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Determination of Tangency Point between the Cylindrical Sharp Stylus and a Helical Surface of the Cylindrical Worms

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Abstract

In this paper is studied the point of tangency of a helical surface and stylus that is a cylinder shape with a known radius and cut to the bottom with an inclined plane with a known angle. The aim is to develop a method for measuring the helical surfaces on coordinate measuring machines without requiring a special measuring device. Sectional shape between the cylinder and the inclined plane is an ellipse and the scope is to determine the point of tangency between the ellipse and the helical surface of the measured worm flank. The tip of the stylus is positioned in the XY plane where the X axis is positioned along the axis of symmetry of the worm. Y coordinate of the stylus tip is blocked and we approach with the stylus to the helical surface changing the X coordinate. Determination of tangency between the helical surface and curve is done using a numerical method. In order to determine the point of tangency between the helical surface and ellipse, first determine the intersection of the ellipse and a cylinder whose radius varies over the range corresponding to the height of the worm flank. Then we must to determine the intersection of the considered cylinder and the helical surface of the worm flank, the intersection is actually a cylindrical propeller. The next step is to define and measure the distance between the points obtained and the cylindrical propeller and if the distance calculated is in an acceptable range, then the obtained point is the sought point. Knowing the real contact point position can be corrected the error in measurement. The position of the stylus tip is returned by coordinate measuring machine and we associate the stylus tip a position vector written in the worm system. Obtained point we associate a second position vector which is written in the coordinate system of the stylus. This vector can be written in the worm coordinate system using the vectors transformations. The coordinates of the point of contact are obtained by adding the two vectors and are actually the projections of the resulting vector on coordinate system axis. The main contributions are made to the method of determining the tangent point, the designed program and correction of the coordinate measuring point. To determine contact between the stylus and the surface of the worm to determine the surface equations in different coordinate systems were used the coordinate transformations. The program used for the point calculation is Auto-Lisp and the representations are made in AutoCAD.

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1. Introduction

The purpose of this paper is the measurement of helical surfaces of the cylindrical worms flanks using coordinate measuring machines whose stylus is cylinder shape beveled at the bottom with an inclined plane. According to STAS 6845-82 standard, the cylindrical worms are classified as: ZA – worm with a straight-line tooth profile in axial section, ZN – worm with a straight-line tooth profile in normal tooth section, ZE – worm with a straight-line tooth profile in a plane tangent to the main cylinder, ZK – profile formed by a cone ground using a wheel and/or shank tool [11],[12], [13],[15].Studied worm in the paper is cylindrical non-ruled, machined on CNC with end mills positioned inclined at an angle close to the angle of the pressure worm[1] and moved eccentric to axis of symmetry of the worm [2], [3], [16] so that worked profile to be very close to the worm type ZA. Profile checking of the resulting worm was made to representation Mitutoyo Romania, type of machine coordinate measuring used to measure being Contracer CV -3200fig.1.(a).

Stylus available for measurements Fig. 1(b) is a cylindrical shape, the cylinder being chamfered at the bottom with a plane inclined at an angle to the axis of symmetry $\alpha=12^{\circ}$. The radius of the tip is 25μm and the height H = 20mm [4]. Following made measurements conduct to the conclusion that the available stylus for measurements has for the touch zone the shape of an ellipse, which inserts extra measure deviations, contact point between the stylus and the helical surface not being at the intersection of the semi-major axis and ellipse, but on the zone of the ellipse located between the two of its semi-axis.

(a) (b)

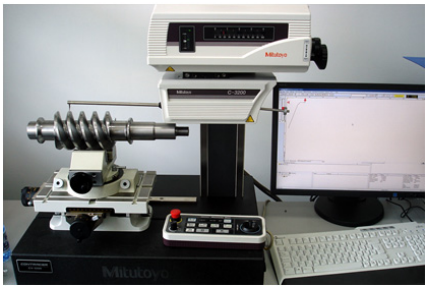

Fig.1. (a). Coordinate Measuring Machine type Mitutoyo Contracer CV-3200; (b). Stylus used in measurements [4]

The knowledge of deviation introduced because of contact between the stylus and the helical surface area is required to correctly position the produced worm in a precision class. There are reported studies on the error correction of the helical surface measurement on the coordinate measuring machines without special devices [5], [6], [9],[14].

Nomenclature

β	ellipse parameter;
r	stylus radius and small semi axis of the ellipse;
R	semi-major axis of the ellipse;
r_c	contact cylinder radius;
δ, a	contact cylinder parameters;
φ	parameter family of surfaces;
r_s	radius end mills;