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Spiral sampling as a fast way of data acquisition in surface topography

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Abstract

In this paper the application of spiral sampling in surface topography measurements is presented. It is a fast way of topography assessment by means of stylus profilometers. In all of the currently used instruments, sampling is based upon a rectangular grid, which is relatively easy to execute, but very time consuming. Spiral sampling offers a potential solution to solve this problem. For this reason it was necessary to create an algorithm for data collection, transmission and processing as well as to construct a measuring setup. This method was elaborated for nominally flat elements. The comparison analysis between a rectangular grid and a spiral one shows that the results of measurements can be similar with up to 70% less time consumption. © 2001 Elsevier Science Ltd. All rights reserved.

Keywords: Surface topography; Measurements; Sampling; Spiral of Archimedes

1. Introduction

The aim of the project (sponsored by Polish Committee for Scientific Research) is to elaborate fast sampling methods enabling fast surface topography measurements by means of stylus profilometers. These devices are the most commonly used ones for assessment of surface asperities. Thus the surface is represented as a set of coordinates of grid points, based on a grid constructed in a certain way. Most of the instruments work on a parallel multiprofile basis, though some trials with concentric profiles were conducted as well. Sampling is done on a rectangular grid, the benefit of which is simplicity in measurement execution. However, a disadvantage is a large measurement time resulting from the necessity of collecting a great number of measuring data. In order to obtain a reliable surface representation the tracing speed must be low. If it is not the stylus may lose contact with the surface being inspected and a flight may occur [1]. A number of papers were devoted to this phenomenon [2,3] as its influence on the results of topography measurements is significant. If and when the flight occurs is dependent not only on the drive system but also on the stylus and surface geometry. The errors caused by the stylus not being in contact with the surface are the biggest obstacle in enlarging the scanning speed in multiprofile

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topography analysis. Thus still more and more often are the efforts to modify dynamics of the drive system in order to enable fast scanning of assessed surface.

One of the possibilities of time consumption reduction in multiprofile topography measurement is to apply a non-rectangular grid [4,5]. The most popular grids are triangular and hexagonal ones, the latter in particular gives a good time reduction (up to 15%) as well as a smaller database. However, the sampling system has to be more complicated.

For this reason spiral sampling was proposed as a potential solution of the problem. The solution is a novelty and does not exist in references or in practical applications, not even in theoretical considerations. It should give several times faster measurement, maintaining good surface representation. For the sake of analysis it was necessary to create a mathematical basis, an algorithm of data collection, transmission and converting as well as construction of a device for precise sample rotation and special software for control and parameter calculation. This method was elaborated for nominally flat elements. It is based on sampling that is a combination of two movements in the same time: a linear and rotational one, giving a spiral as a result.

2. Spiral sampling

A spiral of Archimedes is a set of points on a plane determined by a point moving with a uniform motion along the half-line rotating around its origin with a constant angular velocity (Fig. 1).

Assuming that initially a point P_0 moving along a half-line is in the pole, and the half-line is on the pole axis. Let the speed of the moving point be equal to *c*. A path covered by the point during a period of time denoted by *t* is equal to:

$$\rho=ct \tag{1}$$

Let the angular velocity of the rotating half-line be equal to ω. The angular path covered by the half-line during the same period of time *t* is: $\phi=\omega t$. Thus, eliminating *t* one can obtain a polar equation of a spiral of Archimedes in a form of:

$$\rho=\frac{c}{\omega}\phi \tag{2}$$

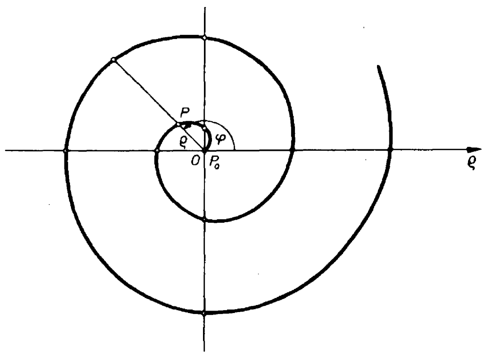

Fig. 1. The shape of spiral of Archimedes.