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Test conditions for machining centres —

Part 9: Evaluation of the operating times of tool change and pallet change

Conditions d'essai pour centres d'usinage —
Partie 9: Évaluation des temps opératoires de changement d'outils et de changement de palettes

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ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.ch
Web www.iso.ch

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this part of ISO 10791 may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

International Standard ISO 10791-9 was prepared by Technical Committee ISO/TC 39, *Machine tools*, Subcommittee SC 2, *Test conditions for metal cutting machine tools*.

ISO 10791 consists of the following parts, under the general title *Test conditions for machining centres*:

— *Part 1: Geometric tests for machines with horizontal spindle and with accessory heads (horizontal Z-axis)*

— *Part 2: Geometric tests for machines with vertical spindle or universal heads with vertical primary rotary axis (vertical Z-axis)*

— *Part 3: Geometric tests for machines with integral indexable or continuous universal heads (vertical Z-axis)*

— *Part 4: Accuracy and repeatability of positioning of linear and rotary axes*

— *Part 5: Accuracy and repeatability of positioning of work-holding pallets*

— *Part 6: Accuracy of feeds, speeds and interpolations*

— *Part 7: Accuracy of a finished test piece*

— *Part 8: Evaluation of the contouring performance in the three coordinate planes*

— *Part 9: Evaluation of the operating times of tool change and pallet change*

— *Part 10: Evaluation of the thermal distortions*

— *Part 11: Evaluation of the noise emission*

Annex A of this part of ISO 10791 is for information only.

Introduction

A machining centre is a numerically controlled machine tool capable of performing multiple machining operations, including milling, boring, drilling and tapping, as well as automatic tool changing from a magazine or similar storage unit in accordance with a machining programme. Most machining centres have facilities for automatically changing the direction in which the workpieces are presented to the tool.

The purpose of ISO 10791 is to supply information as wide and comprehensive as possible on tests and checks which can be carried out for comparison, acceptance, maintenance or any other purpose.

ISO 10791 specifies, by reference to the relevant parts of ISO 230, *Test code for machine tools*, several families of tests for machining centres with horizontal or vertical spindle or with universal heads of different types, standing alone or integrated in flexible manufacturing systems. ISO 10791 also establishes the tolerances or maximum acceptable values for the test results corresponding to general purpose and normal accuracy machining centres.

ISO 10791 is also applicable, totally or partially, to numerically controlled milling and boring machines, when their configuration, components and movements are compatible with the tests described herein.

Test conditions for machining centres —

Part 9:
Evaluation of the operating times of tool change and pallet change

1 Scope

This part of ISO 10791 specifies certain standard test conditions for assessing the conventional length of the operating times spent by the machine to carry out different metal cutting functions. It considers two types of operating times, namely those taken by the functions of:

— automatic tool change (see clause 5);

— automatic pallet change (see clause 6).

The purpose of the methods described in this part of ISO 10791 is to permit the comparison of the performance of different machining centres of similar size and features.

The data obtained may also be used to establish conventional change times in technical literature in a uniform and comparable way. It is also possible to check them on a machine, both when it is new and during its working life.

2 Normative references

The following normative documents contain provisions, which, through reference in this text, constitute provisions of this part of ISO 10791. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this part of ISO 10791 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO 10791-1:1998, *Test conditions for machining centres — Part 1: Geometric tests for machines with horizontal spindle and with accessory heads (horizontal Z-axis)*.

ISO 10791-2:2001, *Test conditions for machining centres — Part 2: Geometric tests for machines with vertical spindle or universal heads with vertical primary rotary axis (vertical Z-axis).*

ISO 10791-3:1998, *Test conditions for machining centres — Part 3: Geometric tests for machines with integral indexable or continuous universal heads (vertical Z-axis).*

3 Terms and definitions

For the purposes of this part of ISO 10791, the following terms and definitions apply.

3.1
cut-to-cut tool change time
CTC
interval of time between the beginning of the removal of a tool to be changed from a reference position, P_R, in the machining volume and the end of the approach of the next tool to the same position

NOTE CTC is more suitable to judge the automatic tool change operation than the pure tool change time, because CTC takes into account all the steps required for changing tools in an automatic process.

3.2
pallet change time
PCT
interval of time between the beginning of the removal of a pallet to be changed from a reference position, P_R, in the machining volume and the end of the approach of the next pallet to the same position

4 Preliminary remarks

4.1 Measuring units

In this part of ISO 10791 all linear dimensions are expressed in millimetres and time is expressed in seconds.

4.2 Measuring instruments

The measuring instruments indicated are only examples. Other instruments, measuring the same quantities and having at least the same accuracy, may be used.

4.3 Test to be performed

When testing a machine, it is not always necessary or possible to carry out all the tests described in ISO 10791. When the tests are required for acceptance purposes, it is up to the user to choose, in agreement with the supplier/manufacturer, those tests relating to the components and/or the properties of the machine which are of interest. These tests are to be clearly stated when ordering a machine. The mere reference to ISO 10791 for the acceptance tests, without specifying the tests to be carried out and without agreement on the relevant expenses, cannot be considered as binding for the contracting parties.

4.4 Safeguarding

For safety reasons, the machine, where reasonably practicable, should be fully assembled and guarded, with guards and protective devices in place and functional.

5 Evaluation of the cut-to-cut tool change time (CTC)

5.1 Process

CTC includes, where applicable:

a) the movement between the reference position, P_R, and the tool change position, P_C;

b) the search for the next tool (in most cases, see Table A.2);

c) the tool change;

d) the opening and closing of movable covers between the tool store and the work zone;

e) the return to the reference position from the tool change position.

NOTE Spindle deceleration and acceleration times are assumed to be contained within phases a) and e) mentioned above.

5.2 Reference position and tool change position

5.2.1 Identification of the machining volume

The machining volume shall be identified by the maximum working travel distances of the three main coordinate axes. The extensions of the travel ranges of these coordinate axes which are used for auxiliary functions only (such as tool change or pallet change) shall be considered outside the machining volume.

Movable components in excess of the three main coordinate axes, such as sliding spindles, quills or rams, shall be maintained retracted, in a position not requiring their movement for the tool change.

5.2.2 Reference position, P_R

The reference position, P_R, is a position in the machining volume generally defined by the values along the three main coordinate axes as specified in this part of ISO 10791.

5.2.2.1 Machining centres with horizontal Z-axis

For machine configurations such as those shown in Figure 1 of ISO 10791-1:1998, the reference position is identified by the following values:

— X_R at mid-travel of the X-axis;

— Y_R at 1/4 of the Y-travel from its lower limit;

— Z_R at a position where the spindle nose is at the edge of the table nearest to the column.

If the table is rectangular, its longer side shall be parallel to the X-axis.

5.2.2.2 Machining centres with vertical Z-axis

For machine configurations such as those shown in Figure 1 of ISO 10791-2:— and ISO 10791-3:1998, the reference position is identified by the following values:

— X_R at mid-travel of the X-axis;

— Y_R at mid-travel of the Y-axis;

— Z_R at mid-travel of the Z-axis.

5.2.3 Tool change position, P_C

The tool change position, P_C, is determined by the machine configuration. Its coordinates are X_C, Y_C and Z_C.

5.3 Tool store configurations

5.3.1 General

The three configurations of tool stores given in 5.3.2 to 5.3.4 can be considered, where N indicates the store capacity in number of spaces.

5.3.2 Drum or chain type bidirectional tool stores

In this type of tool store the last tool T_N is the closest to T_1 and $T_{N/2}$ is the furthest from T_1.

5.3.3 Drum or chain type unidirectional tool stores

In this type of tool store, the last tool T_N is the closest to T_1 in one direction and the furthest in the opposite direction.

5.3.4 Box or matrix type tool stores

In this type of tool store, the last tool T_N is the furthest from T_1 and T_2 is the closest to T_1.

5.4 Tool store management

5.4.1 General

As far as the store management is concerned, the two types of tool stores given in 5.4.2 and 5.4.3 are considered in this part of ISO 10791.

5.4.2 Fixed access tool stores

In these types of stores, tools are directly exchanged between the machine spindle and the store, and the management of the tool handling is rigid, in that each tool shall be put back in its slot before the next one can be taken. They may be movable tool stores (for instance drum or chain stores) or fixed tool stores (for instance box type stores) where each tool is assigned to its own slot.

5.4.3 Random access tool stores

In these types of stores, a two-position tool changer is used to exchange tools between the machine spindle and the store. This design allows a random positioning by which a tool can be stored in any one of the empty slots after the next one has been loaded into the machine spindle. They may be movable tool stores (for instance drum or chain stores) or fixed tool stores (for instance stores served by a robot).

5.5 Test procedure

5.5.1 Data to be measured

With both fixed access tool stores and random access tool stores, the tool change time is variable, depending mainly on the search time. Therefore, this part of ISO 10791 specifies methods enabling the maximum and the minimum values of the tool change time to be measured.

5.5.2 Testing equipment

The test requires a minimum of two tool holders and a stopwatch. A dial gauge can be used to record that the spindle has reached the reference position.

5.5.3 Test execution

5.5.3.1 General

The complete test is made up of ten tool change cycles carried out under numerical control without interruption of the test programme between the start and the finish.

The test programme starts with the first tool holder in the spindle and the other(s) ready in the appropriate slot(s) of the store according to the time to be measured (as specified in 5.5.3.2.1, 5.5.3.2.2 or 5.5.3.3.1) or in the waiting position of the tool changer (see 5.5.3.3.2). The machine axes shall be in the reference position, P_R, specified in 5.2.2.

The test programme ends when all the programmed tool change cycles have taken place, with the last tool holder in the spindle and the machine axes back in the reference position, P_R.

Each test cycle shall start with a rapid traverse from the reference position, P_R, to the tool change position using any one of the machine axes if necessary.

A tool change operation then follows, followed by a rapid traverse to the reference position, P_R.

For the purposes of this clause, the spindle does not need to rotate, and the dwell time in the reference position, P_R, shall be zero. It shall be oriented, if necessary, in the position for changing the tool.

After the test programme has been completed, the total measured time will be divided by ten in order to obtain the required time.

5.5.3.2 Fixed access tool stores

5.5.3.2.1 Maximum cut-to-cut tool change time

To determine this value, each tool change operation is carried out drawing from the store the tool which is furthest from the one just stored.

5.5.3.2.2 Minimum cut-to-cut tool change time

To determine this value, each tool change operation is carried out drawing from the store the tool which is closest to the one just stored.

5.5.3.3 Random access tool stores

5.5.3.3.1 Maximum cut-to-cut tool change time

To determine this value, each tool change operation is carried out drawing from the store the tool which is furthest from the one just stored.

Since the search time is partially masked by other functions during the cycle, the first cycle may have a different length from the others. Therefore, in this case, eleven cycles are run during the course of the test programme, and the time to be measured starts when the spindle returns to the reference position, P_R, for the first time. The first cycle is then disregarded, and ten identical cycles are measured.

5.5.3.3.2 Minimum cut-to-cut tool change time

To determine this value, the test programme simulates the circumstances in which the entire search time is masked by the machining time and, therefore, does not appear in the tool change time.

For this purpose, the next tool does not need to be drawn from the store; it shall be ready in the waiting position of the tool changer.