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3D modeling of rough surface from the measurement data

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ABSTRACT – Surface is an important object of tribologycal research. Analyzing the real surface can be performed by finite element method. A three-dimensional (3D) finite element model of real surface can be constructed from measurement data. The aim of this research is to create an interface tool so that the 3D surface measurement data is used to develop the 3D finite element model. Next, many tribologycal analyzes may be performed easily toward the developed surface.

1. INTRODUCTION

A real surface topography (RST) of engineering surface is rough on micro-scale [1]. The RST consists of hill and valley, where the hill is called as asperity, see Figure 1. It is an important object for tribologycal aspect. When two engineering surface are in contact, in fact the contact occurs at asperities level. The RST can be used for further analyses, such as running-in of rolling contact [1] or running-in of rolling-sliding contacts [2].

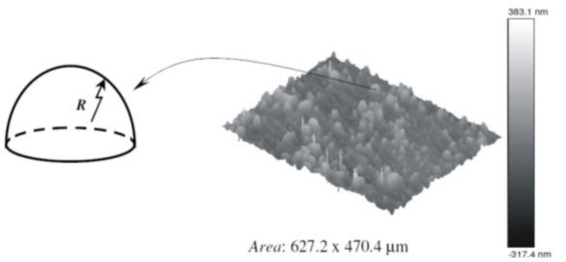

Figure 1 Engineering surface and its asperities [1].

Studying the RST behavior is difficult because the dimension of the RST is very small. There are several methods in analyzing the RST such as experimental method (direct observation), analytical method (mathematical model) or numerical method (for instance finite element analysis). Experimental method needs many time, tools and relatively expensive. Analytical method uses mathematical equations. However, the analytical method is limited to simple model, such as spherical geometry model [3-9] to represent an asperity. This simplification approach will affect the accuracy of the results. The finite element (FE) model the real surface as it is, therefore the results will be better compare to the aforementioned methods.

Unfortunately to make the RST into FE model is not available in most of the commercial finite element analysis software. It requires interface software to create a 3D model from the measurement data. Several studies have performed the employment of the interface software. David et al. [10], for instance, have demonstrated it by simulating the RF MEMS. They used either an optical profilometer (VEECO) or an Atomic Force Microscope (AFM) to capture the three dimensional data points of the contact surfaces. Then, using some functions of Matlab software, they convert the closed surface from a stereo-lithographic format to an ASCII file which is compatible with ANSYS Parametric Design Language (APDL). In the final step, the rough surface was obtained by creating key points from the imported file. Since the key points are not co-planar, ANSYS uses Coons patches to generate the surface, and then a bottom up solid modeling was used to create the block volume with the rough surface on the top. Thompson [11] presented a method for generating, using, and operating on non-uniform varieties for the incorporation of probabilistic rough surfaces in ANSYS.

However, Thompson’s model shows asperities with sharp peak instead of smooth. Meanwhile, the topography of the asperities in the rough surface is considered as either hemisphere or ellipsoid as have been proved by many previous works. This paper propose a new interface model to make a 3D finite element of the surface based on the measurement data.

2. METHOD

Figure 2 shows three steps to change the RST data from measurement of an engineering surface to be the 3D real surface model using the interface. First, the RST was measured by means of, for instance using an interference microscope. The height h (x, y) of the surface topography contains a collection of asperities in the form of nodes coordinates. Second, the nodes coordinates were then processed by using the interface model. The interface model was arranged by mathematic and CAD softwares. An automatic approach was used in connecting the nodes in the CAD software for generating the rough surface. A substrate was constructed below the rough surface to model the thickness of the rough surface specimen. Next, the 3D real surface model is saved using the Initial Graphics Exchange Specification (IGES) format or other format which support to read in the most of the commercial finite element analysis softwares.

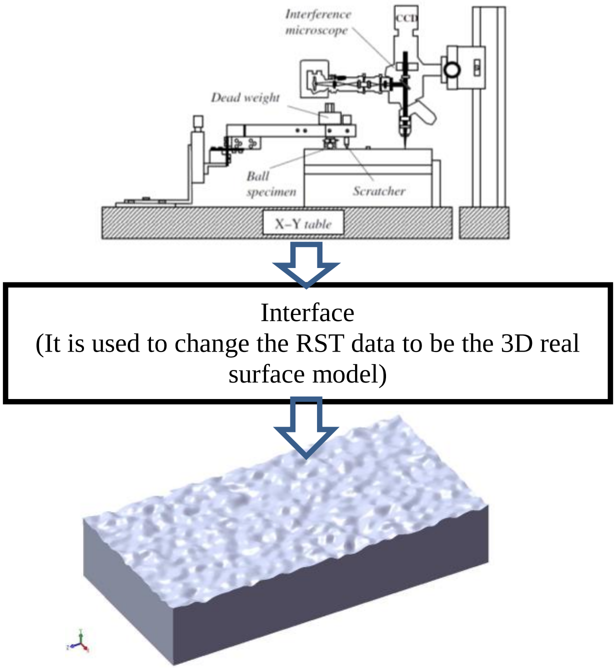

Figure 2 The proposed method for constructing 3D real surface model from the measurement data.

3. RESULTS AND DISCUSSION

Figure 3 shows the result of the 3D real surface model from the measurement data. In this figure, mesh of the surface is finer on the top (surface) and become coarser at the body below the surface. The 3D real surface model is in IGES format and can be opened in most of Computer Aided Engineering (CAE) software and easily to be meshed to design the elements.

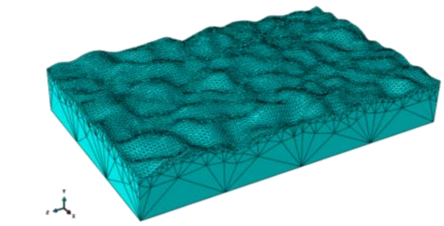

Figure 3 The 3D real surface model with mesh.

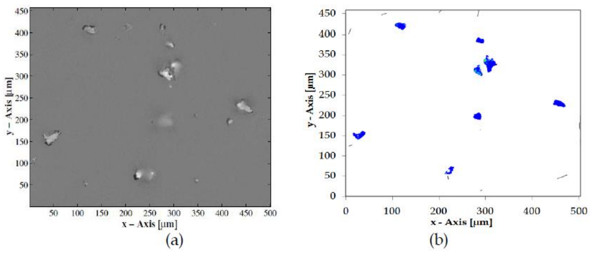

Figure 4 The comparison of the measured and calculated contact area: (a) measured contact area [1] and (b) contact area prediction using finite element analysis.

In order to verify the accuracy of the developed 3D real rough surface, the surface is analyzed using FEA software for contact analysis. Figure 4 shows the comparison between the experimental results of [1] and the FEM analysis for a normal static contact. It can be said from this figure that the developed 3D rough surface model is very good.

4. CONCLUSION

The interface model to change the RST data to be the 3D real surface model has been proposed. The interface model employ the mathematical and CAD software. The model shows a good agreement with the experimental data.

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