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Test conditions for numerically controlled turning machines and turning centres —

Part 2:

Geometric tests for machines with a vertical workholding spindle

Conditions d'essai des tours à commande numérique et des centres de tournage —

Partie 2: Essais géométriques pour les machines à broche verticale

(Revision of ISO 13041:2000)

ICS 25.040.20

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Foreword

ISO (the International Organization for Standardization) is a world-wide 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 organisations, 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.

International Standard 13041-2 was prepared by Technical Committee ISO/TC 39, *Machine tools*, Subcommittee SC 2, *Test conditions for metal cutting machine tools*.

ISO 13041 consists of the following part, under the general title *Test conditions for NC turning machines and turning centres* :

- Part 1: Geometric tests for machines with horizontal workholding spindle
- Part 2: Geometric tests for machines with vertical workholding spindle
- Part 3: Geometric tests for machines with inverted vertical workholding spindle
- Part 4: Accuracy and Repeatability of positioning of linear and rotary axes
- Part 5: Accuracy of speeds, feeds and interpolations
- Part 6: Accuracy of a finished test piece
- Part 7: Evaluation of contouring performance in the three coordinate planes
- Part 8: Evaluation of thermal distortions

Annex A of this part of ISO 13041 is for information only.

Introduction

A numerically controlled turning machine is a machine tool in which the principal motion is the rotation of the workpiece against the stationary cutting tool(s) and where cutting energy is brought by the workpiece and not by the tool. This machine is controlled by a numerical control (NC) providing automatic function according to 3.3 of ISO 13041-2 and can be of single spindle or multi-spindle type.

A turning centre is a NC turning machine equipped with power driven tool(s) and the capacity to orientate the work holding spindle around its axis. This machine may include additional features such as automatic tool changing from a magazine.

The object of ISO 13041 is to supply information as wide and comprehensive as possible on geometric, positional, contouring, thermal and machining tests which can be carried out for comparison, acceptance, maintenance or any other purpose.

ISO 13041 specifies, with reference to the relevant parts of ISO 230 *Test Code for Machine Tools,* tests for turning centres and numerically controlled turning machines with / without tailstocks standing alone or integrated in flexible manufacturing systems. ISO 13041 also establishes the tolerances or maximum acceptable values for the test results corresponding to general purpose and normal accuracy turning centres and numerically controlled turning machines.

Test conditions for numerically controlled turning machines and turning centres —

Part 2:

Geometric tests for machines with a vertical workholding spindle

1 Scope

This part of ISO 13041 specifies, with reference to ISO 230-1, the geometric tests on general purpose and normal accuracy numerically controlled (NC) turning machines and tuning centres with vertical workholding spindles as defined in 3.4.

This part of ISO 13041 specifies the applicable to tolerances corresponding to the above mentioned tests.

This part of ISO 13041 explains different concepts or configurations and common features of NC turning machines and turning centres with vertical workholding spindle. It also provides a terminology and designation of controlled axes.

This part of ISO 13041 deals only with the verification of the accuracy of the machine. It does not apply to the operational testing of the machine (e.g. vibration, abnormal noise, stick slip motion of components) nor to machine characteristics (e.g. speeds, feeds) as such checks are generally carried out before testing the accuracy.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 230-1:1996 *Test code for machine tools — Part 1: Geometric accuracy of machines operating under no-load or finishing conditions*.

ISO 841:2001, *Industrial automation systems — Physical device control — Coordinate system and motion nomenclature*

ISO/FDIS 13041-1:2003 *Test conditions for NC turning machines and turning centres — Part 1: Geometric tests for machines with horizontal workholding spindle*

3 Definition of the machining operations carried out on these machines

For the purpose of this standard and the following definitions apply.

3.1 Numerically controlled turning machine

A machine tool in which principle movement is the rotation of the workpiece against the stationary cutting tool(s) and where cutting energy is brought by the workpiece and not by the tool. This machine is controlled by a numerical control (NC) providing automatic function.

3.2 Turning centre

A NC turning machine equipped with power driven tool(s) and the capacity to orientate the work holding spindle around its axis. This machine may include additional features such as automatic tool changing from a magazine.

3.3 Machine modes of operation

A mode of operation of the NC or data entry devices where entries are interpreted as functions to be executed.

a) Machine mode of NC
Non-automatic mode of NC of a machine in which the operator controls it without the use of pre-programmed numerical data, for example, by push button or joystick control.

b) Manual data input mode
The entry of programme data by hand at the NC.

c) Single block mode
The mode of NC in which, at the initiation of the operator, only one block of control data is executed.

d) Automatic mode
The mode of NC in which the machine operates in accordance with the programme data until stopped by the programme or the operator.

3.4 Vertical turning centre

A NC vertical turning machine is a machine with one or two type heads and a turret type head, and sometime a slide head with an indexable turret. Typical machines consist of a base supporting the horizontal table or chuck. Attached to the base is a single vertical column or dual vertical columns which carries the cross rail. The cross rail carries one or two heads, each head consisting of a saddle (turret rail head or rail head) which moves horizontally on the rail, and a ram or slide which moves vertically on the saddle. On some machines a slide head is mounted on the right vertical column way, so that the side head saddle moves vertically, and the side head ram or slide moves horizontally. This machine equips power driven tool(s) and the capacity to orientate the work holding spindle around its axis. This machine may include additional features such as automatic tool changing from a tool magazine.

This machine is divided into two types owing to work holding system. one is the table type and the other is the chuck type. A chuck type vertical turning centre is usually used for small size of workpieces, whilst a table type vertical turning centre is used for large size of workpieces.

4 Preliminary remarks

4.1 Measuring units

In this International Standard, all linear dimensions, deviation and corresponding tolerances are expressed in millimetres; angular dimensions are expressed in degrees, and angular deviations and the corresponding tolerance are expressed in ratios but in some cases microradians or arcseconds may be used for clarification purpose. The equivalence of the following expressions should always be kept in mind.

$$0{,}010/1000 = 10\ \mu rad \approx 2''$$

4.2 Reference to ISO 230-1

To apply this International Standard, reference should be made to ISO 230-1, especially for installation of the machine before testing, warming up of the spindle and over moving components, description of measuring methods and recommended accuracy of testing equipment.

In the “Observation” block of the tests described in the following sections, the instructions are followed by a reference to the corresponding clause in ISO 230-1 in cases where the test concerned is in compliance with the specifications of that part of ISO 230-1 Tolerances are given for each test (see G1 to G20)

4.3 Machine leveling

Prior to conducting tests on a machine, the machine should be leveled according to the recommendations of the supplier/manufacturer (see 3.11 of ISO 230-1:1996).

4.4 Test sequence

The sequence in which tests are presented in this International Standard in no way defines the practical order of testing. In order to make the mounting of instruments or gauging easier, tests may be performed in any order.

4.5 Test to be performed

When testing a machine, it is not always necessary or possible to carry out all the tests described in this International Standard. 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. Mere reference to this International Standard for the acceptance tests, without specifying the tests to be carried out, and without agreement on the relevant expenses, can not be considered as binding for any contracting party.

4.6 Diagrams

For reasons of simplicity, diagrams in this International Standard are based on a machine type with one workhead and one turret.

4.7 Software compensation

When built in software facilities are available for compensating geometric, positioning, contouring and thermal deviations, their use during these tests should be based on an agreement between the user and the supplier/manufacturer. When the software compensation is used, this shall be stated in the test reports.

4.8 Minimum tolerance

When the tolerance for a geometric test is established for a measuring length different from that given in this International Standard (see 2.311 of ISO 230-1:1996), it shall be into consideration that the minimum value of tolerance is 0,005mm.

4.9 Descriptions, terminology and designation of axes

Vertical turning machines and vertical turning centres can be generally classified into two further groups:

Type A: Machine with single column (Fig. 1.1).

Type B: Machine with dual columns (Fig. 1.2).

Fixed columns (bridge) – Portal type

Movable columns (bridge) – Gantry type

4.9.1 Type A: Machine with single column

Generally the table/chuck is mounted on the base, but sometimes it can be mounted on the saddle and moved horizontally on the base. The work spindle axis is vertical.

On the vertical turning machines, turret(s) hold stationary tools. On the vertical turning centres, turret(s) hold both stationary tools and power driven tools. The turret(s) are mounted on the turret slide fixed / moved vertically on the turret railhead of the column. The turret railhead is moved horizontally on the cross rail fixed on the column. In some cases, there are also independent tool spindle(s) for rotary tools and stationary tools mounted on railhead ram which is moved vertically in the railhead. In such cases, a tool exchanger and a tool magazine may also be required. Sometime, horizontal side head rams are equipped on the right side column and moved horizontally in the side head which is moved vertically on the column.

Typical example of type A is shown in Table 2 with some example of axes symbols for the direction of motions. These directions of motions are defined by ISO 841.

4.9.2 Type B: Machine with dual columns (bridge)

Generally the table/chucking is mounted on the base, sometime on the saddle or the table moved horizontally on the base. The work spindle axis is vertical.

On the vertical turning machines, turret(s) hold stationary tools. On the vertical turning centres, turret(s) hold both stationary tools and power driven tools. The turret(s) are mounted on the railhead(s) fixed / moved horizontally on the cross rail. The cross rail is fixed/moved vertically on the column. In some cases, there are also independent tool spindle(s) for rotary tools and stationary tools mounted on railhead ram which is moved vertically in the railhead. In such cases a tool exchanger and a tool magazine may also be required. Sometime, horizontal side head rams are equipped on the right side column and moved horizontally in the side head which is moved vertically on the column.

This machine is divided into two types based on the (1) fixed columns (bridge) (2) movable column (bridge). These types are (1) portal type, (2) gantry type.

(1) Portal type: This type has two columns fixed on the base face, across the table/chuck which is mounted on the base. The cross rail is either fixed or moved vertically on these columns supports the railhead which is moved horizontally on the cross rail. The turret head moves vertically on the railhead ram. Sometime a side head ram is either fixed or moved vertically on the column, supports the tool turret which is moved horizontally.

The other of this type is two columns fixed on the base face each other across the table/chuck which is mounted on the table which is moved horizontally on the base. The cross rail fixed / moved vertically on these columns supports the railhead moved horizontally on the cross rail. The turret head moves vertically on the railhead ram. Sometime a side head ram fixed / moved vertically on the column supports the tool turret which is moved horizontally.

(2) Gantry type: Two columns are moved horizontally on the base face across the table which is mounted on the base. The cross rail fixed / moved vertically on these columns supports the rail head moved horizontally on the cross rail. The turret head ram moves vertically on the rail head ram.

Sometimes a side head ram which is fixed / moved vertically on the column supports the tool turret which is moved horizontally.

Typical example of Type B is shown respectively in Table 2 with some examples of axes symbols for the direction of motions. These directions of motions are defined by ISO 841.

4.10 Linear motions

For simplicity, all the machine examples shown in Table 2 use the axis designation of a letter and a number (e.g. X, X1, X2….) as defined in Section 6.1 of ISO 841. In all examples the use of the letters U, V, or W could be substituted.

4.11 Turrets

As already explained in 3.1, 3.2 and 3.4 vertical turning centres have not only stationary tools but also power driven rotary tools which are located on the turret and/or the rail head rum. When the number of tools expected to be used exceeds the capacity of the turret, an automatic change of tools in turret, or a change of turret, may be provided. An automatic tool change device may also be required in cases of power driven spindles in which the tool can be automatically set. The typical settings of turret are two types, the one is the turret mounted on the turret slide parallel to the work spindle axis, the other is the turret mounted on swivel head.

4.12 Machine size category

The machines are classified into three categories, on the basis of the criteria specified in Table 1.

Table 1 - Category of machine size

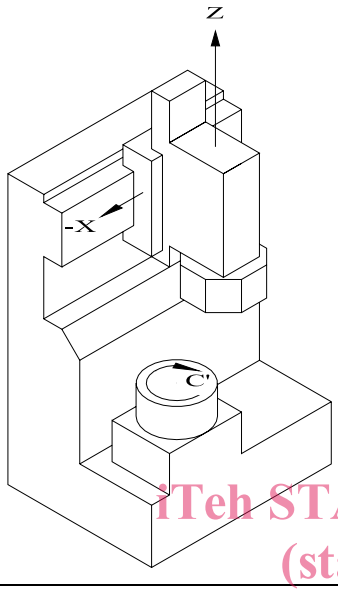
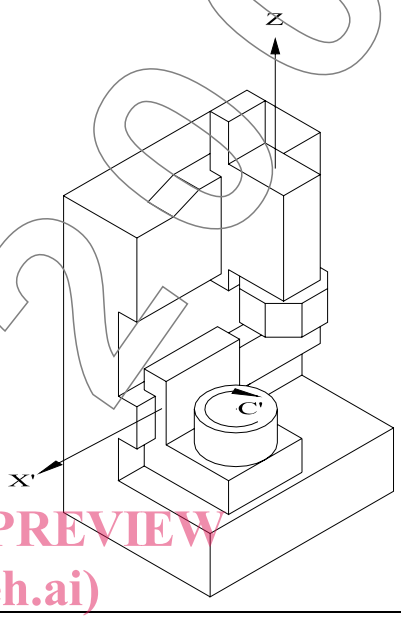
Criteria	Category 1	Category 2	Category 3	Category 4
Nominal chuck diameter	$d \leq 500$	$500 < d \leq 1000$	$1000 < d \leq 5000$	$5000 < d$
Diameter of turn table	$d \leq 500$	$500 < d \leq 1000$	$1000 < d \leq 5000$	$5000 < d$

NOTE 1 - Nominal chuck diameter is defined in ISO 3442.

NOTE 2 - The choice of the criteria is at the manufacturer's discretion.

Table 2 – Examples of machine Configurations

Table 2.1 – Single column machines

Compound head type	Shared motion (moving table saddle) type
	
Compound table type	**Shared motion (moving head saddle) type**