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Industrial automation systems and integration - Physical device control- Data model for Computerised Numerical Controllers

Part 121:

TOOLS FOR TURNING

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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.

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Attention is drawn to the possibility that some of the elements of this part of ISO 14649 may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

International Standard ISO 14649-12 was prepared by Technical Committee ISO/TC 184, *Industrial automation systems and integration*, Subcommittee SC 1, *Physical device control*.

ISO 14649 consists of the following parts, under the general title

Data model for Computerized Numerical Controllers

- Part 1: *Overview and fundamental principles, published as actual DIS Phase 1*
- Part 2: *Language bindings, Fundamentals, will be published as Phase 3*
- Part 3: *Language binding in Java, will be published as Phase 3*
- Part 9: *Glossary, will be published as Phase 3*
- Part 10: *General Process Data, published as actual DIS Phase 1*
- Part 11: *Process Data for Milling, published as actual DIS Phase 1*
- Part 12: *Process Data for Turning, will be published as Phase 3*
- Part 13: *Process Data for EDM, will be published as Phase 3*
- Part 50: *AIM of General Process Data, will be published as Phase 2 as AP238*
- Part 51: *AIM of Process Data for Milling, will be published as Phase 2 as AP238*
- Part 52: *AIM of Process Data for Turning, will be published as Phase 3 as AP238*
- Part 53: *AIM of Process Data for EDM, will be published as Phase 3 as AP238*
- Part 111: *Tools for Milling, published as actual DIS Phase 1*
- Part 121: *Tools for Turning, will be published as Phase 3*

Introduction

This schema serves as a basic tool schema including just the most important information. It is intended to give the controller enough information to select the tool specified in the NC-program for turning.

In ISO 6983, the tool is defined just with its number (e.g. T8). No further information concerning the tool type or geometry is given. This information is part of the tool set-up sheet, which is supplied with the NC-program to the machine. The tool set-up sheet gives the relationship between the tool location and the type of tool.

The approach of this tool sheet to ISO 14649-121 is to include the information which is contained in the tool set-up sheet mentioned above in the NC program for turning. Therefore, the most important information which needs to be included in the tool description is:

- Type of the tool body
- Geometry of the tool body.
- Type of the indexable insert,
- Geometry of the indexable insert,
- Expected tool life
- Geometry of the tool body assembly component

The tool schema does not include information which is part of the tool database. The tool database is related to the machine and the tools themselves but independent of the NC program. This means that data like the following data types are not included in the tool schema :

- normative tool life,
- tool location in the tool changer.

It is important to understand that all length measure types used in this part are not toleranced length measure types because they are used to describe the tools **required** for the manufacturing of a workpiece, not the actual dimensions of the tools available at the machine. A real tool must be selected by the tool management based on the actual tool dimensions and the tolerances of features.

The overall structure of the tool description in this part and part 10 of this standard is the same with ISO/DIS 13399. Many definitions of tool body and it's geometry are referenced from the ISO/DIS 13399-3, ISO/DIS 13399-4.

Industrial automation systems and integration — Physical device control — Data model for Computerised Numerical Controllers — Part 121: Tools for Turning

1 Scope

This part of ISO 14649 specifies the data elements needed as tools for turning. They work together with Part 12 of the same standard, the process data for turning. These data elements can be used as a criteria to select one of several turning and boring type tools.

Therefore, leaving out optional attributes gives the controller more freedom to select from a larger set of tools. The NC controller is assumed to can access the complete description of specific tools in a database.

The scope of this part of ISO 14649 does not include tools for any other technologies, like milling, grinding, contour cutting, or EDM. Tools for these technologies will be described in further parts of this standard.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of ISO 14649.

ISO 14649 Part10: Data model for computerised numerical controllers: General process data.

ISO 10303 Part111: Industrial automation systems and integration: Tools for milling.

ISO/DIS 13399 Part1: Cutting tool data representation and exchange: Overview and fundamental principles.

ISO/DIS 13399 Part2: Cutting tool data representation and exchange: Reference hierarchy for cutting tools.

ISO/DIS 13399 Part3: Cutting tool data representation and exchange: General data for cutting tools.

ISO/DIS 13399 Part3: Cutting tool data representation and exchange: General data for turning tools.

3 Terms and definitions

3.1 Cutting tool

A tool used in machining or chip removal operations to remove workpiece material through a shearing action at the cutting edge(s) of the tool [ISO/DIS 13399-2, Table 1]

3.2 Cutting component

The portion or portions of the cutting tool that perform the chip-forming operations. The cutting component refers to either the fixed cutting edges on solid or brazed tools or the inserts that are mounted on the cutting tool. [ISO/DIS 13399-2, Table 5]

3.3 Tool body

The part of a cutting tool which holds the cutting blades or inserts, or on which are formed the cutting edges, as defined in 3.2.1 of ISO 3002-1:1982. The tool body is driven or held by the machine tool through either an integral shank(i.e., shank_mount) or by being mounted on an arbor. [ISO/DIS 13399-2, Table 2]

3.4 Boring tool

A cutting tool with a round shank used to machine internal profiles, such as enlarging or finishing internal holes coaxial with the tool axis. Boring tool may have a single or multiple cutting points. And, it may be used as a rotating or stationary cutting tool. [ISO/DIS 13399-2, Table 2]

4 Symbols (and abbreviated terms)

No symbols defined in this part.

5 Tools for turning

5.1 Header and references

The following gives the header for this schema and the list of types and entities which are referenced within this schema.

```

SCHEMA turning_tool_schema;

( *
  Version : 01
  Date    : 04.22.2001
  Author   : ISO TC184/SC1/WG7
  Contact  : Suk-Hwan Suh (shs@postech.ac.kr) or
            Heusinger (stefan.heusinger@isw.uni-stuttgart.de)
*)

( * ***** *)
( * Types from machining_schema          ISO 14649-10      *)
( * ***** *)
REFERENCE FROM machining_schema (
  Direction,
  label,
  length_measure,
  machining_tool,
  material,
  plane_angle_measure,
  time_measure);

( * ***** *)
( * Types from turning_schema            ISO 14649-12      *)
( * ***** *)
REFERENCE FROM turning_schema (
  turning_technology);

```

5.2 Turning tool

Entity to describe a turning tool as such. It is a subtype of the entity `machining_tool` (not `cutting_tool`) defined in Part 10 of this standard. A turning tool consists of the turning tool body, turning cutting component, and assembly component. The optional `its_technology` attribute connects the tool with a machining technology.

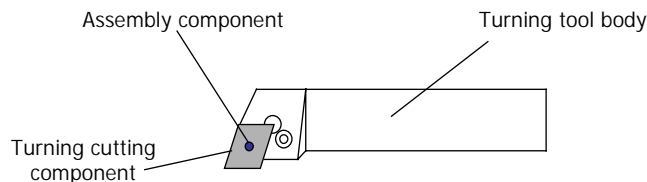


Fig. 1: Turning tool

```

ENTITY turning_tool;
  ID:
    its_tool_body:      turning_tool_body;
  label;

```



```

its_cutting_component:    LIST [0:?] OF turning_cutting_component;
its_assembly_component:  assembly_component;
tool_offset_length:      LIST [1:?] OF length_measure;
overall_assembly_length: OPTIONAL length_measure;
direction_for_spindle_orientation: OPTIONAL direction;
tool_holder_diameter_for_spindle_orientation: OPTIONAL length_measure;
its_technology:          OPTIONAL turning_technology;
expected_tool_life:      OPTIONAL time_measure;
END_ENTITY;

```

ID :	An identifier to specify a specific instance of a turning tool.
its_tool_body :	The information describing the kind of turning tool and it's corresponding characteristics.
its_cutting_component :	This attribute describing the cutting component(s) of the turning tool.
its_assembly_component :	This attribute describing the assembly component(s) of the turning tool.
tool_offset_length :	The measured distance form the turning tip(s) to a designated standard reference point on the tool holding assembly for tool presetting.
overall_assembly_length :	The entire length of the assembly tooling measured along the tooling axis for tool collision check.
direction_for_spindle_orientation :	The direction of spindle orientation for a specific tool.
tool_holder_diameter_for_spindle_orientation :	The diameter of the tool holder.
its_technology :	The attribute defines the spindle speed and the feed of the tool which guarantee expected_tool_life.
expected_tool_life :	The expected number of hours that a given cutting tool can be used before tool wear significantly impacts the performance parameters. This value will also be dependent on a number of external factors, including workpiece material, desired part tolerances, and selected cutting parameters.

5.2.1 Turning tool body

This is the abstract base class for all types of turning tool bodies. These types consist of main tool body and tool body assembly component.



Fig. 2: Turning tool body

```

ENTITY turning_tool_body
  ABSTRACT SUPERTYPE OF (ONEOF(solid_turning_tool, insertable_turning_tool,
    solid_boring_bar, insertable_boring_bar, tool_body_assembly_component,
    catalogue_knurling_tool));
  its_tool_body_length : length_measure;
  mininum_bore_diameter : length_measure;
  its_shank_style: shank_type;
  vibration_damping : BOOLEAN ;
END_ENTITY;

```

its_tool_body_length:	The attribute defines overall length of tool body.
minimum_bore_diameter :	The minimum size hole that the boring tool can cut. This attribute is equivalent to the cutting diameter for a fixed diameter bore.
its_shank_style :	The attribute defines styles of tool body shank.
vibration_damping :	The attribute defines which the tool is specially constructed to dampen vibrations.

5.2.1.1 Shank type

The entity define types of tool body shank. This type has three types; round, rectangle, tapered.

```
ENTITY shank_type
  ABSTRACT SUPERTYPE OF (ONEOF(round, rectangle, tapered));
  shank_height: length_measure;
  shank_width : length_measure;
END_ENTITY;
```

shank_height : The attribute defines height of shank.

shank_width : The attribute defines width of shank.

5.2.1.1.1 Round

This entity describes round type of shank.

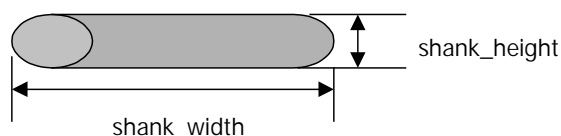


Fig. 3: Round

```
ENTITY round
  SUBTYPE OF (shank_type);
END_ENTITY;
```

5.2.1.1.2 Rectangle

This entity describes rectangle type of shank.

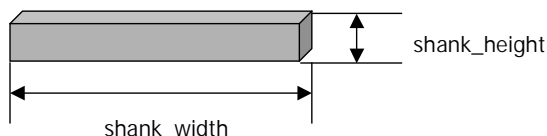


Fig. 4: Rectangle

```
ENTITY rectangle
  SUBTYPE OF (shank_type);
END_ENTITY;
```

5.2.1.1.3 Tapered

This entity describes tapered type of shank.

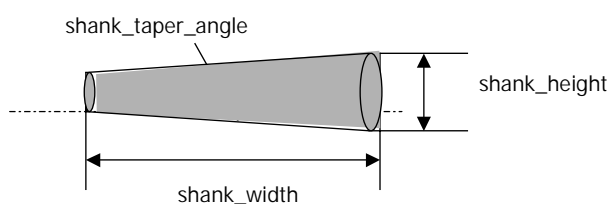


Fig. 5: Tapered

```
ENTITY tapered
  SUBTYPE OF (shank_type);
  shank_taper_angle : plane_angle_measure;
END_ENTITY;
```

shank_taper_angle : The attribute defines taper angle.

5.2.1.2 Solid turning tool

This type describes the solid tool which means one body with turning tool body, assembly component and turning cutting component. Turning cutting component information of solid turning tool is described in solid_tool_edge.

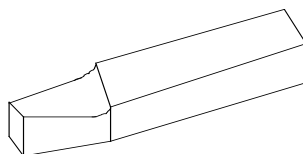


Fig. 6: Solid turning tool

```
ENTITY solid_turning_tool
  SUBTYPE OF (turning_tool_body);
END_ENTITY;
```

5.2.1.3 Insertable turning tool

This entity describe turning tool body which must have insert for machining.

```
ENTITY insertable_turning_tool
  SUBTYPE OF (turning_tool_body);
  head_length: OPTIONAL length_measure;
END_ENTITY;
```

head_length : The nominal distance measured along the axis from the back end of the boring bar head to the specified point of the cutting.

5.2.1.4 Solid boring bar

This entity describes the tool body of solid boring bar.

```
ENTITY solid_boring_bar
  SUBTYPE OF (turning_tool_body);
END_ENTITY;
```

5.2.1.5 Insertable boring bar

This entity describes insertable boring bar

```
ENTITY insertable_boring_bar
  SUBTYPE OF (turning_tool_body);
  head_length: OPTIONAL length_measure;
END_ENTITY;
```

head_length : The nominal distance measured along the axis from the back end of the boring bar head to the specified point of the cutting.

5.2.1.6 Tool body assembly component

This is the abstract base class for tool body assembly component for turning tool.

```
ENTITY tool_body_assembly_component
  ABSTRACT SUPERTYPE OF (ONEOF(tool_blade))
  SUBTYPE OF (turning_tool_body);
  its_material: OPTIONAL material;
END_ENTITY;
```

its_material : The identification of the material composing the tool body assembly component.

5.2.1.6.1 Tool blade

This entity describes the tool blade for machining and parting (cut-off).

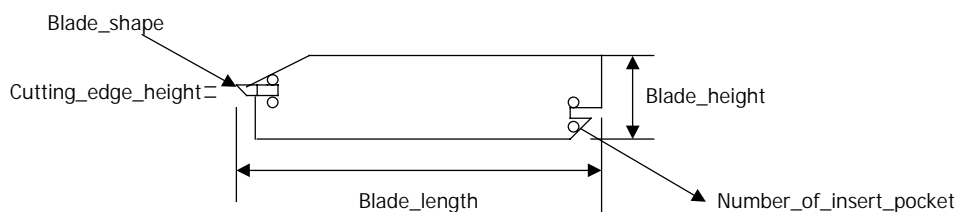


Fig. 7: Tool blade

```
ENTITY tool_blade
  SUBTYPE OF (tool_body_assembly_component);
  blade_width : length_measure;
  blade_length : length_measure;
  blade_height : length_measure;
  cutting_edge_height : length_measure;
  blade_shape : insert_shape;
  number_of_insert_pocket : OPTIONAL INTEGER;
```

END_ENTITY;

blade_width :	The width measurement of the tool blade. Also known as blade thickness.
blade_length :	The length measurement of the tool blade.
blade_height :	The overall height measurement of the tool blade form base to the top surface.
cutting_edge_component :	The nominal distance from the base of the tool blade to the accepted specified point of the cutting edge.
blade_shape :	This attribute describes insert shape.
number_of_insert_pocket :	The number of insert pockets on the tool blade. Some tool blades are manufactured with insert pockets on both ends thereby decreasing tool changes time.

5.2.1.7 Catalogue knurling tool

This entity describe user defined turning tool

```
ENTITY catalogue_knurling_tool
  SUBTYPE OF (turning_tool_body);
  its_id:          STRING;
END_ENTITY;
```

its_id : This attribute describes an identifier to specify instance of a user defined turning tool.

5.2.2 Turning cutting component

This entity describes the name of the material composing the cutting edge of a solid tool or the insert and it's technological data.

```
ENTITY turning_cutting_component
  ABSTRACT SUPERTYPE OF (ONEOF(solid_tool_edge, cutting_insert));
  its_material          :          OPTIONAL material;
  corner_radius         :          OPTIONAL length_measure;
  chamfered_corner_length :          OPTIONAL length_measure;
  chamfered_corner_angle :          OPTIONAL plane_angle_measure;
END_ENTITY;
```

its_material :	The identification of the material composing the cutting edge of a solid tool or the insert (Examples: The attribute material identifier of the entity material can be High speed steel (HSS), Carbide, or Polycrystalline diamond(PCD)) [ISO/DIS 13399-3 , Table 8].
corner_radius :	The nominal radius of a rounded corner measured in the cutting component reference plane.
chamfered_corner_length :	The nominal length of a chamfered corner measured in the cutting component reference plane.

number_of_insert_pocket : The nominal angle between a chamfered corner and the minor cutting edge measured in the cutting component reference plane.

5.2.2.1 Solid tool edge

The entity describes information of tool edge in solid turning tool.

```
ENTITY solid_tool_edge
  SUBTYPE OF (turning_cutting_component);
  cutting_edge_length : length_measure;
END_ENTITY;
```

cutting_edge_length : The attribute describes length of cutting edge.

5.2.2.2 Cutting insert

The entity describes cutting insert.

```
ENTITY cutting_insert
  ABSTRACT SUPERTYPE OF (ONEOF(simple_shape_insert, irregular_shape_insert))
  SUBTYPE OF (turning_cutting_component);
  number_of_faces_with_chipbreakers      : OPTIONAL length_measure;
  major_cutting_edge_normal_clearance    : OPTIONAL plane_angle_measure;
  minor_cutting_edge_normal_clearance    : OPTIONAL plane_angle_measure;
  insert_normal_rake                     : OPTIONAL length_measure;
  hand_of_insert                         : hand_of_tool;
  cutting_edge_condition                  : cutting_edge_type;
  number_of_cutting_edge                  : OPTIONAL INTEGER;
END_ENTITY;
```

number_of_faces_with_chipbreakers : The number of insert faces that have chip breakers designed into the surface.

major_cutting_edge_normal_clearance :

The angle between the flank and the major cutting edge plane measured in the cutting edge normal plane.

minor_cutting_edge_normal_clearance :

The angle between the flank and the minor cutting edge plane measured in the cutting edge normal plane.

insert_normal_rake : The angle between the face and the insert reference plane measured in the cutting edge normal plane.

hand_of_insert : The intended feed direction of the insert as viewed from the insert cutting edge. For special case, such as for grooving or parting insert, the hand of the insert depends on its shape.

cutting_edge_condition : Geometric description of the insert cutting edge.

number_of_cutting_edge : The number of cutting edges on one or both sides per insert.

5.2.2.2.1 Hand of tool

This type offer 3 different types to describe hand of turning tool.

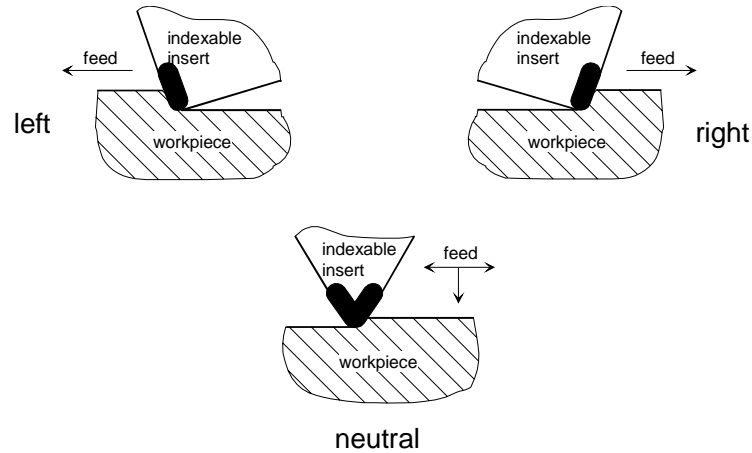


Fig. 8: Hand of tool

```
TYPE hand_of_tool = select(left,right,neutral);
END_TYPE;
```

5.2.2.2.2 Cutting edge type

This type describes geometric description of the insert cutting edge; sharp, rounded, chamfered, chamfered and rounded.



Fig. 9: Cutting edge type

```
TYPE cutting_edge_type = ENUMERATION OF
  (rounded,sharp,chamfered,chamfered_and_rounded);
END_TYPE;
```

5.2.2.3 Simple shape insert

This entity describe the simple shape insert.

```
ENTITY simple_shape_insert
  SUBTYPE OF (cutting_insert);
  its_insert_shape          : insert_shape ;
  cutting_edge_length      : length_measure;
  included_angle           : plane_angle_measure;
```

```

ISO_code          :      lable;
simple_shape_insert_length :      length_measure;
simple_shape_insert_thickness :      length_measure;
tolerance_class    :      lable;
END_ENTITY;

```

its_insert_shape : Geometric description of the shape of the insert face.

cutting_edge_length : Length measured along the longest major cutting edge to theoretical sharp corners.
For round inserts, the value given is equal to the inscribed circle diameter.

included_angle : The size of the largest circle that can be constructed within the insert as viewed from the face.

ISO_code : A designation for the insert specified by the ISO standards organization.

simple_shape_insert_length : The nominal distance measured between the two planar surfaces of the insert's longer sides.

simple_shape_insert_thickness :

Distance between the cutting edge of the corner and the opposing supporting surface of the insert.

tolerance_class : Letter symbol specifying for the insert specified by a standards organization.

5.2.2.3.1 Insert shape

This type offer 11 different entities to describe insert geometry based on ISO 13399 Part 4.












Insert type	form
Square	
Triangle	
Diamond	
Parallelogram	
Hexagon	
Octagon	
Pentagon	
Trigon	
Rectangle	
Round	
trapezodial	

Fig. 10: Insert shape


```

TYPE insert_shape = ENUMERATIOIN OF(square, triangle, diamond, parallelogram,
    hexagon, octagon, pentagon, trigon, rectangle, round, trapezodial);
END_TYPE;

```

5.2.2.4 Irregular shape insert

This entity describe the irregular shape insert.

```

ENTITY irregular_shape_insert
  ABSTRACT SUPERTYPE OF (ONEOF(irregular_shape_insert,
    irregular_shape_threading_insert ) )
  SUBTYPE OF (cutting_insert);
  irregular_shape_insert_width      : length_measure;
  irregular_shape_insert_length     : length_measure;
  irregular_shape_insert_thickness : length_measure;
END_ENTITY;

```

irregular_shape_insert_width : The overall width specification.

irregular_shape_insert_length : The overall length specification.

irregular_shape_insert_thickness : The overall thickness specification.

5.2.2.4.1 Irregular shape threading insert

This entity describes the irregular shape threading insert.

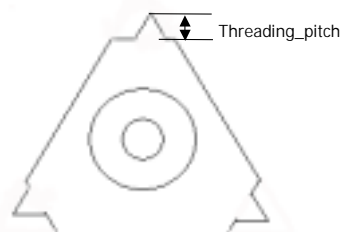


Fig. 11: Irregular shape threading insert

```

ENTITY irregular_shape_threading_insert
  SUBTYPE OF (irregular_shape_insert);
  number_of_teeth_per_cutting_edge : INTERGER;
  thread_pitch                     : OPTIONAL length_measure;
  minimum_thread_pitch             : OPTIONAL length_measure;
  maximum_thread_pitch             : OPTIONAL length_measure;
  hand_of_thread                   : hand_of_tool;
END_ENTITY;

```

number_of_teeth_per_cutting_edge :

The number of thread teeth per cutting edge on the insert.

thread_pitch :	The value for the distance between corresponding points on adjacent threads, measured parallel with the thread axis.
minimum_thread_pitch :	The minimum value for the distance between corresponding points on adjacent threads, measured parallel with the thread axis.
maximum_thread_pitch :	The maximum value for the distance between corresponding points on adjacent threads, measured parallel with the thread axis.
hand_of_thread :	Indication of the hand of thread created by insert. A thread is right-handed if when viewed axially, it winds in a clockwise and receding direction.

5.2.2.4.2 Irregular shape parting grooving insert

This entity describes the irregular shape parting grooving insert.

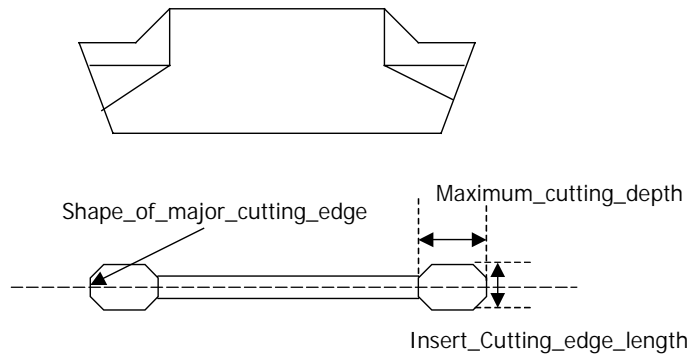


Fig. 12: Irregular shape parting grooving insert

```

ENTITY irregular_shape_parting_grooving_insert
  SUBTYPE OF (irregular_shape_insert);
  maximum_insert_cut_depth      : length_measure;
  insert_cutting_edge_width     : length_measure;
  angle_of_main_cutting_edge    : plane_angle_measure;
  its_shape_of_main_cutting_edge : shape_of_main_cutting_edge;
  groove_profile_angle          : plane_angle_measure;
END_ENTITY;

```

maximum_insert_cut_depth : The maximum value for the depth of the groove that can be achieved with the insert.

insert_cutting_edge_width : The width of insert at cutting edge.

angle_of_main_cutting_edge: The angle measured between a plane which is positioned perpendicular to the grooving or parting direction and the main cutting edge.

its_shape_of_main_cutting_edge :

A description of the shape of main cutting edge.

Groove_profile_angle : Angle of the groove profile created by this insert measured between the two flanks.

5.2.2.4.2.1 Shape of main cutting edge

This type offer 3 different instances to describe shape of main cutting edge in irregular shape parting grooving insert.

```
TYPE shape_of_main_cutting_edge = ENUMERARION OF(straight,profiled,circular);
END_TYPE;
```

5.2.3 Assembly component

This entity describe assembly component to combine turning tool component and turning tool body.

```
ENTITY assembly_component;
    fixing:                fixing_type;
    chip_breaker:          chip_breaker_type;
END_ENTITY;
```

5.2.3.1 Fixing type

The fixing_type denotes how the turning cutting component can be fixed at the turning tool body.

```
TYPE fixing_type = ENUMERATION OF(clamp, screw, nut, fin_lever, wedge,
    shim_seat );
END_TYPE;
```

5.2.3.2 Chip breaker type

This type describes the surface of the indexable insert. If the surface is flat it has no chip breaker. Otherwise a chip breaker can be located at one side of the insert or at both sides if the insert can be turned.

```
TYPE chip_breaker_type = ENUMERATIOIN OF(none, upper_side, both_side);
END_TYPE;
```

Annex A:

EXPRESS listing

The following section shows the EXPRESS listing of Part 121: Tools for Turning.

SCHEMA turning_tool_schema;

(* Version 01 date: 01-04-30

Author : ISO TC184/SC1/WG7

Contact : Suk-Hwan Suh (shs@postech.ac.kr) or

Heusinger (stefan.heusinger@isw.uni-stuttgart.de)

*)

REFERENCE FROM machining_schema (*ISO14649-10*)

(time_measure,

plane_angle_measure,

length_measure,

material,

direction,

label);

REFERENCE FROM turning_schema (*ISO14649-12*)

(turning_technology);

(* ***** *)

(* turning tool *)

(* ***** *)

ENTITY turning_tool

SUBTYPE OF (cutting_tool);

ID: label;

its_tool_body: turning_tool_body;

its_cutting_component: LIST [0:?] OF turning_cutting_component;

```

its_assembly_component:  assembly_component;

tool_offset_length:      LIST [1:?] OF length_measure;

overall_assembly_length:  OPTIONAL length_measure;

direction_for_spindle_orientation:  OPTIONAL direction;

tool_holder_diameter_for_spindle_orientation:  OPTIONAL length_measure;

its_technology:          OPTIONAL turning_technology;

expected_tool_life:      OPTIONAL time_measure;

```

END_ENTITY;

```

(* ***** *)
(* turning tool body *)
(* ***** *)

```

ENTITY turning_tool_body

ABSTRACT SUPERTYPE OF (ONEOF(solid_turning_tool, insertable_turning_tool, solid_boring_bar, insertable_boring_bar, tool_body_assembly_component,user_defined_turning_tool));

```

Its_tool_body_length :    length_measure;

Minumum_bore_diameter :  length_measure;

Its_shank_style:         shank_type;

Vibration_damping :  BOOLEAN ;

```

END_ENTITY;

ENTITY user_defined_turning_tool

SUBTYPE OF (turning_tool_body);

```

its_id:          STRING;

```

END_ENTITY;

```

(* ***** *)
(* shank type *)
(* ***** *)

```

ENTITY shank_type

ABSTRACT SUPERTYPE OF (ONEOF(round, rectangle, tapered));

Shank_height: length_measure;

Shank_width : length_measure;

END_ENTITY;

ENTITY round

SUBTYPE OF (shank_type);

END_ENTITY;

ENTITY rectangle

SUBTYPE OF (shank_type);

END_ENTITY;

ENTITY tapered

SUBTYPE OF (shank_type);

Shank_taper_angle : plane_angle_measure;

END_ENTITY;

(* ***** *)

(* turning tool body *)

(* ***** *)

ENTITY solid_turning_tool

SUBTYPE OF (turning_tool_body);

END_ENTITY;

ENTITY insertable_turning_tool

SUBTYPE OF (turning_tool_body);

Head_length: OPTIONAL length_measure;

END_ENTITY;

ENTITY solid_boring_bar

SUBTYPE OF (turning_tool_body);

END_ENTITY;

(* ***** *)

(* insert shape *)

(* ***** *)

TYPE insert_shape = ENUMERATION OF(square, triangle, diamond, parallelogram, hexagon, octagon, pentagon, trigon, rectangle, round, trapezodial);

END_TYPE;

ENTITY insertable_boring_bar

SUBTYPE OF (turning_tool_body);

Head_length: OPTIONAL length_measure;

END_ENTITY;

(* ***** *)

(* tool body assembly component *)

(* ***** *)

ENTITY tool_body_assembly_component

ABSTRACT SUPERTYPE OF (ONEOF(tool_blade))

SUBTYPE OF (turning_tool_body);

its_material: OPTIONAL material;

END_ENTITY;

ENTITY tool_blade

SUBTYPE OF (tool_body_assembly_component);

Blade_width : length_measure;

Blade_length : length_measure;

```
Blade_height :      length_measure;

Cutting_edge_height :  length_measure;

Blade_shape :      insert_shape;

Number_of_insert_pocket : OPTIONAL INTEGER;

END_ENTITY;

TYPE hand_of_tool = ENUMERATION OF(left,right,neutral);

END_TYPE;
```

```
(* ***** *)
(* turning cutting componet *)
(* ***** *)
```

```
ENTITY turning_cutting_component

    ABSTRACT SUPERTYPE OF (ONEOF(solid_tool_edge, cutting_insert));

    its_material:      OPTIONAL material;

    Corner_radius:     OPTIONAL length_measure;

    Chamfered_corner_length : OPTIONAL length_measure;

    Chamfered_corner_angle : OPTIONAL plane_angle_measure;

END_ENTITY;
```

```
ENTITY solid_tool_edge

    SUBTYPE OF (turning_cutting_component);

    Cutting_edge_length : length_measure;

END_ENTITY;
```

```
ENTITY cutting_insert

    ABSTRACT SUPERTYPE OF (ONEOF(simple_shape_insert, irregular_shape_insert))

    SUBTYPE OF (turning_cutting_component);

    number_of_faces_with_chipbreakers:      OPTIONAL length_measure;
```


Major_cutting_edge_normal_clearance: OPTIONAL plane_angle_measure;

Minor_cutting_edge_normal_clearance: OPTIONAL plane_angle_measure;

Insert_normal_rake: OPTIONAL length_measure;

Hand_of_insert : hand_of_tool;

Cutting_edge_condition: cutting_edge_type;

Number_of_cutting_edge : OPTIONAL INTEGER;

END_ENTITY;

TYPE cutting_edge_type = ENUMERATION OF(rounded,sharp,chamfered,chamfered_and_rounded);

END_TYPE;

ENTITY simple_shape_insert

SUBTYPE OF (cutting_insert);

Its_insert_shape : insert_shape ;

Cutting_edge_length : length_measure;

Included_angle : plane_angle_measure;

ISO_code : label;

Simple_shape_insert_length : length_measure;

Simple_shape_insert_thickness : length_measure;

Tolerance_class : STRING;

END_ENTITY;

ENTITY irregular_shape_insert

ABSTRACT SUPERTYPE OF

(ONEOF(irregular_shape_parting_grooving_insert,irregular_shape_threading_insert))

SUBTYPE OF (cutting_insert);

Irregular_shape_insert_width: length_measure;

Irregular_shape_insert_length : length_measure;

Irregular_shape_insert_thickness : length_measure;

END_ENTITY;

ENTITY irregular_shape_threading_insert

SUBTYPE OF (irregular_shape_insert);

Number_of_teeth_per_cutting_edge : INTEGER;

Thread_pitch : OPTIONAL length_measure;

Minimum_thread_pitch : OPTIONAL length_measure;

Maximum_thread_pitch : OPTIONAL length_measure;

Hand_of_thread : hand_of_tool;

END_ENTITY;

ENTITY irregular_shape_parting_grooving_insert

SUBTYPE OF (irregular_shape_insert);

Maximum_insert_cut_depth: length_measure;

Insert_cutting_edge_width: length_measure;

Angle_of_main_cutting_edge: plane_angle_measure;

Its_Shape_of_main_cutting_edge: Shape_of_main_cutting_edge;

Groove_profile_angle: plane_angle_measure;

END_ENTITY;

TYPE shape_of_main_cutting_edge = ENUMERATION OF(straight,profiled,circular);

END_TYPE;

(* ***** *)

(* assembly component *)

(* ***** *)

ENTITY assembly_component;

its_fixing_type: fixing_type;

its_chip_breaker_type: chip_breaker_type;

END_ENTITY;

TYPE fixing_type = ENUMERATION OF (clamp, screw, nut, fin_lever, wedge, shim_seat);

END_TYPE;

TYPE chip_breaker_type = ENUMERATION OF (none, upper_side, both_side);

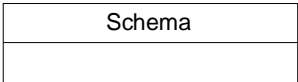
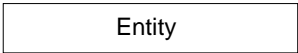
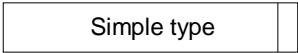

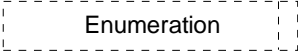
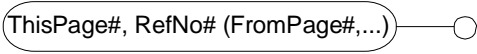
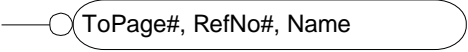



END_TYPE;

END_SCHEMA; (*turning tool schema*)

Annex B:

EXPRESS-G

The following section shows the EXPRESS-G figures of Part 121: Tools for Turning. According to the notation of EXPRESS-G the used symbols and their respective meaning are listed in brief.

	Schema name
	Entity name
	Predefined type like boolean, real, or string
	User defined types
	Enumeration like [left, right]
	Reference target from other pages. RefNo will be unique within this page.
	Refers to the page where e.g. an entity will be found.
	Relationship for attributes.
	Relationship for optional attributes.
	Relationship supertype <-> subtype (inheritance).

