IE352 Manufacturing Processes -2

Process Planning

Industrial Engineering Department
King Saud University

Process Planning

Process planning is also called: manufacturing planning, process planning, material processing, process engineering, and machine routing.

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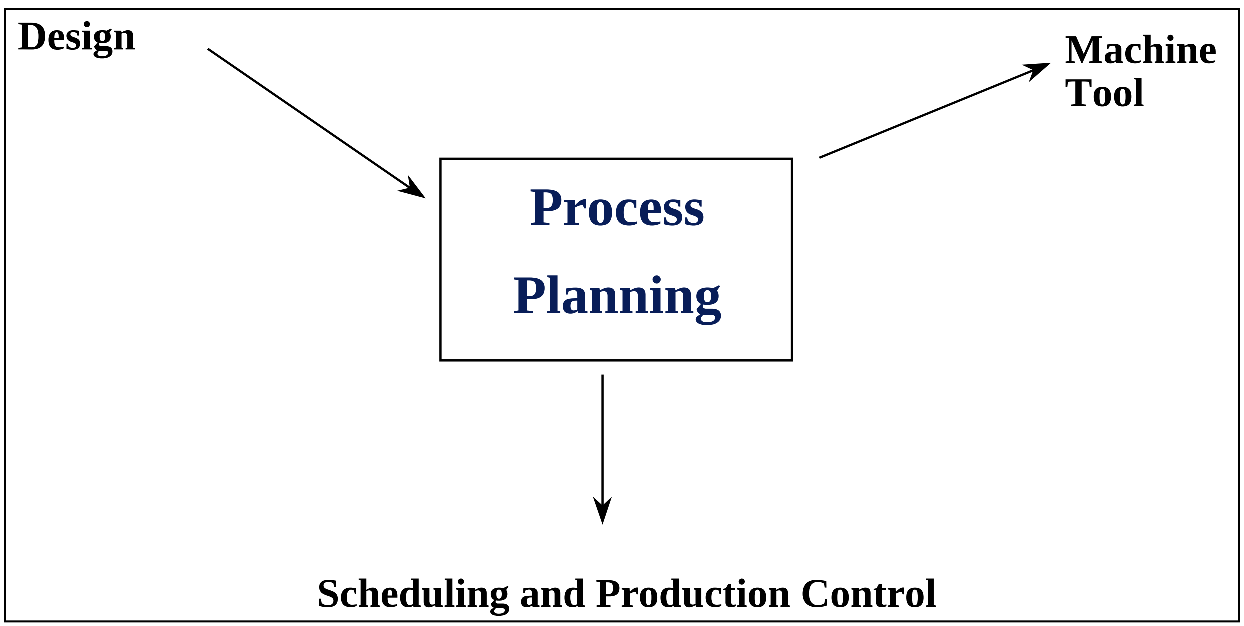
Process Planning: is the function within manufacturing facility that establishes which processes and parameters are to be used **to convert a part from its initial form to a final form predetermined in an engineering drawing**.

Process planning can be defined as: the act of preparing detailed work instructions to produce a part.



The person who develops the process plan for producing a workpiece is often called **the process planner**.

The functions included in process planning are:

- Raw material preparation
- Processes selection
- Process sequencing
- Machining parameter selection
- Tool path planning
- Machine selection
- Fixture selection

Factors affecting process Plan selection

- Shape
- Tolerance
- Surface finish
- Size
- Material type
- Quantity
- Value of the product
- Urgency
- Manufacturing system itself
- etc.

There are two approaches to carrying out the task of process planning:

1- Manual Process Planning

2- Computer Aided Process Planning (CAPP).:

VARIANT

GT based

Computer aids for editing

Parameters selection

GENERATIVE

Some kind of decision logic

Decision tree/table

Artificial Intelligence

Objective-Oriented

Still experience based

AUTOMATIC

Design understanding

Geometric reasoning capability

Manual Process Planning

In order to prepare a process plan, a process planner has to have the following knowledge:

1. Ability to interpret an engineering drawing.
2. Familiarity with manufacturing processes and practice.
3. Familiarity with tooling and fixtures.
4. Know what resources are available in the shop.
5. Know how to use reference books, such as machinability data handbooks.
6. Ability to do computations on machining time and cost.
7. Familiarity with the raw materials.

To prepare a process plan, the following are some steps that have to be taken:

- Study the overall shape of the part, to identify features and all critical dimensions.
- Thoroughly study the drawing. Try to identify all manufacturing features.
- Determine the best raw material shape to use if raw stock is not given.
- Identify datum surfaces. Use information on datum surfaces to determine the setups.
- Select machines for each setup.
- Determine the rough sequence of operations necessary to create all the features for each setup.
- 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.
- Select tools for each operation. Try to use the same tool several operations if possible. Keep in mind the trade-off on tool-change time and estimated machining time.
- Select or design fixtures for each setup.
- Evaluate the plan generated and make necessary modifications.
- Select cutting parameters for each operation.

PROCESS PLAN

- Also called : operation sheet, route sheet, operation planning summary, or another similar name.
- The detailed plan contains:

  route

  processes

  process parameters

  machine and tool selections

  fixtures
- How detail the plan is depends on the application.
- Operation: a process
- Operation Plan (Op-plan): contains the description of an operation, includes tools, machines to be used, process parameters, machining time, etc.
- Op-plan sequence: Summary of a process plan.

Example 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

Study of the Part Drawing

The part drawing provides the following features:

- Basic form and size of the workpiece.
- Outer envelop of the workpiece.
- Part features (shapes) to be produced.
- Dimensional and geometric tolerances.
- Required surface finish (roughness).
- Datum surfaces for setup and measurement.
- Material of the workpiece.

The information needed to prepare part drawing for NC include:

- The type of coordinate systems offered by the machine tool.
- Machine datum systems.
- Selection of the program datum (zero).
- Machine envelope.
- Machine operation capacity (spindle speed, feed, tolerance, and accuracy).

Datum Selection

A datum is a specific surface, line, plane, or other feature that is assumed to be perfect and is used as a reference point for dimensions or features.

A workpiece datum: can be defined as point, line , surface, or cylinder from which dimensions are referenced.

The following examples may be used as guidelines for selecting datum surfaces:

1. Important surfaces to the function of the workpiece or the assembly.
2. Reference planes for mating parts of an assembly.
3. Previously machined surfaces.
4. Surfaces that are easy to establish at the machine tool.
5. Surfaces that are parallel to machine movements.

A datum can be explicitly or implicitly indicated in the part drawing.

A datum is normally called out by an identification symbol such as:

-A-

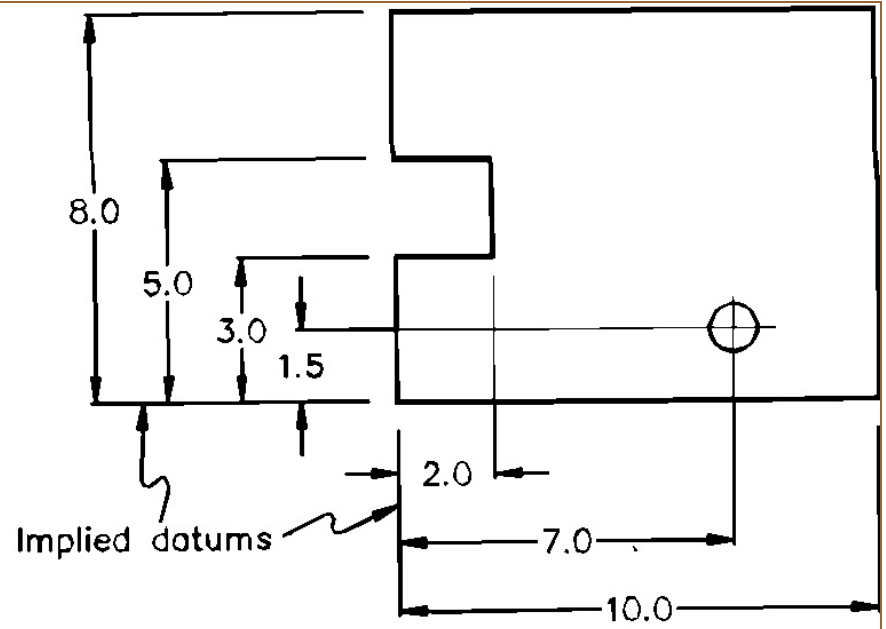


FIGURE 6.4
Implied datums.

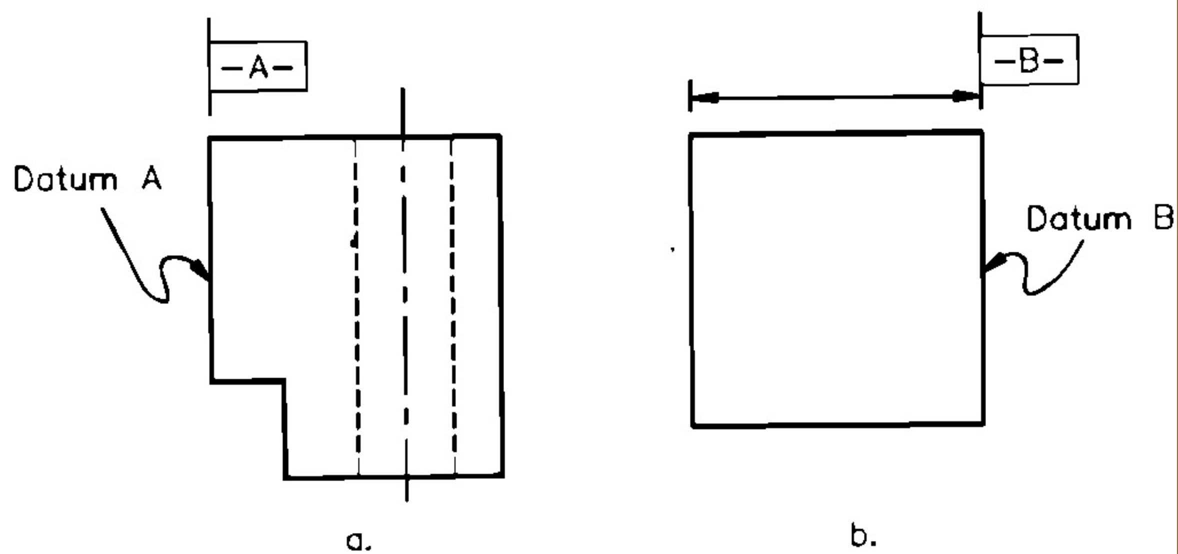


FIGURE 6.5
Datum indicated on the extension line of a feature.

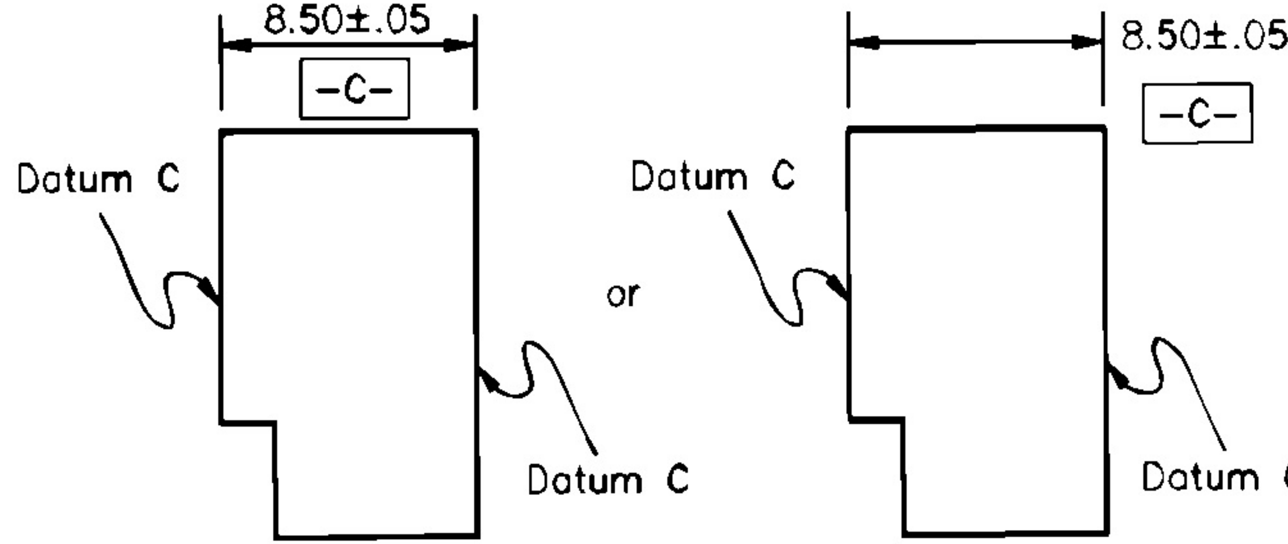


FIGURE 6.6
Datum indicated on the dimensional line.

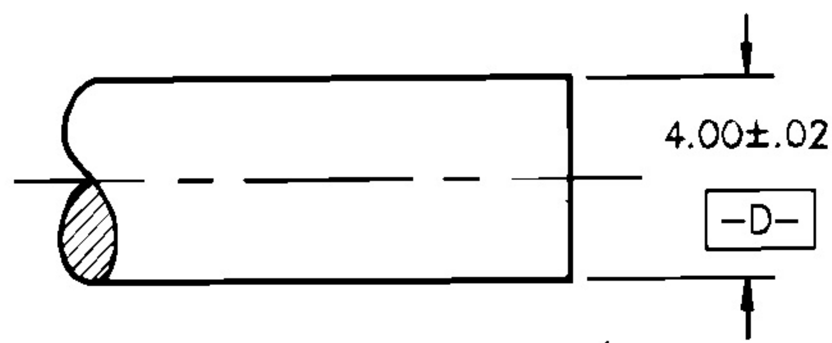


FIGURE 6.7
Datum applied to the center line.

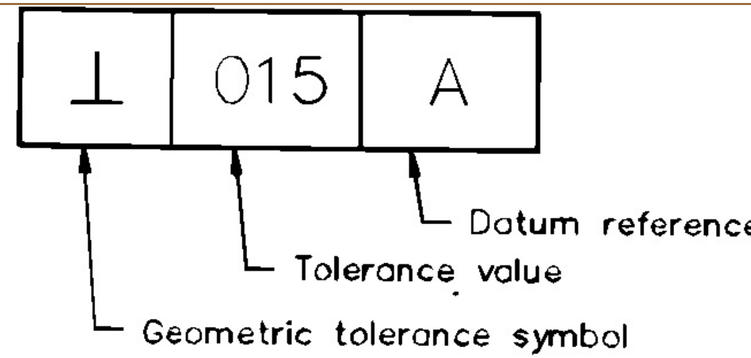


FIGURE 6.8
Feature control system.

	Characteristics	Symbol
Form Tolerances	Straightness	—
	Flatness	⏥
	Roundness	○
	Cylindricity	⌭
	Profile of a line	⌒
	Profile of a surface	⌓
	Angularity	∠
	Perpendicularity	⊥
	Parallelism	//
Location Tolerances	Position	⌖
	Concentricity	◎
	Symmetry	⌯
Runout Tolerances	Circular	↗
	Total	⌰

FIGURE 6.9
Basic geometric characteristics.

Considerations for Raw Material

The features of raw material have a significant effect on:

1. The amount of material to be removed
2. The ease of workholding
3. Machine efficiency

The raw material of a part can be prepared from the standard commercially available stock, or it may be a casted or forged, in which the rough shape and size have been formed. Commercially available stock appears in the following forms:

- Bars (round, square, hexagonal, octagonal, flat, triangular, and half-round)
- Plates
- Sheets and coils
- Pipes and tubes
- Structural shapes (beams, angles, tees, zees, and channels)

In preparing raw material from standard stock, the following rules should be followed:

1. Make optimal use of the stock to minimize the amount of removed or wasted material.
2. Pre-machine datum surfaces with a manually operated machine, if possible, to facilitate the workholding setup.
3. Prepare the raw material drawing.

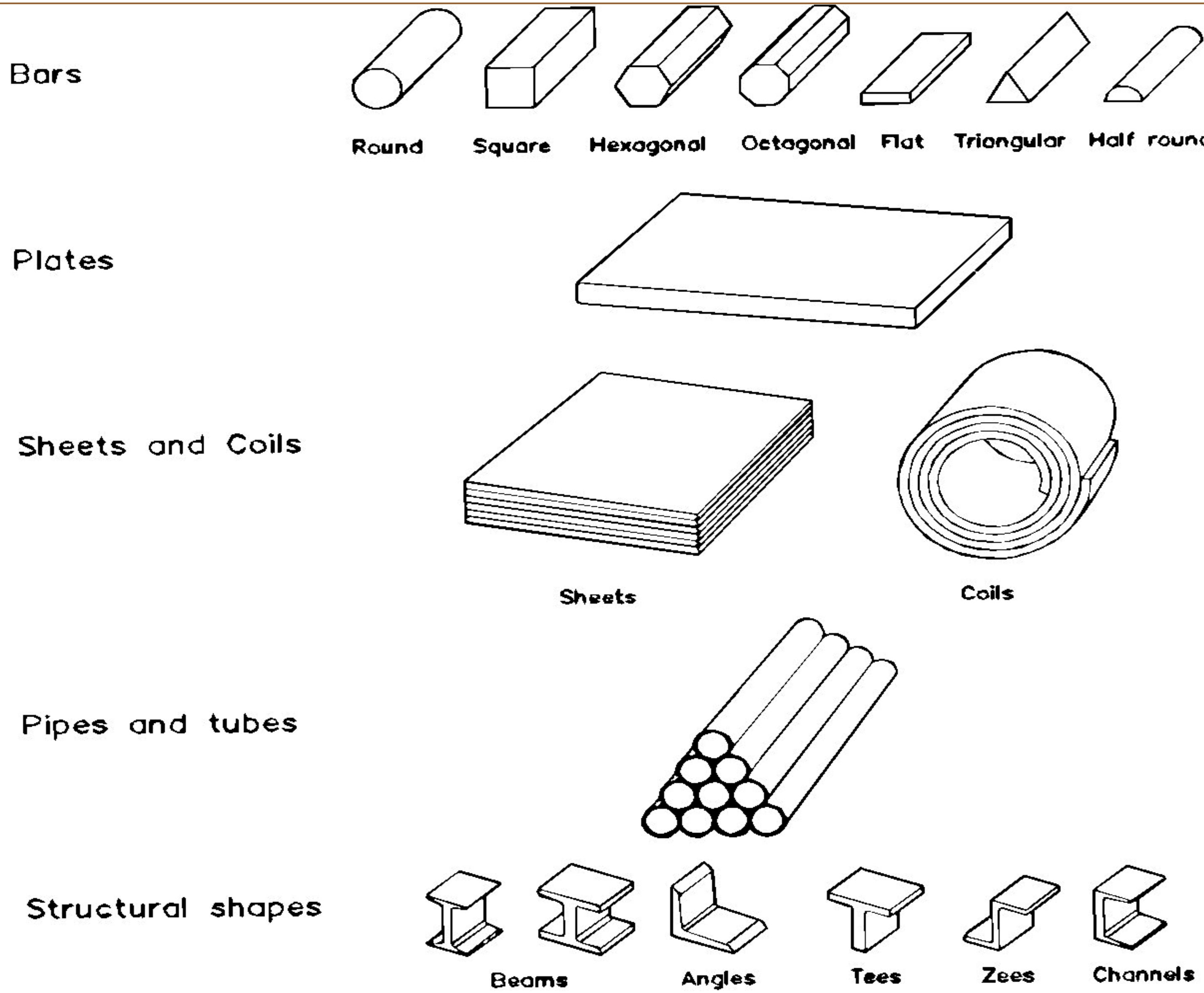


FIGURE 6.11
Standard raw material stocks.

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

The machining processes include:

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

Many features must be considered in selecting machining processes. They include:

1. Part features
2. Required dimensional and geometric accuracy and tolerance
3. Required surface finish
4. Available resources, including (numerical controlled) NC machines and cutting tools
5. Cost

Part features

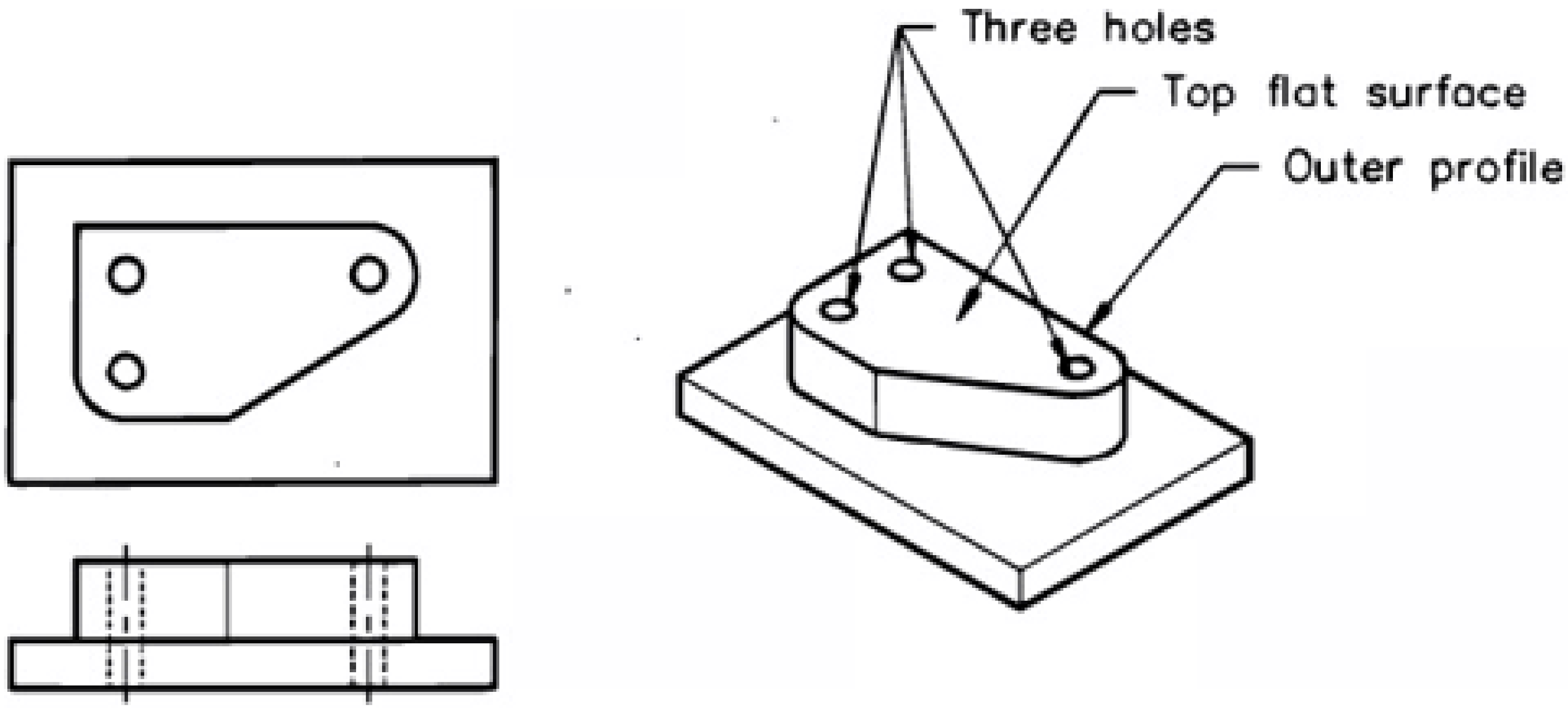
A part feature is the distinctive geometric form or shape to be produced from raw material; thus it determines process type, tool types (shapes and size), machine requirements (3-, 4-, or 5-axis), and tool path.

There are two types of part features:

1. **Basic features**: are those simple forms or shapes that may require only one machining operation. They include holes, slots, pockets, shoulders, profiles, and angles.
2. **Compound features**: are those that consist of two or more basic part features. For example, the combined result of two holes with different diameters.

EXAMPLE: MACHINING PROCESSES SELECTION

- Select the machining processes for the part shown in the Figure.
- Assume that the required dimensional accuracy and surface roughness are within the process capability of drilling and milling operations.
- The four sides of the raw material have been premachined to the required dimensions.



Solution

Three part features can be identified from the part drawing:

- Top flat surface
- Outer profile
- Three holes

The recommended machining processes for these features are

- Rough Face-milling the top surface
- Finish Face-milling the top surface
- Rough-milling the outer profile
- Finish-milling the outer profile
- Center-drilling the three holes
- Drilling the three holes

Computer Aided Process Planning

Advantages:

- It can reduce the skill required of a planner.
- It can reduce process-planning time.
- It can reduce both process-planning and manufacturing costs.
- It can create more consistent plans.
- It can produce more accurate plans.
- It can increase productivity.

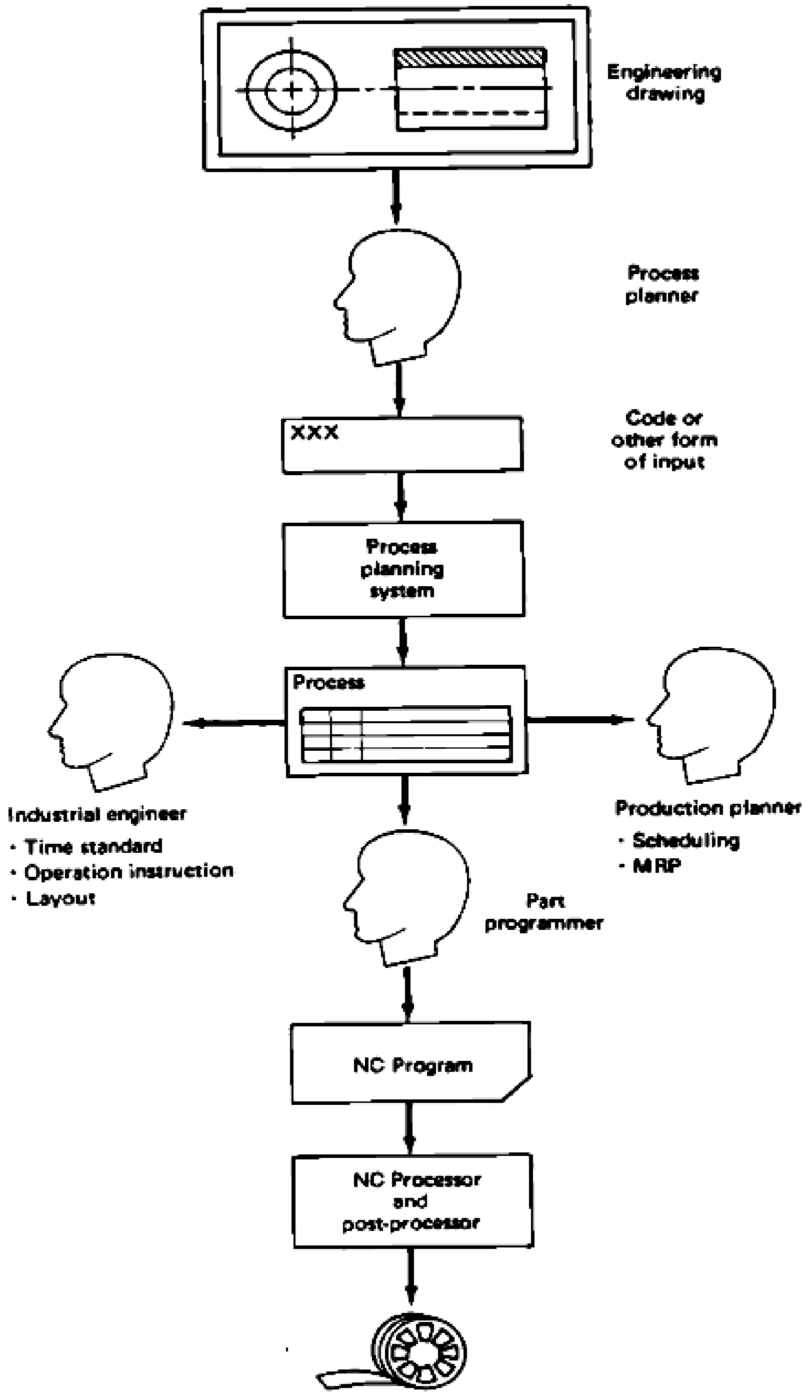
Two approaches for computer-aided process planning have been pursued:

1. Variant CAPP method
2. Generative CAPP method

The variant approach uses library retrieval procedures to find standard plans for similar components. The standard plans are created manually by process planners.

The generative approach is considered more advanced as well as more difficult to develop. In a generative process-planning system, process plans are generated automatically for new components without referring to existing plans.

A typical process planning system



Process planning is the critical bridge between design and manufacturing (Figure 3). Design information can be translated into manufacturing language only through process planning systems. Today, both computer-aided design **(CAD)** and manufacturing **(CAM)** have been implemented. **Integrating, or bridging, these functions requires automated process planning**.

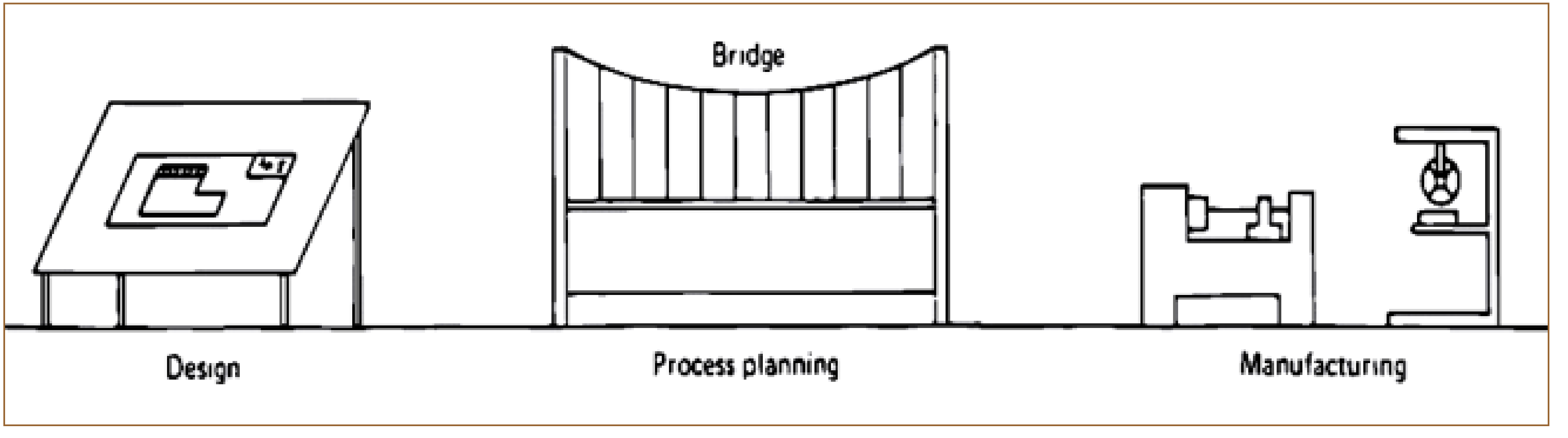


Figure 3. Process planning bridges design and manufacturing.