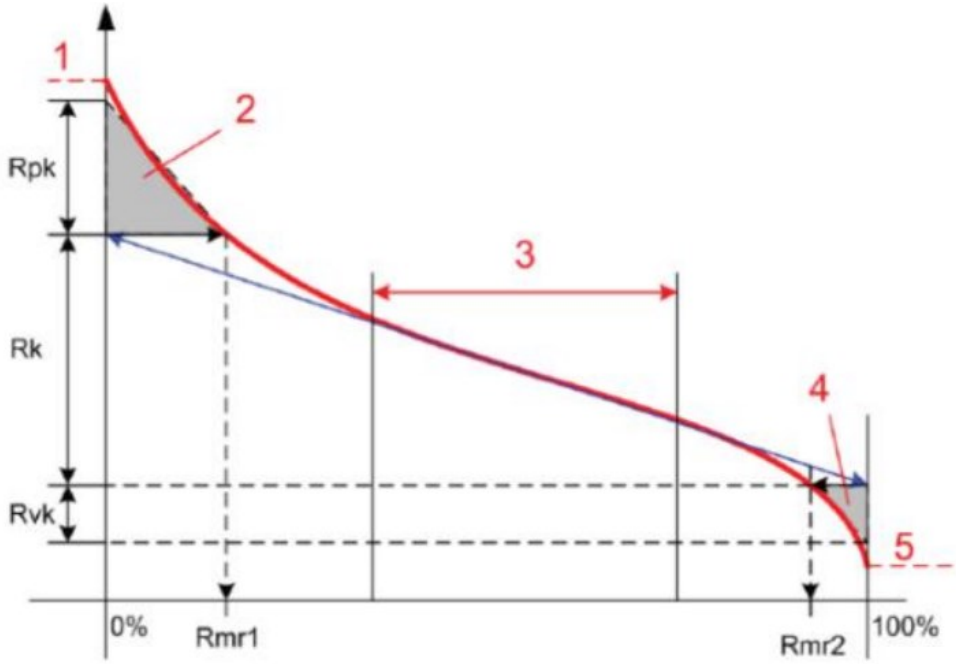


Figure 12. curve of Abbott-Firestone (Kubátová & Melichar, 2019, pp.2-3)



As shown in fig. 12, through (Rmr1) the base profile where the percentages of the materials above it are shown, and through (Rmr2) the roughness profile where the percentages of the materials below it are shown, and this is clearly determined by the (X) axis.

Currently, Abbott-Firestone curve parameters are increasingly used in industry and these parameters are mainly used.

Due to the technical benefit of the Abbott-Firestone curve through the results achieved, it is recommended to conduct the evaluation using the Abbott-Firestone curve in measurement laboratories to compare the results of the achieved survey (Kubátová & Melichar, 2019, pp.2-3).

3 Surface roughness standards

ISO 1302:2002 & ISO 21920:2022 are standards which are considered in the requirements for engineering drawings, more specifically when determining the surface roughness of a material.

The surface roughness standard ISO 1302 is a withdrawn standard, which is replaced by the new surface roughness standards ISO 21920 (ISO 1302:2002, 2002 & ISO 21920:2022, 2022).

The withdrawn standard caused many issues, such as corrosion, coating, etching, plastic deformation, casting, abrasion, cutting, casting, and sintering, which were corrected in the new standard (ISO 1302:2002, 2002 & ISO 21920:2022, 2022).

Furthermore, the withdrawn standard consists of different standards, these are ISO 8785: 1998, ISO 4287: 1997, ISO 4288: 1996, ISO 468: 1982, and ISO 10135-1: CD. These standards deal with properties of surfaces. The ISO 8785: 1998 deals with surface defects, which includes parameters, terms and definitions. The ISO 4287: 1997 deals with surface texture, which includes parameters of surface texture, profile, definitions, and terms. The ISO 4288: 1996 deals with surface texture, which includes includes samples roughness comparison. The ISO 468: 1982 deals with the requirements for surface roughness. The ISO 10135-1: CD considers the production of shaped products (ISO 1302:2002, 2002 & ISO 21920:2022, 2022).

3.1 SFS-EN ISO 1302

The surface roughness standard SFS-EN ISO 1302 within the specifications and engineering dimensions of the product, which was prepared by the Technical Committee ISO/TC 213. This specification is also considered as a (GPS) standard (ISO 1302:2002, 2002, p.1).

Between the years 1996 and 1997 the version of ISO 1302 was developed and became radically different from the old version of the 1980s. In addition, this version differed more specifically in drawing indicators, which became a basic rule within all new standards for the surface texture following the ISO 1302 standard (ISO 1302:2002, 2002, p.1).

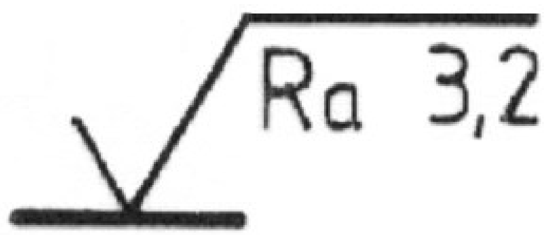
Issuance indicators ISO 1302 are still developing into a detailed and separate standard, and this development falls under the responsibility of the same technical committee ISO/TC 213, (ISO 1302:2002, 2002, p.3).

The technical documents of ISO 1302 contain surface texture databases where both text indicators and the graphic symbols route define those rules for surface texture data such as reports, specifications, contracts, and drawings, (ISO 1302:2002, 2002, p.1).

This applies through profile parameters within the ISO 4287 standard related to structural parameters (P), ripple parameters (W), and roughness parameters (R), as well as that determination applies according to the shape parameters related to ripple and roughness within the standard ISO 12085, and the parameters of the material ratio curve is one of the most important parameters that affect the determination of those rules are within the standard ISO 13565-3 and ISO 13565-2, (ISO 1302:2002, 2002, p.1).

The symbol of standard EN ISO 1302: 2002 as shown in fig. 13 (Actual pdf document of surface roughness standard SFS-EN ISO 1302, (ISO 1302:2002, 2002).

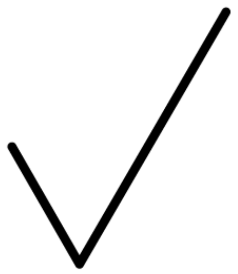
Figure 13. Symbol of standard (EN ISO 1302: 2002, 2002)



3.1.1 Definition

(Wz), (Ra), (AR), (Wz1max), (Ramax), (Rpq) and (Rpk) are numeric values and characters for parameter symbols. A basic graphic symbol is a graphic symbol, which symbolizes the necessary need for surface texture, as shown in fig. 14 (ISO 1302:2002, 2002, p.3).

Figure 14. Graphical basic symbol (ISO 1302:2002, 2002)



Extended graphic symbol is a basic graphic symbol, which symbolizes the need to remove the material or not to remove it and to obtain a specific surface texture. The symbols as shown in fig. 15-16 (ISO 1302:2002, 2002, p.3-4).

Figure 15. Graphical symbol of material required removal (ISO 1302:2002, 2002)

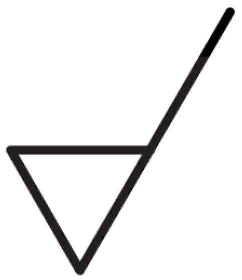
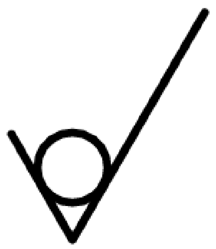


Figure 16. Graphical symbol of material removal that is not permitted (ISO 1302:2002, 2002)



A full graphic symbol is a basic, broad graphic symbol, denoting complementary surface texture requirements and the process of facilitating their addition. The symbols as shown in Fig. 17- 18. and 19 (ISO 1302:2002, 2002, p.4).

Figure 17. For any manufacturing process that permitted, (ISO 1302:2002, 2002)

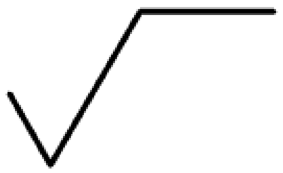


Figure 18. For material shall that be removed, (ISO 1302:2002, 2002)

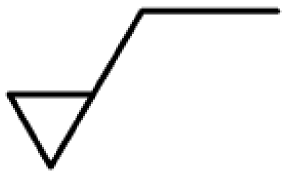
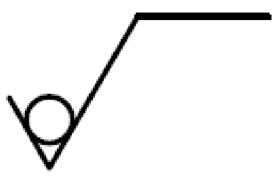


Figure 19. For material shall that not be removed, (ISO 1302:2002, 2002)



Surface texture parameters are one of the precise engineering properties of a material's surface. The surface modulus symbol is a special symbol, where this symbol stands for one type of surface texture parameter, (ISO 1302:2002, 2002, p.4).

3.1.2 Surface texture graphic symbols

Generic symbol, a set of graphical symbol variants that have a specific meaning into the technical documentation of a product, where these symbols are referred to as surface texture requirements, (ISO 1302:2002, 2002, p.5).

A basic graphic symbol, consisting of two straight lines of unequal length and an angle of inclination of 60 degrees above the base line. This basic graphic symbol is used to provide collective indicators and the basic graphic symbol is not used alone, which means without supplementary information, as shown in fig. 20-21 (ISO 1302:2002, 2002, p.5).

Figure 20. Indication of majority of surfaces that with same required for surface texture (ISO 1302:2002, 2002)

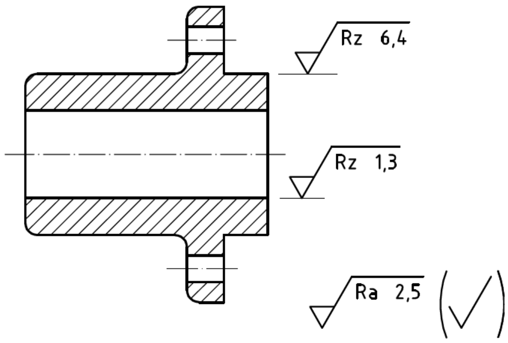


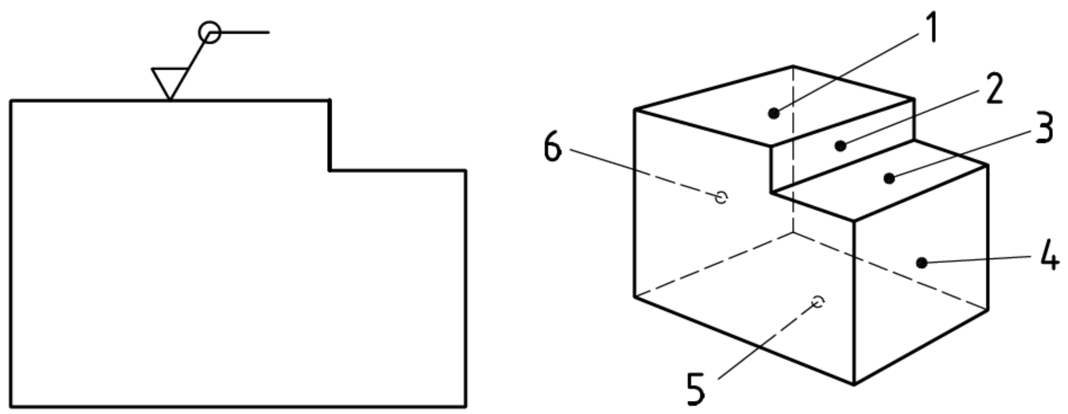
Figure 21. Indication of surface texture requirements for unspecified process of manufacturing (ISO 1302:2002, 2002)

Expanded graphic symbols, which are symbols used either until a material is removed by a required machine in order to determine the required surface with the need to add the basic graphic symbol bar, and in this case the expanded graphic symbol is not used alone, which means without supplementary information as shown in fig. 15 , or until the removal of materials that are not allowed to be removed in order to determine the required surface with the need to add the basic graphic symbol circle as shown above in fig. 16 (ISO 1302:2002, 2002, p.5).

A complete graphic symbol, which is a symbol used in contracts or reports by adding a line on the longest arm of any one of the graphic symbols, and this occurs in the case of specifying the complementary requirements for the properties of the surface texture through the matters such as, APA4 permitted manufacturing process, MRR5 material shall be removed, NMR6 shall not be removed as shown above in fig.17, 18, and 19 (ISO 1302:2002, 2002, p.5).

Graphical symbol around the outline of the work piece and used for all surfaces when the same surface texture is required with integrated features with the addition of a full graphic symbol circuit as shown in fig. 19, 20, 21 above, and fig. 22 below, (ISO 1302:2002, 2002, p.5)

Figure 22. All six surfaces of surface texture requirements which are represented on the workpiece (ISO 1302:2002, 2002).



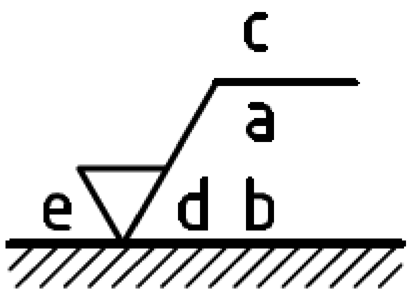
3.1.3 Full surface texture graphic symbol

A generic symbol, from which a reference is added to the numerical value and the surface texture parameter. This occurs when the surface texture requirements are ascertained almost identical to the conditions while specifying other requirements such as possible operating allowances, manufacturing process, surface position, sample length or transmission range, and surface orientation, (ISO 1302:2002, 2002, p.5).

To ensure that there are nearly identical functional properties to the requirements of the surface texture, the requirements for various surface texture parameters must be prepared, (ISO 1302:2002, 2002, p.5).

The importance of the position of the complementary surface texture requirements and their mandatory placement of the various surface texture requirements in full graphic symbols as shown in fig. 23 (ISO 1302:2002, 2002, p.5).

Figure 23. (a-e) position of complementary requirements for location (ISO 1302:2002, 2002)



Whereas:

a single surface texture requirement, a – b two or more surface texture requirements, c manufacturing method, d surface lay and orientation, and e machining allowance, (ISO 1302:2002, 2002, p.5).

3.1.4 Surface texture parameters and indication

The surface texture parameters and indication are used to set the numerical value associated with the parameter through 4 key elements. The three surface profiles R, W or P, the lengths and number of samples that make up the evaluation length, the profile and its properties, and the limit of specification and its interpretation, (ISO 1302:2002, 2002, p.6).

Parameters ISO 12085, ISO 4287, ISO 13565-3, and ISO 13565-2 can be defined according to the table below table. 2 (ISO 1302:2002, 2002).

Table 2. Parameter types (ISO 1302:2002, 2002)

	Parameters							
	Profile			Motif		Material ratio curve		
						linear	probability	
	R	*W*	*P*	*R*	*W*	*R*	*R*	*P*
Designation	See E.2	See E.2	See E.2	See E.3	See E.3	See E.4.2	See E.4.3	See E.4.3
Evaluation length	See F.2	See F.2	See F.2	See F.3	See F.3	See F.4	See F.4	See F.4
Tolerance limit	See 6.4							
Transmission band	See G.2	See G.2	See G.2	See G.3	See G.3	See G.4	See G.4	See G.4

The parameter assignments and their indication default interpretation are the specification limit 16% rule, and this occurs when parameter assignments do not contain modifiers, (ISO 1302:2002, 2002, p.6).

(In) Evaluation Length Statement is generic code, defined as the default evaluation length when parameter assignment is free of modifiers. In addition to setting the parameter sampling lengths by setting them in the absence of a default definition of sampling lengths and their preparation within the evaluation length, and through this it is possible to obtain almost identical surface texture requirements, and profile parameters ISO 4287 are known as R-profile, W-profile, and P-profile, (ISO 1302:2002, 2002, p.7).

Parameters of the stimulus can be ISO 12085 indicated between two slashes if the assessment length differs from the default number by 16 mm, ISO 13565-2, and ISO 13565-3, (ISO 1302:2002, 2002, p.7).

Parameters adoption ISO 13565-2, and ISO 13565-3 are highly dependent on the material ratio curve by specifying R-profile, and P-profile only, (ISO 1302:2002, 2002, p.7).

3.1.5 Limit and explanation of tolerance

The limits of surface texture specifications can be indicated in two ways: maximum rule as shown in fig. 24 and 16% rule as shown in fig. 25 (ISO 1302:2002, 2002, p.7).

Figure 24. 16 %-rule applies (Parameter indication) (ISO 1302:2002, 2002)

Figure 25. max-rule applies (Parameter indication) (ISO 1302:2002, 2002)

ISO 4287 Profile parameters, in the specified profile parameters the two rules maximum rule and 16% rule are applied ISO 1302:2002, 2002. ISO 12085 Catalyst parameters, by base 16% only design parameters can be specified (ISO 1302:2002, 2002, p.8).

ISO 13565-2, ISO 13565-3, where parameters are highly dependent on the material ratio curve and thus maximum rule and 16% rule are applied in ISO 13565-2, and ISO 13565-3, (ISO 1302:2002, 2002, p.8).

3.1.6 Indication lay of surface position

There are traces left by the tools used during the manufacturing process, so using the full symbol can refer here to the surface and the directions of the pop-up layer, and the vertical symbol cannot apply to text indicators, where the vertical symbol is one of the specified symbols as shown in fig. 26 and table. 3 shown the symbols (ISO 1302:2002, 2002).

Figure 26. Lay of surface pattern indicated perpendicular for drawing plane (ISO 1302:2002, 2002, p.12)

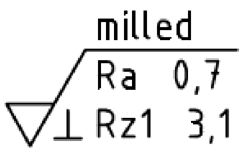


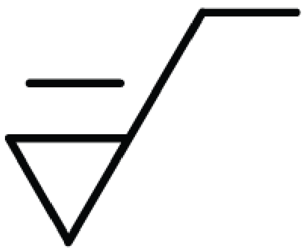
Table 3. Surface lay of indication (ISO 1302:2002, 2002)

Graphical symbol	Interpretation and example	
=	Parallel to plane of projection of view in which symbol is used	Direction of lay
⊥	Perpendicular to plane of projection of view in which symbol is used	Direction of lay
X	Crossed in two oblique directions relative to plane of projection of view in which symbol is used	Direction of lay
M	Multi-directional	
C	Approx. circular relative to centre of surface to which symbol applies	
R	Approx. radial relative to centre of surface to which symbol applies	
P	Lay is particulate, non-directional, or protuberant	

3.2 SFS-EN ISO 21920

It is considered as the Engineering Product Specification (GPS) standard, and this standard affects the texture of the surface of the profile through the (A) series bond is among the series of standards, (ISO 21920:2022, 2022, p.7).

Figure 27. Graphic symbol of standard ISO 21920, (ISO 21920:2022, 2022)



An overview can be obtained via the ISO GPS system, through the ISO 14638 standard. In the document ISO 14253-1, the default decision rules apply to special specifications, while in the document ISO 8015 the basic rules apply here. It also shown in table 4 about the relationship of the (GPS) matrix with the other criteria, (ISO 21920:2022, 2022, p.7).

Table 4. ISO documents of surface texture (ISO 21920:2022, 2022)

	Chain links						
	A	B	C	D	E	F	G
	Symbols and indications	Feature requirements	Feature properties	Conformance and non-conformance	Measurement	Measurement equipment	Calibration
Profile surface texture	ISO 21920-1	ISO 21920-2	ISO 21920-3 ISO 16610-2x ISO 16610-3x ISO 16610-4x	ISO 14253 series		ISO 25178-6 ISO 25178-6xx	ISO 25178-7x ISO 25178-70x ISO 12179
Areal surface texture	ISO 25178-1	ISO 25178-2	ISO 25178-3 ISO 16610-6x ISO 16610-7x ISO 16610-8x	ISO 14253 series		ISO 25178-6 ISO 25178-6xx	ISO 25178-7x ISO 25178-70x

3.2.1 Tolerance rules

There are three rules for accepting tolerances which refer to the texture of the surface of the profile, and these rules serve to guide on how to apply tolerances and their limits to the values of parameter measurements. As shown in table 5 about the standard ISO 21920-3: 2021 (ISO 21920:2022, 2022, p.8).

Table 5. Settings of general default (ISO 21920-3:2022, 2022, p.8)

Criterion	Default setting
Procedure of profile extraction	Mechanical profile
Profile direction	The direction yielding the maximum values of roughness height parameters (perpendicular to the dominant lay direction)
Profile position	The profile position depends on the tolerance acceptance rule according to ISO 21920-1. For the maximum tolerance acceptance rule: location on that part of the surface on which critical values can be expected. If this location cannot be clearly identified separate traces shall be distributed equally over this part of the surface. For the 16 % tolerance acceptance rule and for the median tolerance acceptance rule: uniformly distributed traces shall be taken to represent the entire surface, see NOTE 1.
Tolerance type	Upper tolerance limit
Tolerance acceptance rule	The maximum tolerance acceptance rule according to ISO 21920-1
Profile S-filter type	Gaussian filter according to ISO 16610-21
Profile L-filter type (for R-parameters) Profile S-filter type (for W-parameters)	Gaussian filter according to ISO 16610-21 Exception: The default L-filter for Rk, Rpk, Rvk, Rpkx, Rvkx, Rmrk1, Rmrk2, Rak1, Rak2, Rpq, Rmq and Rvq is the robust Gaussian filter, second order according to ISO 16610-31, see NOTE 2.
Profile F-operator association method and element	Association and removal of the specified form element with total least square, see NOTES 3 and 4.
NOTE 1 For the verification, this part of the surface can be identified, for example, by visual inspection. NOTE 2 The change of the default filter type for Rk, Rpk, Rvk, Rpkx, Rvkx, Rmrk1, Rmrk2, Rak1, Rak2, Rpq, Rmq and Rvq leads to a better elimination of large-scale components and can generate slightly differing values of these parameters from the values obtained on the basis of ISO 13565-1. NOTE 3 For the definition of "Association" see ISO 17450-1. NOTE 4 For a circle, the radius shall also be included in the least square optimization and not held fixed to the nominal value. The F-operator is applied to the evaluation length.	

Base tolerance and maximum tolerance Tmax, there is no measured value of the tolerance limit can be exceeded by this maximum tolerance acceptance rule (ISO 21920:2022, 2022, p.8).

The tolerance acceptance rule 16%, which is indicated by the symbol T16% when it is valid for the parameter on the line. At the upper tolerance limit and the lower tolerance limit, the 16% of all measured values will be violated and this is what happens when setting a binary tolerance on a single line (ISO 21920:2022, 2022, p.8).

The 16% tolerance acceptance rule can be used when determining and applying tolerance limits for measured values (ISO 21920:2022, 2022, p.8).

Median tolerance rule Tmed, within the tolerance limits, the mean value should constitute all the measured values for one parameter when determining the median tolerance rule (ISO 21920:2022, 2022, p.8).

3.2.2 Main elements of lateral surface fabric specification

Here the operator specification and surface requirements of the workpiece are determined by important licenses for the surface texture of the profile. Among the most important things that need to be determined are the profile surface texture and parameter symbol, profile surface texture and parameter tolerance limit, and profile surface and tolerance graphic symbol, (ISO 21920:2022, 2022, p.9).

Additional or non-default requirements can be specified with optional indicators as follows:

Tmax , T16% or Tmed symbol for specify a tolerance acceptance rule. Tolerance type such as lower, upper or bilateral tolerance limit.

S-filter profile type for W-parameters or L-filter profile type for R-parameters. S-filter profile nesting index N_{ic} for W-parameters or L-filter profile nesting index N_{ic} for R-parameters.

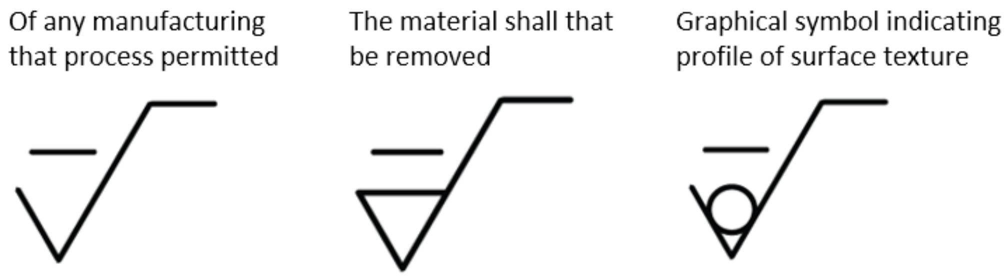
n_{sc} sections number and l_{sc} the length of the section to the section length parameters. l_e to the evaluation length parameters. F-operator profile nesting index. F-operator profile element and association method. S-filter profile nesting index. S-filter profile type.

For specify a setting class can be use S_{cn} symbol. For specify other requirements can be use OR(*n*) symbol. Direction of profile. Direction and surface lay. Process of manufacturing. The profile extraction method (ISO 21920:2022, 2022, p.9).

3.2.3 Lateral surface texture

One of the graphic symbols in fig. 28 is used in the technical specifications of the products to determine the requirements for the texture of the lateral surface, (ISO 21920:2022, 2022, p.10).

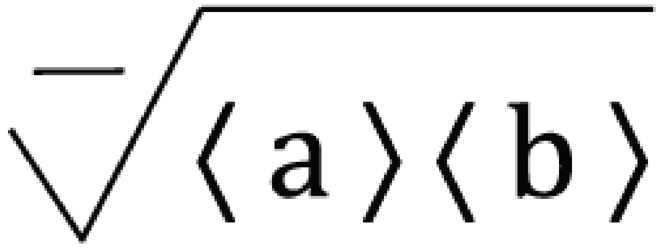
Figure 28. Graphical symbols indicating profile surface texture (ISO 21920:2022, 2022)



Therefore, the minimum surface texture indicators are set for the graphic symbols and the parameter tolerance limit, and its value are set as shown in fig. 29 (ISO 21920:2022, 2022, p.11)

The first line parameter is the appropriate parameter in order, to indicate the default settings. This happens by specifying all the parameters, and one blank character is used to separate the specifications and its elements, (ISO 21920:2022, 2022, p.11).

Figure 29. For parameter the minimal indication that with defined defaults (ISO 21920:2022, 2022, p.11)



The requirements of the production process, the shape of the graphic symbols is according to the type as requiring. As shown above in fig. 29 (ISO 21920:2022, 2022, p.11).

The slightest signal is a ratio of parameters with or without default values, due to the inability to apply default settings for all parameters, and this occurs when specifying the minimum number of indicators that apply all defaults (ISO 21920:2022, 2022, p.11).

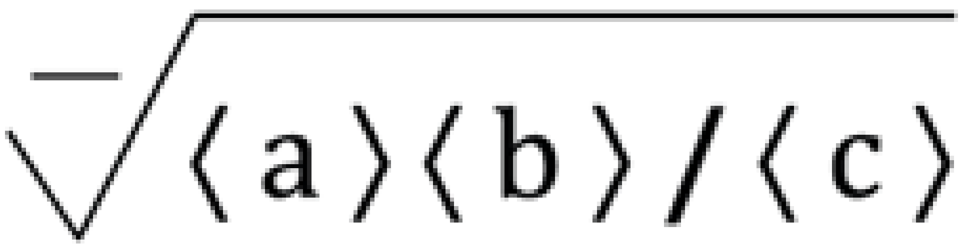
The parameters of the default settings and the sign of the minimum profile surface texture requirement can be obtained as shown above in fig. 30, where a = symbol for the parameter and b = value of tolerance limit with profile surface texture parameter (ISO 21920:2022, 2022, p.11).

Parameters and indication of minimum surface texture requirements can also be obtained without default settings (ISO 21920:2022, 2022).

It also uses the default value (S-filter nesting index Nic) with parameters (W) or another default value (L-filter nesting index Nic) with parameters (R) to specify all default settings as well (ISO 21920:2022, 2022, p.11).

As mentioned above with the symbol (c), as (a = symbol for the parameter), (b = the value of the tolerance limit with the parameter of the surface texture of the profile). To separate specification sections, a symbol (/) is used, (ISO 21920:2022, 2022, p.11).

Figure 30. For parameter the minimal indication that without defined defaults (ISO 21920:2022, 2022).



3.2.4 Lateral surface texture specifications and basic rules

To avoid ambiguity the reference to the profile of the lateral surface texture is determined in an ordered manner. Reasonable and repeatable results can be obtained on surfaces when default settings are specified in specification elements with variable values(ISO 21920:2022, 2022, p.16).

The maximum and the parameter specified by the tolerance type are the basis for the default settings (ISO 21920:2022, 2022, p.16)

This occurs when there is a minimum indicator when the parameter is included in ISO 21920-3: 2021, as shown in tables 6-9, and if this does not happen, then the base default setting is expressed by the set class or index value of the filter profile's nesting, (ISO 21920:2022, 2022, p.16).

Table 6. For Ra, Rq, Rz, Rp, Rv, Rzx, and Rt default settings that based on the upper tolerance limit (ISO 21920:2022, 2022)

	Setting class				
	Sc1	**Sc2**	**Sc3**	**Sc4**	**Sc5**
Specified parameter	**Upper tolerance limit (U) of the specified parameter**				
Rz, µm	U ≤ 0,16	0,16 < U ≤ 0,8	0,8 < U ≤ 16	16 < U ≤ 80	U > 80
Ra, µm	U ≤ 0,02	0,02 < U ≤ 0,1	0,1 < U ≤ 2	2 < U ≤ 10	U > 10
Rp, µm	U ≤ 0,06	0,06 < U ≤ 0,3	0,3 < U ≤ 6	6 < U ≤ 30	U > 30
Rv, µm	U ≤ 0,10	0,10 < U ≤ 0,5	0,5 < U ≤ 10	10 < U ≤ 50	U > 50
Rq, µm	U ≤ 0,032	0,032 < U ≤ 0,16	0,16 < U ≤ 3,2	3,2 < U ≤ 16	U > 16
Rzx, µm	U ≤ 0,23	0,23 < U ≤ 1,15	1,15 < U ≤ 23	23 < U ≤ 115	U > 115
Rt, µm	U ≤ 0,26	0,26 < U ≤ 1,3	1,3 < U ≤ 26	26 < U ≤ 130	U > 130
Profile L-filter nesting index N_{ic} (cut-off λ_c) mm	0,08	0,25	0,8	2,5	8

	Setting class				
	Sc1	**Sc2**	**Sc3**	**Sc4**	**Sc5**
Evaluation length l_e, mm	0,4	1,25	4	12,5	40
Profile S-filter nesting index N_{is} (cut-off λ_s) µm	2,5	2,5	2,5	8	25
Maximum sampling distance d_x µm	0,5	0,5	0,5	1,5	5
Maximum nominal tip radius r_{tip} µm	2	2	2	5	10
Only for section length parameters, for example Rz, Rp, Rv					
Section length l_{sc} mm	0,08	0,25	0,8	2,5	8
Number of sections n_{sc}	5	5	5	5	5

Table 7. For Ra, Rq, Rz, Rp, Rv, Rzx, and Rt default settings that based on bilateral tolerance limit (ISO 21920:2022, 2022)

	Setting class				
	Sc1	**Sc2**	**Sc3**	**Sc4**	**Sc5**
Specified parameter	**Tolerance centre (C) of the bilateral tolerance of the specified parameter**				
Rz, µm	C ≤ 0,128	0,128 < C ≤ 0,64	0,64 < C ≤ 12,8	12,8 < C ≤ 64	C > 64
Ra, µm	C ≤ 0,016	0,016 < C ≤ 0,08	0,08 < C ≤ 1,6	1,6 < C ≤ 8	C > 8
Rp, µm	C ≤ 0,048	0,048 < C ≤ 0,24	0,24 < C ≤ 4,8	4,8 < C ≤ 24	C > 24
Rv, µm	C ≤ 0,08	0,08 < C ≤ 0,4	0,4 < C ≤ 8	8 < C ≤ 40	C > 40
Rq, µm	C ≤ 0,026	0,026 < C ≤ 0,13	0,13 < C ≤ 2,6	2,6 < C ≤ 13	C > 13
Rzx, µm	C ≤ 0,184	0,184 < C ≤ 0,92	0,92 < C ≤ 18,4	18,4 < C ≤ 92	C > 92
Rt, µm	C ≤ 0,208	0,208 < C ≤ 1,04	1,04 < C ≤ 20,8	20,8 < C ≤ 104	C > 104
Profile L-filter nesting index N_{ic} (cut-off λ_c) mm	0,08	0,25	0,8	2,5	8
Evaluation length l_e mm	0,4	1,25	4	12,5	40
Profile S-filter nesting index N_{is} (cut-off λ_s) µm	2,5	2,5	2,5	8	25
Maximum sampling distance d_x µm	0,5	0,5	0,5	1,5	5
Maximum nominal tip radius r_{tip} µm	2	2	2	5	10

	Setting class				
	Sc1	**Sc2**	**Sc3**	**Sc4**	**Sc5**
Only for section length parameters, for example Rz, Rp, Rv					
Section length l_{sc} mm	0,08	0,25	0,8	2,5	8
Number of sections n_{sc}	5	5	5	5	5

Table 8. For Ra, Rq, Rz, Rp, Rv, Rzx, and Rt default settings that based on the lower tolerance limit (ISO 21920:2022, 2022)

	Setting class				
	Sc1	**Sc2**	**Sc3**	**Sc4**	**Sc5**
Specified parameter	**Lower tolerance limit (L) of the specified parameter**				
Rz, µm	L ≤ 0,08	0,08 < L ≤ 0,4	0,4 < L ≤ 8	8 < L ≤ 40	L > 40
Ra, µm	L ≤ 0,01	0,01 < L ≤ 0,05	0,05 < L ≤ 1	1 < L ≤ 5	L > 5
Rp, µm	L ≤ 0,03	0,03 < L ≤ 0,15	0,15 < L ≤ 3	3 < L ≤ 15	L > 15
Rv, µm	L ≤ 0,05	0,05 < L ≤ 0,25	0,25 < L ≤ 5	5 < L ≤ 25	L > 25
Rq, µm	L ≤ 0,016	0,016 < L ≤ 0,08	0,08 < L ≤ 1,6	1,6 < L ≤ 8	L > 8
Rzx, µm	L ≤ 0,115	0,115 < L ≤ 0,57	0,57 < L ≤ 11,5	11,5 < L ≤ 57	L > 57
Rt, µm	L ≤ 0,13	0,13 < L ≤ 0,65	0,65 < L ≤ 13	13 < L ≤ 65	L > 65
Profile L-filter nesting index N_{ic} (cut-off λ_c) mm	0,08	0,25	0,8	2,5	8
Evaluation length l_e mm	0,4	1,25	4	12,5	40
Profile S-filter nesting index N_{is} (cut-off λ_s) µm	2,5	2,5	2,5	8	25
Maximum sampling distance d_x µm	0,5	0,5	0,5	1,5	5
Maximum nominal tip radius r_{tip} µm	2	2	2	5	10
Only for section length parameters, for example Rz, Rp, Rv					
Section length l_{sc} mm	0,08	0,25	0,8	2,5	8
Number of sections n_{sc}	5	5	5	5	5

Table 9. For Pt default settings that based on the tolerance limit (ISO 21920:2022, 2022)

	Setting class				
	Sc1	Sc2	Sc3	Sc4	Sc5
Specified parameter **Pt**, µm	**Upper tolerance limit (U)**				
	U ≤ 0,27	0,27 < U ≤ 1,35	1,35 < U ≤ 27	27 < U ≤ 135	U > 135
	Centre (C) of the bilateral tolerance limits				
	C ≤ 0,216	0,216 < C ≤ 1,08	1,08 < C ≤ 21,6	21,6 < C ≤ 108	C > 108
	Lower tolerance limit (L)				
	L ≤ 0,135	0,135 < L ≤ 0,68	0,68 < L ≤ 13,5	13,5 < L ≤ 68	L > 68
Evaluation length ***le***	Length of the specified feature				
Profile S-filter nesting index N_{is} (cut-off λ_s) µm	2,5	2,5	2,5	8	25
Maximum sampling distance d_x µm	0,5	0,5	0,5	1,5	5
Maximum nominal tip radius r_{tip} µm	2	2	2	5	10

3.2.5 Profile surface texture and parameter

The basis of the calculation is defined by the first letter R, W or P of the parameter symbol, which indicates the profile of the specified range. As for the definition of the parameter, it is indicated by other consecutive letters (ISO 21920:2022, 2022, p.17).

The profile surface texture parameter and its tolerance limit value, since immediately after the parameter symbol there is one space separating it and this indicates the tolerance limit value of the parameter (ISO 21920:2022, 2022, p.17).

The types of tolerances for the requirements of the lateral surface texture are binary tolerance and mono-tolerance and symbolized by minimum tolerance L, maximum tolerance U, (ISO 21920:2022, 2022, p.17).

3.2.6 Simplified indicators

To clearly read the technical documentation of the product, simplified indicators should be used (ISO 21920:2022, 2022, p.23).

At a distance from the drawing title block the general tolerances sign should be placed, since here the profile surface texture requirements are not needed when the cursor is placed on all the features and after that comes the graphic symbol as shown in fig. 31 and all requirements are optionally placed in parentheses as shown in fig. 32 (ISO 21920:2022, 2022, p.23).

Figure 31. Indication followed by graphic symbols (ISO 21920:2022, 2022)

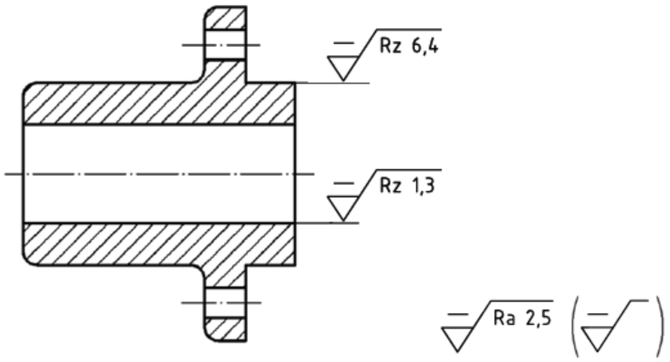
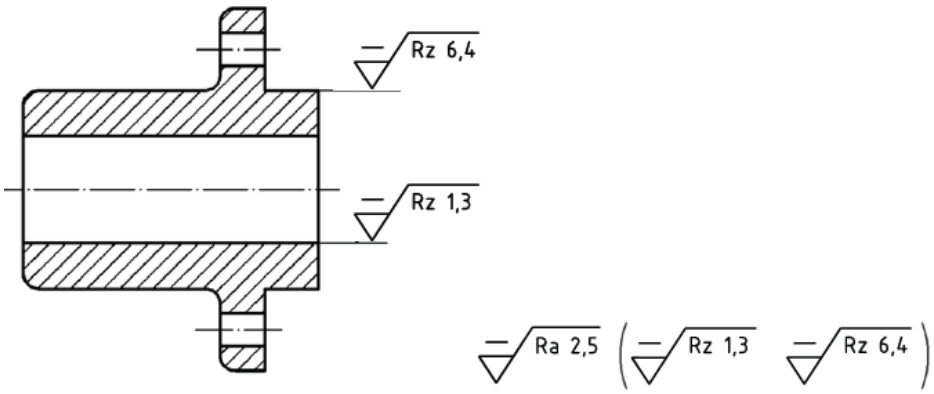


Figure 32. Indication followed by all other indicated of requirements (ISO 21920:2022, 2022)



The position of the surface without a reference is indicated within table 10, as for the characteristics of the work piece, the direction of the position and the position of the surface are indicated within table 11 (ISO 21920:2022, 2022, p.23).

Table 10. Graphic symbols interpretation, with examples for indication surface lay (ISO 21920:2022, 2022).

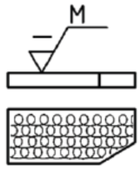
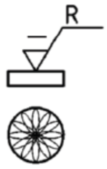
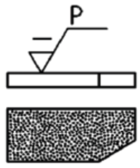
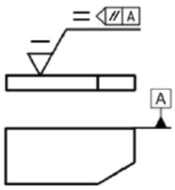
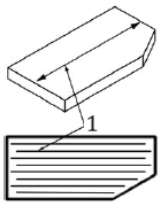
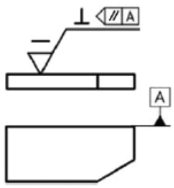
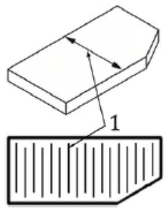
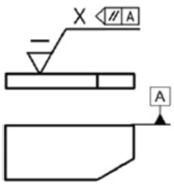
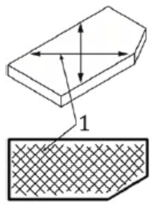
Graphical symbol	Interpretation and example	
M	Multidirectional	
C	Circular relative to centre of surface to which symbol applies	
R	Radial relative to centre of surface to which symbol applies	
P	Lay is particulate, non-directional or protuberant	

Table 11. Graphic symbols examples of the indication and interpretation of the surface and direction lay (ISO 21920:2022, 2022)

Graphical symbol	Example of indication	Interpretation	Required direction of lay
=		Parallel to the direction, given by the intersection plane indicator and the datum feature indicator	
⊥		Perpendicular to the direction, given by the intersection plane indicator and the datum feature indicator	
X		Crossed in two oblique directions relative to the direction, given by the intersection plane indicator and the datum feature indicator	

There are two ways in which profile orientation can be indicated. The work piece and its feature are as shown in table. 12, and the prevailing surface orientation is as shown in fig. 33 (ISO 21920:2022, 2022, p.24).

Table 12. Graphic symbols for indication of profile direction (ISO 21920:2022, 2022, p.29)

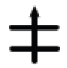
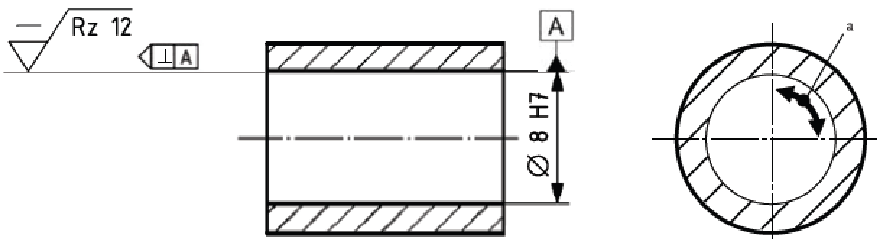
Graphical symbol	Interpretation
	Perpendicular to the predominant direction
	Parallel to the predominant direction
	Circular to the centre of the surface to which the symbol applies
	At a defined angle to the predominant direction (0° < *n* < 90°)

Figure 33. Indication of profile direction relative for a workpiece feature (ISO 21920:2022, 2022)



3.3 Used methods and filtering

3.3.1 Dimentions and propotions of the graphic symbol

All rules and conditions contained in the ISO 81714-1 standard, matching the size of document symbols with the symbols for inscriptions such as geometric variations and dimensions on technical drawings, should apply here (ISO 21920:2022, 2022, p.32).

The shape of the capital letter (vertical letter B) corresponding to ISO 3098-2 is the same as that of the basic graphic symbol as shown in figures. 34- 36, figure 35, (c) to (g), (ISO 21920:2022, 2022, p.32).

There is a sign placed above and below the length of the horizontal line of the symbols as shown in fig. 34 as for the dimensions, they are shown in fig. 36. The horizontal line is equal to (1) for simplified signs, (ISO 21920:2022, 2022, p.32).

Figure 34. Proportions of basic graphic (ISO 21920:2022, 2022)

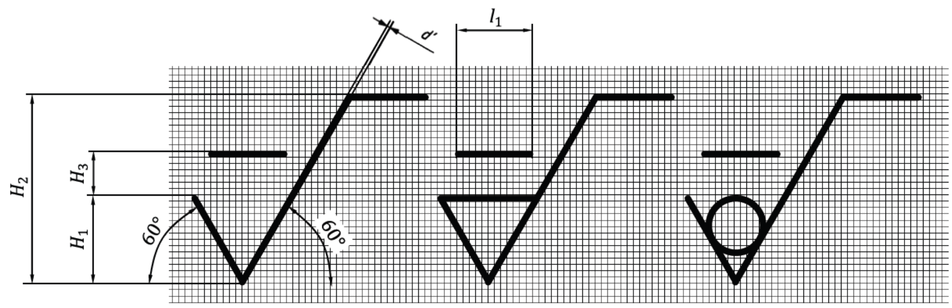


Figure 35. Proportions of symbols (ISO 21920:2022, 2022)

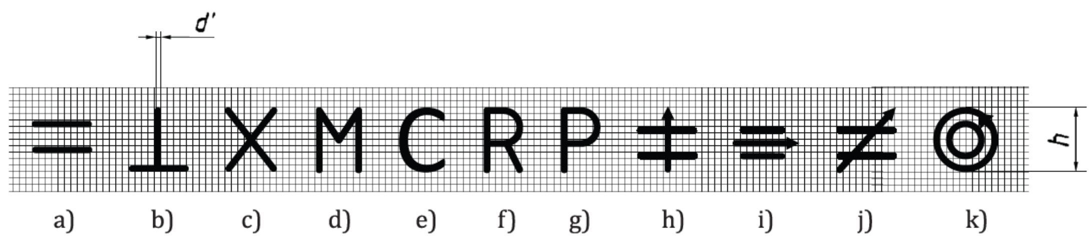
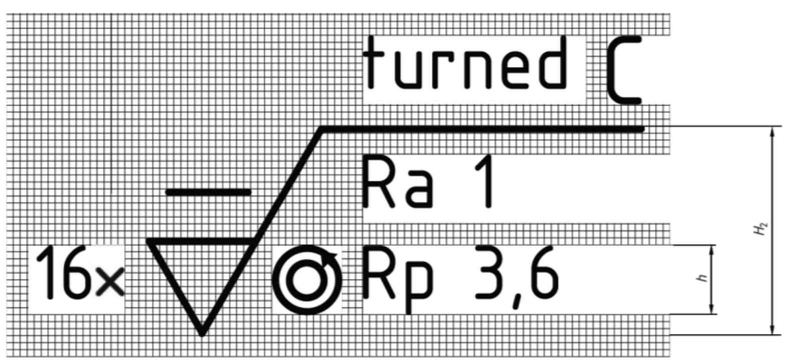


Figure 36. Dimensions and proportions (ISO 21920:2022, 2022)



The table below table. 13 shows the dimensions of the graphic symbol, as well as additional indicators, (ISO 21920:2022, 2022, p. 32).

Table 13. The dimensions (mm) (ISO 21920:2022, 2022)

Height of numerals and letters, h (see ISO 3098-2)	2,5	3,5	5	7	10	14	20
Line width for symbols, d' Line width for lettering, $(h/10)$	0,25	0,35	0,5	0,7	1	1,4	2
Height, H_1	3,5	5	7	10	14	20	28
Height, H_2 (minimum)[a]	7,5	10,5	15	21	30	42	60
Height, H_3	2	2,5	3,5	5	7	10	14
Length, l_1	3	4,5	6	8,5	12	17	24

[a] H_2 depends on the number of lines of indication.

Methods and association elements

Table 14. Symbol for association elements and methods (ISO 21920:2022, 2022)

Symbol	Association elements
L	Line
P*n*	Polynomial, *n* for the order
C	Circle

Symbol	Association method
TLS	Total least square
LS	Least square

3.4 Markings to drawing

In the ISO 129-1 standard, the graphic symbol is read from the right side or from the bottom side of the graphic (ISO 21920:2022, 2022, p.23).

Apart from the dimension line, a graphical symbol of the texture of the profile surface can be indicated, and the signal is applied at the beginning of the extension line in the case of a cylindrical feature only, that is, the signal is not applied from the opposite surface, which is defined by the dimension line as shown in figures of CAD drawings 37 - 48, (ISO 21920:2022, 2022, p.23).

Figure 37. Graphic symbol of geometrical tolerance indications (ISO 21920:2022, 2022)

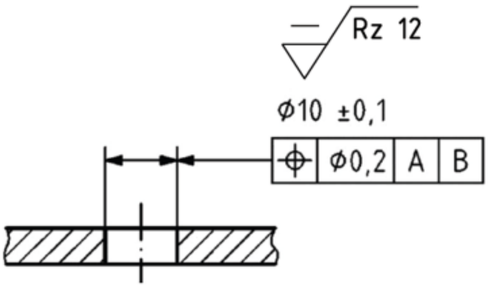


Figure 38. Graphic symbol in 3D model with a leader line (ISO 21920:2022, 2022)

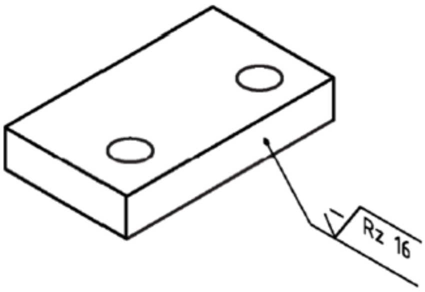


Figure 39. CAD-1 Graphic symbol that readable from bottom (ISO 21920:2022, 2022)

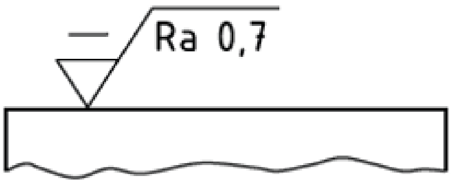


Figure 40. CAD-2 Graphic symbol that readable from bottom (ISO 21920:2022, 2022)

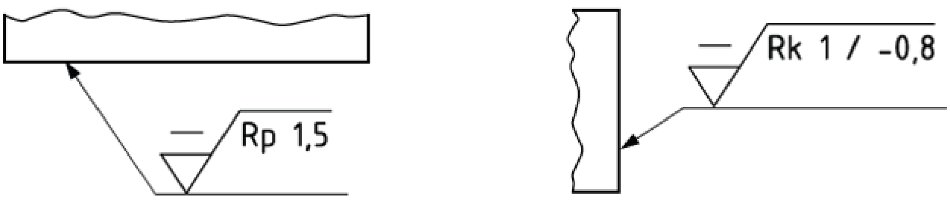


Figure 41. CAD-3 Graphic symbol that readable from right-hand side surface (ISO 21920:2022, 2022)

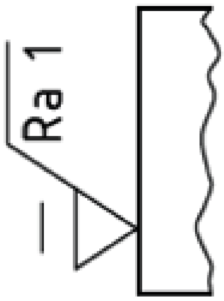


Figure 42. CAD-4 Graphic symbol that readable from bottom (ISO 21920:2022, 2022)

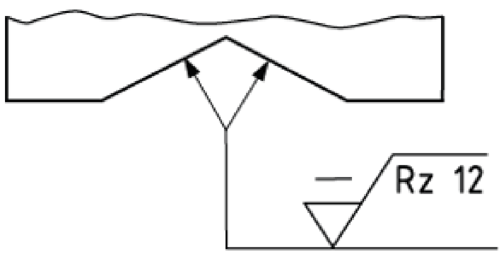


Figure 43. CAD-5 Graphic symbol on workpiece of top view that readable from bottom (ISO 21920:2022, 2022)

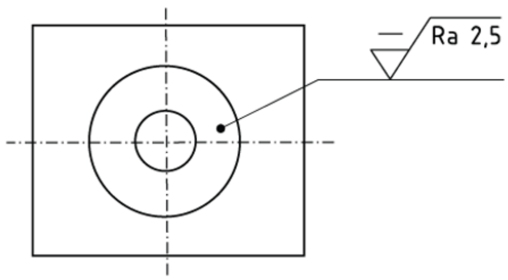


Figure 44. CAD-6 Graphic symbol that readable from bottom in an arrowhead (ISO 21920:2022, 2022)

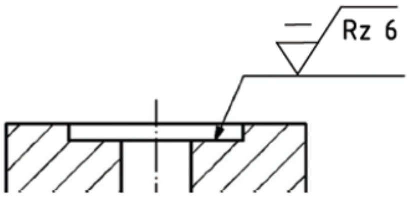


Figure 45. CAD-7 Graphic symbol that readable from bottom on dimension line (ISO 21920:2022, 2022)

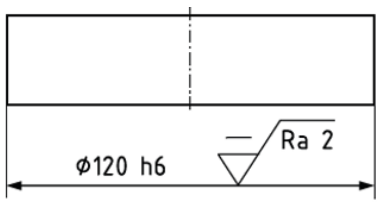


Figure 46. CAD-8 Graphic symbol that readable from bottom on extension line (ISO 21920:2022, 2022)

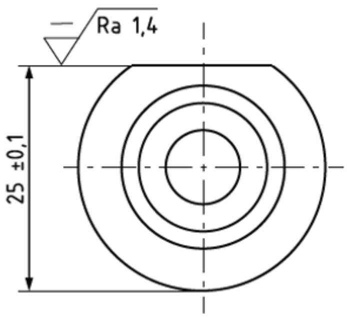


Figure 47. CAD-9 Graphic symbol that readable from bottom on leader line in arrowhead on extension line (ISO 21920:2022, 2022)

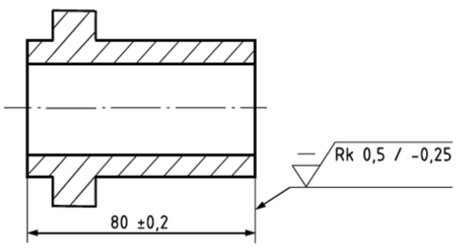
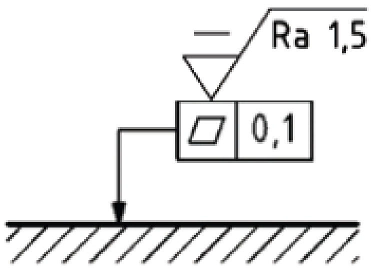


Figure 48. CAD-10 Graphic symbol that readable from bottom on tolerance frame of form, run out requirement, location, or orientation (ISO 21920:2022, 2022)



4 Study material of surface roughness

4.1 Study material target of learning

The target of learning is to study surface roughness by updating the old standard ISO 1302 and replacing it with the modern standard ISO 21920 and adopting it in manufacturing as an upgraded and new version (ISO 21920:2022, 2022)

Making the evolution of the old version of the standard ISO 1302 to the standard of the new version ISO 21920, to make the designer's intent easy to understand by subcontractors by means of a special graphic language describing technical drawings to produce mechanical workpieces compatible with the conditions in terms of their geometry and tolerances and its dimensions (ISO 21920:2022, 2022).

When designers fail to comply with the terms of production, in resolving such disputes, reference is made to the technical drawing, which is considered as a basic reference and a contract signed by all parties, (ISO 21920:2022, 2022).

4.2 Study material content

The content includes studying the difference between the modern version of the ISO 21920 standard and the old version of the ISO 1302 standard within the main and sub-overlaps of the same standards, and this is explained through successive matters such as a new specification code, the maximum rule instead of the default tolerance rule, the introduction of the drawing (Base values and specifications) Instead of values estimated from the parameter of the determinant, use an overlap index and set it depending on the specified values of (Rz) or (Ra), (ISO 21920:2022, 2022).

After setting the parameters, the direct tolerance limit is updated, using the evaluation section, except for a few exceptions, we can specify the parameters, specifications tolerance limits are binary with simplified notation, (1) or (EP) for profile acquisition by visual methods and their identification, few parameters of (Rv), (Rz) and (Rp) and their definitions by profile name rather than a single measure section or sampling length, non-periodic and periodic profiles are the same, within specified tolerance limits (ISO 21920:2022, 2022).

The mean value of all measured values should fall in (Tmed) expressing a third rule of acceptance tolerance, including defects such as pores or scratches when checking by location of an element engineering when not nothing else is determined, (ISO 21920:2022, 2022).

Finally, another modified root ISO 25178 code with a trapezoid square, which indicates the specification of the region, was quoted as shown in fig. 49 (Blateyron , 2021).

Figure 49. Graphic symbol of standard ISO 25178-2:2022 (Blateyron, 2021)

4.3 SFS-EN ISO 25178 and formulas

The new standard SFS- EN ISO 25178-2: 2022 applied to surface texture parameters has made significant progress in the development of surface texture structure compared to the withdrawn standard SFS- EN ISO 25178-2: 2012, (Blateyron, 2021). Among the most important changes in the structure of the surface texture are:

Separation of feature parameters with the addition of a debugger definition for closed and open decorations that were not in use correctly for the tribology in the old definition, (Blateyron, 2021).

Adding a smart complement that evaluates the height, slope, and area by using the horizontal plane to describe the shape of the decorations, by adding new groups for feature parameters, (Blateyron, 2021).

To determine the average curvature of the hole and the density of drilling in the same way as to determine the peaks, two other parameters were added, (Blateyron, 2021).

In order, to harmonize the standard ISO 25178 with the standard ISO 21920 for profiles, therefore, improvements were added to the revised text of the standard, and this serves to determine the interconnectedness of the concepts for both standards.

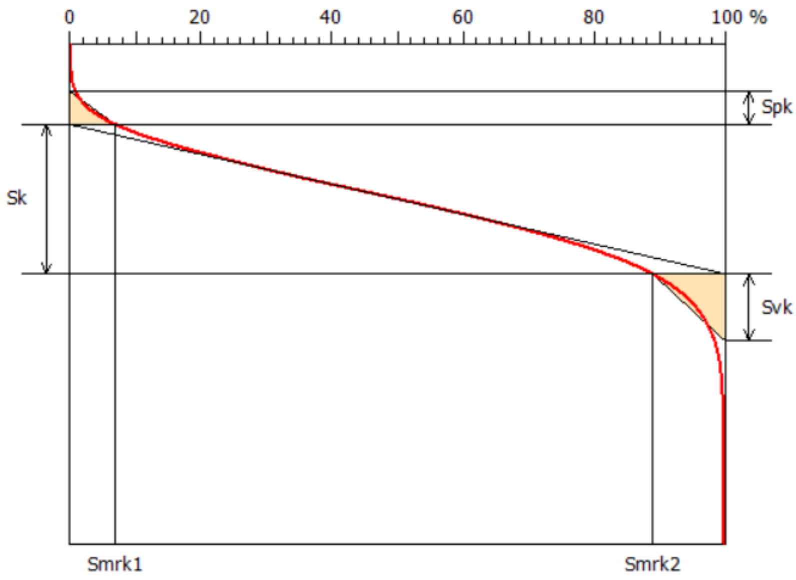
For specific profiles, the dominant spatial wavelength parameter (Ssw) has been added, (Blateyron, 2021).

Name modifications for the parameter, where the new name for the section height difference (Sdc) instead of the maximum peak height (Sxp), and many improvements have been added to the values and proportions of the default materials, (Blateyron, 2021).

Indicated (from above) a peak relative to the Smr level, such as the definition of profiles in ISO 4287 (Blateyron, 2021)

(Sk) with additional (k) became consistent in the recent version Sak1, Sak2, Smrk1, Smrk2 as shown in fig.50 (Blateyron, 2021).

Figure 50. (Sk) with additional (k) (Blateyron, 2021)



Equation 1. Formula of the new standard SFS- EN ISO 25178-2: 2022 below, (ISO 25178-2: 2022, 2022, p.25)

$$S_{dc} = S_{mc}(p) - S_{mc}(q)$$

Equation 2. Formula of the withdrawn standard SFS- EN ISO 25178-2: 2012 below, (ISO 25178-2: 2012, p. 19)

$$S_{xp} = S_{mc}(p) - S_{mc}(q)$$

5 Conclusion

The purpose of this thesis was to compare the new surface roughness standard SFS-EN ISO 21920-1: 2022 with withdrawn surface roughness standard SFS-EN ISO 1302: 2002 and to clarify all the characteristics of the surface roughness structure measurement standards including measurements concisely within the constants available in the approved technical documents.

With mentioning the importance of quoting the new surface roughness standard SFS- EN ISO 25178-2: 2022 from the discarded material from the surface roughness standard for the SFS-EN ISO 25178-2: 2012 among the important features that helped bring about a radical change in the development of industry and industrial products and special scientific activities in mechanical engineering designs and other industrial fields.

Therefore, the innovators and developers helped to develop the texture of the surface structure standrad using alternative symbols and inferred evidence through long tests that lasted for a period of decades in order, to avoid all the problems of the surface structure such as corrosion, paint, pits, cracks, and other defects, which were a major obstacle in the areas of design mechanical engineering, industry, production, and other fields.

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