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DIFFERENCE OF PROFILE PARAMETERS DUE TO ERRORS OF POINTS COLLECTIONS – SIMULATION ANALYSIS

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Abstract: In last decades, the metrology of the surface profile has developed dynamically. This trend is the result of new technologies, especially in the motor, aircraft or electronic industry. New requirements are not just question of how the product is manufactured, but also its final improved properties, like robustness and efficiency of a car engine. In the world around us, all the surfaces are rough. One of important problems is also the surface measurement credibility and reproducibility of results [1]. In this paper, the author presents the results of simulations for profile surface measurements with different distributions of errors of profile points collections.

Keywords: profile measurement, simulations, Matlab software.

1. INTRODUCTION

In the world around us, all the surfaces are rough. Most of surfaces in mechanics are very complicated, and in order to describe it with certain values, the measurement and analysis of some parameters should be performed. Before 1980 roughness analysis was based on 2D measurements, which gave two-dimensional characteristics of the surface. During the last decades, many scientists and constructors became convinced that the third dimension should be added to the analysis. Profile surfaces measurements (2D) still are applied particularly in the industry. Results of these measurements often show large differences because of the large variety of instruments for surface roughness analysis. The values of these differences are often difficult to qualify, various measuring instruments use various algorithms of profile processing like calculation of reference elements or filtration of the acquired signal. The idea of the project emerged at one of research — industry meetings, with a question: what differences in parameter values can we expect measuring the same surface a number of times with difference devices? The project titled *The analysis of credibility and reproducibility of surface roughness measurement results* was completed in 2007 [2]. The discussion about obtained results was presented in [1]. The main conclusion was: in spite of measurement repeatability conditions in all measurement laboratories, this analysis revealed high variability of parameters. That could be caused by various factors like mechanical factors (slideway errors, geometry of stylus) and other reported already some time ago, variability of software (difference in filtrations algorithms and parameters calculation) or simply human factor. Similar investigations in relation to 3D parameters were recently done in European laboratories [3, 4, 5].
One of important problems is also the way of measurement (points collection) for further analysis. The errors of profile points collections be can one of causes of the high variability of surfaces parameters. To analyze this, some simulation investigations were realized. Simulation analyzes of surfaces measurement are often used as efficient tool in scientific research [6, 7, 8, 9].

2. PREPARATION OF SAMPLES

Five kinds of typical surface finishing were investigated: super-finish, grinding, high-speed milling, finish turning, abrasive blasting and three standards type D2, C3 and D1. The data points for surface topography were collected by means of a TOPO L50 stylus profilometer Fig. 1. Generally sampling lengths selected for measurements were 0.25 mm, 0.8 mm, 2.5 mm (cut-off value).

Fig. 1. TOPO L50 stylus profilometer

For the above mentioned samples, the following parameters [10, 11] were calculated and evaluated: Ra, Rq, Rz, Rt, Rku, Rsk. They are defined as:

- Ra — arithmetic mean deviation of the assessed roughness profile;
- Rq — root-mean-square (RMS) deviation of the assessed roughness profile;
- Rz — maximum height of the roughness profile within a sampling length;

- Rt — total height of the profile on the evaluation length;
- Rku — kurtosis of the profile;
- Rsk — skewness (asymmetry) of the assessed profile;

3. DATA ANALYSIS WITH MATLAB SOFTWARE

Nowadays, measuring devices are not isolated units, most of them require cooperation with external computer, software or database. Unfortunately, external software for control and data transmission is sold optionally, and generally is expensive [12]. Moreover, it is impossible to change anything in most of the programs, to fit it to the particular task dependent on the enterprise.

The Matlab software set contains functions that enable data transmission and receiving from outer devices connected to a computer. This way, the control commands may be sent to the device, and the data collected by the device may be received. Matlab in standard version enables to program all the devices connected to the computer via the serial interface RS 232. Our team tested [13] the procedures of RS 232 connection with a profilometer HOMMELWERKE T500 (Fig. 2).

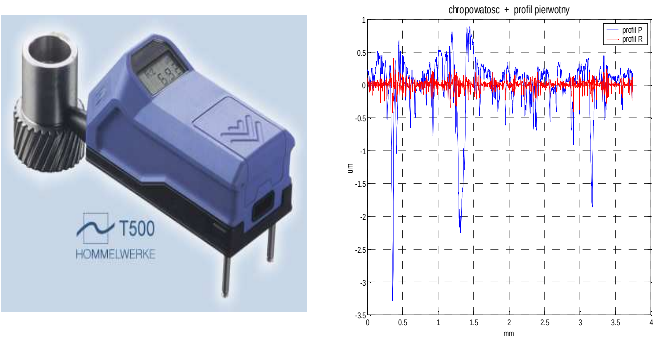

Fig. 2. Portable profilometer HOMMELWERKE T500, and the measured profile with its filtration by program Matlab

In order to complete the simulation analysis of profile surface measurement with different distributions of errors of profile points collections, the program 2D measurement application had to be created. It was based on Matlab software, but our team worked out original program for surface analysis, 2D and 3D alike. Four modules were worked out:

- the initial data processing module,
- digital filtration module,
- basic 2D parameters calculating module,
- data visualization module,

Examples of modules are shown in the Figures 3.

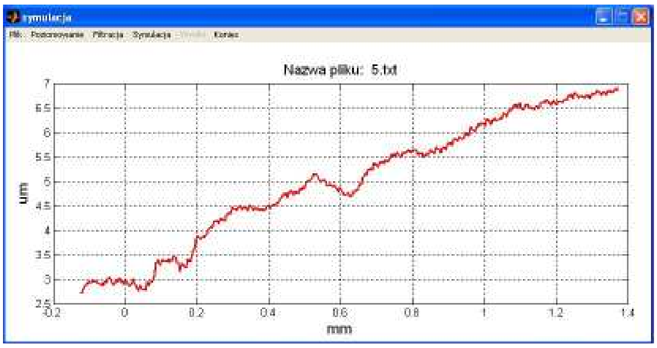

Fig. 3. The initial data processing module – visualization of collected profile

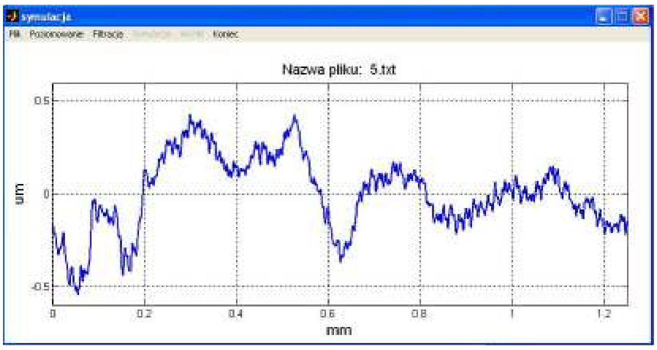

Fig. 4. The collected profile after detrend

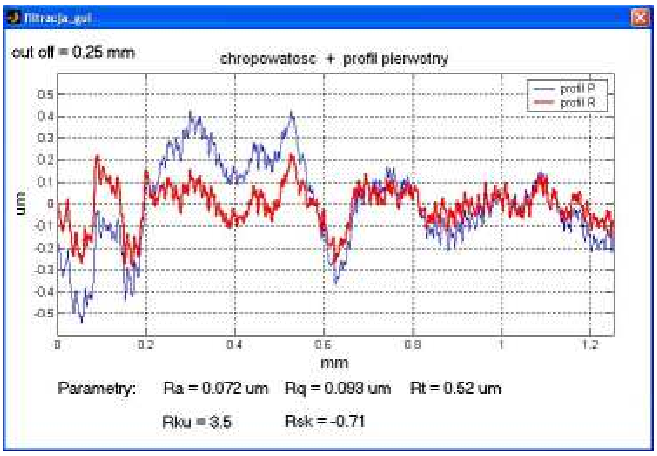

Fig. 5. The digital filtration module and basic parameters calculating module

4. SIMULATION PROCEDURE

Simulation was performed by collecting the “measuring points” from obtained profile with putting errors on each points. The whole algorithm was executed in Matlab package with various procedures. The following are six procedures Fig. 6 :

1) the profile file reading, 2) the calculation of profile parameters (Ra, Rq, Rz, Rt, Rku, Rsk), 3) generating the distribution of errors – Gaussian and rectangular error

distributions were used , 4) putting errors on the profile, 5) the calculation of new profile parameters, 6) save the results.

Next, the procedures are repeated for different profile, and after the simulation is finished, the graph of the parameters differences is generated (Fig. 7 – 9).

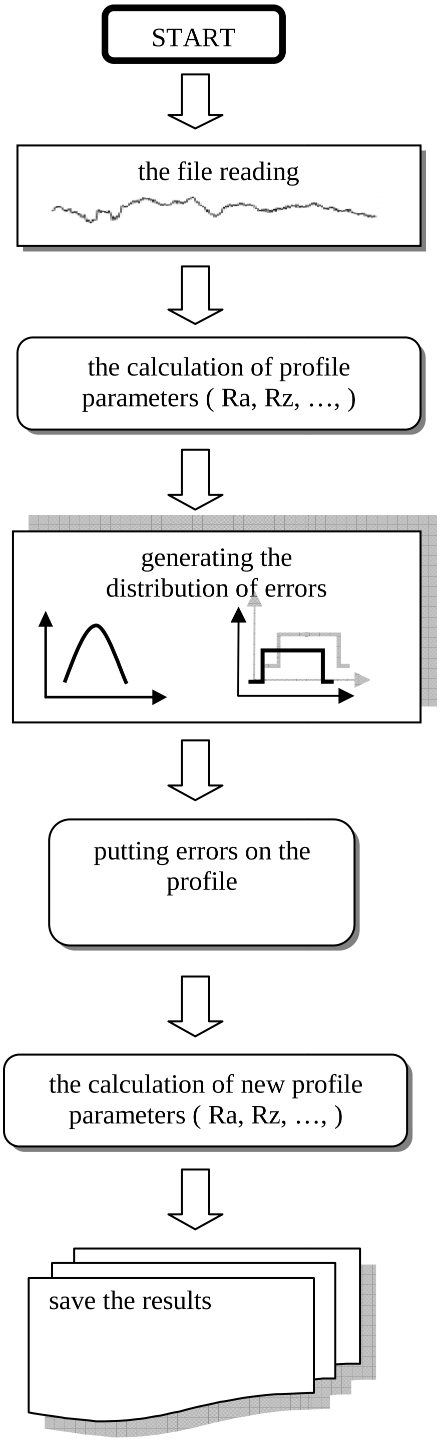

Fig. 6. The diagram of simulation procedure

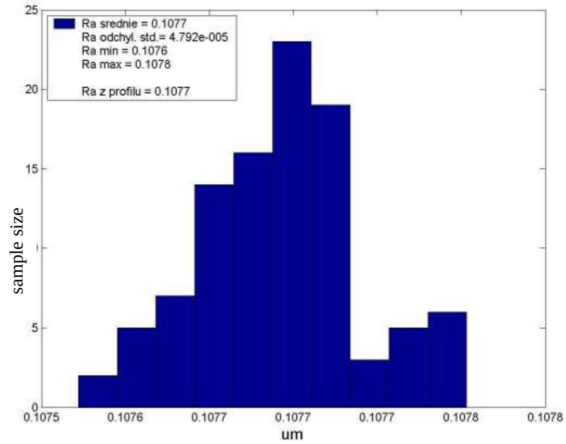

Fig. 7. Examples of the graph of the parameters differences – parameter Ra (error of points collection 5%)

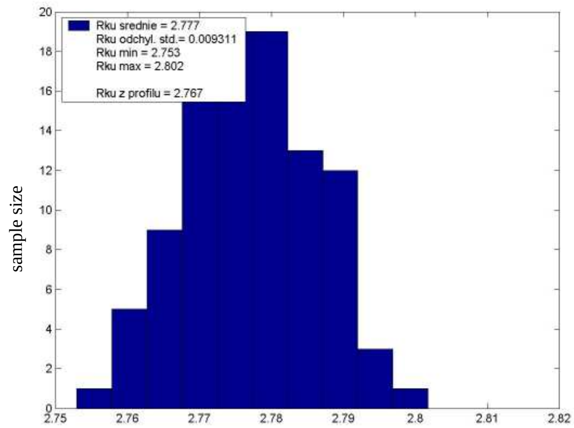

Fig. 8. Examples of the graph of the parameters differences – parameter Rku (error of points collection 5%)

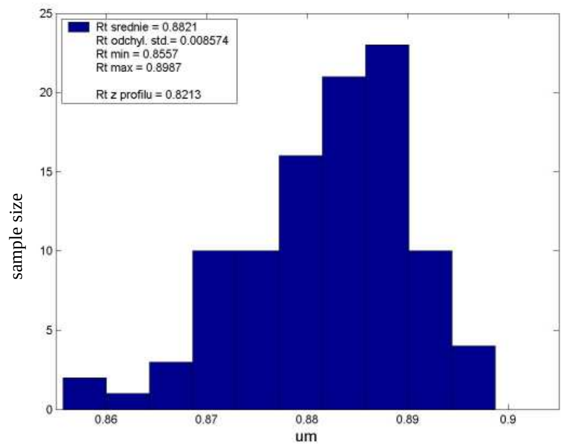

Fig. 9. Examples of the graph of the parameters differences – parameter Rt (error of points collection 10%)

5. RESULTS AND CONCLUSION

The simulations and analyses for all samples and standards were made.

An example of the results for all analyzed parameters for profile obtained from standard KNT 2070/03 are presented in graphical form in Fig. 10 and Fig. 11 shows the results for high-speed milling samples.

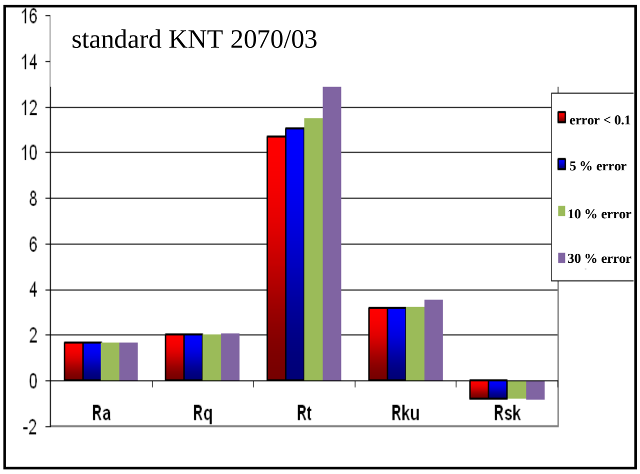

Fig. 10. Examples of results for all analyzed parameters for profile obtained from standard KNT 2070/03

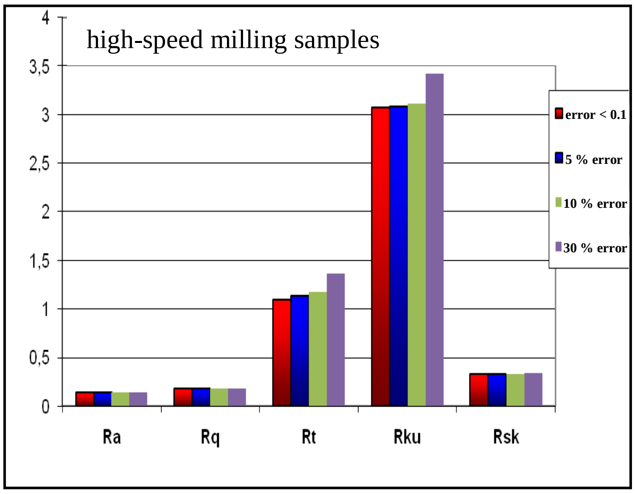

Fig. 11. Examples of results for all analyzed parameters for profile obtained from high-speed milling samples

For all analyses profiles the parameters for which the least difference were observed are: Ra, Rq, Rsk. Parameters for which the highest difference appeared were: Rt, Rku. For all parameters the difference did not cross to 10%.

Only parameters 2D were analyzed, so the next step to understand and characterize the variability of 2D parameters will be analyses for others parameters like spatial (Rsm) and functional (Rk, Rpk, Rvk, Mr1, Mr2).

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