Workholding

Training Objectives

After watching the program and reviewing this printed material, the viewer will gain knowledge and understanding of the basic workholding methods and devices used on lathes, mills, and machining centers.

- the basic requirements for workholding are explained
- both high and low volume methods are featured
- machining center workholding is fully explored
- the use of chucks, collets, and other lathe workholding devices are detailed

Workholding Principles

Workholding includes any device used to present and hold a workpiece to a cutting tool. These devices include clamps, vises, chucks, fixtures and more. The decision about how to hold a part influences:

- which surfaces or holes can be designated as reference surfaces, or datums
- which surfaces can be machined in a single setup
- the overall accuracy of the machining process
- allowable cutting forces, which may include speeds and feeds
- the tool path
- possibly the tool size and shape

Other important factors include:

- cutting tool access to work
- ease of loading and unloading from workholding device
- simplicity of workholding setup and teardown
- use of standard catalog workholding components for economy

To correctly machine a part it must be held in a setup that guarantees a definite location and orientation. This setup must be repeatable throughout the production run. Additionally, the workholding device must hold the part securely in position while cutting forces, vibrations, centrifugal force, and gravity act to dislodge it.

Defining the workholding location begins with visualizing the coordinate system representing a solid object in space, known as the six degrees of freedom. These six coordinates consist of the plus and minus movement in the "x", "y", "z" axes, and in clockwise and counter-clockwise directions around each of these three axes. There are twelve directions of movement that make-up these six degrees of freedom. to accurately locate a workpiece for machining, it must be secured to restrict movement in these twelve directions. Workholding determines the "locators" which will negate, or cancel out, movement along these axes. The locators are points of contact, or attachment, that systematically restrain the workpiece. Once a workpiece is properly located in space and secured, all six degrees of freedom are canceled.

Accuracy and productivity demand that as many machining operations as possible occur for a single workholding procedure. Reclamping, rechucking, and other repositioning of work compromises the accuracy of the work, increasing non-value added time to the manufacture of the part. Sometimes multiple set-ups are needed when datum surfaces must be machined first, or a through hole has steps on both sides, or a part has blind holes on opposite sides.

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Milling and Machining Center Workholding

In small-lot milling operations, the simplest clamps and vises can be used. Production machining centers often require the use of quick-acting single and multiple clamps, sometimes hydraulically or pneumatically actuated. For mass- production of a part, a dedicated fixture is often used.

The number and variety of clamping devices for milling and machining centers is extensive. among them are:

- strap clamps
- cam clamps
- toggle clamps
- push-pull clamps
- latch clamps

Similarly there are many types of machine table mounted vises. There are single- and multiple-jaw types, as well as swivel and tilting base models. Many vises can be operated automatically. Vises may be mounted on a cube or column or on a "tombstone" or indexer. Rotary tables permit four sides of a workpiece to be machined in one setup, and allow the machining of holes and surfaces at odd angles. The two types of rotary tables include:

- indexing tables, which allow parts to be quickly set and locked in position
- full rotary tables, which traverse during cutting to generate shapes

Many horizontal machining centers have rotary tables built in, and may also have second accessory rotary tables added atop the first to provide another axis.

Some fixturing systems are modular, and allow various standard interchangeable components to be configured quickly for a variety of workholding situations. These modular fixtures may start from drilled and tapped base plates, or from base plates having a series of parallel "T" slots.

Many horizontal machining centers accept workpieces clamped to pallets and change pallets automatically in seconds. Fixturing is built on the pallets rather than on the machine table. Workpieces are unloaded and new parts loaded on the pallet outside the machining zone while work on a second pallet is being machined. Once done, these pallets swap, and the unloading/loading process begins again. Vertical machining centers may also be fitted with mini-pallet transfer systems for quick loading to the work table.

A dedicated fixture for machining centers, as opposed to modular fixturing, is created for one specific part and cannot be adapted to a different use. However, dedicated fixtures offer the highest accuracy, repeatability and loading/unloading speed.

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Lathe Workholding

In turning, the workpiece rotates instead of the cutting tool, so the workholding devices must transmit torque to rotate the workpiece and withstand the centrifugal force developed by that rotation.

Chucks are the primary workholding tools in turning operations. Also used is the collet, the mandrel and the face driver. Each have distinct applications.

Chucks:

- may have 2, 3, 4, or 6 jaws to hold work by external or internal surfaces
- many chucks operate manually, but in CNC lathes they operate automatically
- indexing chucks can index to different positions to present multiple surfaces of a workpiece to the cutting tool
- for longer parts, a tailstock support is used with the chuck or other lathe workholding
- chucks may also be magnetic, to grip irregularly-shaped ferrous workpieces

Collets:

- accurately and tightly hold the smooth surfaces of round bar and cylindrical slug workpieces
- special collets can grip square and hex shapes
- collets may be multi-sized, with a stepless gripping size range
- collets are available for workpieces that are decimal, metric, and non-standard sizes
- collets are often used in conjunction with automatic bar stock feeders

Chucks or collets are used for between-center turning of long workpieces. A tailstock supports the end of the work opposite the chuck or collet. Since cutting forces must be limited when between-center turning, a steady rest is sometimes used to support long thin work.

The face driver is used for shaft turning. The face driver attaches to the end face of the work rather than its periphery. This allows the cutting tool access to the entire length of the workpiece.

Mandrels, also called arbors, grip workpieces from their interior surfaces. This allows the cutting tool full access to the exterior of the part.

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Review Questions

1. The "six degrees of freedom" refers to:
   a. cutting tool movement
   b. workpiece movement
   c. cutting tool rotation
   d. location of datum surfaces

2. A "locator" is a:
   a. probe coordinate
   b. contact point
   c. chuck alignment point
   d. axial center point

3. Multiple setups may be justified:
   a. to speed production
   b. to ease loading and unloading
   c. when datum surfaces need to be machined first
   d. to check repeatability

4. A rotary table that has a number of fixed positions is:
   a. a full rotary table
   b. a tilting rotary table
   c. a four-sided rotary table
   d. an indexing rotary table

5. A fixture used for a specific workpiece is called:
   a. a modular fixture
   b. a "T" slot fixture
   c. a pallet
   d. a dedicated fixture

6. The primary toolholder for turning is a:
   a. chuck
   b. collet
   c. face driver
   d. tailstock

7. A turning device which grips work by its interior surface is a:
   a. steady rest
   b. face driver
   c. mandrel
   d. stepless collet

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Answer Key

1. b
2. b
3. c
4. d
5. d
6. a
7. c