Manufacturing Processes (2), IE-352

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# Manual Process Planning

# Chapter Outline



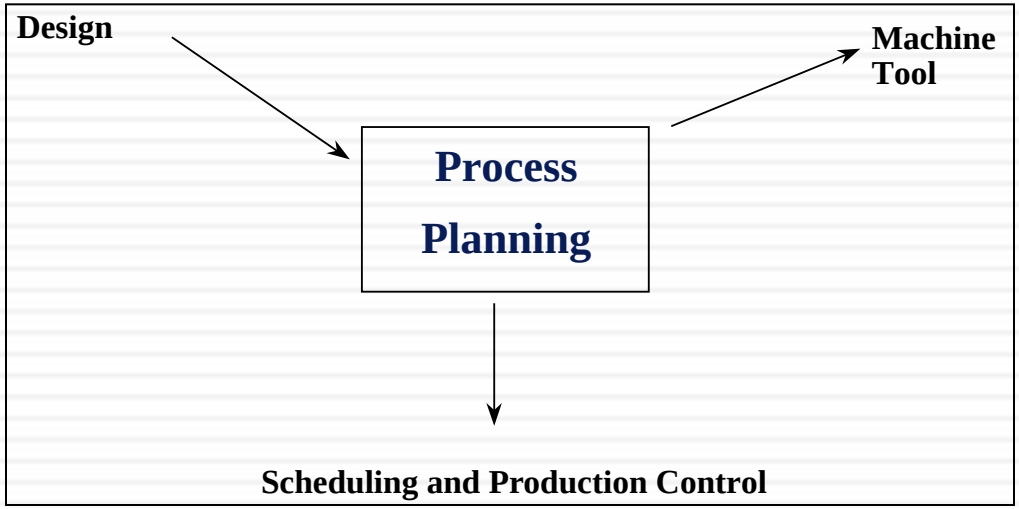
1. Introduction
2. Manual Process Planning
3. Process Plan
4. Part Features Identification and Processes Selection
5. Processes Sequencing

# Introduction



## Process Planning

- Known as:
  - manufacturing planning
  - material processing
  - process engineering
  - machine routing




- Definition:
  - act of preparing detailed work instructions to produce a part
  - it's a function within the manufacturing facility (see figure)
  - establishes processes and parameters used to convert part from initial form to final form
  - predetermined in an engineering drawing
  - person who develops process plan: often called process planner

# Introduction



- Functions included in process planning:
  - Raw material preparation
  - Processes selection
  - Process sequencing
  - Machining parameter selection
  - Tool path planning
  - Machine selection
  - Fixture selection

# Introduction



- Factors Affecting Process Plan Selection:
  - Shape
  - Tolerance
  - Surface finish
  - Size
  - Material type
  - Quantity
  - Value of the product
  - Urgency
  - Manufacturing system itself
- Two approaches to carry out task of process planning:
  - Manual Process Planning
  - Computer Aided Process Planning (CAPP)

# Manual Process Planning



- Process planner must have following knowledge:
  - Ability to interpret an engineering drawing
  - Familiarity with manufacturing processes and practice
  - Familiarity with tooling and fixtures
  - Know what resources are available in the shop
  - Know how to use reference books (e.g. machinability data handbooks)
  - Ability to do computations on machining time and cost
  - Familiarity with raw materials

# Manual Process Planning



- Some necessary steps to prepare a process plan
  1. Study overall shape of part $\Rightarrow$ identify features, all critical dimensions
  2. Thoroughly study the drawing; try to identify all manufacturing features and notes
  3. Determine best raw material shape to use if raw stock not given
  4. Identify datum surfaces; Use information on datum surfaces to determine the setups
  5. Select machines for each setup.
  6. Determine rough sequence of operations necessary to create all the features for each setup

# Manual Process Planning



- Cont. Some necessary steps to prepare a process plan
  7. Sequence the operations determined in the previous step.
     - Check whether there is any interference or dependency between operations
     - Use this information to modify the sequence of operations.
  8. Select tools for each operation.
     - Try to use the same tool for several operations if possible.
     - Keep in mind the trade-off on tool-change time and estimated machining time.
  9. Select or design fixtures for each setup.
  10. Evaluate the plan generated and make necessary modifications.
  11. Select cutting parameters for each operation.

# Process Plan



- Process Plan AKA (among others):
  - operation sheet
  - route sheet
  - operation planning summary

- Detailed plan contains:
  - route
  - processes
  - process parameters
  - machine and tool selections
  - fixtures

# Process Plan



- The level of details in the plan depends on the application:
  - **Operation**: a process
  - **Operation Plan** (*Op-plan*): description of an operation
    - includes tools, machines to be used, process parameters, machining time, etc.
  - **Op-plan sequence**: Summary of a process plan

# Process Plan:
# Examples of Process Plans



Route Sheet by: T.C. Chang

Part No. S1243
Part Name: Mounting Bracket

| | workstation | Time(min) |
|---|---|---|
| 1. | Mtl Rm | |
| 2. | Mill02 | 5 |
| 3. | Drl01 | 4 |
| 4. | Insp | 1 |

**Rough plan**

**Detailed plan**

PROCESS PLAN — ACE Inc.

Part No. S0125-F — Material: steel 4340Si
Part Name: Housing
Original: S.D. Smart Date: 1/1/89 — Changes: Date:
Checked: C.S. Good Date: 2/1/89 — Approved: T.C. Chang Date: 2/14/89

| No. | Operation Description | Workstation | Setup | Tool | Time (Min) |
|---|---|---|---|---|---|
| 10 | Mill bottom surface1 | MILL01 | see attach#1 for illustration | Face mill 6 teeth/4" dia | 3 setup 5 machining |
| 20 | Mill top surface | MILL01 | see attach#1 | Face mill 6 teeth/4" dia | 2 setup 6 machining |
| 30 | Drill 4 holes | DRL02 | set on surface1 | twist drill 1/2" dia 2" long | 2 setup 3 machining |
| | | | | | |

# Part Features Identification and Processes Selection



- A wide variety of manufacturing processes are used to produce a workpiece
- These processes can be classified as:
  - Casting processes
  - Forming and shaping processes
  - Machining processes
  - Joining processes
  - Finishing processes

# Part Features Identification and Processes Selection



- Machining processes
  - Drilling
    - drilling, countering, countersinking, deep-hole drilling, etc.
  - Boring
  - Tapping
  - Milling
    - face milling, end milling
  - Turning
    - facing, straight turning, taper turning, parting, etc.
  - Threading

# Part Features Identification and Processes Selection



- Features that must be considered in selecting machining processes include:
  - part features
  - required dimensional and geometric accuracy and tolerance
  - required surface finish
  - available resources, including NC machines and cutting tools
  - cost

# Part Features Identification and Processes Selection



- Part features:
  - distinctive geometric form or shape to be produced from raw material
  - it determines process type, tool types (shapes and size), machine requirements (3-, 4-, or 5-axis), and tool path
- Two types of part features
  - **Basic features**
    - simple forms/shapes that require only one machining operation
    - include holes, slots, pockets, shoulders, profiles, and angles
  - **Compound features**
    - consist of two or more basic part features
    - e.g. the combined result of two holes with different diameters

# Part Features Identification and Processes Selection



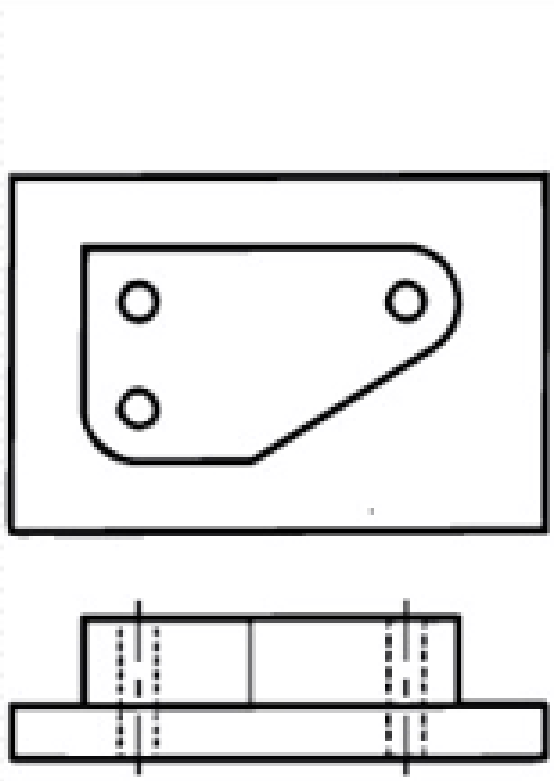
**Example: Machining Processes Selection**

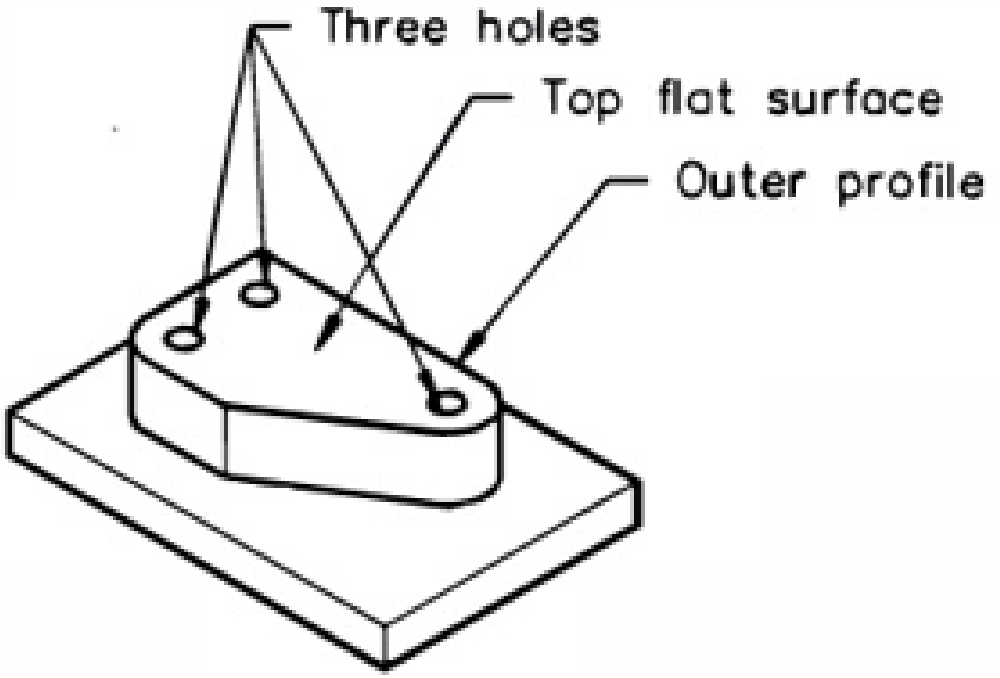
- Select the machining processes for the part shown in the figure given in the next slide.
- Assume required dimensional accuracy and surface roughness are within process capability of drilling and milling operations.
- The four sides of the raw material have been pre-machined to required dimensions.

# Part Features Identification and Processes Selection



**Example: Machining Processes Selection (cont.)**





# Part Features Identification and Processes Selection



**Example: Machining Processes Selection (cont.)**

**Solution:**

- Top flat surface
- Outer profile
- Three holes

- Recommended machining processes for features are
  - Face-milling: the top surface
  - Rough-milling: the outer profile
  - Finish-milling: the outer profile
  - Center-drilling: the three holes
  - Drilling: the three holes

# Processes Sequencing



Sequence of operations determined by three considerations:

1. Datum surfaces should be machined first if multiple work-holding setups required
   - If possible, datum surfaces should be pre-machined in manually operated machine to facilitate workpiece locating and clamping
   - In cases where ≥ 2 holding setups are required:
     - rough datum surfaces are preprocessed in a manually operated machine
     - then used as setup references to produce finished datum surfaces for the final work-holding
     - this ensures the accuracy of the finished part

# Processes Sequencing



Sequence of operations determined by 3 considerations (cont.)

2. Surfaces with larger area have precedence
   - Larger surfaces tend to be more adaptable to disturbances resulting from machining operations
3. Feature interference should be avoided.
   - Feature interference occurs when machining of one feature destroys a requirement for the production of other features
   - This happens when there is interaction or dependency between machining operations

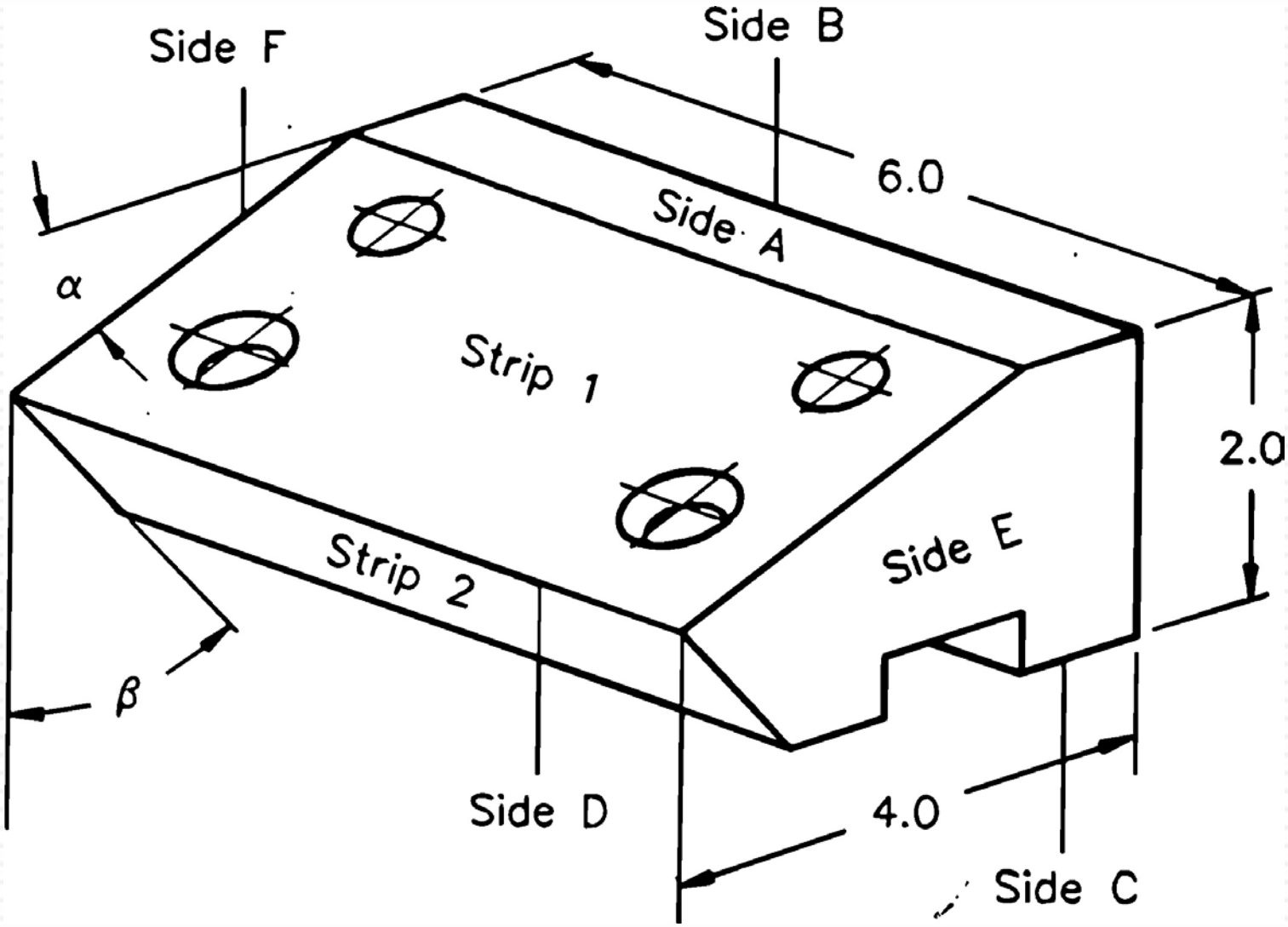
# Processes Sequencing: Example



- The figure shown in the next slide is a workpiece in which some features are interrelated.
- The workpiece has five basic features
  - a through slot in side C
  - two angle strips (strip 1, strip 2)
  - two through holes on strip 1 that are perpendicular to side A
  - compound features are two tapped holes perpendicular to strip 1
- Develop the process sequence for producing the part.

# Processes Sequencing: Example (cont.)





# Processes Sequencing: Example (cont.)



**Solution:**

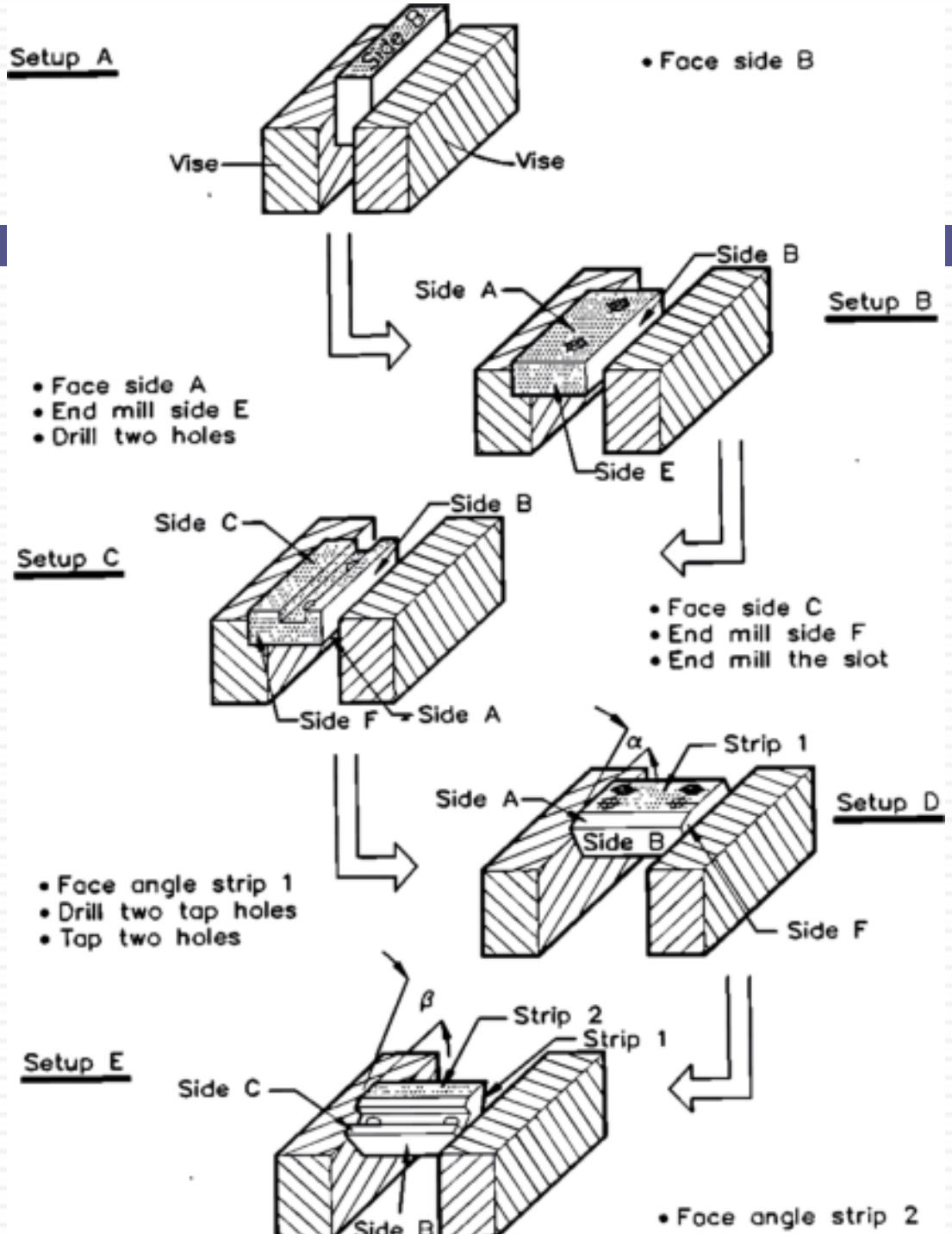
- The raw material is cut from a block stock with dimensions: 6.25 x 4.25 x 2.25 in
- Studying the part features reveals:
  - 2 through holes on strip 1 interact with the formation of angle $\alpha$
  - slot in side *C* interacts with the cutting of angle $\beta$
- Machining angle strip 1 first $\Rightarrow$ difficulty in drilling 2 holes
  - $\Rightarrow$ 2 holes must be produced before angle strip 1
- Likewise, making angle strip 2 first $\Rightarrow$ difficulty in setting up workpiece to produce the through slot
  - $\Rightarrow$ the slot has to be machined before angle strip 2 is made

# Processes Sequencing: Example (cont.)



Recommended processes sequence is:

- Setup *A* for machining side *B*
- Setup *B* for:
  - machining sides *A* and *E*
  - also drilling two holes on Side *A*
- Setup *C* for:
  - machining sides *C* and *F*
  - also cutting the slot in side *C*
- Setup *D* for:
  - cutting angle strip 1
  - drilling two tap holes and tapping the two holes.
- Setup *E* for cutting angle strip 2


Setup A
Side B
Vise
Vise
• Face side B
Side A
Side B
Setup B
Side E
• Face side A
• End mill side E
• Drill two holes
Setup C
Side C
Side B
Side F
Side A
• Face side C
• End mill side F
• End mill the slot
α
Strip 1
Side A
Setup D
Side B
Side F
• Face angle strip 1
• Drill two tap holes
• Tap two holes
β
Strip 2
Strip 1
Setup E
Side C
Side B
• Face angle strip 2