BTME 505 CAD/CAM/CIM

UNIT V – GROUP TECHNOLOGY AND CAPP

UNIT III GROUP TECHNOLOGY AND CAPP

History Of Group Technology – role of G.T in CAD/CAM Integration – part families classification and coding – DCLASS and MCLASS and OPTIZ coding systems – facility design using G.T – benefits of G.T – cellular manufacturing. Process planning - role of process planning in CAD/CAM Integration – approaches to computer aided process planning – variant approach and generative approaches – CAPP and CMPP systems.

GROUP TECHNOLOGY (GT)

- GT is a manufacturing philosophy in which similar parts are identified & grouped together to make advantage of their similarities in design and production.
- Similar parts bare arranged into part families, where each part family possesses similar design and/or manufacturing characteristics.
- Grouping the production equipment into machine cells, where each cell specializes in the production of a part family, is called cellular manufacturing

History of GT

- 1925 – F.W.Taylor need for standardization, inspection and supervision
- 1925 – R.Flanders presented a paper in ASME about organisationing manufacturing, USA.
- 1937 – A.sokolovskiy essential features of GT at Soviety Union
- 1949 – A.korling of Sweden presented a paper in paris “Group Productiion”
- 1959 – S.P Mitrofanov a Russian, Published a book entitled “Scientific Principal of GT”
- 1960 – west german and Great Britain started serios studies about GT technology

  H.opitz german researcher, studied work parts manufactured and coding system
- 1963 – Concept of GT is well recognized and widely applied in many industries
- 1990 – concepts of CMS involved

Implementing Group Technology (GT)

1. ***Identifying the part families*** If the plant makes 10,000 different parts, reviewing all of the part drawings and grouping the parts into families is a substantial task that consumes a significant amount of time.

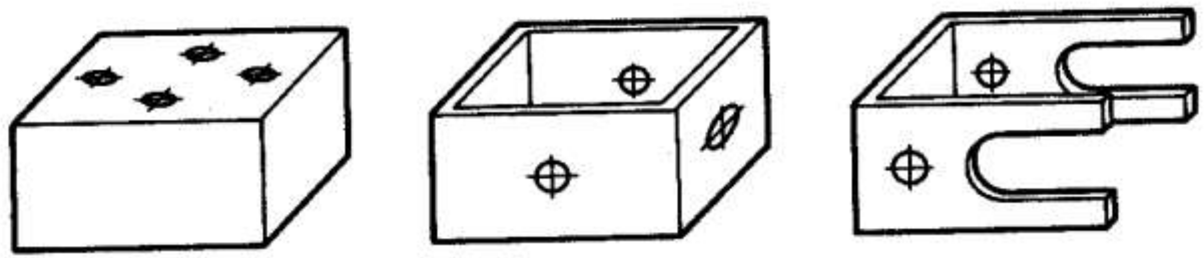
2. ***Rearranging production machines into cells*** It is time consuming and costly to plan and accomplish this rearrangement, and the machines are not producing during the change over.

Part Families

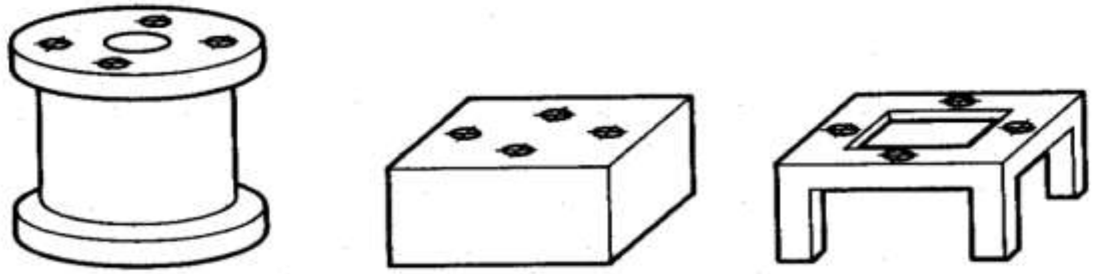
- **Part family** - *Group of similar parts*
- **Machine cell** - *Group of machineries* used to *process an individual part family*
- **Part family** is a *Collection of parts that are similar* either because of *geometric shape and size* or because similar processing steps are required in their manufacture.

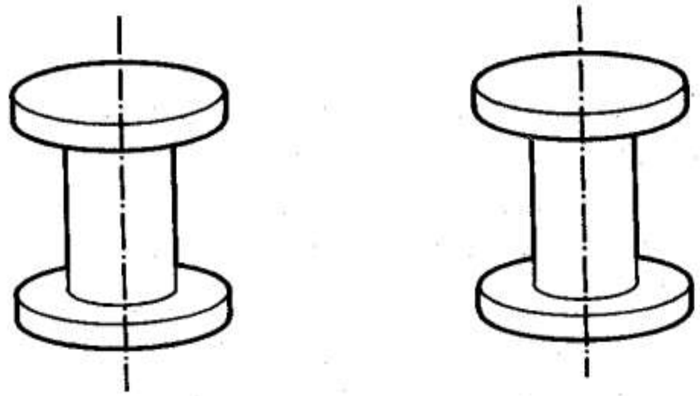
Part Families

Similar prismatic parts requiring similar milling operations



Dissimilar parts requiring similar machining operations (hole drilling, surface milling

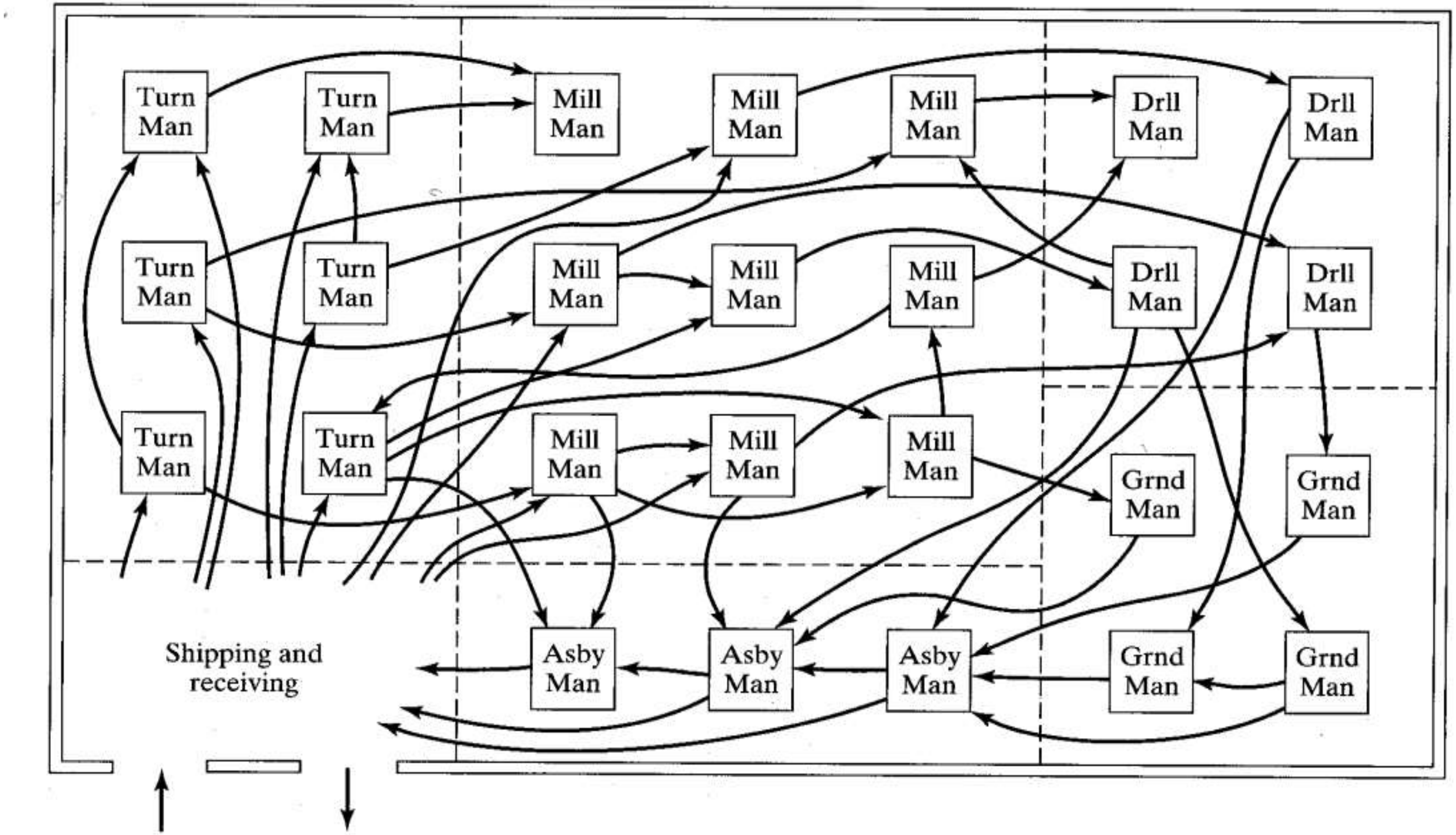




Material: Plastic   Material: Steel

Identical designed parts requiring completely different manufacturing processes

- One of the important manufacturing advantages of grouping work parts into families can be explained with reference to figures below



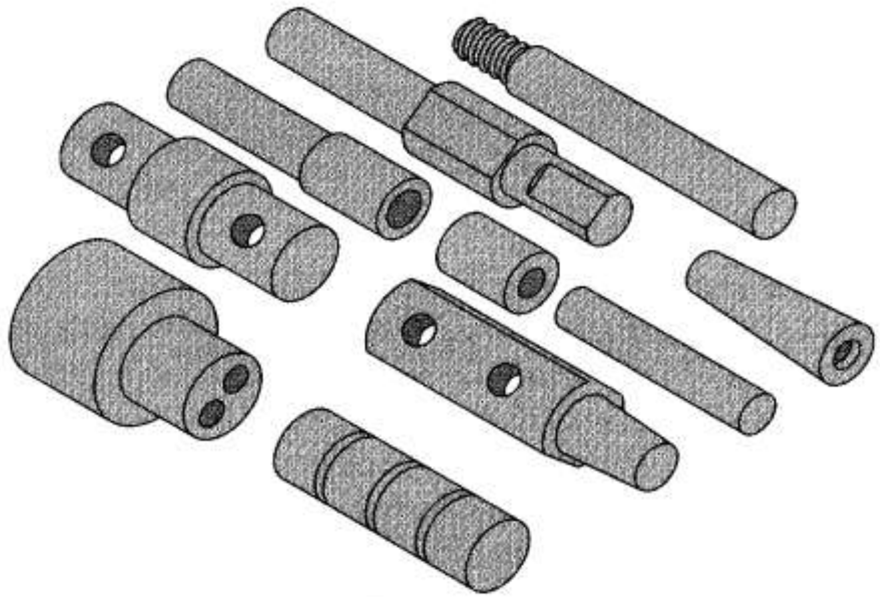
METHODS FOR PART FAMILY

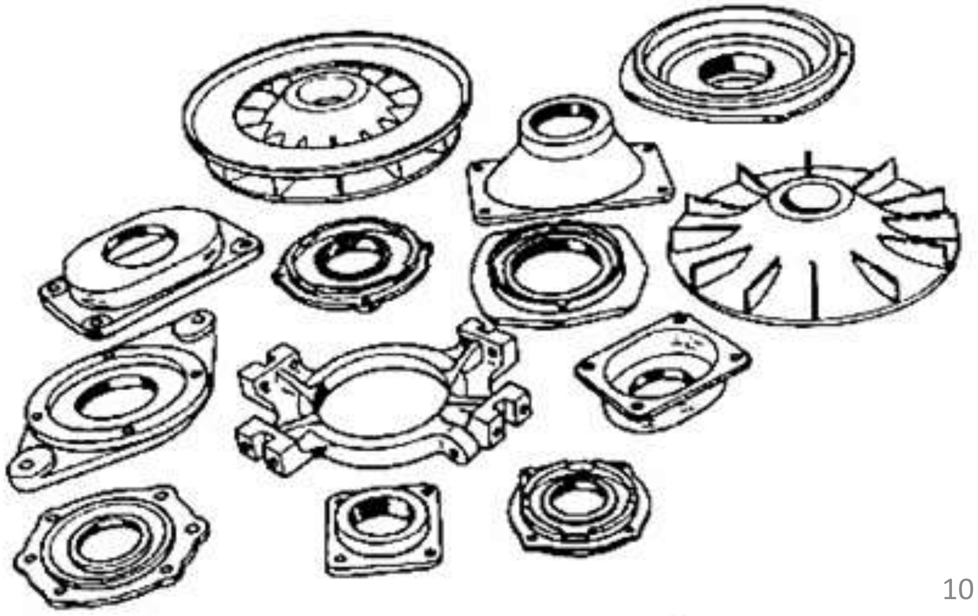
There are three general methods for solving part families grouping. All the three are time consuming and involve the analysis of much of data by properly trained personnel. The three methods are:

- Visual inspection.
- Parts classification and coding.
- Production flow analysis.

Visual Inspection Method

- The visual inspection method is the least sophisticated and least expensive method.
- It involves the classification of parts into families by looking at either the physical parts or their photographs and arranging them into groups having similar features.





Parts Classification and Coding Method

- In parts classification and coding, similarities among parts are identified, and these similarities are related in a coding system.

- Two categories of part similarities can be distinguished:

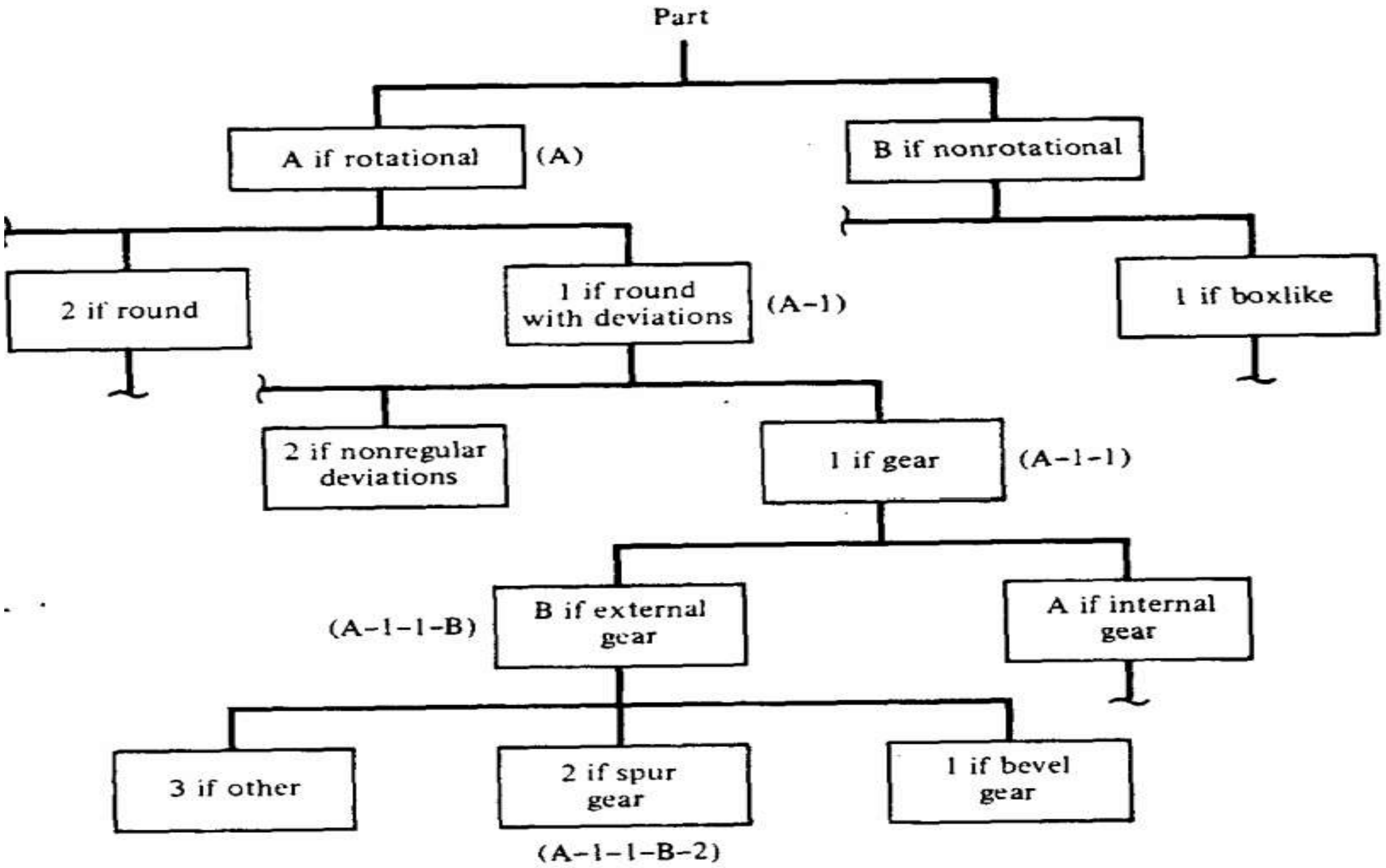
  1. ***Design attributes,*** which concerned with part characteristics such as geometry, size and material. (Basic external and internal shape Rotational or rectangular shape, L/D ratio, Aspect ratio, Dimensions and Tolerances)

  2. ***Manufacturing attributes,*** which consider the sequence of processing steps required to make a part.(Major processes, Minor operations, Operation sequence, Dimension, Surface finish, Machine tool Production cycle time)

- There are three basic code structures used in group technology
  - Monocode or hierarchical code
  - Polycode or attribute
  - Hybrid or mixed code

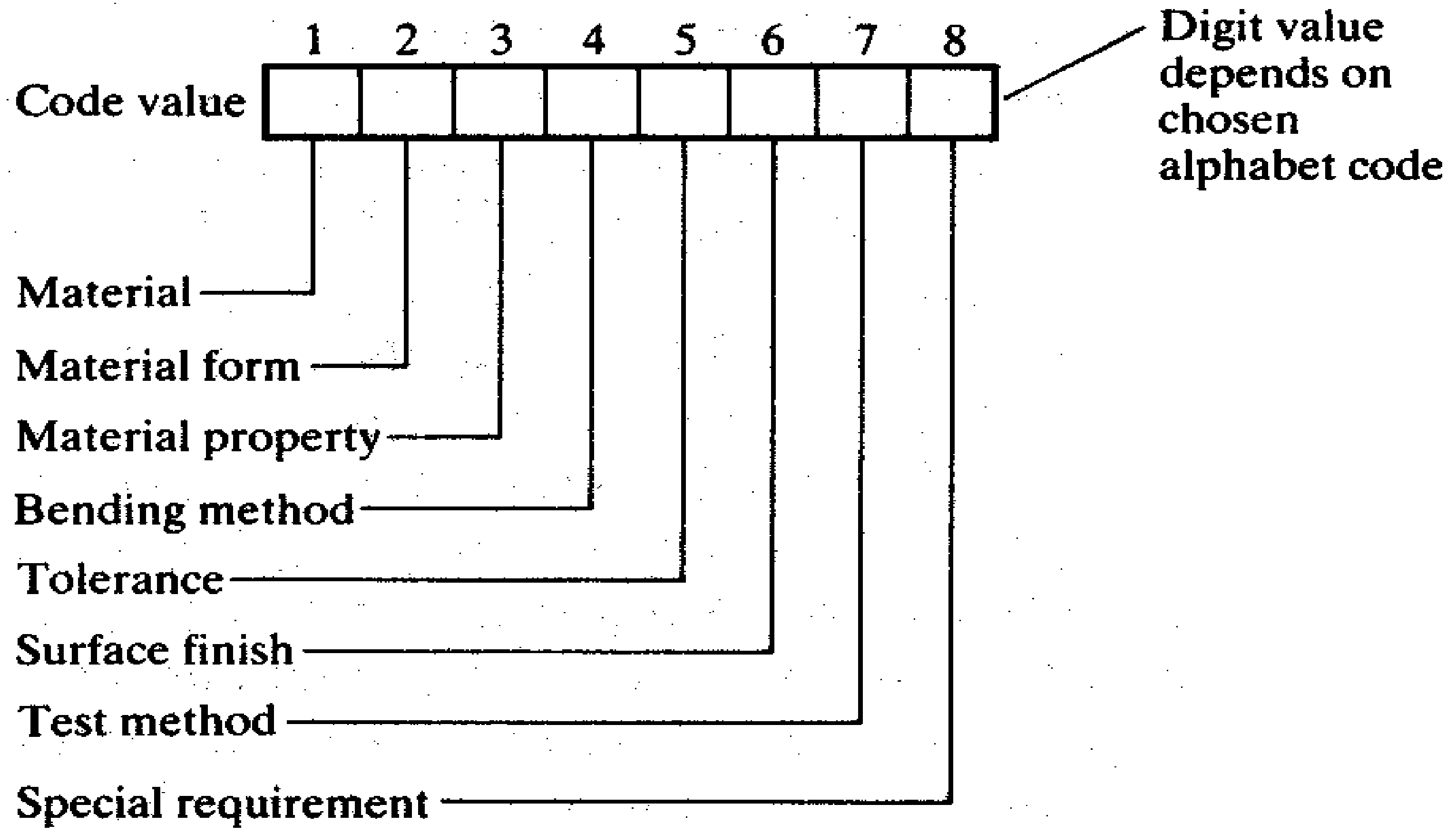
Monocode or Hierarchical code

In which the interpretation of each successive symbol depends on the value of the preceding symbols.



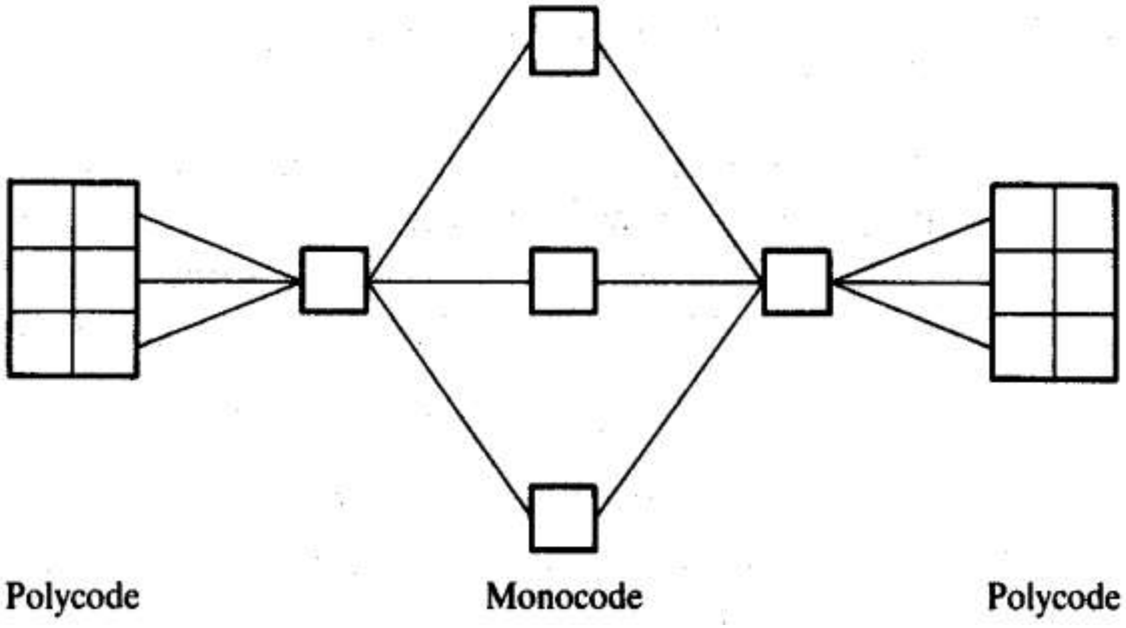
Polycode or Attribute Code

- In which the interpretation of each symbol in the sequence is always the same, it does not depend on the value of the preceding symbols.



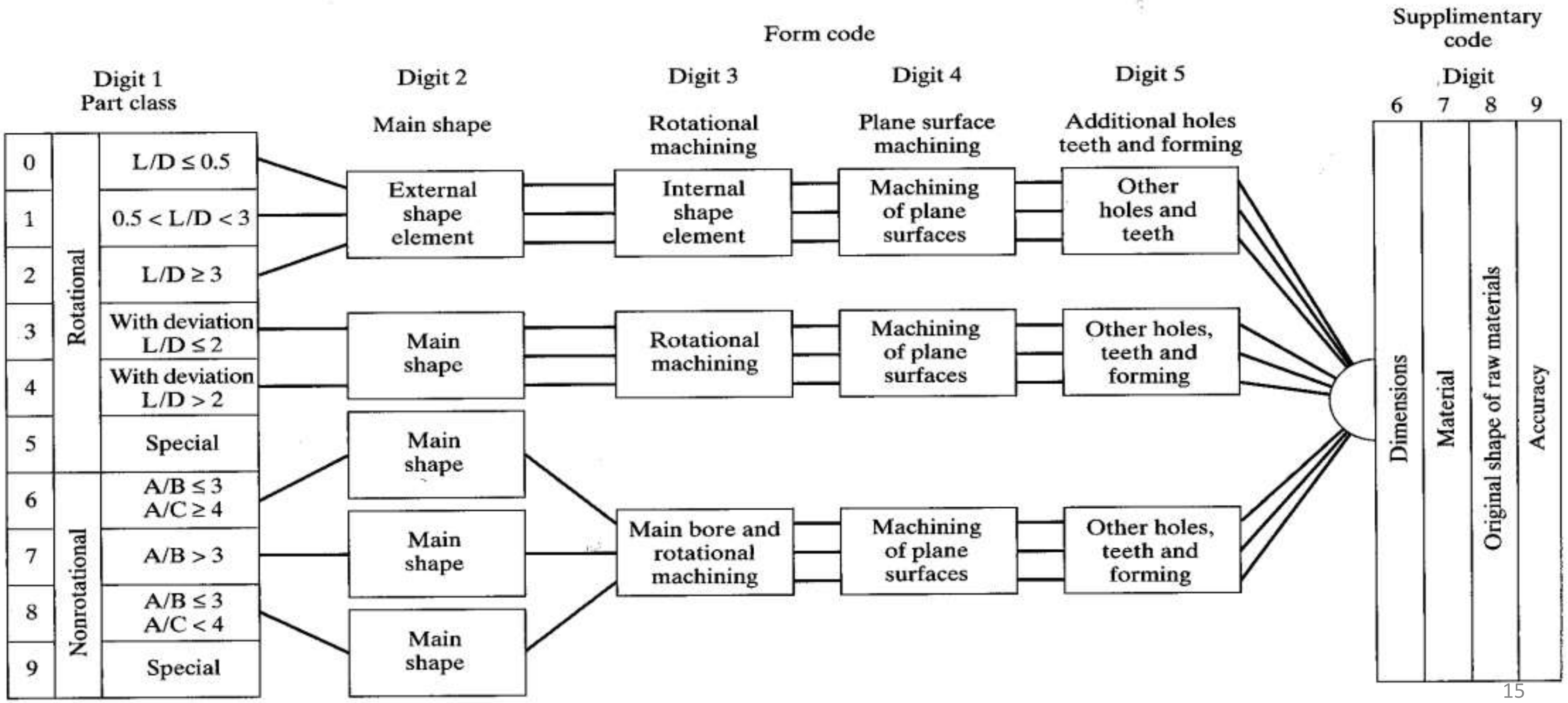
Hybrid or Decision Code

- Construction to combine the best features of monocodes and polycodes
- Best examples of a hybrid code is the opitz code and classification system



Opitz Classification System (H.opitz university of Aachen in Germany)

Form Code	1 2 3 4 5	*for design attributes*
Supplementary Code	6 7 8 9	*for manufacturing attributes*
Secondary Code	A B C D	for production operation type & sequence



Opitz Coding System

Digit 1

Part Class

0	Rotational	$L/D \leq 0{,}5$
1	Rotational	$0{,}5 < L/D < 3$
2	Rotational	$L/D \geq 3$
3	Rotational	With deviation $L/D \leq 2$
4	Rotational	
5	Rotational	
6	Non-rotational	
7	Non-rotational	
8	Non-rotational	
9	Non-rotational	

Digit 2

External shape, external shape elements

0			Smooth, no shape elements
1	Stepped to one end		No shape elements
2	Stepped to one end	Or smooth	Thread
3	Stepped to one end	Or smooth	Functional groove
4	Stepped to both ends		No shape elements
5	Stepped to both ends		Thread
6	Stepped to both ends		Functional groove
7			Functional cone
8			Operating thread
9			All others

Digit 3

Internal shape, internal shape elements

0		No hole, no breakthrough
1	Smooth or stepped to one end	No shape elements
2	Smooth or stepped to one end	Thread
3	Smooth or stepped to one end	Functional groove
4	Stepped to both ends	No shape elements
5	Stepped to both ends	Thread
6	Stepped to both ends	Functional groove
7		Functional cone
8		Operating thread
9		All others

Digit 4

Plane surface machining

0	No surface machining
1	Surface plane and/or curved in one direction, external
2	External plane surface related by graduation around the circle
3	External groove and/or slot
4	External spline
5	External plane surface and/or slot, external spline
6	Internal plane surface and/or slot
7	Internal spline
8	Internal and external polygon, groove and/or slot
9	All others

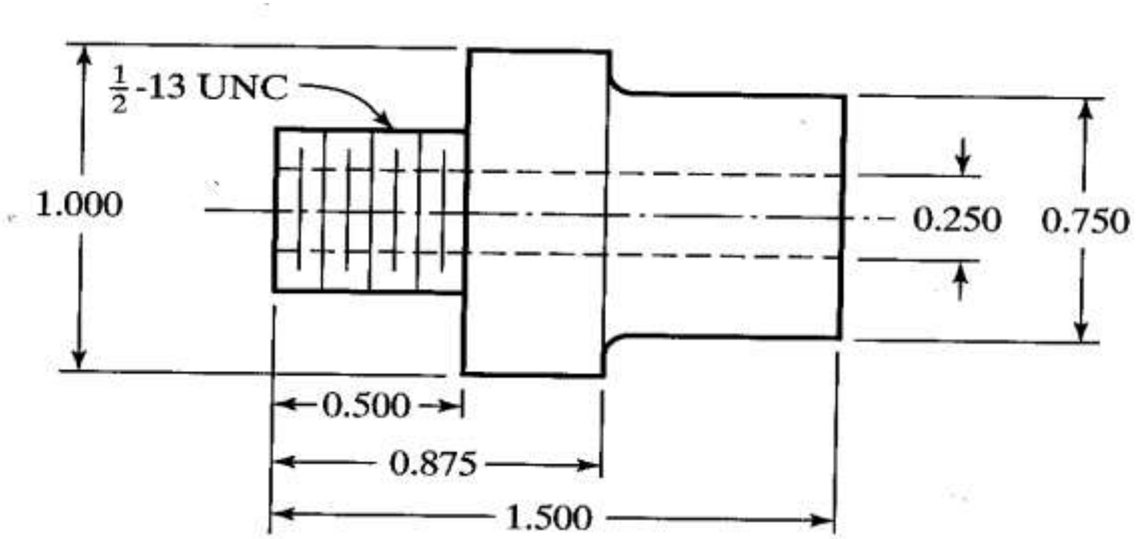
Digit 5

Auxiliary holes and gear teeth

0	No gear teeth	No auxiliary hole
1	No gear teeth	Axial, not on pitch circle diameter
2	No gear teeth	Axial on pitch circle diameter
3	No gear teeth	Radial, not on pitch circle diameter
4	No gear teeth	Axial and/or radial and/or other directions
5	No gear teeth	Axial and/or radial on PCD and/or other directions
6	With gear teeth	Spur gear teeth
7	With gear teeth	Bevel gear teeth
8	With gear teeth	Other gear teeth
9	With gear teeth	All others

Example: *Optiz part coding System*

- Given the rotational part design below, determine the form code in the Optiz parts classification and coding system.



Solution

- ***Length-to-diameter ratio*: L/D = 1.5** **Digit 1 = 1**
- ***External shape*: both ends stepped with screw thread on one end** **Digit 2 = 5**
- ***Internal shape:* part contains a through hole** **Digit 3 = 1**
- ***Plane surface machining*: none** **Digit 4 = 0**
- ***Auxiliary holes, gear teeth, etc.*: none** **Digit 5 = 0**

The form code in the Optiz system is 15100

MICLASS System

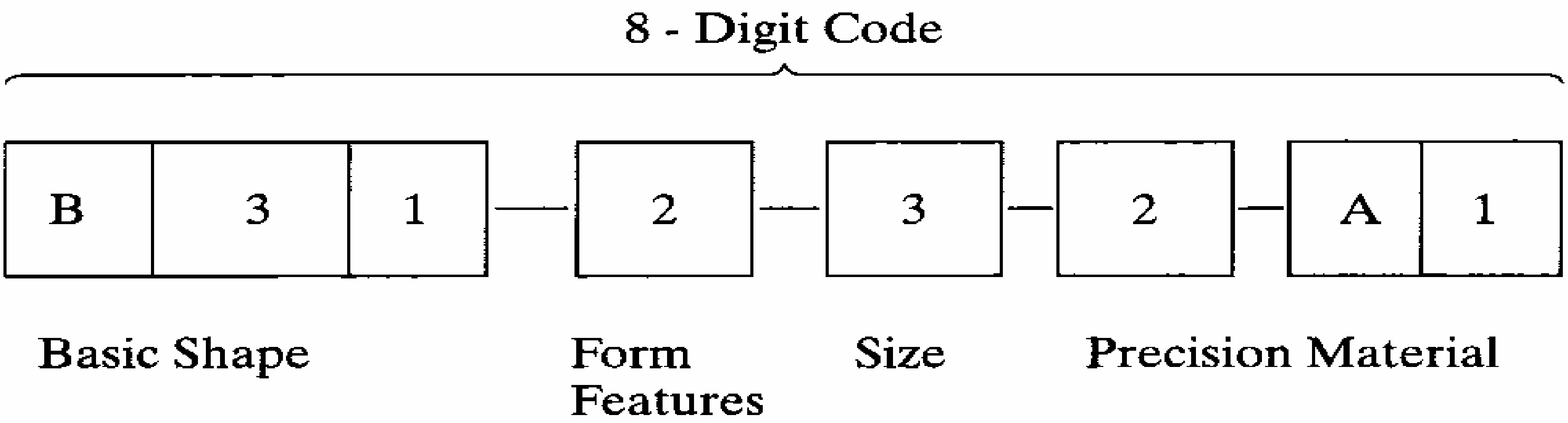
- It stands for **M**etal **I**nstitute **C**lassification system and developed by Netherlands Organization for Applied Scientific research. It is referred as Multiclass system.
- MICLASS classification range from 1 to 30 digits. Universal code the first 12 digits code and next 18 digits are Supplementary code

Code Position	Item
1	Main shape
2	Shape elements
3	
4	Position of shape element
5	Main dimension
6	
7	Dimension ratio
8	Auxiliary dimension
9	Tolerance codes
10	
11	Material codes
12	

DCLASS Coding system

DCLASS Stands for Design and Classification Information System It was developed at Brigham Young University

The DCLASS part family code is comprised of eight digits partitioned into five code segments



Production Flow Analysis (PFA)

- Production flow analysis (PFA) is a method for identifying part families and associated machine groupings that uses the information contained on process plans rather than on part drawings.
- Steps involved in PFA
  - ✓ Data collection
  - ✓ Sortation of process routings
  - ✓ Preparation of a PFA chart and
  - ✓ Cluster analysis

Production Flow Analysis (PFA)

- The procedure of Production flow analysis (PFA) consists of the following steps:

1. ***Data Collection***. The minimum data needed in the analysis are the part number and operation sequence, which is obtained from process plans.

2. ***Sortation of process plans*** A sortation procedure is used to group parts with identical process plans.

3. ***PFA Chart*** The processes used for each group are then displayed in a PFA chart as shown below.

4. ***Clustering Analysis*** From the pattern of data in the PFA chart, related groupings are identified and rearranged into a new pattern that brings together groups with similar machine sequences.

Example #1

Consider a problem of 5 machines and 6 parts. Try to group them by using *Rank Order Clustering Algorithm.*

	Part 'Number'						
Machine ID		1	2	3	4	5	6
	1			1		1	
	2		1	1			
	3	1			1		
	4		1	1		1	
	5	1			1		1

Step 1:

	Part Numbers							Decimal equivalent	Rank
Machine ID		1	2	3	4	5	6		
	B. Wt:	2^5	2^4	2^3	2^2	2^1	2^0		
	1			1		1		$2^3+2^1 = 10$	5
	2		1	1				$2^4+2^3 = 24$	4
	3	1			1			$2^5+2^2=36$	2
	4		1	1		1		$2^4+2^3+2^1 = 26$	3
	5	1			1		1	$2^5+2^2+2^0=37$	1

Step 2: Must Reorder!

Step 2:

		Part Number					
		1	2	3	4	5	6
Machine ID	5	1			1		1
	3	1			1		
	4		1	1		1	
	2		1	1			
	1			1		1	

Step 3:

			Part Number					
		B. WT.	1	2	3	4	5	6
Machine ID	5	2^4	1			1		1
	3	2^3	1			1		
	4	2^2		1	1		1	
	2	2^1		1	1			
	1	2^0			1		1	
Decimal equivalent			$2^4+2^3 = 24$	$2^2+2^1=6$	$2^2+2^1+2^0=7$	$2^4+2^3=24$	$2^2+2^0=5$	$2^4=16$
Rank			1	5	4	2	6	3

Step 4: Must Reorder

Back at Step 1:

		Part Number						D. Eqv	Rank
		1	4	6	3	2	5		
B Wt:		2^5	2^4	2^3	2^2	2^1	2^0		
	5	1	1	1				$2^5+2^4+2^3=56$	1
	3	1	1					$2^5+2^4=48$	2
	4				1	1	1	$2^2+2^1+2^0=7$	3
	2				1	1		$2^2+2^1=6$	4
	1				1		1	$2^2+2^0=5$	5

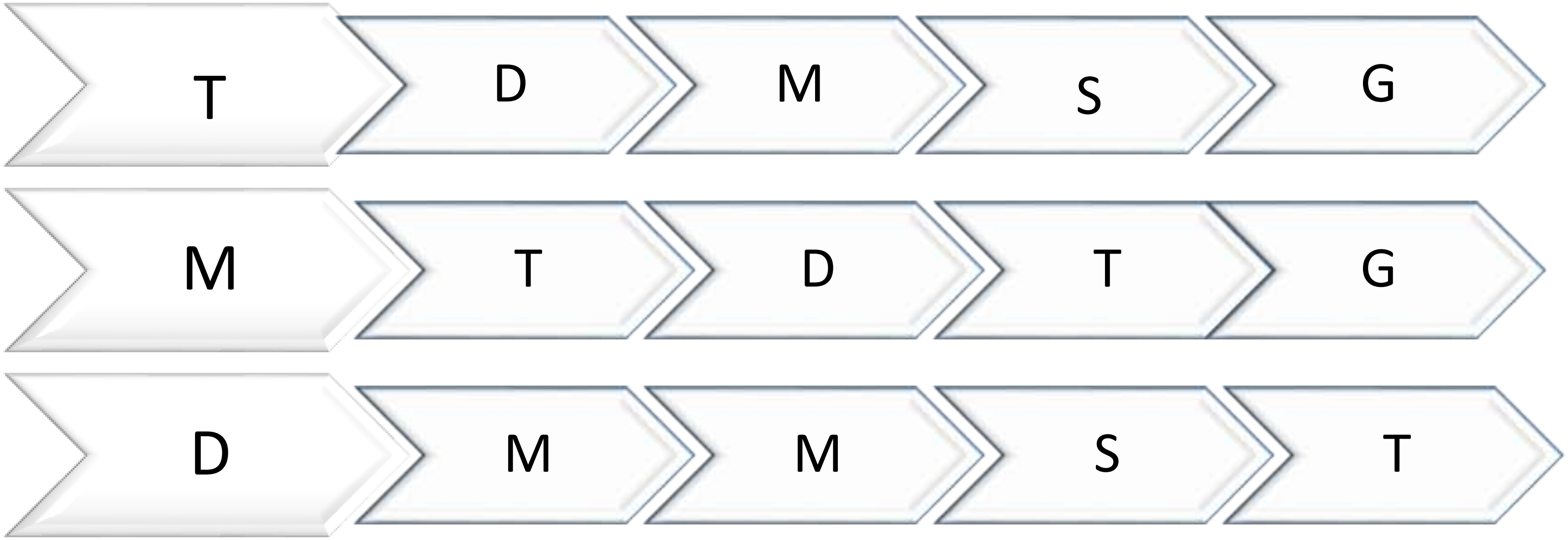
Order stays the same: STOP!

Plant layout using GT

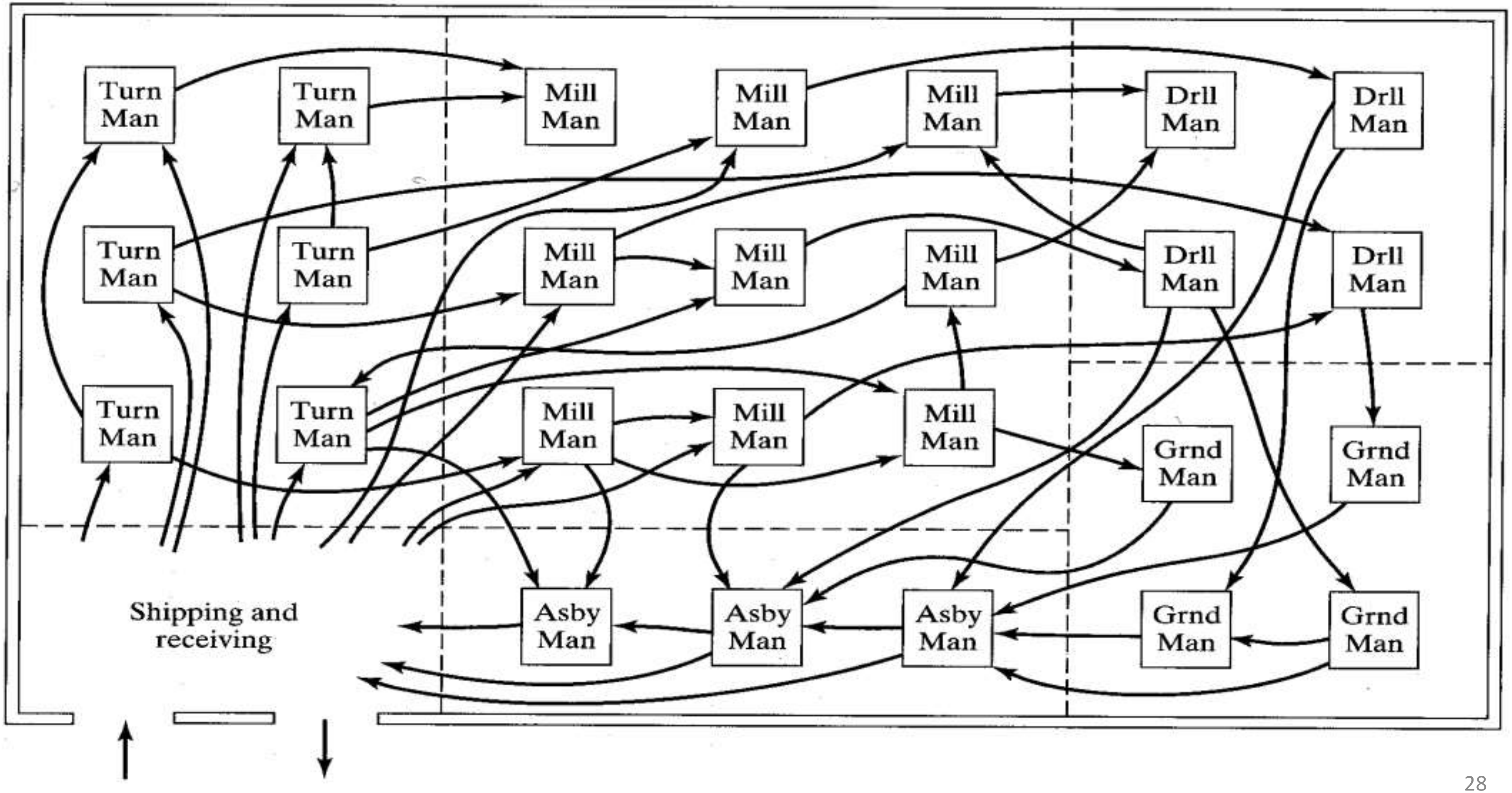
The objective of the plant layout, refers to the physical arrangement that most economically meets the required output quantity and quality.

There are basic ways to arrange the machines in shop

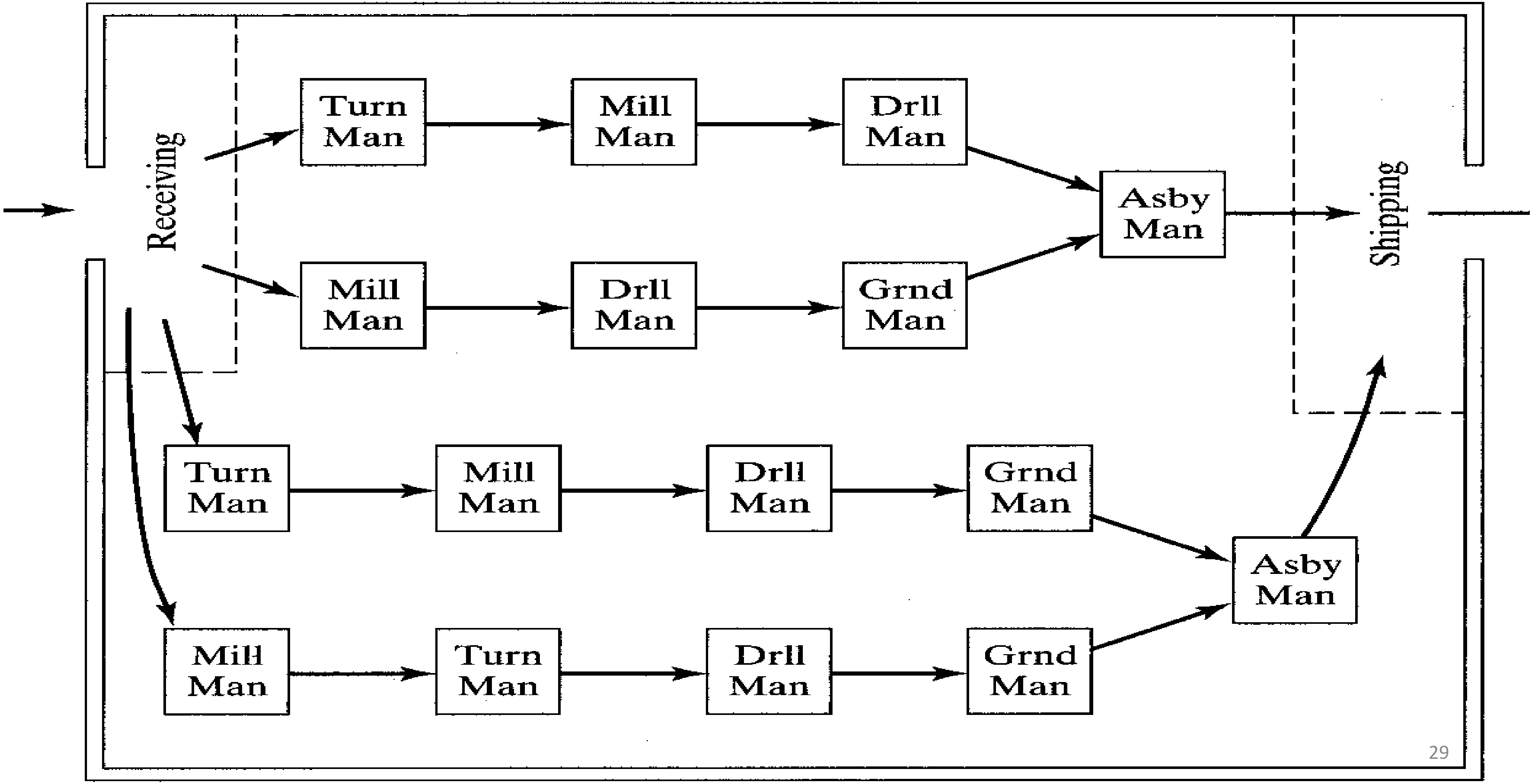
- Line (or) product layout
- Functional (or) process layout
- Group (or) combination layout



Functional (or) process layout



Group (or) Combination Layout



BENEFITS OF GT

- Engineering Design
- Tooling and setups
- Materials and Handling
- Production and Inventory control
- Process planning
- Management and employees

Cellular Manufacturing

Application of group technology in which dissimilar machines or processes are aggregated into cells, each of which is dedicated to the production of a part family or limited group of families

Typical objectives of cellular manufacturing:

- ✓ To shorten manufacturing lead times
- ✓ To reduce WIP
- ✓ To improve quality
- ✓ To simplify production scheduling
- ✓ To reduce setup times

Before - Parts are processed and moved between different departments in large lots.

After - Parts are completed within the cell in small lots.

Rank Order Clustering Algorithm (ROC)

Rank Order Clustering Algorithm is a simple algorithm used to form ***machine-part groups.***

Step 0: Total number of components and components sequence

Step 1: Form the machine-component incidence matrix using the component sequences.

Step 2: Assign binary weight and calculate a decimal weight for each row.

Step 3: Rank the rows in order of decreasing decimal weight values.

Step 4: Repeat steps 2 and 3 for each column.

Step 5: Continue preceding steps until there is no change in the position of each element in the row and the column.

Example #1

Consider a problem of 5 machines and 6 parts. Try to group them by using *Rank Order Clustering Algorithm.*

	Component (j)						
Machines (i)		1	2	3	4	5	6
	1			1		1	
	2		1	1			
	3	1			1		
	4		1	1		1	
	5	1			1		1

Step 1:

	Component (j)							Decimal equivalent	Rank
Machines (i)		1	2	3	4	5	6		
	B. Wt:	2^5	2^4	2^3	2^2	2^1	2^0		
	1			1		1		$2^3+2^1 = 10$	5
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	4		1	1		1		$2^4+2^3+2^1 = 26$	3
	5	1			1		1	$2^5+2^2+2^0=37$	1

Step 2: Must Reorder!

Step 2:

		Component (j)					
		1	2	3	4	5	6
Machines (i)	5	1			1		1
	3	1			1		
	4		1	1		1	
	2		1	1			
	1			1		1	

Step 3:

			Component (j)					
		B. WT.	1	2	3	4	5	6
Machines (i)	5	2^4	1			1		1
	3	2^3	1			1		
	4	2^2		1	1		1	
	2	2^1		1	1			
	1	2^0			1		1	
Decimal equivalent			$2^4+2^3 = 24$	$2^2+2^1= 6$	$2^2+2^1+ 2^0=7$	$2^4+2^3= 24$	$2^2+2^0= 5$	$2^4=16$
Rank			1	5	4	2	6	3

Step 4: Must Reorder

Back at Step 1:

		Component (j)						D. Eqv	Rank
		1	4	6	3	2	5		
B Wt:		2^5	2^4	2^3	2^2	2^1	2^0		
Machines (i)	5	1	1	1				$2^5+2^4+2^3=56$	1
	3	1	1					$2^5+2^4=48$	2
	4				1	1	1	$2^2+2^1+2^0=7$	3
	2				1	1		$2^2+2^1=6$	4
	1				1		1	$2^2+2^0=5$	5

Order stays the same: STOP!

Clustering Methods

- Using Process Similarity methods:
  - Create Machine – Part Matrices
  - Compute machine ‘pair-wise’ similarity Coefficient comparisons:

$$S_{ij} = \frac{x_{ij}}{\left(x_{ij} + x_{jj}\right)}$$

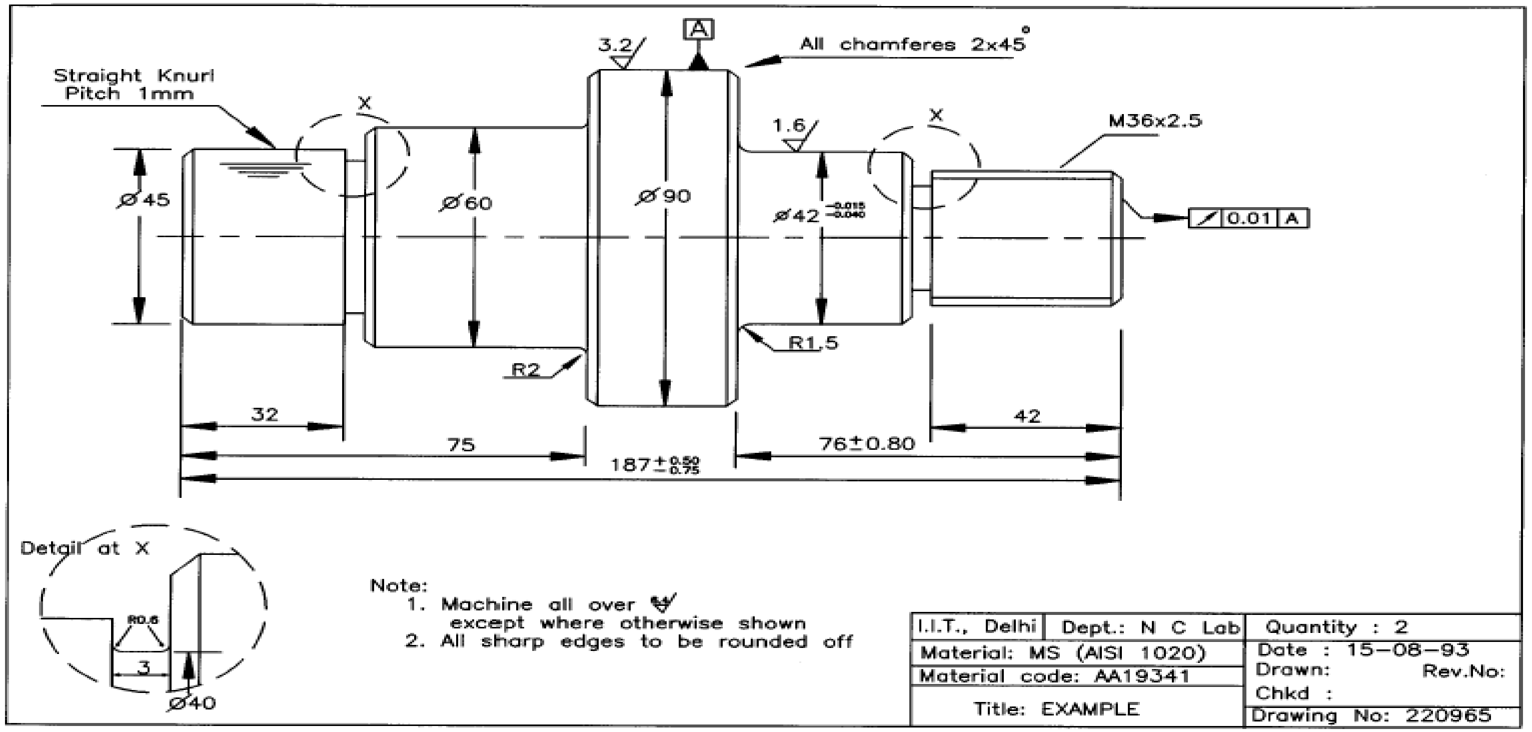
Where x_{ij} is the number of parts visiting both machines of the pair

x_{jj} is the number of parts visiting one but not both machine

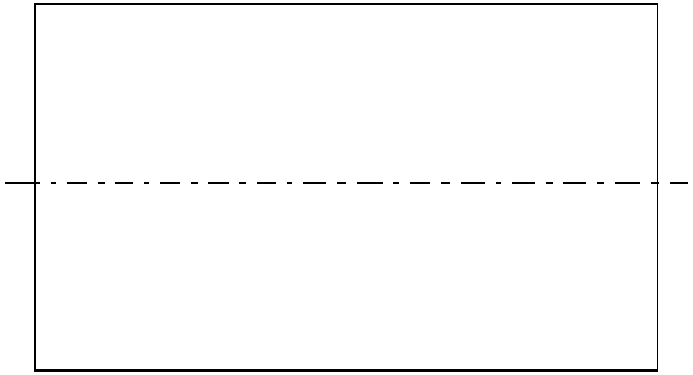
Defining Process planning

- Process planning can be defined as the systematic determination of the detailed methods by which work pieces or parts can be manufactured economically and competitively from initial stages (raw material form) to finished stages (desired form). The activity of developing such a plan is called process planning.
- Geometrical features, dimensional sizes, tolerances, materials, and surface finishes are analyzed and evaluated to determine an appropriate sequence of processing operations.

Final Form



Initial Form



Process Planning Steps

Route Sheet — XYZ Machine Shop, Inc.

Part no.	Part name	Planner	Checked by	Date	Page
081099	**Shaft, generator**	MPGroover	N. Needed	08/12/XX	1/1

Material	Stock size	Comments
1050 H18 Al	60 mm diam., 206 mm length	

No.	Operation description	Dept	Machine	Tooling	Setup	Std.
10	Face end (approx. 3 mm). Rough turn to 52.00 mm diam. Finish turn to 50.00 mm diam. Face and turn shoulder to 42.00 mm diam. and 15.00 mm length.	Lathe	L45	G0810	1.0 hr	5.2 min.
20	Reverse end. Face end to 200.00 mm length. Rough turn to 52.00 mm diam. Finish turn to 50.00 mm diam.	Lathe	L45	G0810	0.7 hr	3.0 min.
30	Drill 4 radial holes 7.50 mm diam.	Drill	D09	J555	0.5 hr	3.2 min.
40	Mill 6.5 mm deep x 5.00 mm wide slot	Mill	M32	F562	0.7 hr	6.2 min.
50	Mill 10.00 mm wide flat, opposite side.	Mill	M13	F630	1.5 hr	4.8 min.

Responsibilities of Process Planning

- Part print analysis and symbols
- Gathering the fundamental details of product design
- Selecting the machining processes
- Selecting proper machining tool
- Sequencing the operations
- Deciding on the inspection equipment
- Determining appropriate production tolerances
- Proper cutting tools and cutting conditions
- Calculating the overall times using work measurement techniques

PROCESS PLANNING ACTIVITES

ANALYSIS (part requirements)

↓

DETERMINE (operation sequence)

↓

SELECTION OF MACHINES (equipment)

↓

CALCULATE (processing times)

↓

DOCUMENT (process planning)

↓

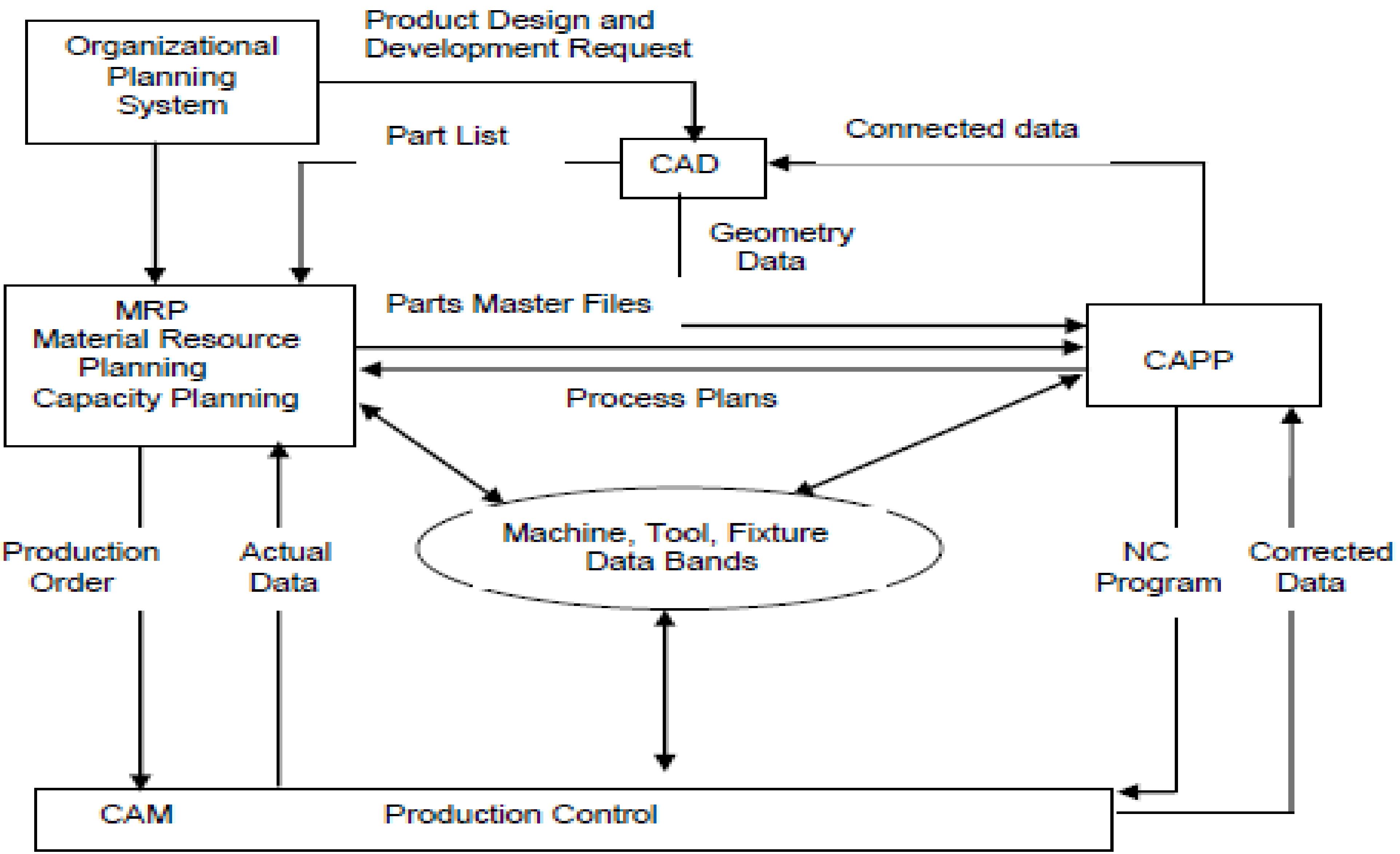
COMMUNICATION (mfg. engr. To shop floor)

Role of Process Planning in CAD/CAM Integration

Process Planning In Product Cycle

- Process planning acts as a bridge between design and manufacturing.
- If the design of the product has evolved, its manufacturing necessitates careful planning and scheduling of the various processes of manufacture.
- The cycle from concept to design, planning, production, quality control and feedback to design goes on in which one can easily understand the crucial role of planning.

Role of Process Planning in CAD/CAM Integration



Manual process planning

Advantages of MPP

- ❖ Very much suitable for small scale company
- ❖ Low investment cost

Disadvantages of MPP

- ❖ Skilled process planner
- ❖ Very complex and time consuming job
- ❖ More possibilities for human error
- ❖ Increases paper work

Computer Aided Process Planning

- Process rationalization and standardisation
- Productivity improvement
- Product cost reduction
- Elimination of human error
- Reduction in time
- Reduced paper work
- Faster response
- Improved legibility

Approaches to CAPP

Types of Approaches

- Variant Approach - Computer **search** for existing or similar process plans of similar part families using codes, **retrieves** and then **edit** according to new process sequence.

- Generative Approach - Computer **generates new** process plan every time when a new plan is needed.

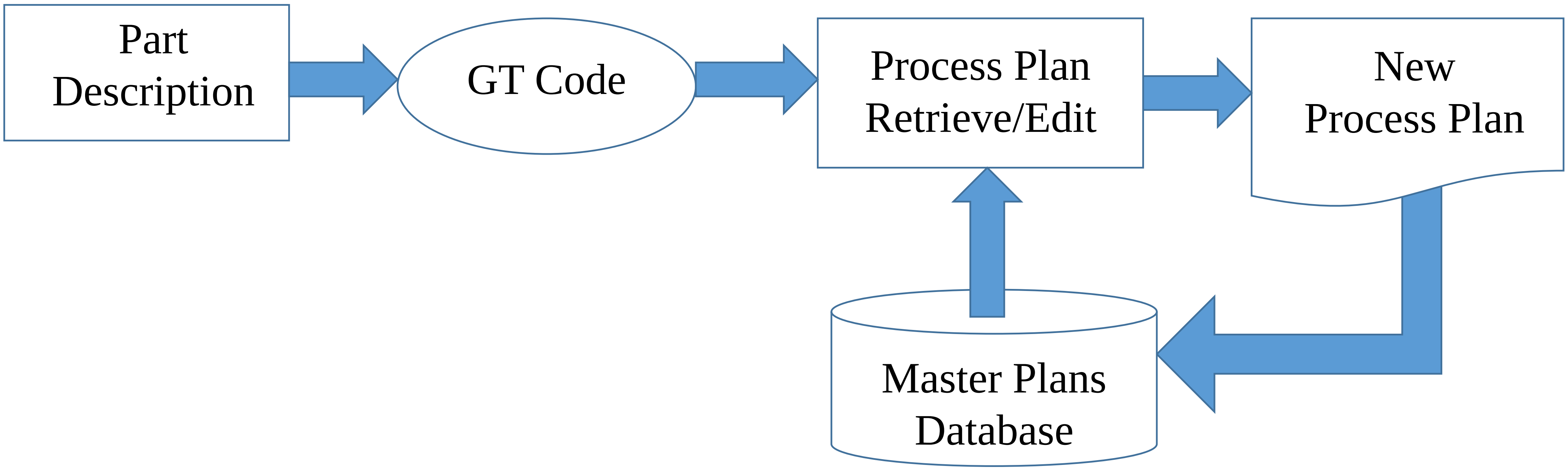
Data Input to CAPP

- Generally the geometric model of the part is the input for the process planning system.
- The input to the process planning system may be engineering drawing or CAD model.

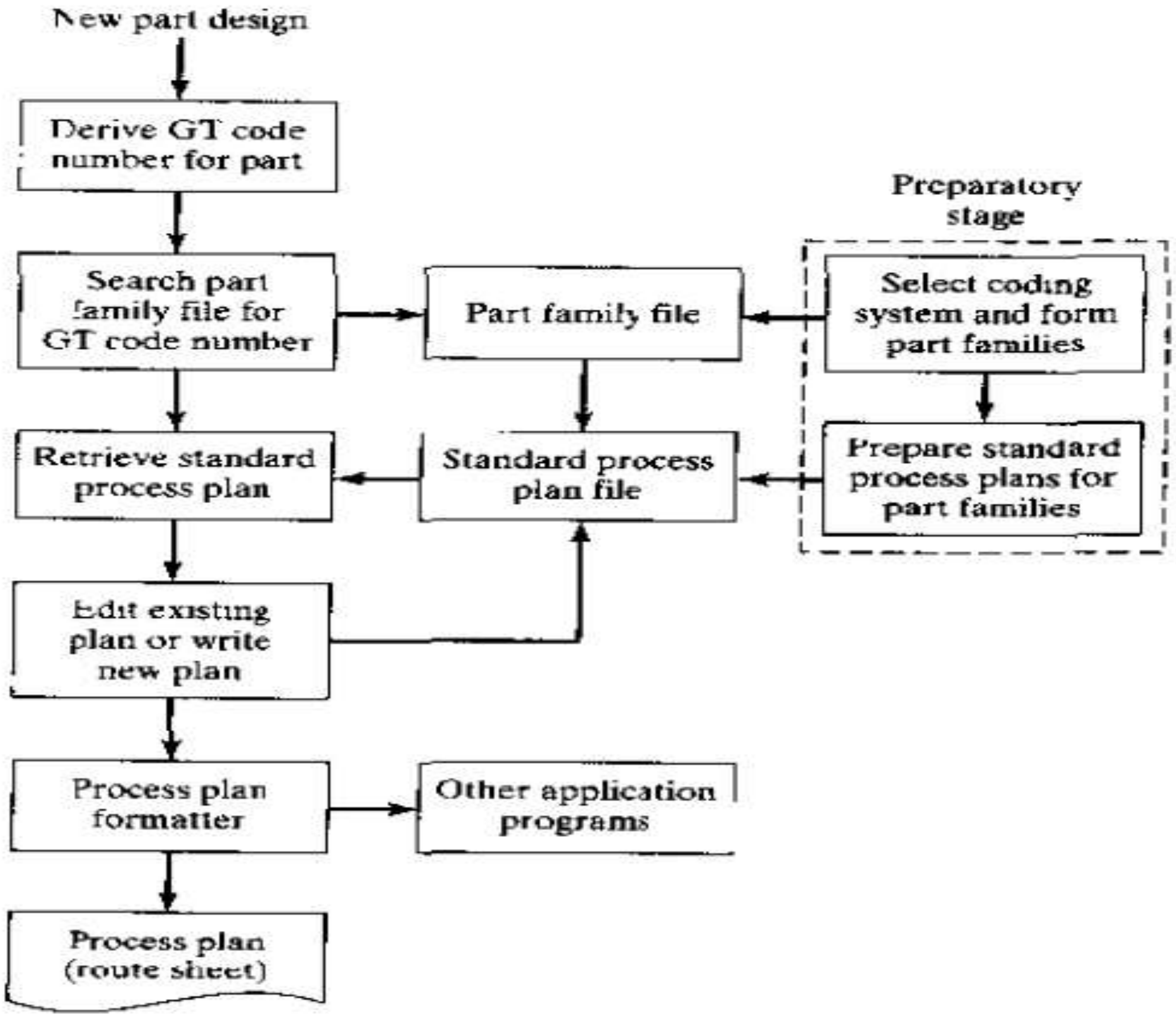
The other prerequisites for process planning are given below:

- Parts list
- Annual demand/batch size
- Accuracy and surface finish requirement (CAD Database)
- Equipment details (Work centre Database)
- Data on cutting fluids, tools, jigs & fixtures, gauges
- Standard stock sizes
- Machining data, data on handling and setup

Variant or Retrieval Approaches to CAPP



Retrieval CAPP system



Variant CAPP Examples

System name	Company	Part data IP	Decision logic	Planning functions
CUTPLAN	Metcut	Code	Standard plans and decision tree	Process sequence Materials Machines Tools and Fixtures
CAPP	CAM-I	Code	Standard plans	Process sequence
DCLASS	CAM lab BYU	Intractive Part Description	Decision Tree	Process sequence Materials Machines Tools and Fixtures

Advantages / Disadvantages of Variant type CAPP

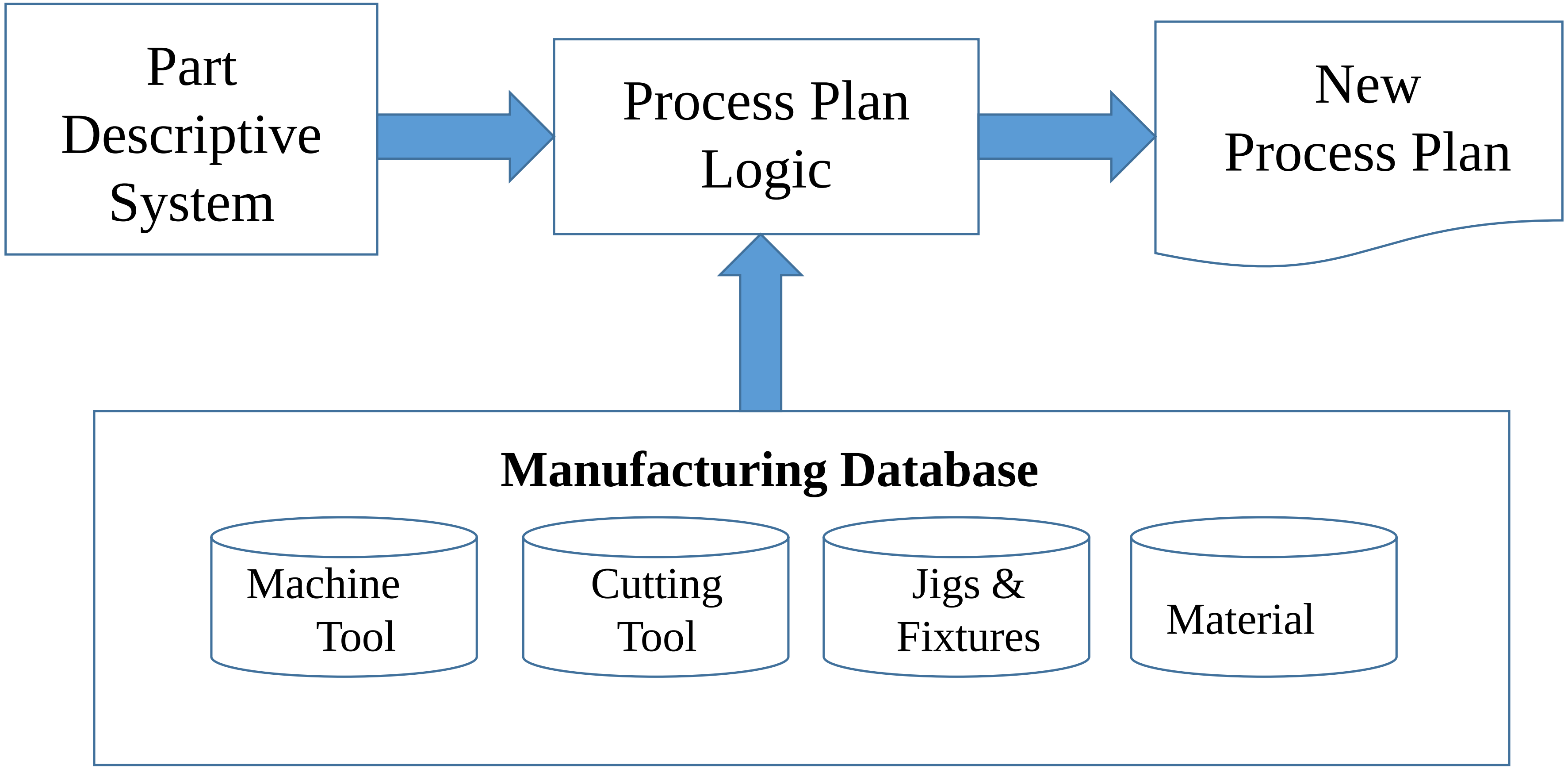
Advantages

- Reduction of time and labour requirement.
- Processing and evaluation of complicated activities and managerial issues are done in an efficient manner.
- Structuring manufacturing knowledge of the process plans to company’s needs through standardized procedures.

Disadvantages

- Difficult to maintain consistency during editing.
- Proper accommodation of various combinations of attributes such as material, geometry, size, precision, quality, alternate processing sequence and machine loading among many other factors are difficult.
- Quality is dependent on knowledge and skill of planner.

Generative Approaches to CAPP



Generative CAPP Examples

- APPAS
- CADAM
- BYUPLAN
- GENPLAN
- PROPLAN

MERITS AND DEMERTIS

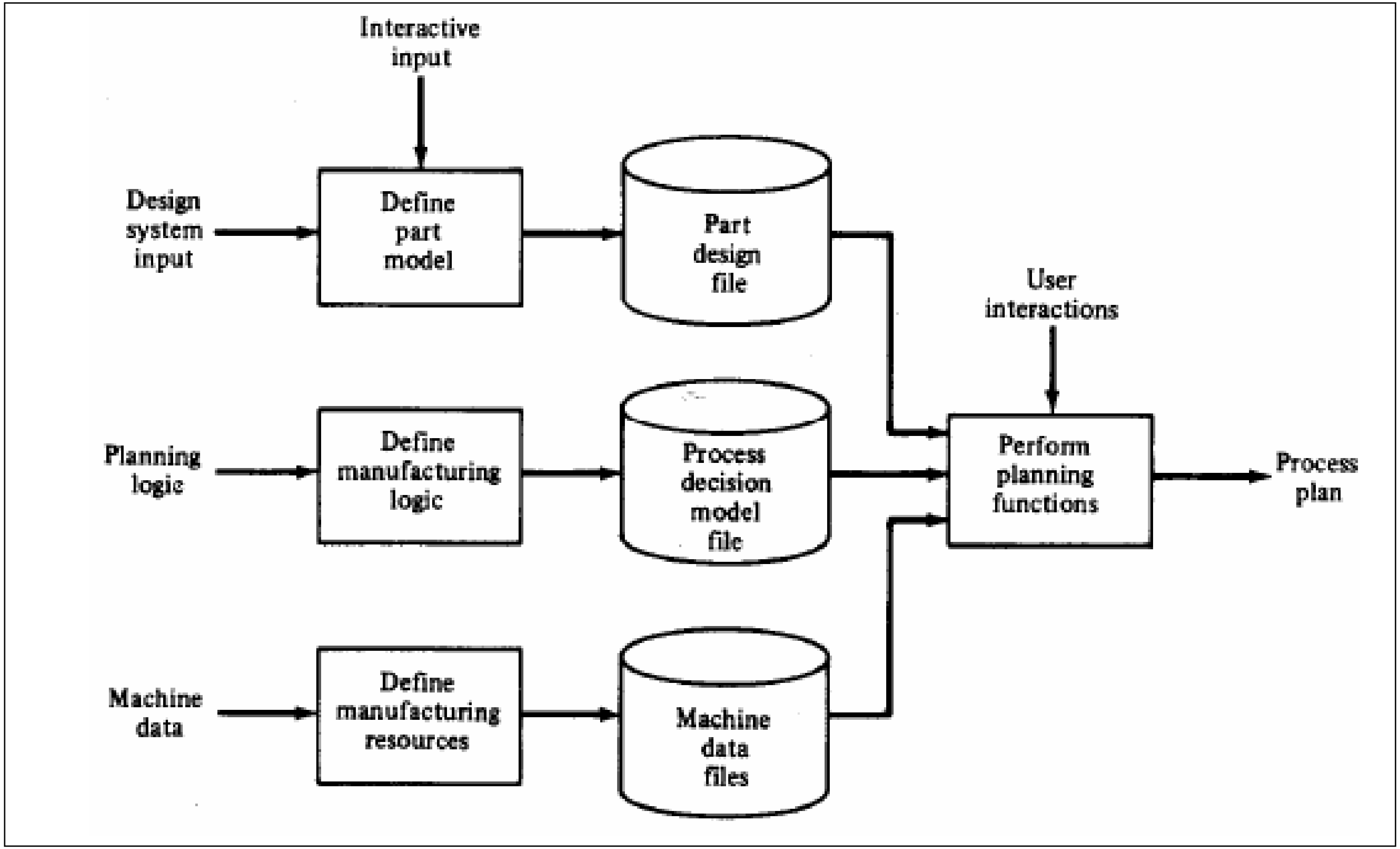
- New components can be planned easily as existing components
- Drawbacks is complex and very difficult to develop

Computer Managed Process Planning (CMPP)

- It is a generative system capable of automatically making process decisions.

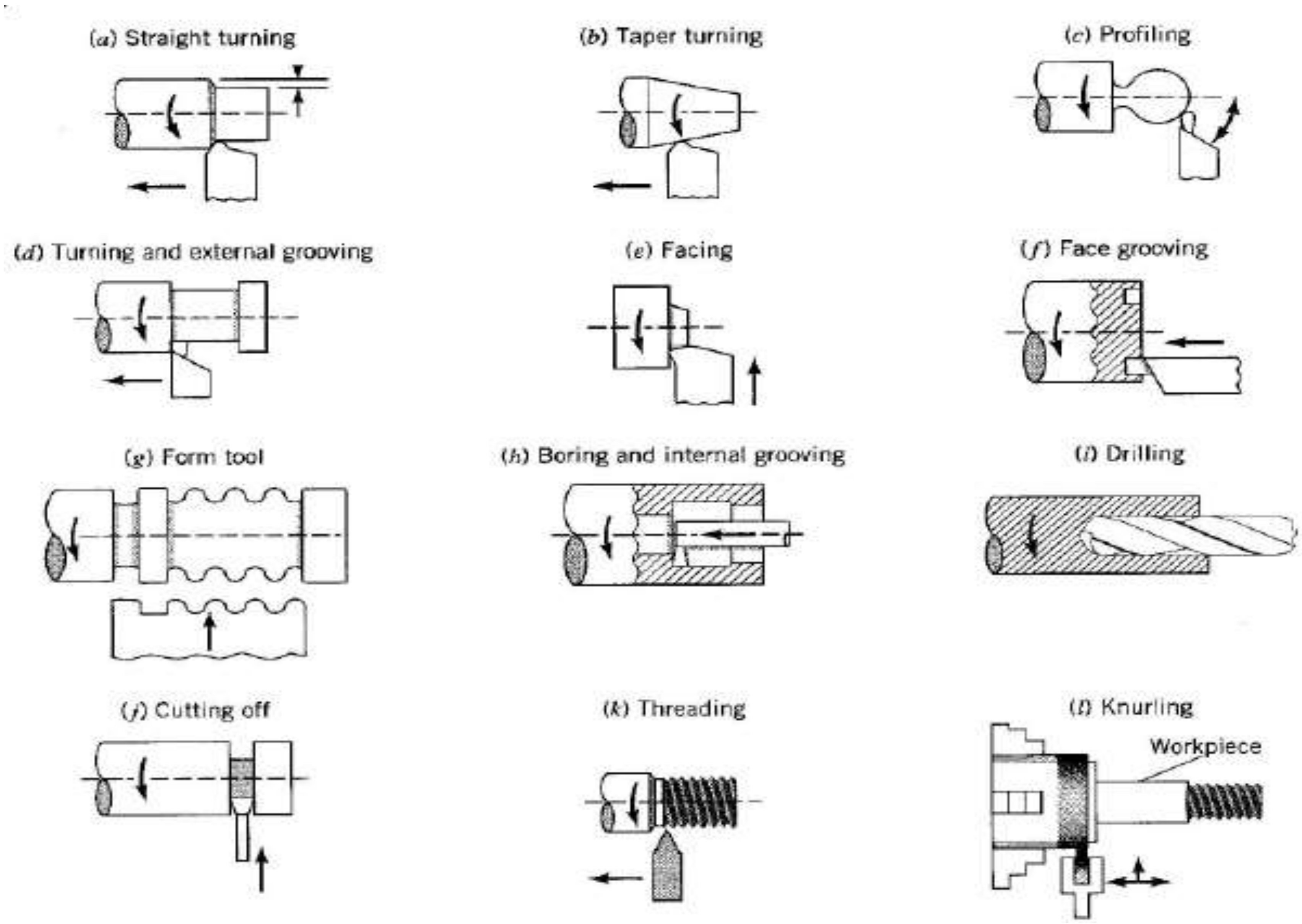
- An extensive interactive capability is provided which permits the use to examine and modify a process plan as it is developed.

CMPP System Overview



Computerized Manufacturing Process Planning (CMPP)

Turning Operations



IMPORTANT QUESTIONS

1. Define Group Technology and its role in CAD/CAM Integration.
2. What is Part Families Classification And Coding?
3. Explain – DCLASS / MCLASS with suitable examples.
4. Explain OPTIZ Coding Systems with illustrations.
5. Explain facility design using G.T and its benefits of GT.
6. Define Cellular Manufacturing.
7. What is Process Planning and explain its role Of Process Planning in CAD/CAM Integration.
8. What are the types/approaches to CAPP? Explain Variant or Retrieval Approach / Generative Approaches
9. Compare and contrast CAPP And CMPP Systems.