How to Select the most Relevant Roughness Parameters of a Surface: Methodology Research Strategy

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Abstract. In this paper, the foundations for new methodology creation which provides solving problem of surfaces structure new standards parameters huge amount conflicted with necessary actual floors quantity of surfaces structure parameters which is related to measurement complexity decreasing are considered. At the moment, there is no single assessment of the importance of a parameters. The approval of presented methodology for aerospace cluster components surfaces allows to create necessary foundation, to develop scientific estimation of surfaces texture parameters, to obtain material for investigators of chosen technological procedure. The methods necessary for further work, the creation of a fundamental reserve and development as a scientific direction for assessing the significance of microgeometry parameters are selected.

1. Introduction
Increased number of parameters describing quantitatively surfaces structure is caused by requirements for stability and production quality being raised up. Also, increased amount of considered methodology parameters is caused by technological processes control capabilities rise which is required by processing surfaces durability increasing. With that there would be possible to acquire better technical and economic parameters of manufacture (incl. ICE engine sleeves surface and inner textures of aerospace technics long-length shafts).

The present article examines foundations for new methodology creation which provides solving problem of surfaces structure new standards parameters huge amount conflicted with necessary actual floors quantity of surfaces structure parameters which is related to measurement complexity decreasing.

By the concept of article [1] there is Rz variable used, while it would be possible to describe composing structure fully only with parameters complexity applying. That sort of method is being used by most of mechanical engineering investigators (incl. aerospace ones). Specialists on metrology use reverse method which is rise of applying parameters number.

Nevertheless, parameters number increasing is not well-defined factor at all. In 1982 in article [2] Whitehouse D.J. suggested some reckless point in parameters number applying. Over 30 years later, in 2011 he proposed surfaces structure parameters types which are supposed to be used in micromeasurement to nanomeasurement transfer in monography [3] (which is adapted partly to V.N. Krootikov tutorial handbook [4]).

Nowadays the surfaces structure parameters number is not decades but hundreds ones. Partially it could be explained by both need for different surfaces morphology considering and various applying
spheres, also relational simplicity of new wide range parameters types mathematic conclusions. That fact is provided by huge variety of surfaces microprofile filtering methods.

It is quite rare event to contemplate different parameters importance; there are none of optional parameter unitary estimation methods at the moment. There are private efforts to determinate significant parameters of different technological processes known, f.e. article [5] presents to us estimation of rolling structures parameters. In present project "FoncRug3D" 29 investigators from different scientifical institutions take part; they analyzed 56 surface textures parameters in sphere of rolling and accepted Vmc as most significant parameter. Applying of Vmc could be useful in specialists practice in relation to aerospace cluster [6, 7]. Although, great variety of mechanical engineering technologies and ways to apply them requires new types of methodology.

The methodology examined in present article allows us to create practically necessary foundation, to research scientific direction of surface textures parameters estimating, also to obtain materials for technological processes investigators. Our task is devoted to problem solving of new standards excessive parameters amount conflicted with fact of surface structures parameters amount certain minimum.

2. Profiling of machines components surfaces
The authors point following research stages (figure 1):

![Roughness standards evolution](image)

**Figure 1.** Roughness standards evolution.

I.
(a) ASME B46.1. 1940. Surface Roughness. Updated in 1947, 1955, 1962, 1971, 1978, 1985, 1995, 2002, 2009.
(b) GOST 2789 (since 1973 - 2.309). 1943. Surface Roughness. Description and parameters. Updated in 1945, 1951, 1959, 1973, 1981.

In presented standards there were well-known 2D parameters examined (such as Ra, Rz, etc.). Nowadays GOST 2.309 is not being actual anymore (in contrast to microhardness parameters GOST P 8.748-2011 based on ISO 14577-2002). The term "roughness" is relevant.

II.
EUR 15178N. 1993. The development of methods for the characterisation of roughness in three dimensions. Commission of the European Communities.

One of the first standards to estimate 3D roughness.

III. (a) ASME B46.1. 1995. Surface Texture: Surface Roughness. New York: Waviness, and Lay, American Society of Mechanical Engineers.
(b) ISO 11562: 1996, Geometrical Product Specifications (GPS) – Surface Texture: Profile Method -- Metrological Characteristics of Phase Correct Filters (International Organization for Standardization, Geneva, 1996).

Entering of the terms "texture", "structure". Components surface structure is described by its 2D profile and 3D topography (which is cluster of connected profiles) and determines its texture. H.i.a. term "roughness" will be replaced by the term "surface texture".

IV. (a) ISO 12781-1:2011 Geometrical Product Specifications (GPS) - Flatness - Part 1: Vocabulary and parameters of flatness.
(b) ISO 25178-2:2012 Geometrical product specifications (GPS) - Surface texture: Areal - Part 2: Terms, definitions and surface texture parameters.

New standards differentiation in two by the plane and texture parameters.

There are some efforts to extend new parameters knowledge in Russia proposed, not on standards position, but on position of methodological notices. There are terms "surface structure" and "surface texture" (already using by foreign investigators) were presented by The All-Russian Research Institute for Optical and Physical Measurements Federal State Unitary Enterprise; also methodological notices of surface topography standardization was formed [4].

Committee B46 ASME is forming standard at the moment [8].

It would be practical to use all stages parameters during new methods research cause of insolvent applying of GOST 2.309-73 parameters only. That can be shown by following example (figure 2-3).

![Figure 2. Same value of Ra parameter - different surfaces.](image)

![Figure 3. Same value of Rmax parameter - different surfaces.](image)

Standards of stages II-III determine new parameters types; ISO 25178 determine 30 new parameters, EUR15178N determine 30 new parameters also (only several of them are identical to ISO 25178). Entering another time there are 16 parameters of sample rate.

Standards of stages IV determine 7 new parameters by each one; parameters of ISO 25178-2 are identical to parameters of ASME B.46.1 (which took 6 years to adapt american standart in Europe).
Here is methodology realization notion associating all types parameters presented; it allows to select most significant ones.

3. Methodology concept
The indication of methodology research ways providing the theoretical and experimental arguments for surface structure parameters minimal quantity cluster determination which is proved by confirmation with surface processed by any technology (such as summit honing). The determination of significant parameters would be executed in two stages by solving of directional and reverse tasks (figure 4-5).

Methodology research stages:
1. Directional task solving (quantitatively estimated 3D profile): acquiring of model mathematical description after model processing by chosen technology with following algorithmic and programmed realization for surface textures parameters values obtaining;
2. Reverse task solving (parameters values as 3D profile creation basis): comparing of synthetic surface characterization parameters values (as results of directional task) to consecutive variation of characterization parameters amount findings until asked validity completion (which is determined on base of functional properties accordance, f.e. on oil absorption of native and synthetic surfaces);
3. Comparison of obtained by solving both tasks parameters; selection of parameters with values variation most wide range (with appropriate rate of variation).

Nowadays there are analysis methods of surface response used for influence ascertainment of technological parameters to surface textures ones. Nevertheless, only parameter Ra is considered at the moment [9, 10].

It is supposed to be significant that processed surfaces texture new parameters values obtained on base of developing methodology and its mathematical description will be analyzed with computer-intensive methods incl. bootstrap (detalized while solving directional task). Estimation of forming synthetic processed surface based on surface textures new parameters value allows to obtain methodology accuracy conclusions (while solving reverse task).

Figure 4. Methodology realization scheme – direct task.
4. Notices and methods
There is applying of computer-intensive methods acquired which relate to Monte Carlo processes various types incl. methods of unparametric statistics (stcs. bootstrap). It caused by hard chance of experiment authentic reassignation obtaining (surface textures forming conditions) due to stochasticity of structures parameters creation (if processing type forming regular surface texture is not being used, f.e. vibration smoothing; also if quasiregular microsurface is created due to low accuracy of technological process, f.e. beating).

Unlike usual asymptotic method, the modeling of experimental spreading in that method will be acquired by generation of repetitive samples. The forming of quasisamples allows to obtain required texture wanted parameter properties such as mathematical expectation value, dispersion, confidence interval (CI). These methods include three particles: randomization, bootstrap and jackknife. It would be relevant to apply bootstrap itself.

The present method allows to create new cluster of values instead of original one; also the repeating of synthetic values statistics analysis procedure compared to original values analysis conclusions (method was presented in 1992-1993: [11, 12]; b. Russian edition in 2013: [13]); the present method was applying by french and british investigators during research of most significant parameter d. the sheet-metal rolling. One of the authors, Efron B., professor at the Stanford University, has proved progress of computer-intensive methods in article [14] in 1979. Speaking of executed analysis authors admit that resampling methods applying (not using of asymptotic methods type) is appropriate way to research present conception methodology.

5. Conclusion
The approval of presented methodology for aerospace cluster components surfaces allows to create necessary foundation, to develop scientific estimation of surfaces texture parameters, to obtain material for investigators of chosen technological procedure (f.e., force-controlled honing, surfaces plastic deformation).

By authors thought, processed surfaces textures new parameters values obtained on base of mathematical description are supposed to be analysed by computer-intensive methods incl. bootstrap. The estimation of forming synthetic processed surface based on surfaces textures new parameters values allows to obtain methods accuracy data.

High requirements for components surface layer applying in aerospace cluster need to be detected with new methods for processing modes assignment. Present being developed conception could be used in that sphere of mechanical engineering after approval.
References
[1] A process model for force-controlled honing simulations, Procedia CIRP. Italy, Naples: 3rd CIRP Global Web Conference on Production Engineering Research: Advancement Beyond State of the Art, CIRPe 2014.
[2] Whitehouse D J 1982 The parameter rash - is there a cure Wear. 83 75-8.
[3] David J Whitehouse 2011 Handbook of Surface and Nanometrology, Second Edition. (CRC Press). ISBN: 978-1-4200-8201-2.
[4] Krootikov V N 2011 Metrological support of nanotechnologies and nanoindustry products. (Moscow: Logos) 592 p.
[5] Deltombe R, Kubiak K J and Bigerelle M 2013 How to select the most relevant 3D roughness parameters of a surface Scanning. 36(1) pp 150-60.
[6] Abulkhanov S R, Skuratov D L, Khaimovich A I and Shvetcov A N 2014 Analytical approach to determining of parameters which characterize surface layer quality of the parts hardened by a traveling diamond sphere International Journal of Engineering and Technology. 6(5) pp 2191-200.
[7] Khaimovich A I and Balaykin A V 2014 Analysis of plastic properties of titanium alloys under severe deformation conditions in machining International Journal of Engineering and Technology. 6(5) pp 2184-90.
[8] Widder Ed ASME B46-PT32 Functional Standards Collection ASME Webcast May 8, 2012
[9] Tripathi B N, Singh N K and Vates U K 2015 Surface roughness influencing process parameters & modeling techniques for four stroke motor bike cylinder liners during honing: Review, International Journal of Mechanical and Mechatronics Engineering. 15(1) pp 106-12.
[10] Jack Feng C -X, Yu Z –G S, Kingi U and Pervaiz Baig M 2005 Threefold vs. fivefold cross validation in one-hidden-layer and two-hidden-layer predictive neural network modeling of machining surface roughness data, Journal of Manufacturing Systems. United States, Peoria, IL: Dept. of Industrial and Manufacturing Engineering and Technology, Bradley University. 24.
[11] Hall P 1992 The Bootstrap and the Edgeworth expansion. (New York:Springer. Verlag).
[12] Efron B and Tibshirani R J 1994 An Introduction to the Bootstrap. (New York: Chapman and Hall). 456 p. ISBN 9780412042317
[13] Vladimir K Shitikov and Gennady S Rozenberg 2014 Randomization and Bootstrap: Statistical Analysis in Biology and Ecology with R. (Togliatti: Cassandra). 314 p.
[14] Efron B 1979 Computers and the theory of statistics: thinking the unthinkable SIAM Review. 21(4) pp 460-80.