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Investigating the possibilities of compensating systematic errors of three-coordinate touch probes using contact signal

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Abstract

During inspection with three-coordinate touch probes, working on the principle of a kinematic resistance system, the total measuring error called backlash has a negative effect on the measurement accuracy. In order to eliminate the effect of backlash, many companies offer various solutions. As an alternative solution, a new system with improved design of the touch probe and is based on the principle of electrical contacts has been developed. The capabilities and limitations of this new touch probe are analysed in this paper. It is shown that the improved design can reduce the fluctuation of the dislodging force caused by the change of the direction of the force, and the addition of the contact system makes it possible to define the systematic measurement errors.

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1. Introduction

The productivity of CNC machine tools can be increased substantially by using three-dimensional touch-trigger probes [1]. By far the most widespread ones work on the principle of a kinematic resistance system (Fig. 1).

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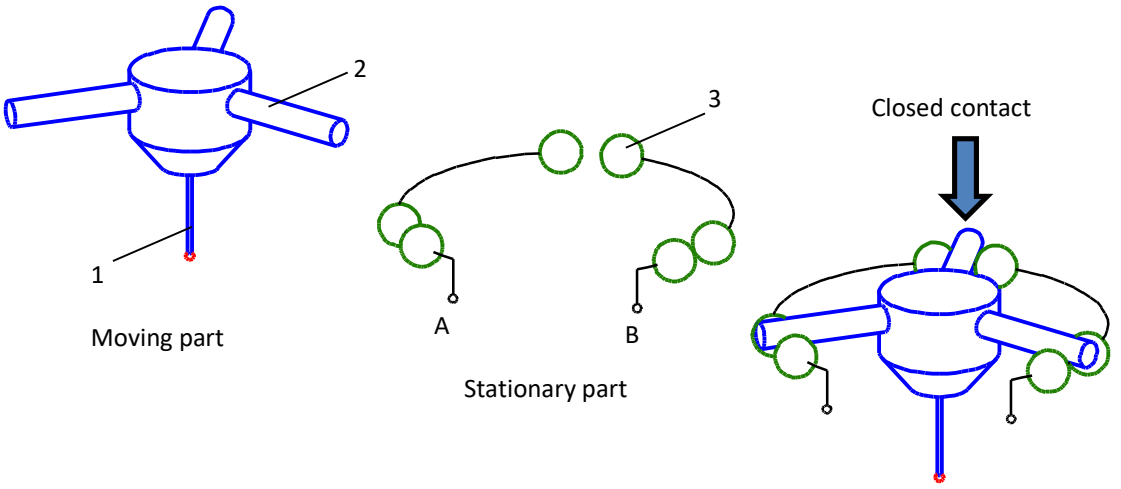

Fig. 1. 3-coordinate kinematic resistance system touch probe.

The moving part of the touch probe consists of the trigger tip (1) and three electrically conductive pins (2) arranged radially with 120^0 angle between them. The stationary part consists of three pairs of electrically conductive spheres (3) connected to an open electrical circuit; they, too, are arranged in a similar manner as the pins. The moving part is pressed towards the spheres with a spring (not shown in the figure). The six spheres uniquely define the position of the moving part. The spheres and the pins form an electrical circuit with normally closed contacts, so in its unloaded state the electrical resistance between the end contacts (*A* and *B*) is zero. When a force with sufficient value is applied to the tip of the probe (this happens when the tip gets in contact with the measured workpiece) the moving part is dislocated from its stable position and the electrical circuit breaks which can be used to register the moment the contact is made.

During inspection with three-coordinate touch probes, working on the principle of a kinematic resistance system, the total measurement error called backlash has a negative effect on the measurement accuracy. This backlash ε_Σ can be calculated [2,3] as:

$$\varepsilon_\Sigma = \Delta + g \pm \omega \tag{1}$$

Δ is the permanent component of the error that does not depend on the direction of the measurement, g is the component whose value depends on the measurement direction, and ω is the random component of the total error caused by backlash. Δ and g are systematic errors that can be measured. The backlash is, in fact, the distance that the touch probe travels between the moment it makes contact with the measured workpiece and the moment it generates a measuring signal.

Calibration is one possible solution for defining the sum of systematic components of the backlash of three-coordinate touch probes, but its application is connected with some considerations and limitations:

- Calibration is necessary after each disassembly of the touch probe or after replacement of the probe tip [3,4,5].
- The capabilities of the MACRO language and the system resources of the FANUC-6 CNC system (or similar) make it possible to define and work with a reduced number of calibration points.
- In many cases, preliminary definition of the expected working points (directions) of the measurement is not possible.
- The time required to calibrate the probe using more points is in fact loss of machine time.

In order to eliminate the above mentioned problems, a number of companies have offered design solutions of three-coordinate touch probes where the principle of a kinematic resistance system is replaced by some other system. More often, these touch probes incorporate additional optical, piezo resonance or tensometric systems