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Test code for machine tools —

Part 10: Determination of the measuring performance of probing systems of numerically controlled machine tools

AMENDMENT 1: Measuring performance with scanning probes

Code d'essai des machines-outils —

Partie 10: Détermination des performances de mesure des systèmes de palpage des machines-outils à commande numérique

AMENDEMENT 1: Performances de mesure avec palpeurs de scanning

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Foreword

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The committee responsible for this document is ISO/TC 39, *Machine tools*, Subcommittee SC 2, *Test conditions for metal cutting machine tools*.

Test code for machine tools —

Part 10: Determination of the measuring performance of probing systems of numerically controlled machine tools

AMENDMENT 1: Measuring performance with scanning probes

Page 3, 3.2.1.2

Delete the Note, “Proportional probes used in continuous scanning mode are not included in the scope of this part of ISO 230.”

Page 38

Add Annex B (see overleaf) before the bibliography.

Page 38, Bibliography

Add the following entry:

[14] ISO 10360-4, *Geometrical Product Specifications (GPS) — Acceptance and reverification tests for coordinate measuring machines (CMM) — Part 4: CMMs used in scanning measuring mode*

Annex B
(informative)

Measuring performance with scanning probes

B.1 Scope

This annex provides test procedures to evaluate the scanning performance of contacting probing systems, integrated with a numerically controlled machine tool, and used in a pre-defined path scanning mode (see B 2.9).

These tests are supplementary to the discrete point tests that are specified in Clauses 6 and 7. Contacting probing systems that do not support discrete point measurement are not covered by this annex.

Clauses 1 to 5 are applicable to this annex.

The test procedures are not intended to distinguish between the various causes of errors. They are intended to demonstrate the combined influence of the environment, machine tool, probing system and probing software on the measuring performance.

The tests in this annex are applicable to both acceptance testing and re-verification testing, and should be run periodically, after a crash of the probe or machine, or if any of the following probing conditions are changed:

— feed speed during measurement;

— stylus system (in particular stylus system length);

— feed speed during qualification;

— probing system orientation during measurement (e.g. vertical or horizontal orientation of probe);

— probe;

— nominal deflection;

— measurement range.

B.2 Terms and definitions

For the purpose of this annex, the following terms and definitions apply.

B.2.1
rest position
position of the centre of the probe's stylus tip when it is stationary and not deflected by contact with a surface

Note 1 to entry: The rest position is a nominal position that is established during qualification. The actual rest position at any time typically varies slightly from this value.

B.2.2
maximum scanning deflection
maximum deflection that can be applied to the centre of the probe's stylus tip during a scanning measurement specified by the manufacturer

Note 1 to entry: The maximum scanning deflection can vary with direction of deflection (*x*,*y*,*z*).

B.2.3
probe over-travel limit
maximum deflection at the centre of the probe stylus tip from the rest position that can be applied without causing damage to the probe stylus assembly

B.2.4
minimum scanning deflection
minimum deflection of the centre of the stylus tip from its rest position that is allowed during a scanning measurement

Note 1 to entry: Deflection is programmed to be large enough to ensure that the stylus tip maintains contact with the surface throughout the measurement.

B.2.5
scanning measurement range
maximum allowed distance between the nominal scan line and the actual scan line, as specified by the manufacturer/supplier

Note 1 to entry: This distance may be expressed separately for the different axes of the probe, e.g. ±0,3mm in X and Y, ±0,2mm in Z.

Note 2 to entry: The scanning measurement range is less than the difference between the maximum scanning deflection and the minimum scanning deflection for a number of reasons, some examples being:

— deviation from the pre-defined tool-path caused by machine tool path following errors;

— approximations during tool-path generation (e.g. approximating a curve by straight line segments);

— additional probe deflection caused by movement along the surface (e.g. friction, local surface normal deviations, surface finish).

B.2.6
stylus tip normal acceleration
acceleration at the centre of the stylus tip relative to the surface being measured, normal to the target surface

Note 1 to entry: Stylus tip normal acceleration is sometimes considered to limit the scanning feed speed for features that have sharp scanning path variations, and would therefore demand high rates of acceleration from the machine tool axes. Scanning performance is affected mostly by acceleration normal to the surface being measured, as machine position errors in the direction of the target scan line do not usually lead to significant measurement errors.

B.2.7
indicated tip centre point
indicated position of the centre of the stylus tip during a measurement

Note 1 to entry: This is also known as an "indicated measured point" (see ISO 10360–1, definition 2.12).

B.2.8
scanning sphere centre position reproducibility
maximum variation of the sphere centre positions obtained through multiple measurements compared to the sphere centre position obtained by the first measurement

B.2.9
pre-defined path scanning
method of scanning in which the motion of the probing system between two defined end points is directed by a target scan line

[SOURCE: ISO 10360-1, definition 7.5]

Note 1 to entry: In this method of scanning, feedback from the probing system is not used to direct the motion of the probing system.

B.3 General considerations

Some sources of measurement error in continuous scanning systems on machine tools are different from those on a CMM. The main differences are as follows.

— A machine tool typically does not control probe deflection while scanning. This means that the positional uncertainty of the workpiece is more likely to affect measurement uncertainty on a machine tool.

— Machine tools are optimized for cutting, not measurement. Machine position reporting errors during qualification and subsequent measurements typically create differences between the measurement accuracy of inside and outside features, for example bores and bosses.

The following tests should be performed using the feed speed and the measurement range specified for the probing system or agreed between manufacturer/supplier and user.

The tests in this annex are sensitive to stylus configuration; especially stylus length and stylus tip diameter. For acceptance testing, the stylus configuration should be agreed between manufacturer/supplier and user. For verification testing, the tests should be run whenever a new stylus configuration is used.

For probing systems that control probe deflection using real-time feedback to adjust the measurement path, the less comprehensive but shorter test specified in ISO 10360-4[14] may be appropriate. For this

type of system, if agreed between manufacturer/supplier and user, the scanning 3D performance test (see B.5) could be replaced by the test specified in ISO 10360-4[14]. If this is done it is nevertheless recommended that the scanning 2D performance test (see B.6) is still performed.

NOTE The scanning 3D performance test contains the measurements required for ISO 10360–4.[14] If required, the measurement data from the scanning 3D performance test can also be analysed to produce ISO10360–4[14] results.

The 3D scanning performance test is performed on an external surface, whereas the 2D scanning performance test is performed on an internal surface. The two tests have been designed to be complementary to each other as scanning systems on machine tools can have significantly different uncertainties when scanning internal and external surfaces. It is recommended that both tests be performed.

The probe should be tool changed and, where applicable, the tool change indexer moved by at least one index position after qualification and between each test.

B.4 Filtering parameters

The filtering algorithms and parameters used during these tests affect the results and should be agreed between manufacturer/supplier and user. They should be stated in the test report.

B.5 Scanning 3D performance test; $E_{SC,3D,POS}$, $E_{SC,3D,DIA}$, $E_{SC,3D,FORM}$, $T_{SC,3D}$, ($Error_{SCanning,3D,POSition}$, $Error_{SCanning,3D,DIAmeter}$, $Error_{SCanning,3D,FORM}$ and $Time_{SCanning,3D}$)

B.5.1 General

This test determines the ability of the probing system to measure a test sphere when the measurement tool-path is not exactly aligned with the test sphere. This test applies to probing systems that can measure a sphere in continuous scanning mode, and simulates the deviation of workpiece position during in-process measurement.

The probe is operated over its full 3D measurement range in this test. This test does not include the effects of temperature variation on positional uncertainty. The user of a contact scanning system is advised to consider the effect of temperature variations on the measurement range requirements.

This test is designed to be run on three-axis machines, including machines that can only interpolate in XY, YZ and ZX planes. The test is specified assuming that the Z-axis of the probe is aligned with the Z-axis of the machine tool so that it is widely applicable.

The time for the test is recorded to give an indication of system speed, and because it may affect accuracy.

B.5.2 Sphere measurement sequence

Refer to Figure B.1.

a) The coordinate system origin is at the centre of the sphere, and is aligned with the X-, Y- and Z-axes of the probe. The pole of the sphere is at X = 0, Y = 0, Z = r (radius of sphere).

b) The arrows on the diagram indicate the directions of travel along the target scan lines.

The direction and feed speed of the approach moves to the target scan lines should be in accordance with the manufacturer/supplier's recommendations.