

11. CNC Tooling

11.1 Cutting tool materials

11.1.1 High speed steel

11.1.2 Cemented carbides

The following guidelines would be useful for selecting a carbide grade.

1. Choose a grade with the lowest cobalt content and the finest grain size consistent with adequate strength to eliminate chipping.
2. Use straight WC grades if cratering, seizure or galling are not experienced in case of work materials other than steels.
3. To reduce cratering and abrasive wear when machining steel, use grades containing TiC.
4. For heavy cuts in steel where high temperature and high pressure deform the cutting edge plastically, use a multi carbide grade containing W-Ti-Ta and/or lower binder content.

11.1.3 Coated carbides

11.1.4 Ceramics

- €# Use the highest cutting speed recommended and preferably select square or round inserts with large nose radius.
- €# Use rigid machine with high spindle speeds and safe clamping angle.
- €# Machine rigid workpieces.
- €# Ensure adequate and uninterrupted power supply.
- €# Use negative rake angles so that less force is applied directly to the ceramic tip.
- €# The overhang of the tool holder should be kept to a minimum; not more than 1.5 times the shank thickness.

- €# Large nose radius and side cutting edge angle on the ceramic insert to reduce the tendency of chipping.
- €# Always take a deeper cut with a light feed rather than a light cut with heavy feed; ceramic tips are capable of cuts as deep as one-half the width of the cutting surface on the insert.
- €# Avoid coolants with aluminium oxide based ceramics.
- €# Review machining sequence while converting to ceramics and if possible introduce chamfer or reduce feed rate at entry.

Table 11.1 Summary of applications for various cutting tool materials

<i>Tool material</i>	<i>Work materials</i>	<i>Remarks</i>
Carbon steels	Low strength, softer materials, non ferrous alloys, plastics	Low cutting speeds, low strength materials
Low/medium alloy steels	Low strength, softer materials, non ferrous alloys, plastics	Low cutting speeds, low strength materials
HSS	All materials of low and medium strength and hardness	Low to medium cutting speeds, low to medium strength materials
Cemented carbides	All materials upto medium strength and hardness	Not suitable for low speed application
Coated carbides	Cast iron, alloy steels, stainless steels, super alloys	Not for Titanium alloys, not for non-ferrous alloys as the coated grades do not offer additional benefits over uncoated.
Ceramics	Cast iron, Ni-base super alloys, non ferrous alloys, plastics	Not for low speed operation or interrupted cutting. Not for machining Al, Ti alloys.

11.2 Turning tool geometry

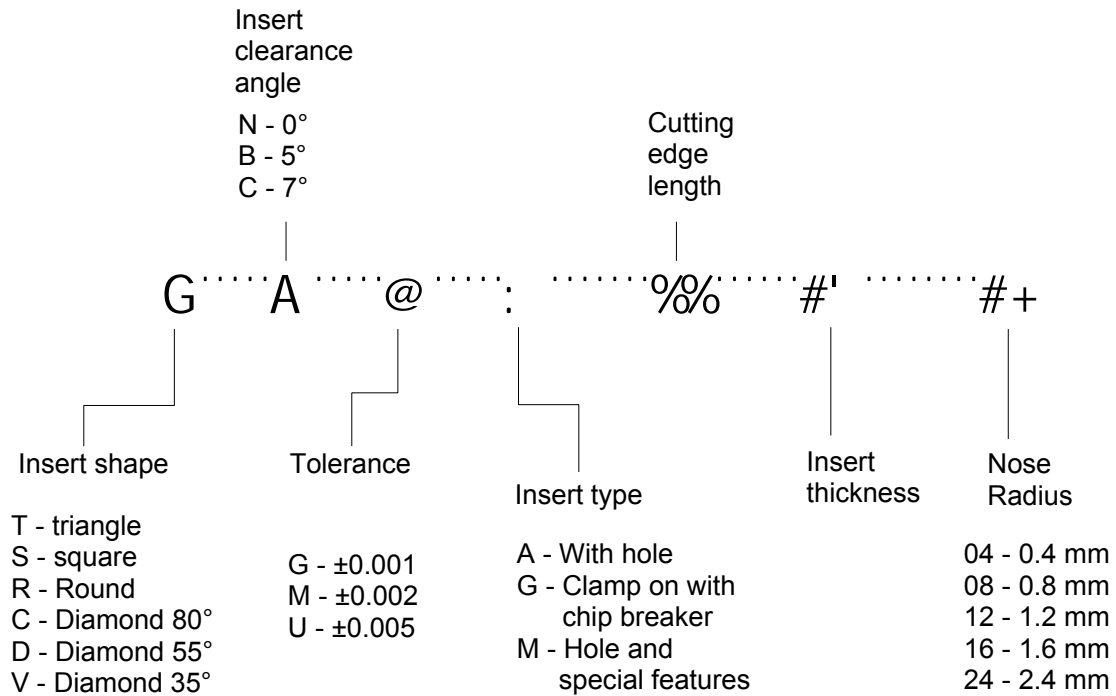


Fig. 11.1 The ISO coding system for tungsten carbide inserts used in turning.

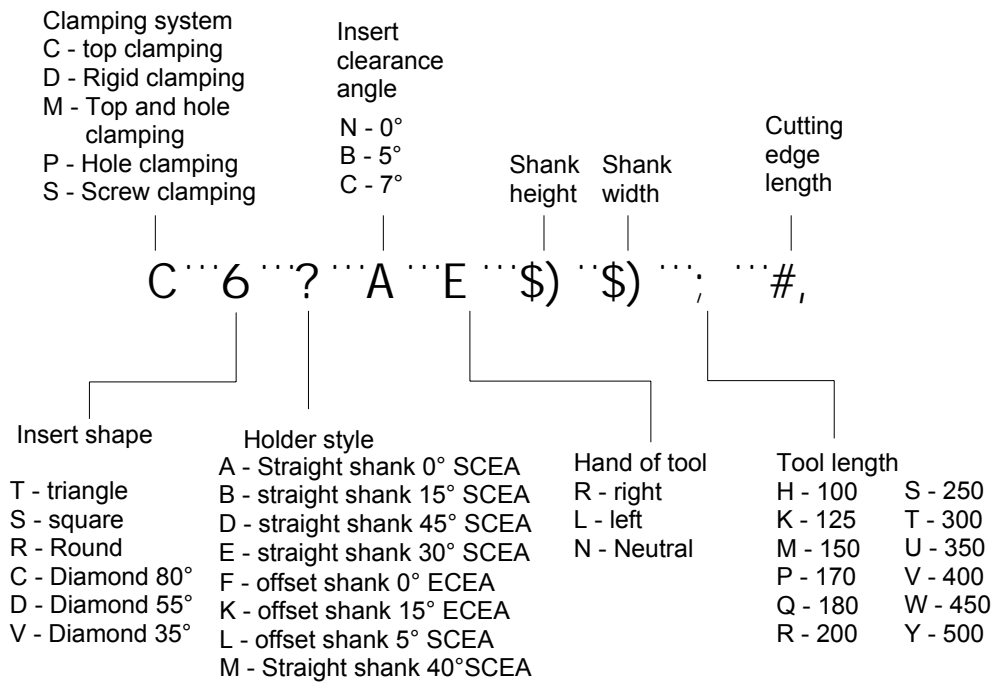


Fig. 11.2 The ISO coding system for tungsten carbide turning tool holders used in external turning (SCEA - side cutting edge angle, ECEA - end cutting edge angle).

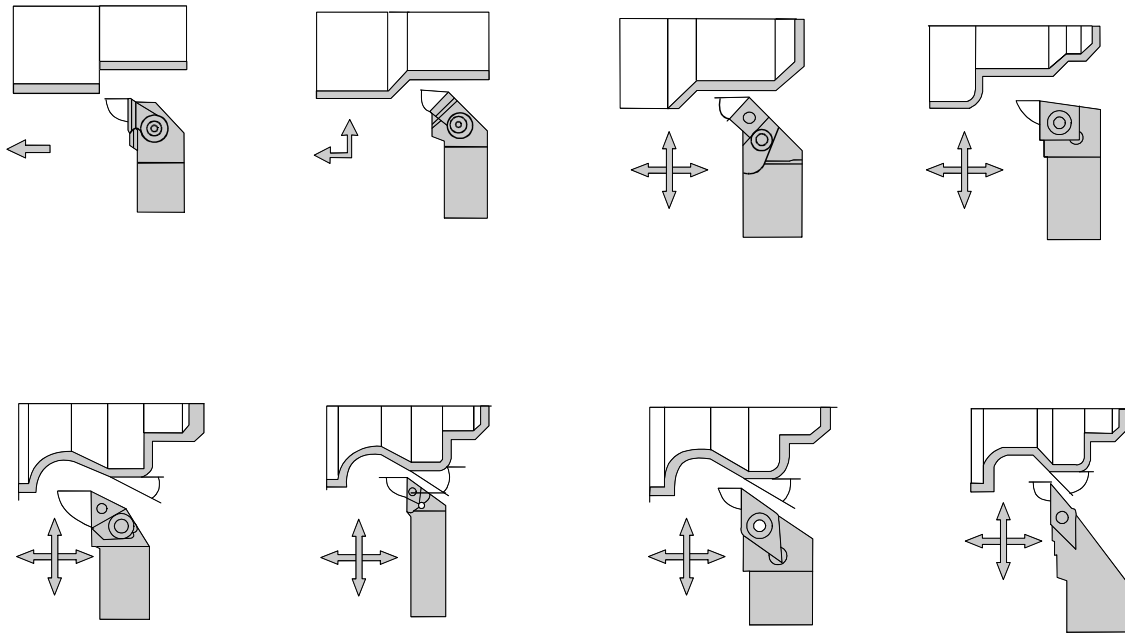


Fig. 11.3 The typical contour capability of external turning tools (Courtesy Seco Tools, Germany. Redrawn from Seco Catalogue)

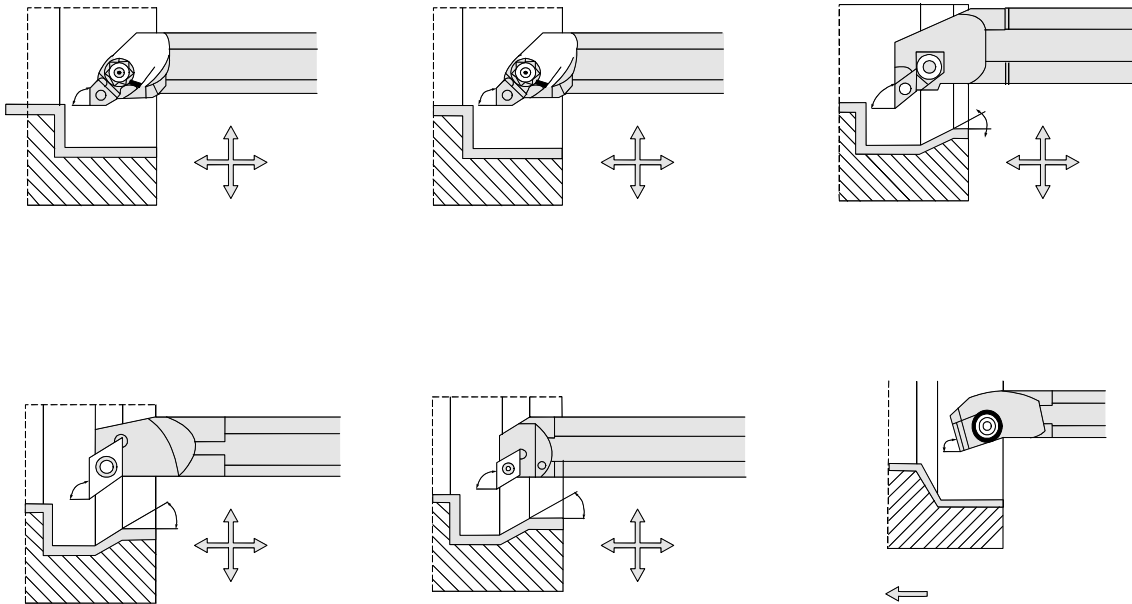


Fig. 11.4 The typical contour capability of internal turning tools (Courtesy Seco Tools, Germany. Redrawn from Seco Catalogue)

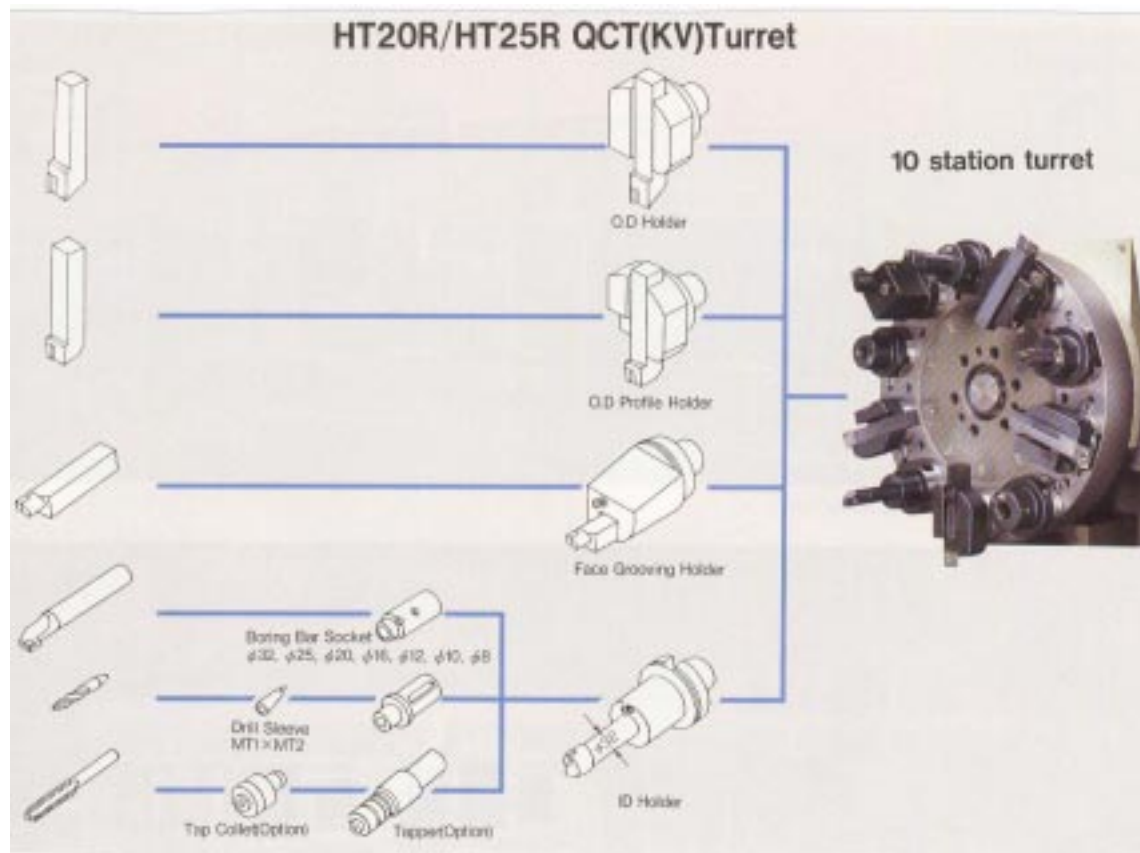


Fig. 11.5 Typical range of tooling used in turning centres
(Courtesy Hitachi Seiki, Japan)

Modular tooling systems for turning

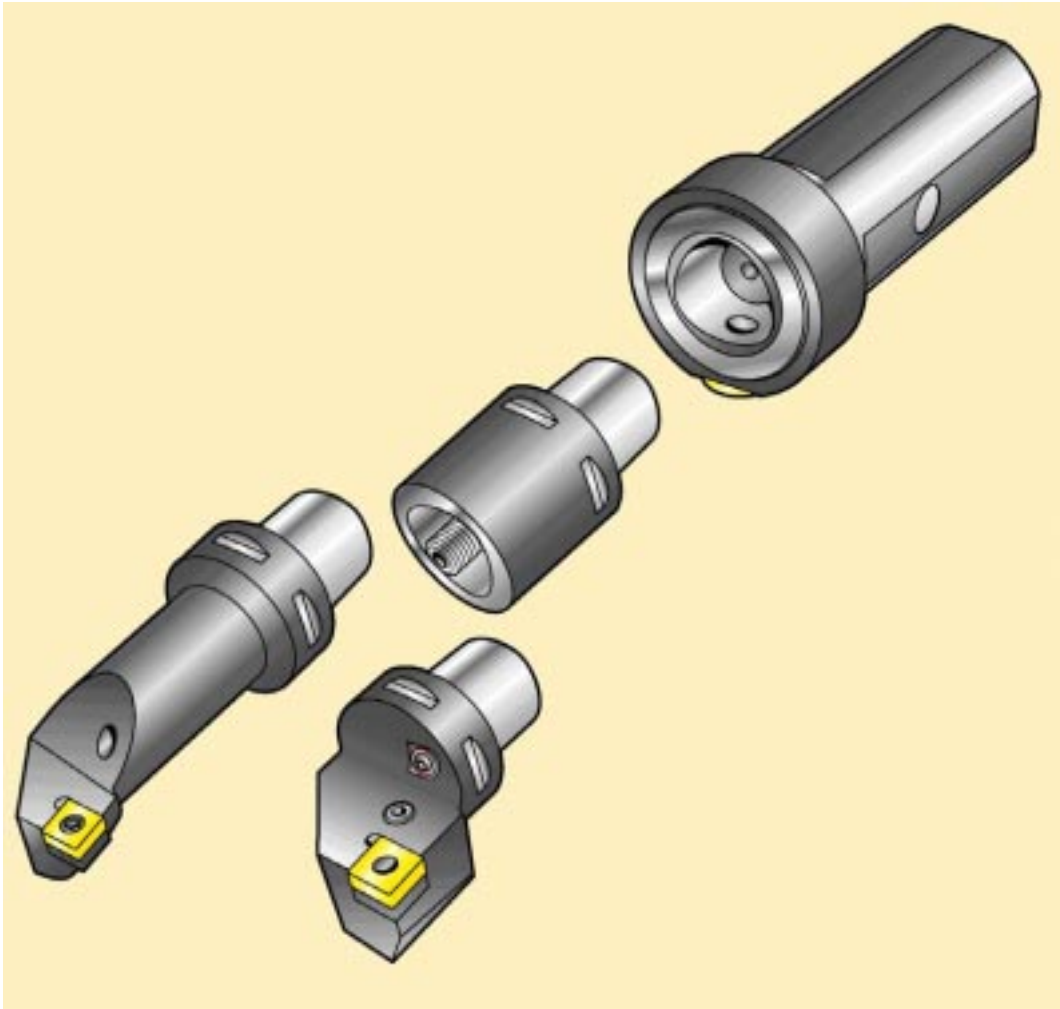


Fig. 11.6 Modular tooling used for turning tools (Courtesy Seco Tools, Sweden)

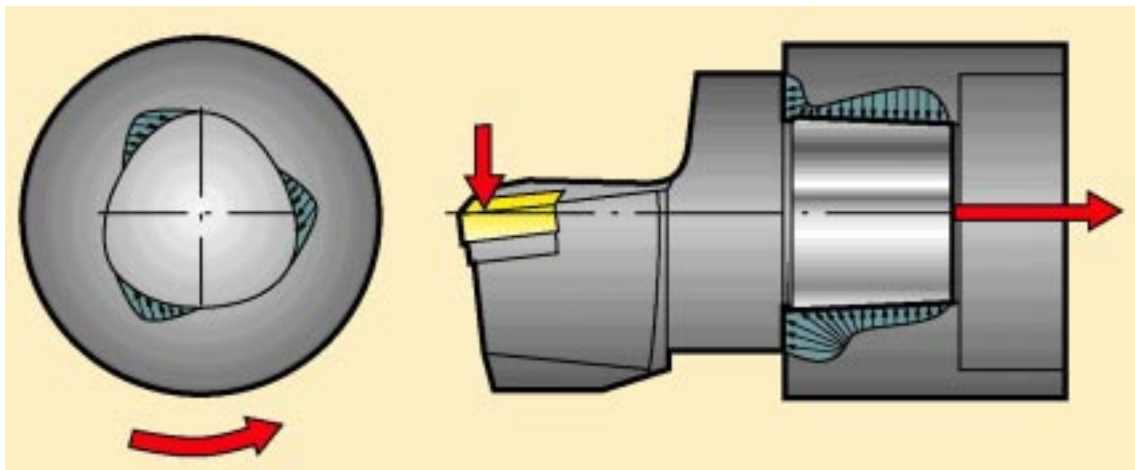


Fig. 11.7 The clamping system used in the Seco Capto® Modular tooling used for turning tools (Courtesy Seco Tools, Sweden)

11.3 Milling Tooling Systems

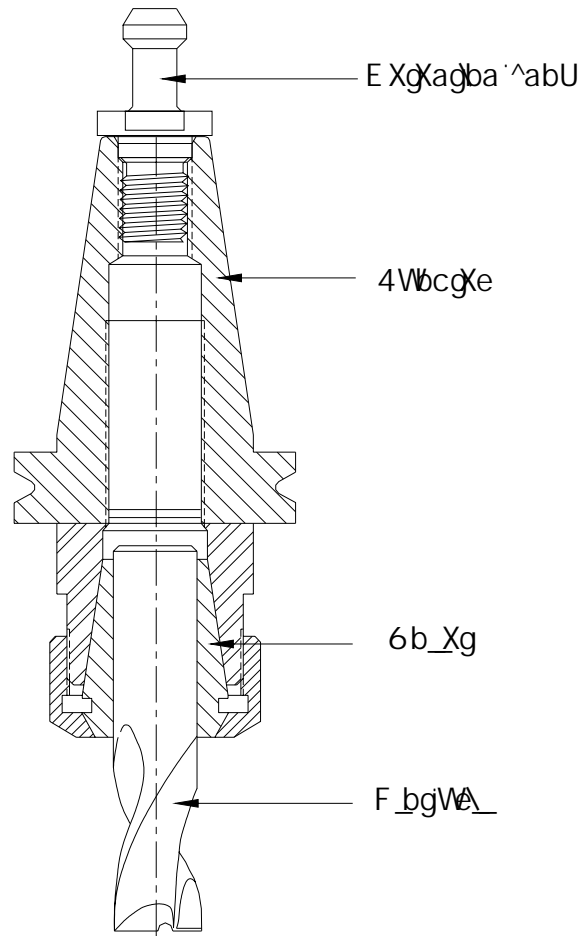


Fig. 11.8 The complete tool assembly (for parallel shank tooling) as used in a CNC machining centre.

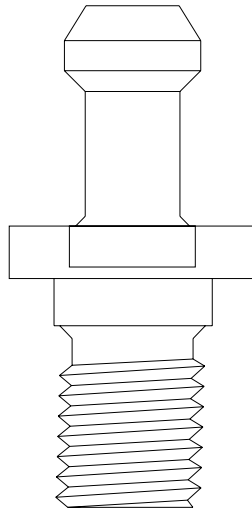


Fig. 11.9 Retention knob as used in the top of tool assembly for clamping and releasing purpose as used in a CNC machining centre.

11.4 Tool presetting

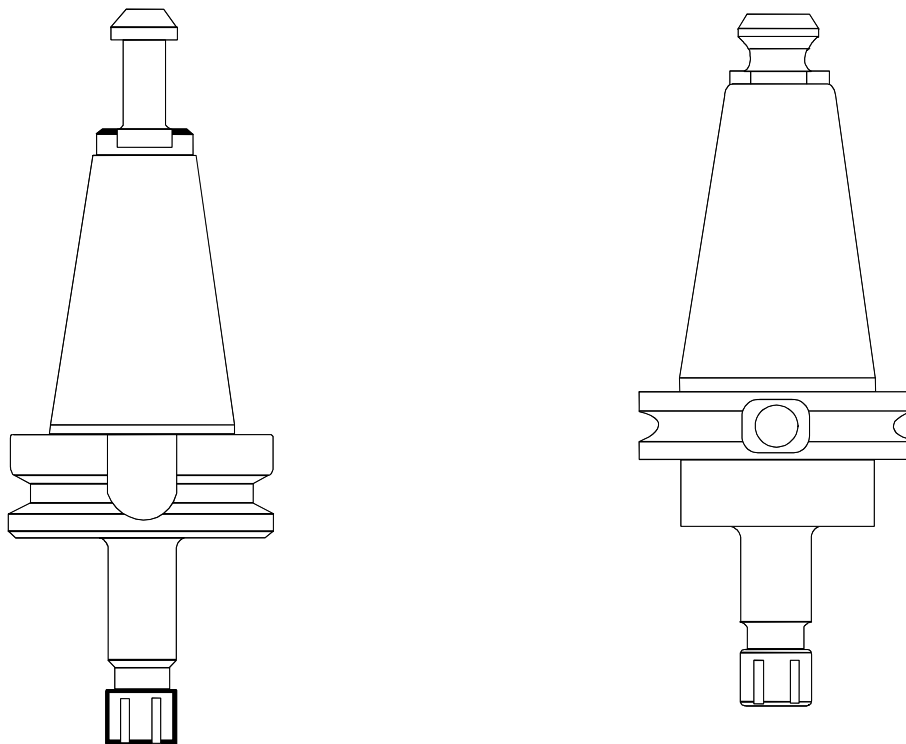


Fig. 11.10 Adapter shapes for a) BT style; b) ANSI CAT-V style for CNC machining centres.

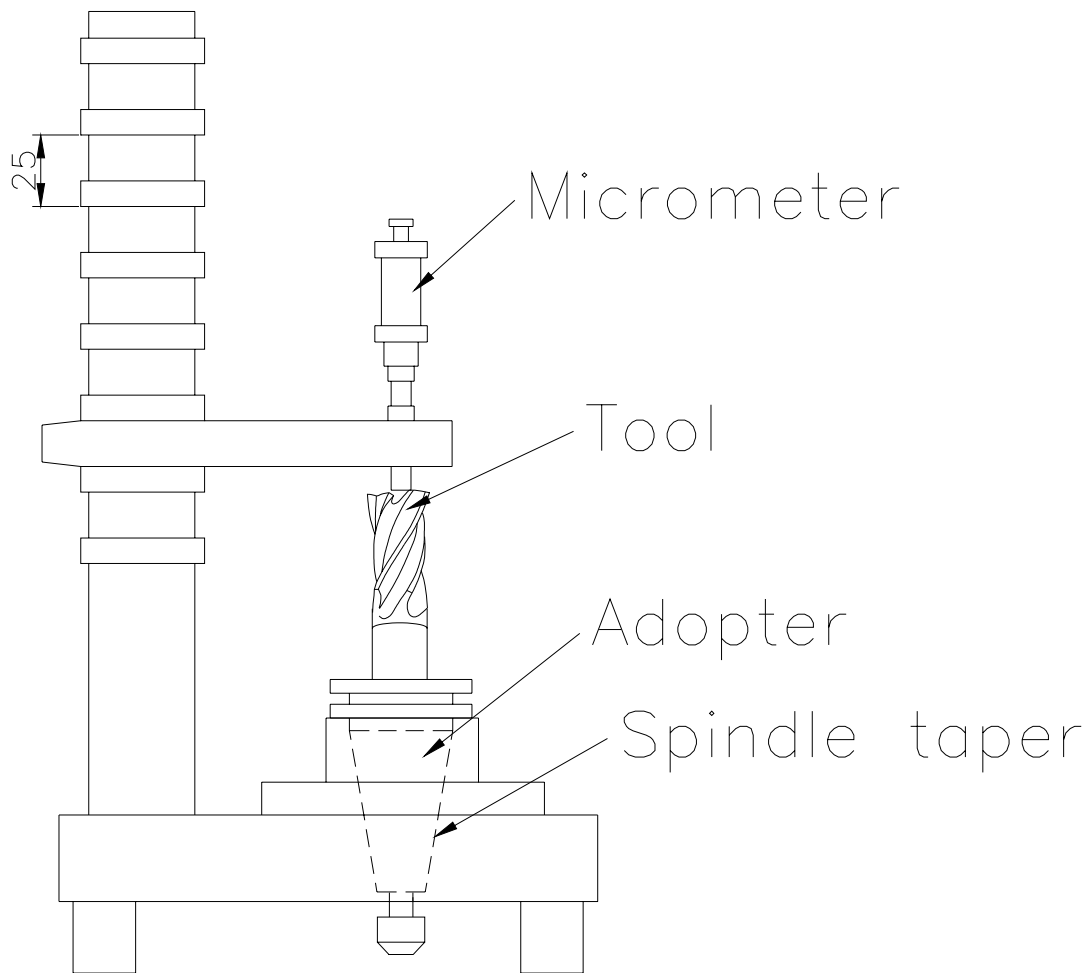


Fig. 11.11 Typical tool setting system useful for machining centre tooling.



Fig. 11.12 Typical digital tool setting system, which is essentially a digital height gauge useful for machining centre tooling (Courtesy Trimos, Switzerland).



Fig. 11.13 Typical tool setter integrated with a CNC turning centre (Courtesy Yamazaki, Japan).

11.5 Automatic tool changers

For the automatic tool changer to operate, it is necessary to have the following:

- a) A tool magazine where sufficient number of tools can be stored.
- b) The tool adopter that has a provision for pick-up by the tool change arm.
- c) The ability in the control to perform the tool change function, and
- d) Tool change procedure.

Tool magazines

Tool magazines to be used have to be considered in terms of the following attributes:

- Storage capacity
- Type and shape
- Tool change procedure.

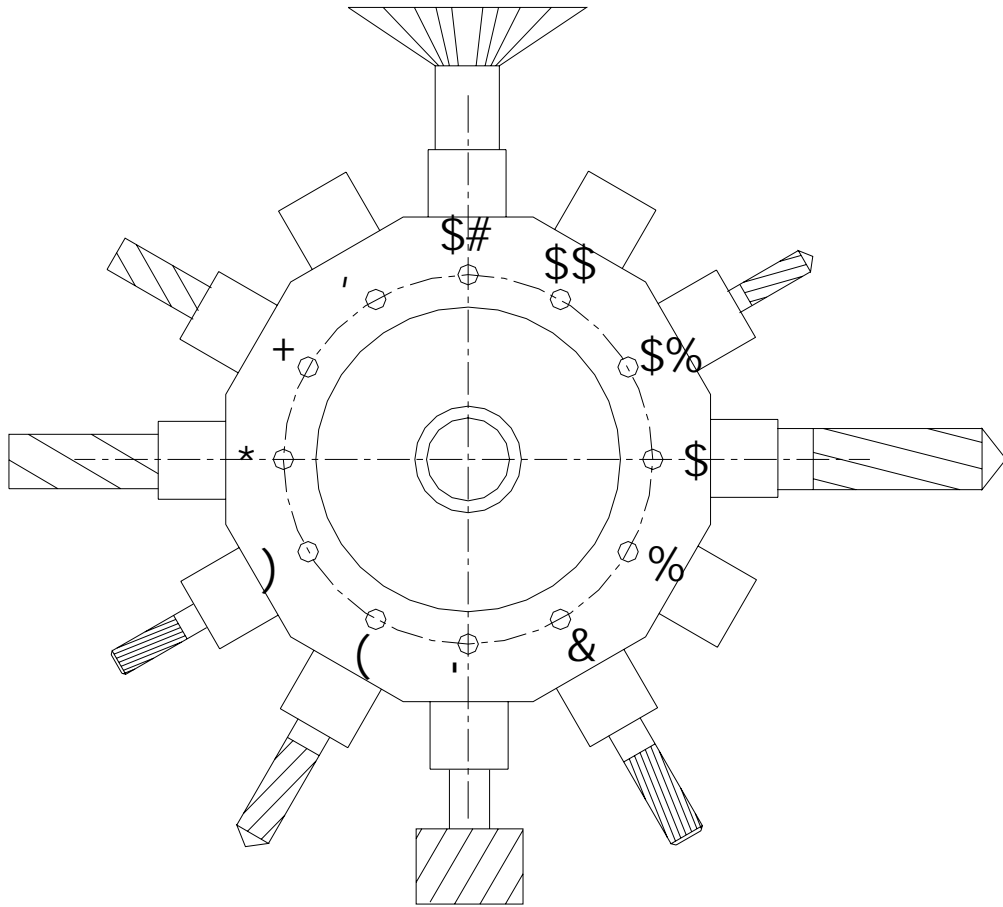


Fig. 11.14 Typical tool turret used in CNC drilling/ milling machines.

11-13 Computer Aided Design and Computer Aided Manufacturing



Fig. 11.15 A CNC drilling machine using a tool turret (Courtesy FANUC, Japan).



Fig. 11.16 A CNC machining centre with a drum type tool magazine (Courtesy OKK Machine tools, Japan).

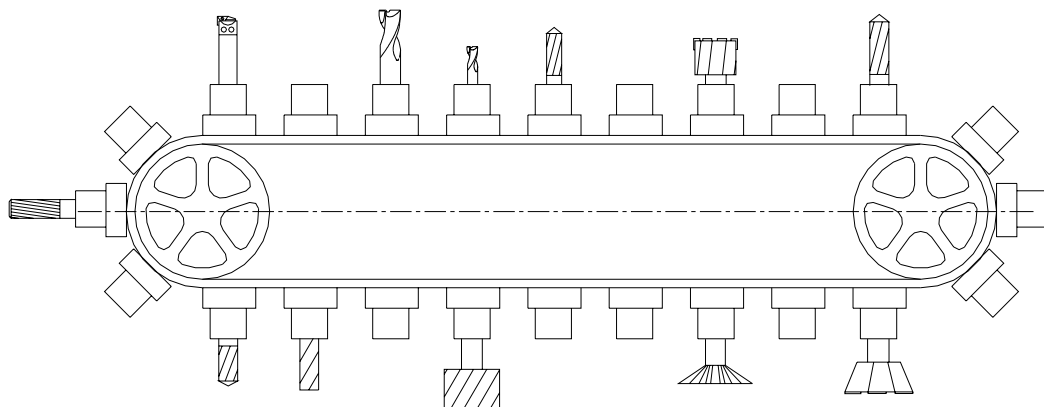


Fig. 11.17 A chain type tool magazine for holding larger number of spindle tooling used in CNC machining centres.



Fig. 11.19 An example of a chain type tool magazine with a capacity of 100 tools (Courtesy Dixi, Switzerland).

Tool changing

The tool change activity requires the following motions:

- i. Stopping the spindle at the correct orientation for the tool change arm to pick the tool from the spindle.
- ii. Tool change arm to move to the spindle.
- iii. Tool change arm to pick the tool from the spindle.
- iv. Tool change arm to index to reach the tool magazine.
- v. Tool magazine to index into the correct position where the tool from the spindle is to be placed.
- vi. Place the tool in the tool magazine.
- vii. Indexing the tool magazine to bring the required tool to the tool change position.
- viii. Tool change arm to pick the tool from the tool magazine.
- ix. Tool change arm to index to reach the spindle.

- x. New tool is placed in the spindle.
- xi. Tool change arm moves into its parking position.

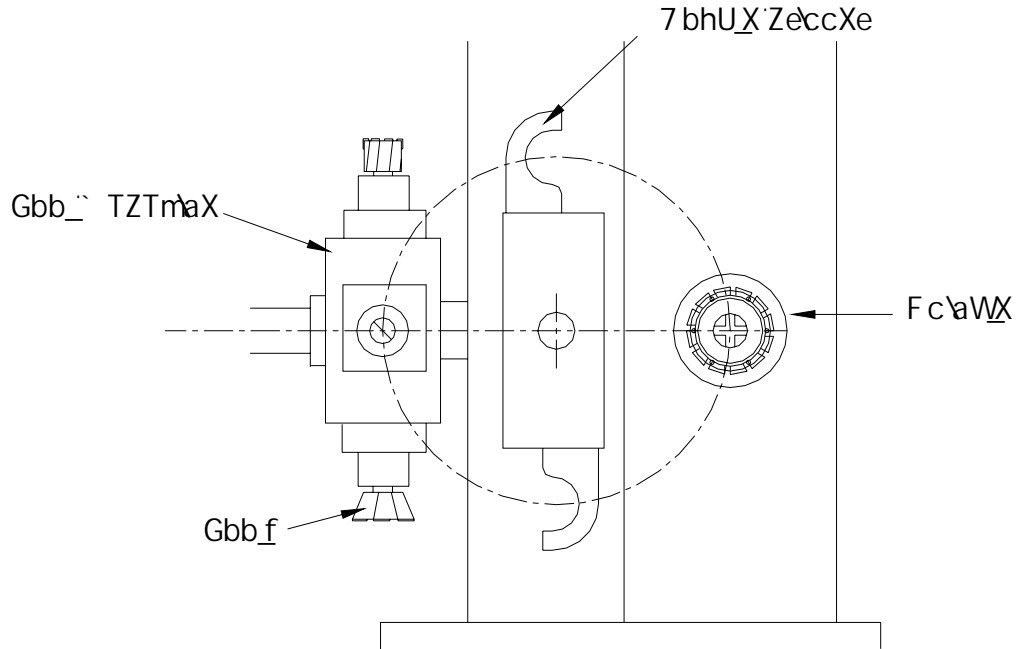


Fig. 11.20 One common type of tool change arm used for tool changing with a double gripper.

- i. Tool magazine to index into the correct position where the tool from the spindle is to be placed.
- ii. Stopping the spindle at the correct orientation for the tool change arm to pick the tool from the spindle (Fig. 11.21a).
- iii. Tool change arm to index to reach the tool magazine.
- iv. Tool change arm to pick the tool from the spindle and the tool magazine simultaneously (Fig. 11.21b).
- v. Tool change arm to index to reach the spindle (Fig. 11.21c).
- vi. New tool is placed in the spindle and the tool magazine (Fig. 11.21d).
- vii. Tool change arm moves into its parking position.

The above sequence is shown schematically in Fig. 11.21.

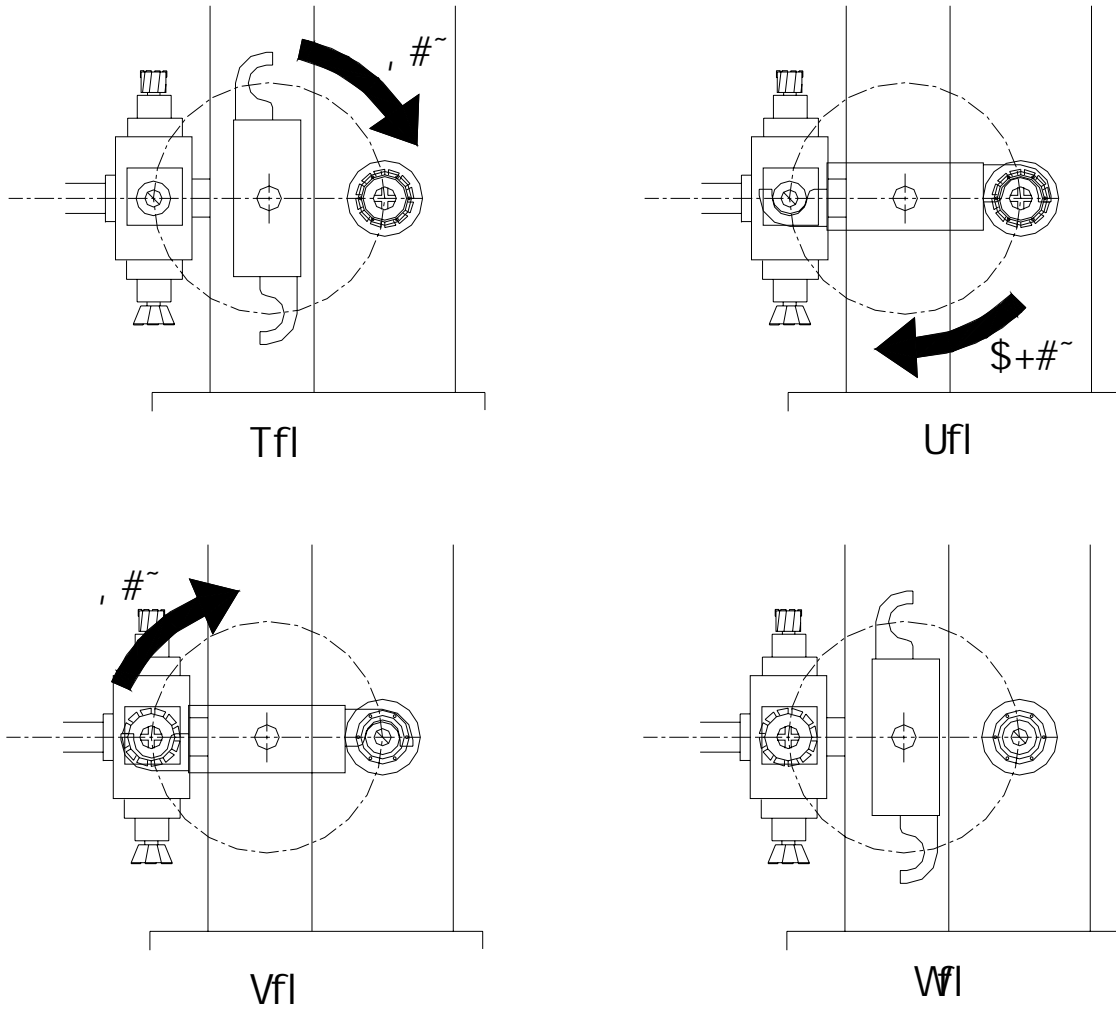


Fig. 11.21 Tool change procedure with a tool change arm having a double gripper.

- i. Tool magazine to index into the correct position where the tool from the spindle is to be placed.
- ii. Tool change arm to index to reach the tool magazine.
- iii. Pick the new tool from the tool magazine.
- iv. Tool magazine indexes to the vacant position where the tool from the spindle is to be placed.
- v. Stopping the spindle at the correct orientation for the tool change arm to pick the tool from the spindle.
- vi. Tool change arm to index to reach the tool magazine.
- vii. Tool change arm to pick the tool from the spindle.
- viii. Tool change arm to index to bring the new tool to the spindle.

- ix. New tool is placed in the spindle.
- x. Tool change arm to index to reach the tool magazine.
- xi. Tool magazine indexes to bring the original pocket of the old tool to the tool change point.
- xii. Old tool is placed into the tool's original pocket in the tool magazine.
- xiii. Tool change arm moves into its parking position.

In the case of turning centres, it is generally the tool turrets so the tool change is not a big problem. However, when the modular tooling is used, then it is necessary to use a tool magazine. There are generally two types of magazines are used:

Disk type, and
Drum type.

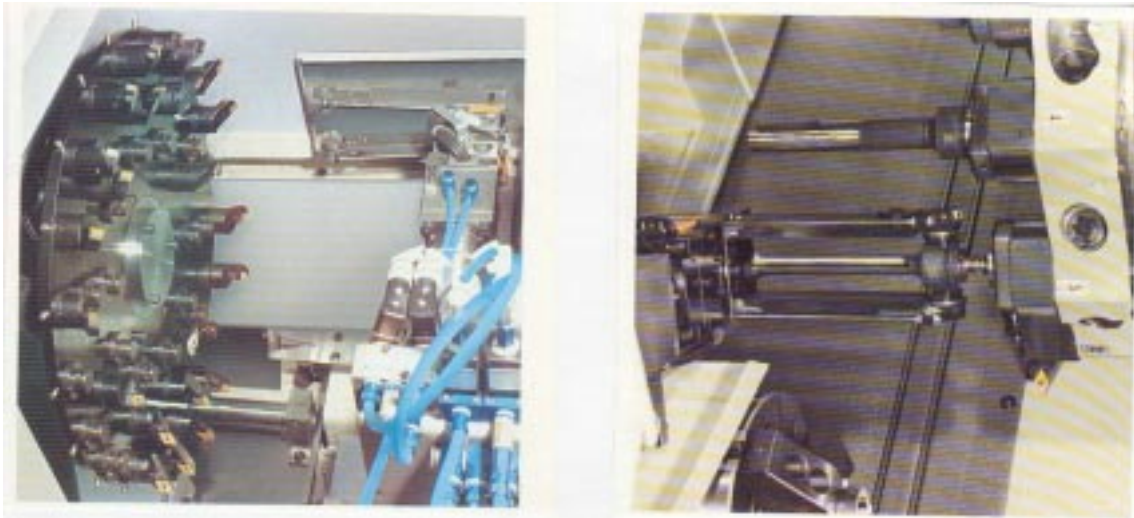


Fig. 11.22 Disc type tool magazine used in CNC turning centres with modular tooling along with a tool change arm (Courtesy Boehringer, Germany).



Fig. 11.23 Drum type tool magazine used in CNC turning centres with modular tooling for storing large number of tools (Courtesy Georg Fischer, Switzerland).

11.6 Work holding

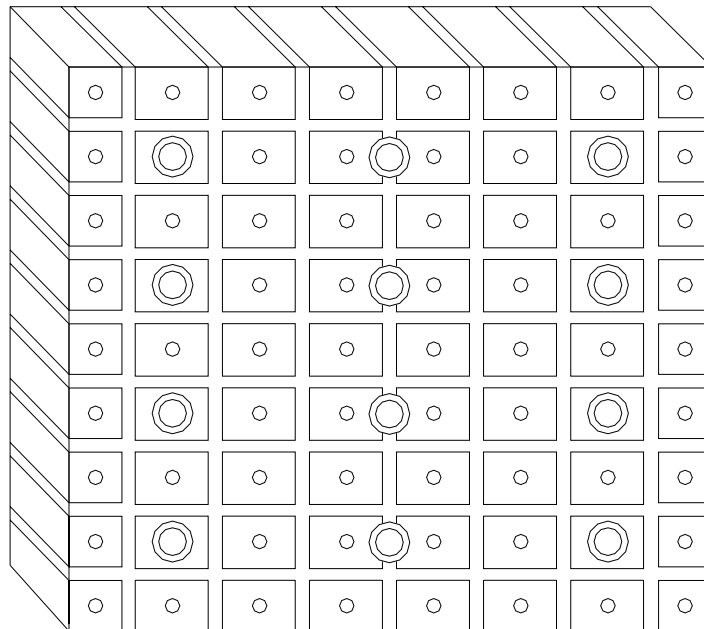


Fig. 11.24 A grid plate with holes which can be used as a machine table.

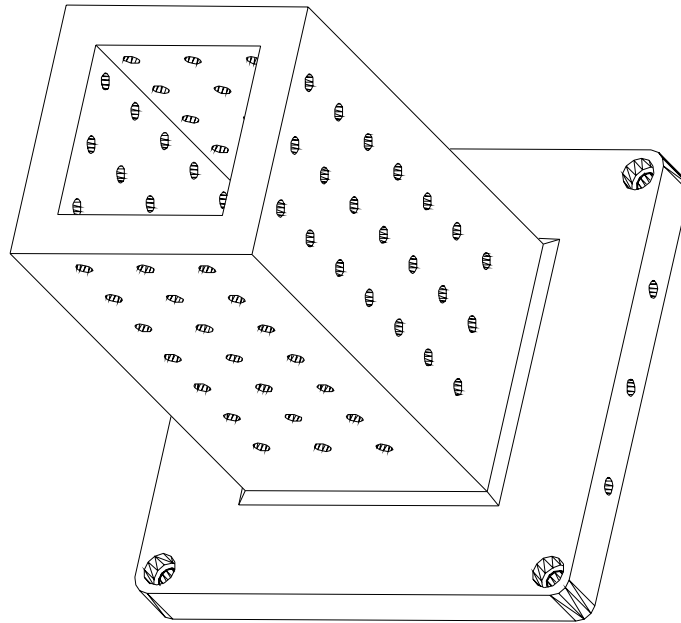


Fig. 11.25 A tombstone for mounting multiple components on different faces.

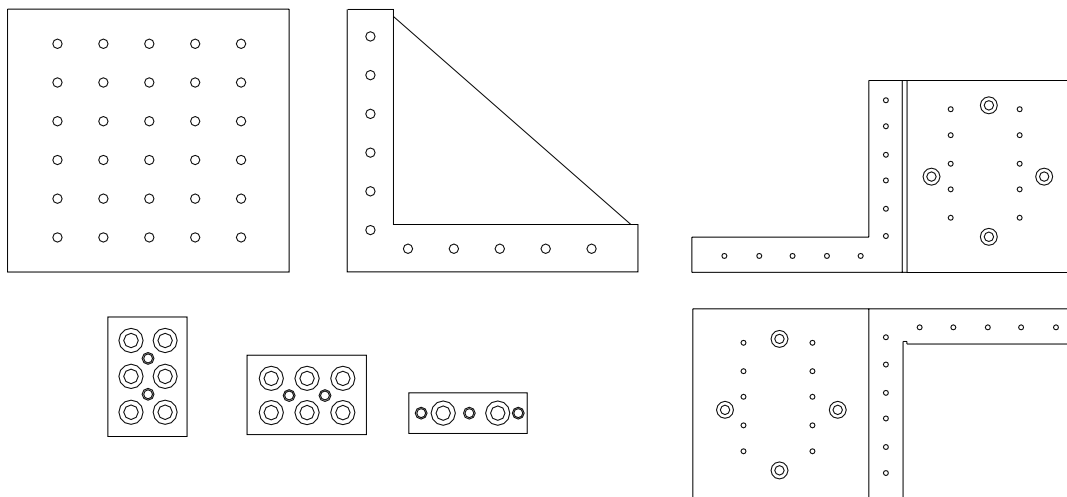


Fig. 11.26 Modular fixture elements used for supporting complex workpieces.