Before you begin: Turn on the sound on your computer. There is audio to accompany this presentation.

Chapter 27
Workholding Devices for Machine Tools

- Workholding device locates work in machine tool with respect to the cutting tool.
- Critical for repeatability.
- Trend toward flexibility: family of parts and manufacturing cells.

Primary functions:
- Locating
- Clamping

INTRODUCTION

- **Fixture** – Specialized workholding device that holds workpiece during machining or assembly operations and establishes size dimensions.
- **Jig** – A special type of fixture that, through built-in features, determines both location and size dimensions that are produced by machining or fastening operations.
1. Locating – function is to orient and position workpiece in the machine tool:
   - Provides positive location for the 12 degrees of location freedom:
     - Linear: \( \pm X, \pm Y, \pm Z \)
     - Rotational: \( \pm A, \pm B, \pm C \)
   - Location by 3–2–1 principle

3-2-1 FIXTURE DESIGN

- 3 Points
- 2 Points
- 1 Point

FIXTURE DESIGN

1. Locating (continued):
   - Repeatability: fool proofing.
   - Low profile: clear cutting path.
1. Locating (continued):
- Cutting forces: press part into locators.
- Accommodation: allowing workpiece variance.

2. Clamping – Function to hold and/or maintain location:
- Adequate: balance strength & deflection.
- Reliability: repeatable clamping forces.
- Clamping forces: toward locators.
- Loading/Unloading time: dependent on clamp type.
3. Other Design Factors:
   - Chip disposal and removal: heat and interference concerns.
   - Ruggedness
   - Construction ease
   - Ergonomics and safety
   - Flexibility

4. Additional Jig Functions:
   - Location - position geometric shapes with respect to each other.
   - Size - size of geometric shapes.
   - Dimension control.
   - Examples:
     - Drill jig
     - Welding jig

Drill Bushings:
- Press Fit
- Slip Fit
TYPES of JIGS

- Plate jig - plate w/drill bushings and locating pins, clamped to part.
- Channel jig - part in open side, locate on outside of part.
- Ring jig - for end/surface of round parts.
- Diameter jig - for cylindrical surfaces.
- Leaf jig - hinged leaf or cover.
- Box jig - boxlike construction, tumble.
- Assembly jig - welding or riveting, open frame typically.
Fixtures categories include:
- Vises
- Lathe chucks and collets
- Faceplate fixtures
- Milling and grinding fixtures
- Modular fixtures
TYPES of FIXTURES

Example of a Lathe Faceplate Fixture

Example of Multiple Parts on Single Fixture
Modular fixtures provide versatility and adaptable to different workpieces.
MASTER (GROUP) FIXTURES

Used for part families:
Group Technology (GT) concept.

CLAMPING
Fixture types which used other clamping methods:

- Magnetic chucks - ferromagnetic materials only.
- Electrostatic chucks - conductive materials only.
- Vacuum chucks.
To determine the economic justification of any special tooling, the following factors must be considered:
1. The cost of the tooling
2. Interest or profit change due to the tooling cost
3. The savings resulting from the use of the tooling, i.e., reduction in cycle time, improvement in product quality, or increased production rate
4. The savings in machine cost due to increased productivity
5. The number of pieces that will be produced using the tooling

The economic relationship between these factors can be expressed in the following manner:

\[
\text{Tooling cost per piece} = \left( \frac{R - R_0}{N} \right) + \left( \frac{C - C_0}{2} \right) + \left( \frac{L - L_0}{N} \right) \]

where:
- \( R \) = labor rate per hour, without tooling
- \( R_0 \) = labor rate per hour, using tooling
- \( L \) = labor rate per piece, without tooling
- \( L_0 \) = labor rate per piece, with tooling
- \( R_0 \) = equipment cost per hour, including all overhead
- \( C_0 \) = cost of the special tooling
- \( n \) = number of tools, each tool will be used
- \( t \) = machine time (in what amount of tooling is worth)
- \( N \) = number of pieces that will be produced with the tooling

Equation (27-2) can be expressed in a simpler form:

\[
\left( R + R_0 \right) - \left( R - R_0 \right) = \frac{C - C_0}{2} \left( n + t \right)
\]