ANALYSIS OF THE POSSIBILITY OF APPLYING THE MACHINE LEARNING METHODS FOR THE PREDICTION THE SURFACE GEOMETRY AFTER ITS TECHNOLOGICAL TREATMENT

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Abstract

The paper presents an idea and preliminary analysis of a new approach to modeling the surface geometry by applying advanced computational and analysis of data methods. It assumes that the material's surface may be treated as a random field and can be analyzed using the time series methods. The research aims to develop a model to predict surface geometry textured by a laser beam. Worked out predictive models supported by machine learning methods would indicate proper texturing process parameters to obtain specific surface geometry proprieties. The final goal of the research is to develop a model to predict the surface geometry parameters according to texturing process parameters. As a data set for the development and testing of the model, data from the profilometric test of samples with a cermet coating after laser with different beam power will be used.

Keywords: Random fields, time series, machine learning, surface geometry

1. INTRODUCTION

Modeling of surface geometry is an important technological stage of manufactured elements, as it allows to obtain of appropriate operational properties. The subject of consideration regarding applying advanced data analysis methods, such as the analysis of time series and random fields, is the WC-Al_2O_3 coating deposited by the electro spark method and then subjected to laser treatment [1-5]. As a result of laser treatment, greater uniformity of layer properties and much better adhesion to the base material were obtained. Experimental studies conducted on the effect of laser treatment on the properties of the cermet layer became an inspiration to analyze the possibility of creating an analytical model based on the performed tests and allowing for the prediction of geometric properties of the layer at other laser operating parameters. Working out such a method would reduce the number of necessary experimental studies requiring manufacturing a series of samples and testing. What is more interesting is that it opens the possibility of modeling the parameters of the laser treatment process in such a way as to obtain the desired geometric properties of the surface.

Time series analysis methods are widely used in modern science, wherever we are dealing with recording measurements of a time-varying process. Thanks to the decomposition of the series, the determination of the trend line and seasonal changes, can be analyzed, and based on them, forecasts analysis can be made. An extensive application of time series can be found in the analysis of stock market data. However, it is also used in production management to analyze production processes, supply, finances, or workforce dynamics. Time series analysis has also been used to analyze medical data and therapy prognosis [6,7].

On the other hand, the analysis of random fields has been used for many years in image processing and analysis, particularly for texture analysis. Texture analsysis allow to proceed quantitative analysis of the images with specyfic area which are differ with such as properties like for example directionality or diversified heterogeneity of elements forming the structure or their nature, e.g. fibers, grains, pores. Both approach for

analysis surface geometry on the base of results of profilometry will be proceed and prediction models will be design [8-11].

2. MATERIALS AND METHODS

Results of experiments and surface analysis which were performed in Kielce University of Technology will be the start point of our research. Three sets of profilometry analysis results, of the samples from three different laser treatment parameters become a data set for series analysis and random fields analysis. The experimental data will be treating as a signal record, but there be analyzed the dynamic of the changes not in time but its dependences of the localization. The key points of the analysis are present on the scheme (**Figure 1**). The analysis starts form uploading data set which will be analyzed applying time series method, which include data filtering, decomposition, properties of the time series it can be designed prediction model (ARIMA, ARMA or SARIMA) [6,7]]. The first stage of the research assume that model should be able to generate the set of data which will represents the same characteristic of changes and will have the same character of specyfic pics like the dataset used for analysis. Then the model will be constructed it shuold be veryfied on the experimental data, and if it's needed, properly adjusted. Next stage of further analysis will be adjust model to predict the shape of the profilometry chart for the sample with different parameters of the laser treatment, what will be obtained applying additionally neural network in design model.

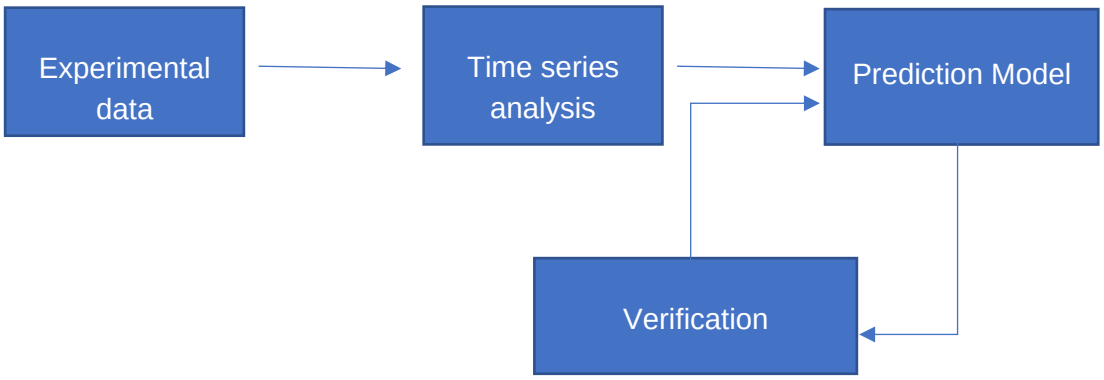

Figure 1 Scheme of analysis concept

Based on the obtained from prediction model it can be possible to generate the curve which will not be exactly the same like the chart form the profilometry test, but the characteristic parameters should be very close to the experimental data. Times series analysis will be performed due to obtained prediction of the profilometry results from the chosen line which is presented as a two-dimensional chart (**Figure 2**).

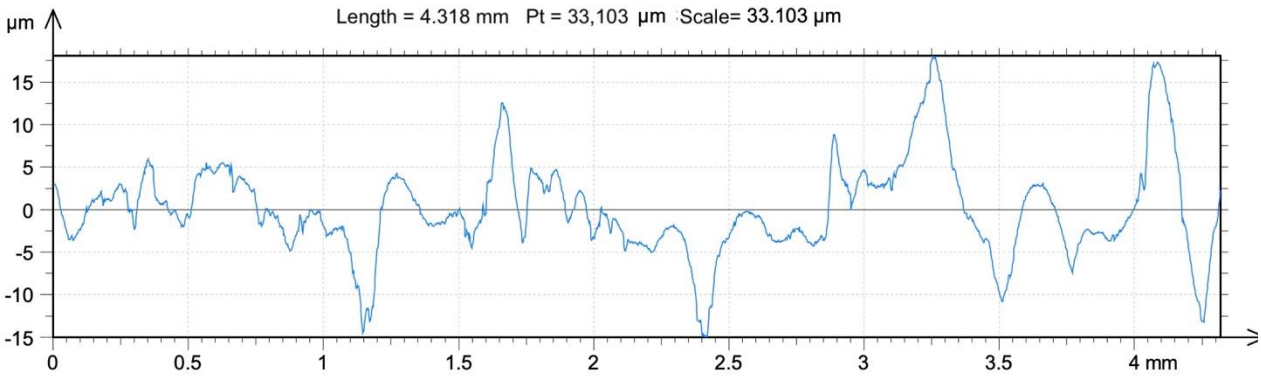

Figure 2 Example of the surface analysis by optical profilometry method

Another interesting research challenge is to analyzed the profilometry results from chosen area. In this case the data set is an image where can be observed changes in the surface geometry and relation between the characteristic subareas. An example of the visualization of profilometry analysis is presented in the **Figure 3** and **Figure 4**. In the **Figure 3** the color image represents the changes of the value of measured points in tested surface. From this image it can be read what value of the measurement was obtained. But the concept of the analysis this results of measurements, presented as a two-dimensional image is based on analysis the grey scale image applying the texture analysis methods. So, the first step is conversion the set of data into a two-dimensional table of values, which will be treat as grey-scale image, what means that each point of the table will be represent by the value of the measured high. It should be noted that **Figure 3** which is presented as a color image, in fact is a data table, and color is used for better visual analysis of the results, because the human vison system much better distinguish different colors than different grey scale values.

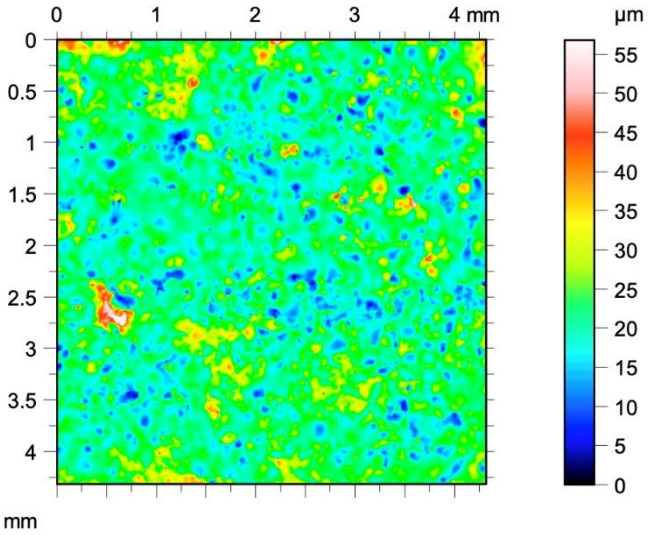

Figure 3 Example of the presentation the results of profilometry analysis on chosen surface area

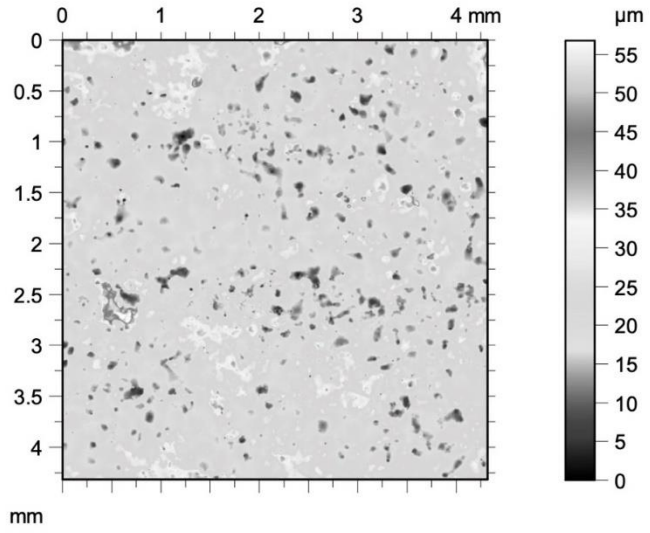

Figure 4 Image of the example image as a two dimensional table, where the scale of the measured values are represents by grey scale

This method also assumes analysis of characteristic areas in the dataset, but this time by applying the methods for texture analysis, first order histogram-based feature [8]. Other methods which are planned to be applied

are co-occurrence matrix based features and Markov random field model. This method deliver good results in texture description and detection as well generation the images of texture which have similar parameters. Based on the quantitative characteristic of surface geometry, applying CNN model the similar surface geometry can be generated. The final stage of planned research is to develop the model which on the base of the experimental data and the laser treatment process will be able to predict the surface geometry for other then tested laser treatment parameters. Comparing the results from presented two approaches the most efficient will be chosen for further development and wider application.

3. CONCLUSION

The application of the advanced analysis of data set methods is challenging in so complex data like surface geometry. But in our opinion that would provide more efficient research, and production planning [12, 13]. The limitation of the analysis is small set of data, but authors are planning to enrich dataset in results from analysis different coatings undergoing the laser treatment due to enhance its properties. Maybe it should be also taken into the consideration analysis of the surface which are texture by laser beam and other technology for surface geometry modelling.

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