Evaluation of the develop of shape of the vertex surface of the roughness after the process of grinding

Ocena kształtu i rozwinięcia powierzchni wierzchołków nierówności powierzchni po szlifowaniu

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DOI: https://doi.org/10.17814/mechanik.2017.10.144

In the publication an evaluation of the develop of shape of the vertex surface of the roughness after the process of grinding was presented. Two different computational methods were used to determine the development of the vertex of surface area for which similar results were obtained.
KEYWORDS: stereometric structure of the surface, roughness, grinding

Geometrical structure of the surface has a great influence on the friction and wear processes of the associated surfaces, which cooperate sliding and sliding as well as: deformation and contact stiffness, stress concentration and fatigue strength, corrosion resistance, vibration damping, joint tightness, contact resistance, contact conductivity heat, magnetic properties, reflection, absorption and penetration (light, electromagnetic, etc.), application processes, adhesion and durability of coatings, aero- and hydrodynamic properties, subjective impression of appearance and preferences of buyers of certain products.

The basis for the selection of parameters that will be used to evaluate the surface, are destiny element and operating conditions. Also useful is the knowledge of the process used to shape the surface [1, 3, 6, 8, 15, 17, 18] (fig. 1).

Forming the surface of precision parts is often done in the process of abrasive machining or eroding. Such surfaces are randomized fractal characteristics, sometimes with a "foreign" main component [1, 3, 13].

The information content of many parameters is quite small. They are gaining in importance after the integration of the information contained therein with the information obtained on the basis of other parameters. Most of the surfaces used are designed to work with other surfaces, so the placement, size and statistical characteristics of potential contact areas are important [1, 3, 5-7].

There is no justification indication of a universal set of parameters to evaluate the surface with different purposes and different functions vehicles. Depending on the conditions of planned operation and to some extent also from the features of the surface shaping process, a set of parameters [1, 3, 9-12] should be created, which will be:

- have the maximum usefulness of information,
- fulfill the condition of complementarity,
- contain information about the dispersion and variability of geometric parameters,
- easy to interpret (it is a clear relation between parameter values and specific surface features),
- allow to determine possible corrections of the surface shaping process.

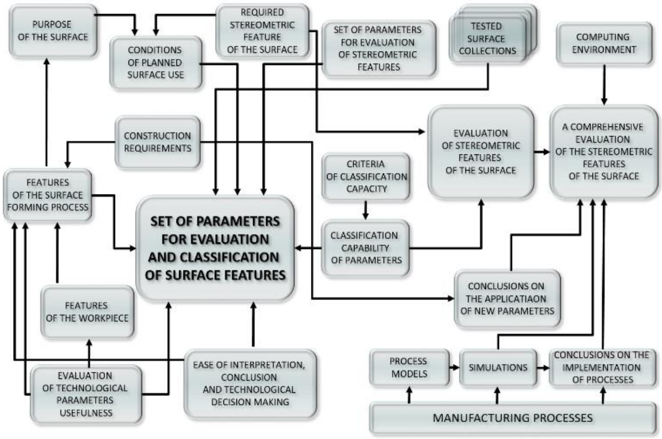

Fig. 1. Schematic diagram of selected set of parameters for surface topography evaluation

Methodology of research and analysis of results

For the analysis of stereometric features of inequality vertices (fig. 2), surface models formed in grinding processes utilized a set of surface models differing in amplitude values of higher harmonic components.

Surface coordinates generator was developed, which uses the mechanism of accumulation of components of varying fractal dimension [2].

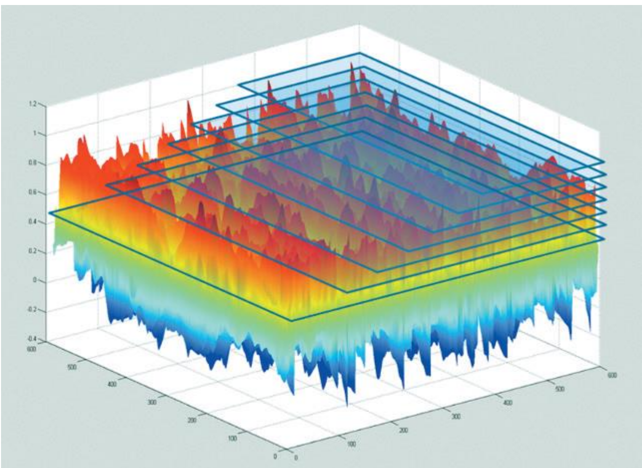

Fig. 2. Diagram for analysis of elevations features and areas of possible contact of cooperating surfaces

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This algorithm takes into account the different probability of material removal on the vertices and the lower parts of the inequality. The authors of the publications in the verification studies have achieved a high level of conformity of modeling results with real surfaces formed in the grinding process. Validation included the assessment of conformity 3D parameters 12 [2].

The developed algorithms allowed to generate surfaces with different number of harmonic components, which are the boundaries of the assigned probabilistic set of random components with different values of amplitude and frequency.

Surveys of real surface after grinding show that in the evaluation of their topography one can distinguish 4 main groups with different values of amplitude and frequency of the main component in a given group. Only 2 main components with amplitudes *A3* and *A4* were modified in the analyzes. Each of these constituents includes a group consisting of a plurality of random components with a frequency band higher than the main component.

A range of amplitude values of *A3* from 0.05 to 0.55 μm was adopted and *A4* amplitudes from 0.03 to 0.33 μm. For each generated surface, the shape and expansion of the apex of the surface above the cut-off plane by the h-segment from the highest vertex (fig. 1) were determined.

The mean wavelengths of the main components were: *lambda3(x)* = 10 μm, *lambda3(y)* = 4.8 μm, *lambda4(x)* = 3 μm, *lambda4(y)* = 2 μm.

Two different computational methods were used to determine the development of the vertex surface (fig. 3). The first was the numerical direct use of the surface coordinates to determine the value of the surface area, and the second method used gradient maps.

Figs. 4-6 show the effect of the amplitudes *A3* and *A4* of the *f4>f3* (*lambda3(x)* = 10 μm, *lambda3(y)* = 4.8 μm, *lambda4(x)* = 3 μm, *lambda4(y)* = 2 μm) to the average relative surface area for unequal surface elevations above the h level from the lowest point (*St* = 2.225 μm).

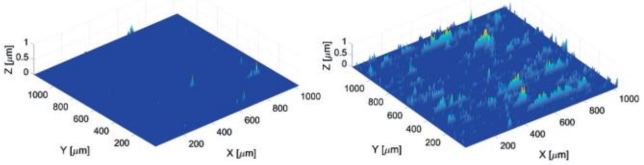

Fig. 3. The 3D view of elevations of the analyzed surface after grinding above the cut-off plane, *h* by distance from the highest vertex: a) *h* = 1 μm, b) *h* = 1.5 μm

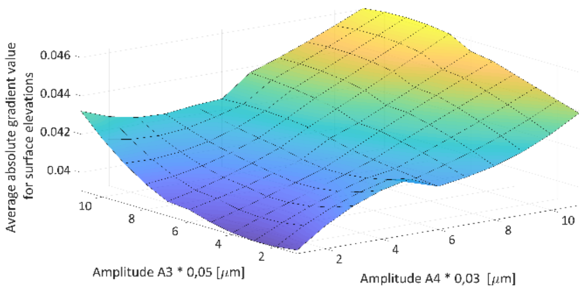

Fig. 4. Influence of amplitude *A3* and *A4* of components with frequency *f4>f3* on average absolute value of gradient for unevenness of surface over 1 μm from lowest point

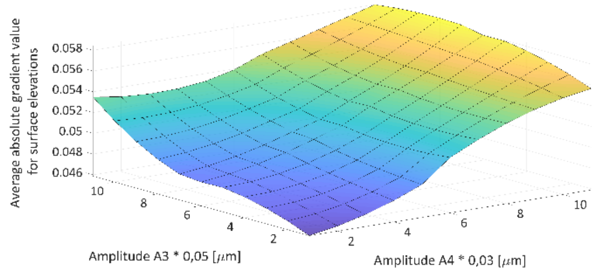

Fig. 5. Influence of amplitude *A3* and *A4* of components with frequency *f4>f3* on average absolute value of gradient for unequal areas above 1.5 μm from the lowest point

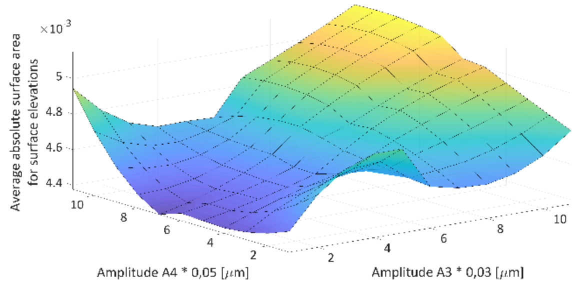

Fig. 6. Influence of amplitude *A3* and *A4* of components with frequency f4>f3 on the average relative surface area for unevenness of surface over 1 μm from the lowest point

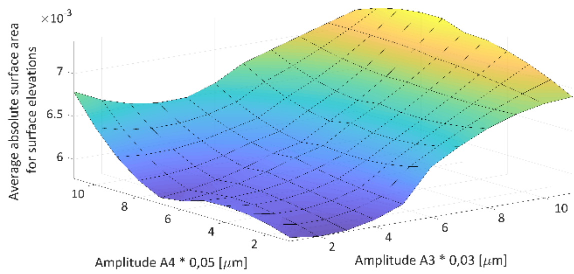

Fig. 7. Influence of amplitude *A3* and *A4* of components with frequency *f4>f3* on the average relative surface area for unevenness of surface over 1.5 μm from the lowest point

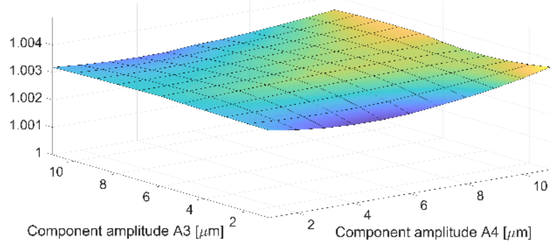

Fig. 8. The ratio of area values calculated using direct surface coordinates to the surface area calculated using a gradient map

Fig. 8 compares results of the unfolding fields obtained by different methods. The graph shows that both methods give approximate results, while the direct surface determination method is strict in the mathematical sense.

Estimating the surface area of elevations based on the average absolute value of the gradient in the elevation areas is facilitated by the implementation of the corresponding function in the computational systems.

Conclusions

Selection of methods [17-20] and parameters for measurement of inequality and evaluation of the geometrical structure of the surface should be made on the basis of: requirements for the implementation of the manufacturing processes and the purpose of the element and its operating conditions. The surfaces of the precision elements, formed in abrasive or erosion processes, have irregular elevations and vertices of inequality, showing randomized fractal characteristics.

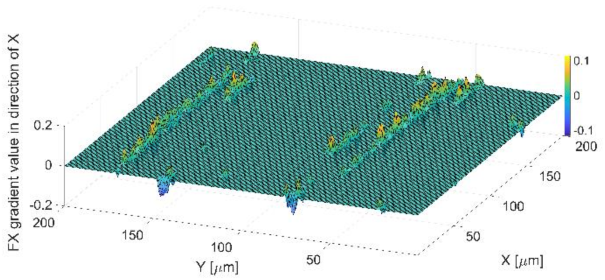

Fig. 9. *FX* gradient values in the *x* direction for *A3* = 0.55 μm and *A4* = 0.33 μm

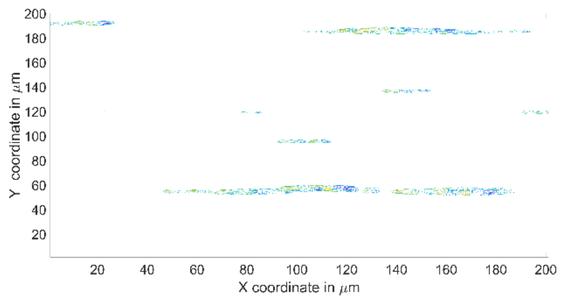

Fig.10. *FX* gradient values in the *x* direction for *A3* = 0.2 μm and *A4* = 0.15 μm

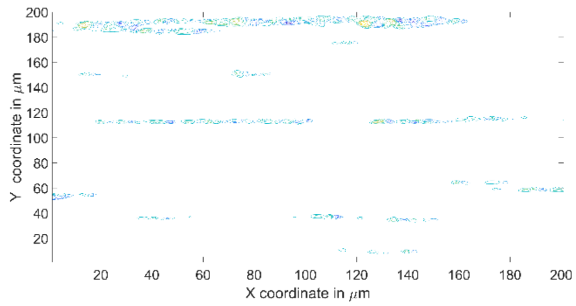

Fig. 11. *FX* gradient values in the *x* direction for *A3* = 0.55 μm and *A4* = 0.33 μm

Most of surfaces used are designed to work with other surfaces, so the placement, size and statistical characteristics of the potential contact areas are important. Manufacturers are often justified in limiting the surface gradient in elevation zones (figs. 9-11).

The results of presented work indicate the need to analyze the shape and development of apex surface roughness as a basis for assessing the operating properties and durability of machine elements.

REFERENCES

1. Grzesik W. „Wpływ topografii powierzchni na właściwości eksploatacyjne części maszyn". *Mechanik*. 88, 8–9 (2015): pages 587–893.
2. Kacalak W., Szafraniec F. „Modelowanie topografii powierzchni po procesie szlifowania z zastosowaniem mechanizmów kumulacji składowych o różnym wymiarze fraktalnym". *Mechanik*. 88, 8–9 (2015): pages 711/152–158.
3. Kacalak W. i in. „*System do analizy i oceny topografii powierzchni technicznych*". Projekt R03 040 03, 2010.
4. Kacalak W., Tandecka K. „Metrologiczne aspekty oceny topografii diamentowych folii ściernych do precyzyjnego mikrowygładzania". *Pomiary Automatyka Kontrola*. 5 (2011).
5. Kacalak W., Szafraniec F., Tomkowski R., Lipiński D., Łukianowicz Cz. „Metodyka oceny zdolności klasyfikacyjnej parametrów charakteryzujących cechy stereometryczne nierówności powierzchni". *Pomiary Automatyka Kontrola*. 57 (2011): s. 542–546.
6. Kacalak W., Tomkowski R., Lipiński D., Szafraniec F. „System oceny struktury geometrycznej powierzchni po obróbce ściernej". *Mechanik*. 8–9 (2014): s. 219–226.
7. Kacalak W., Szafraniec F., Ściegienka R. „Topografia powierzchni elementów ceramicznych szlifowanych z zastosowaniem ściernic o hiperboloidalnej powierzchni czynnej". *Mechanik*. 8–9 (2016): pages 1180–1182, DOI: 10.17814/mechanik.2016.8-9.307.
8. Kacalak W., Tandecka K., Mathia T.G. "A method and new parameters for assessing the active surface topography of diamond abrasive films". *Journal of Machine Engineering*. 16, 4 (2016): pages 95–108.
9. Kacalak W., Różański R., Lipiński D. "Evaluation of classification ability of the parameters characterizing stereometric properties of technical surfaces". *Journal of Machine Engineering*. 16, 2 (2016): pages 86–94.
10. Lipiński, D., Kacalak W. "Metrological aspects of abrasive tool active surface topography evaluation". *Metrology and Measurements Systems*. 23, 4 (2016): pages 567–578, DOI: 10.1515/mms-2016-0043.
11. Lipiński D., Kacalak W. „Zastosowanie metod analizy obrazu do oceny powierzchni czynnej narzędzia ściernego". *Mechanik*. 8–9 (2016): pages 1152–1153. DOI: 10.17814/mechanik. 2016.8-9.293.
12. Lubimow W., Oczoś K.E., Łabudzki R.K. „Klasyfikacja struktur geometrycznych powierzchni (SGP). Obróbka ścierna, podstawy i technika". *Zbiór Prac XIII Naukowej Szkoły Obróbki Ściernej*. 2000.
13. Majumdar A., Bhushan B. "Fractal model elastic-plastic contact between rough surfaces". *Journal of Tribology*. 113 (1991): s. 1–11. 14. McCool J.I. "Comparison of models for the contact of rough surfaces". *Wear*. 107 (1986): pages 37–60.
15. Pawlus P. „*Topografia powierzchni – pomiar, analiza, oddziaływanie*". Rzeszów: Oficyna Wydawnicza Politechniki Rzeszowskiej, 2005, pages 165–168.
16. Kapłonek W. „*Teoretyczne i doświadczalne podstawy zastosowania optycznych metod pomiarowych wykorzystujących analizę światła rozproszonego w ocenie stanu powierzchni przedmiotów i narzędzi ściernych w procesach obróbki ściernej* ". Monografia. Koszalin: Politechnika Koszalińska, 2017.
17. Kapłonek W., Łukianowicz Cz. „Ocena mikronierówności powierzchni obrobionych na podstawie obrazu światła rozproszonego". *Pomiary Automatyka Kontrola*. 56, 1: s. 28–29.
18. Łukianowicz Cz. „*Podstawy pomiarów nierówności powierzchni metodami rozpraszania światła*". Monografia 85. Koszalin: Politechnika Koszalińska, 2001.
19. Reiner J. „*Identyfikacja i modelowanie optyczne systemów wizyjnej kontroli jakości wytwarzania*". Wrocław: Oficyna Wydawnicza Politechniki Wrocławskiej, 2013.
20. Wieczorowski M. „Kierunki rozwoju metrologii nierówności powierzchni".*Mechanik*. 8–9 (2014):pages 467–479/600.■