UNIT-II

GROUP TECHNOLOGY

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CONTENTS:-

What is Group Technology (GT)?

- GT is a theory of management based on the principle that similar things should be done similarly
- GT is the realization that many problems are similar, and that by grouping similar problems, a single solution can be found to a set of problems thus saving time and effort
- GT is a manufacturing philosophy in which similar parts are identified and grouped together to take advantage of their similarities in design and production

Implementing GT

Where to implement GT?

- Plants using traditional batch production and process type layout
- If the parts can be grouped into part families

How to implement GT?

- Identify part families
- Rearrange production machines into machine cells

Types of Layout

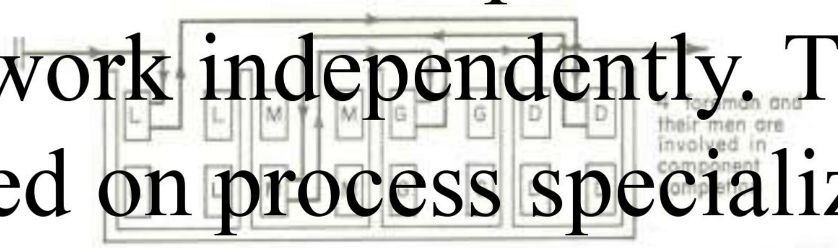
In most of today's factories it is possible to divide all the made components into families and all the machines into groups, in such a way that all the parts in each family can be completely processed in one group only.

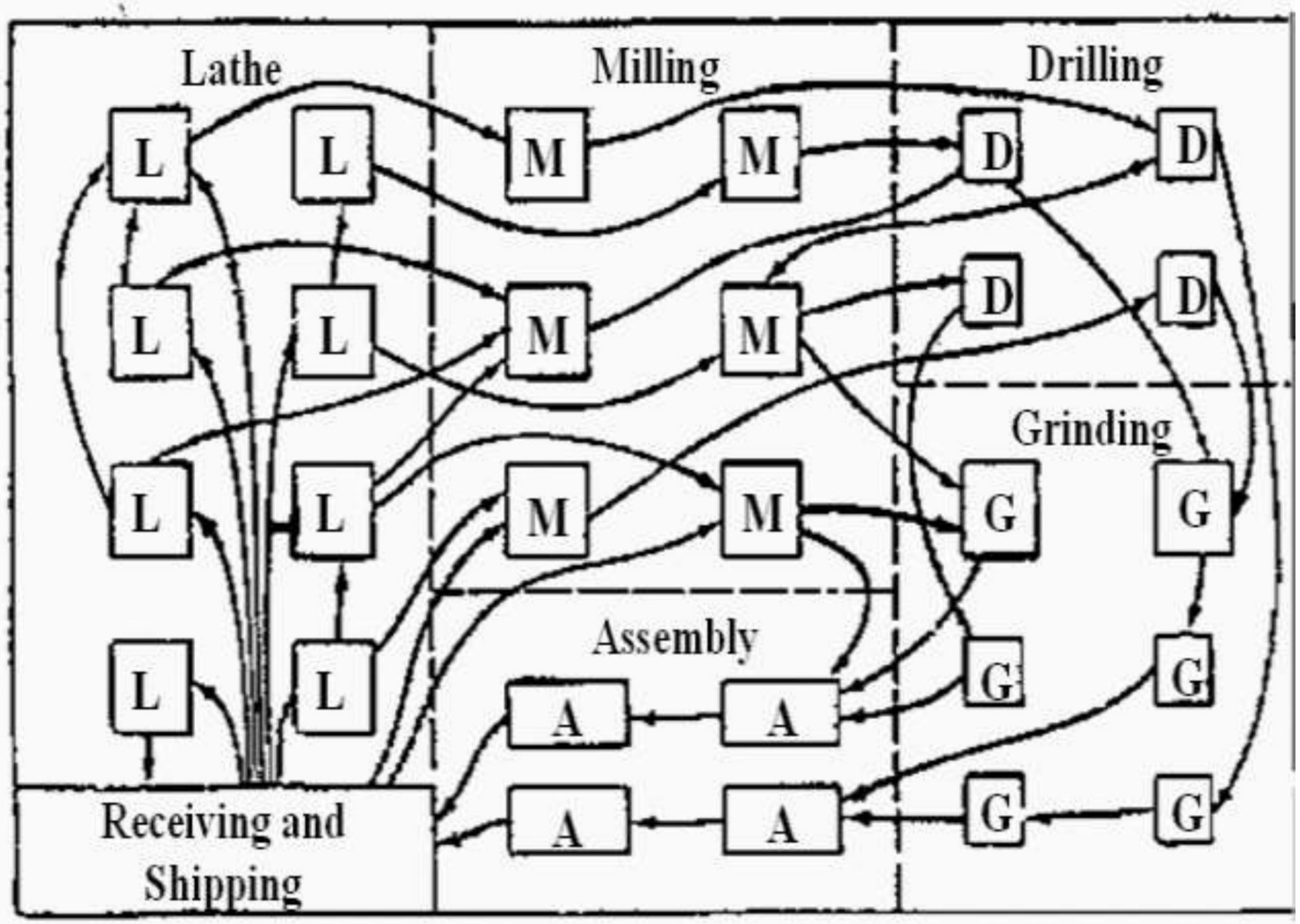
The two main types of layout are:

- Functional Layout
- Group Layout

Functional Layout(or) process layout

- In Functional Layout, all machines of the same type are laid out together in the same section under the same foreman. Each foreman and his team of workers specialize in one process and work independently. This type of layout is based on process specialization.





PROCESS-TYPE LAYOUT

In process lay out all the machine tools of same process are grouped in a single department and placed together.

1. This results in a significant amount of material handling.

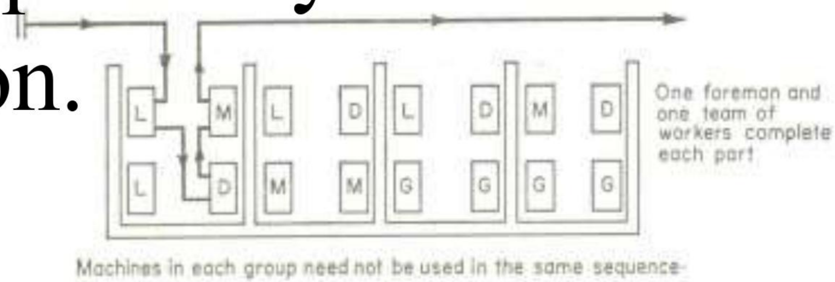
2. A large in process inventory.

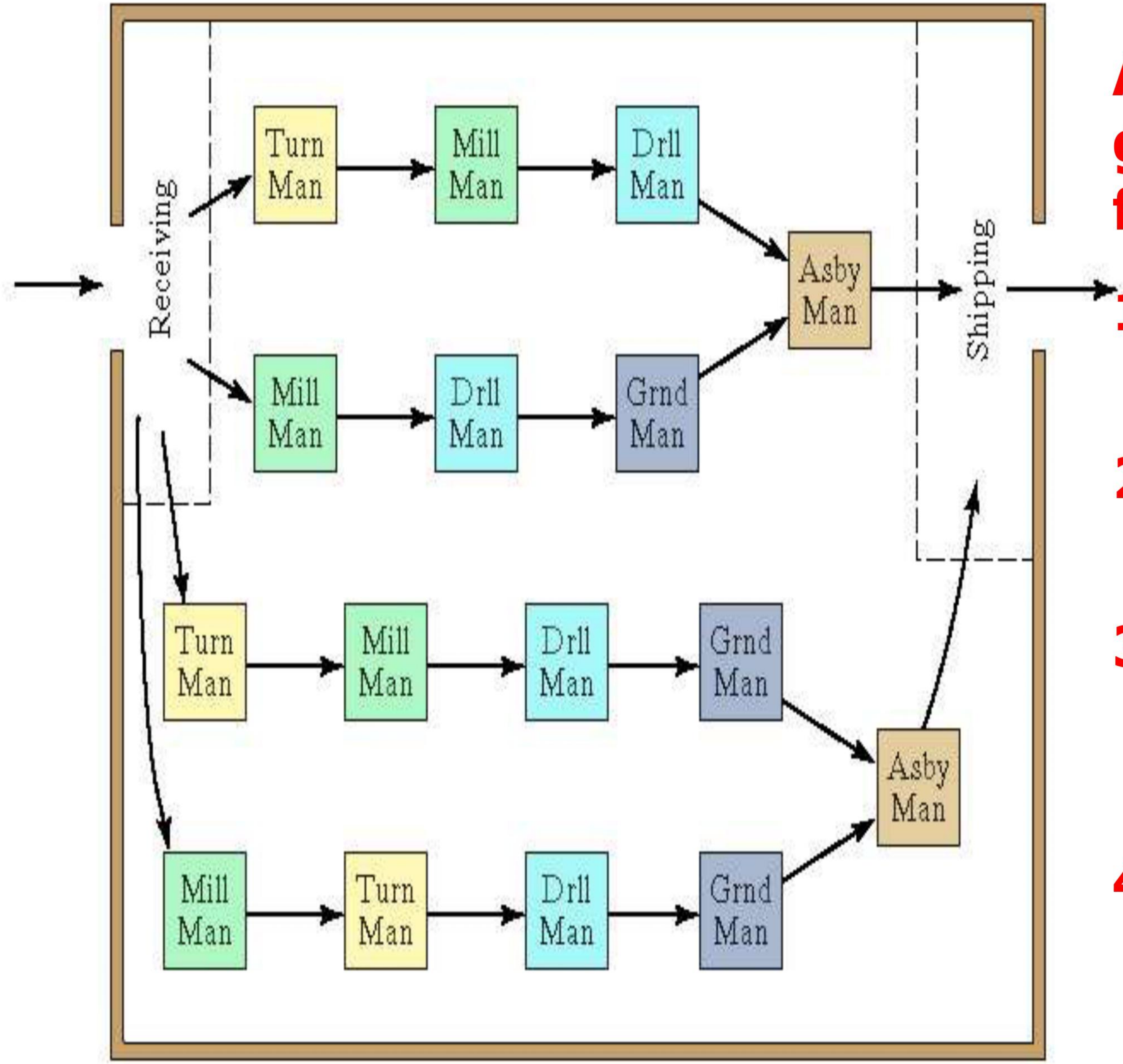
3. Usually more setups than necessary.

4. Long lead times.

Group Layout

•In Group Layout, each foreman and his team specialize in the production of one list of parts and co-operate in the completion of common task. This type of layouts based on component specialization.



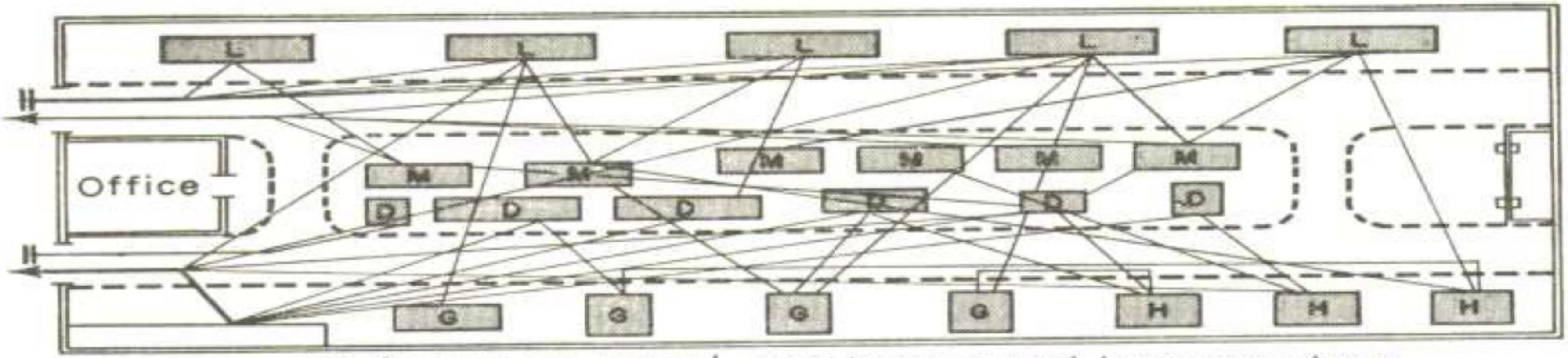


Advantages are gained in the form of reduced

1. **Work piece handling**
2. **Lower setup times**
3. **Less in process inventory**
4. **Less floor space and shorter lead times**

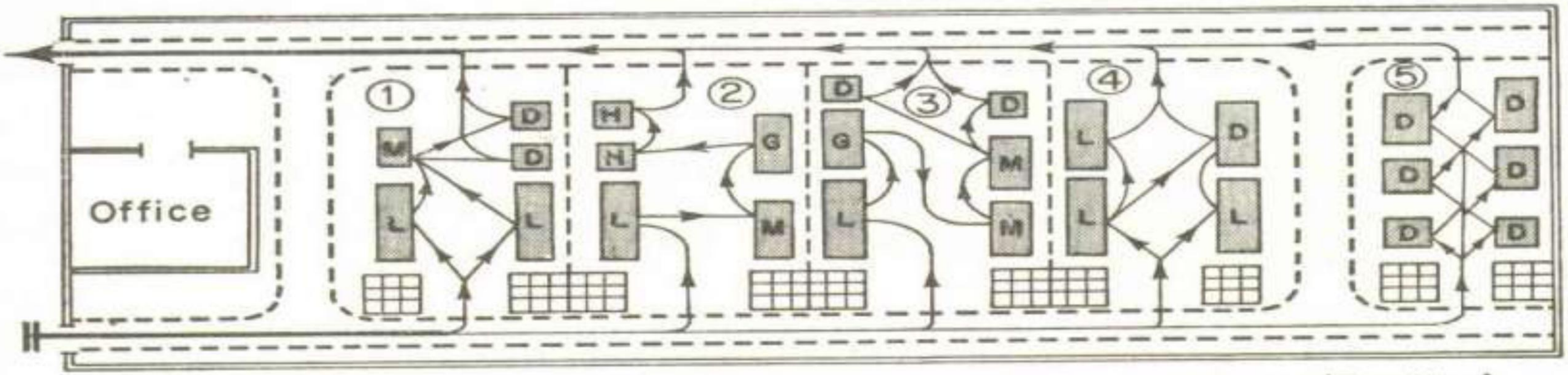
The Difference between group and functional layout:

(i) Complicated



N.B. 'Functional layout' – machines grouped by process type

(ii) Simplified
(By laying out in family machine 'groups')



N.B. 'Group layout' – machines grouped for component 'Families'

The biggest single obstacle in changing over to group technology from a traditional production is the problem of grouping parts into families.

PART FAMILIES:-

A part family is a collection of parts which are similar either because of geometric shape and size or because of similar processing steps are required in their manufacture.

Note:

the parts within a family are different but their similarities are close enough to merit their identification as members of the part family.

Identifying Part Families

Large manufacturing system can be decomposed into smaller subsystems of part families based on similarities in

1. **design attributes** and
2. **manufacturing features**

Identifying Part Families

Design Attributes:

- part configuration *(round or prismatic)*
- dimensional envelope *(length to diameter ratio)*
- surface integrity *(surface roughness, dimensional tolerances)*
- material type
- raw material state *(casting, forging, bar stock, etc.)*

Major dimensions

Basic external shape

Basic internal shape

Length/diameter ratio

Material type

Part function

Tolerances

Surface finish

Identifying Part Families

Part Manufacturing Features:

- operations and operation sequences *(turning, milling, etc.)*
- batch sizes
- machine tools
- cutting tools
- work holding devices
- processing times

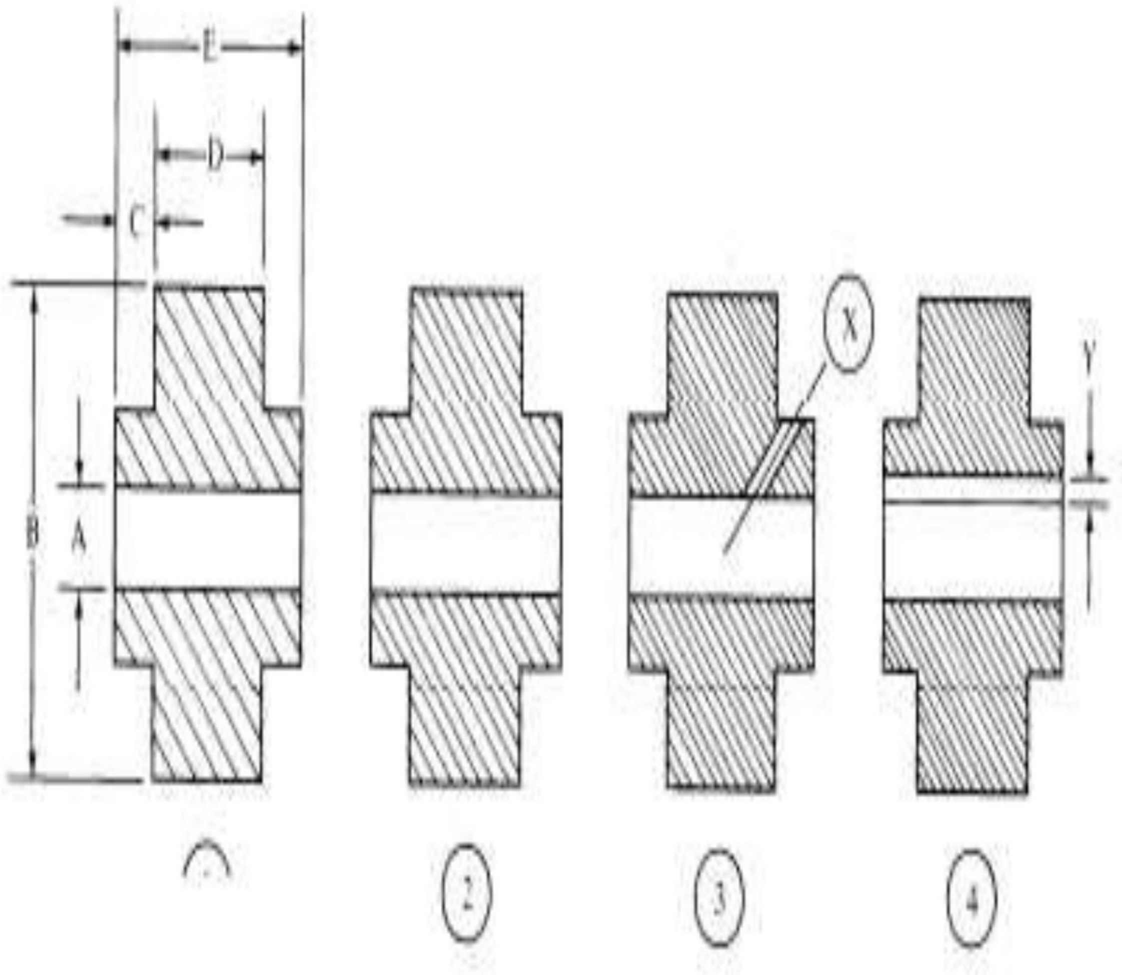
Identifying Part Families

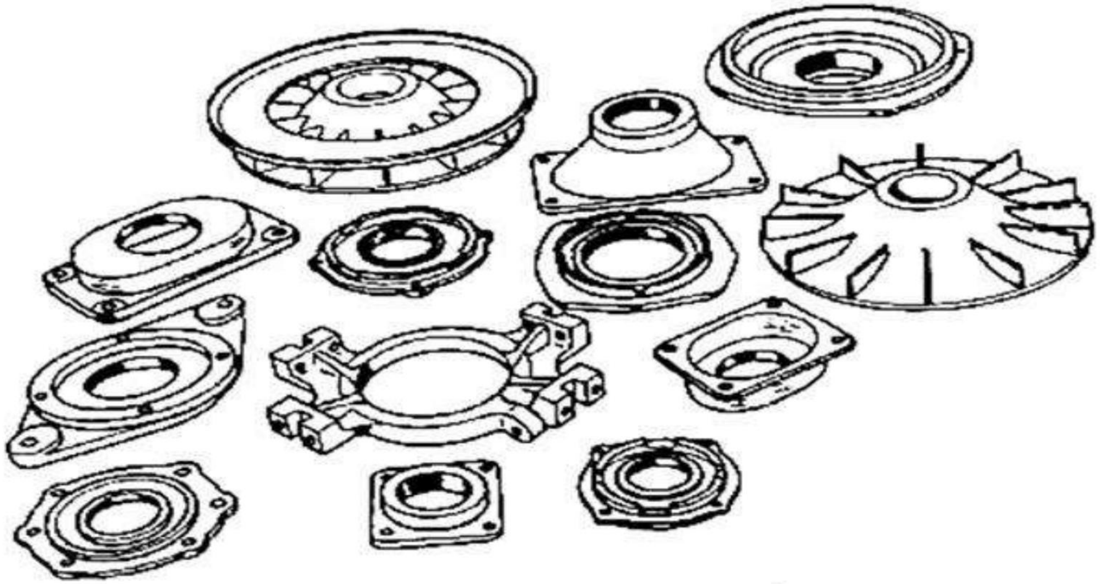
Group technology emphasis on part families based on similarities in design attributes and manufacturing, therefore **GT** contributes to the integration of CAD and CAM.

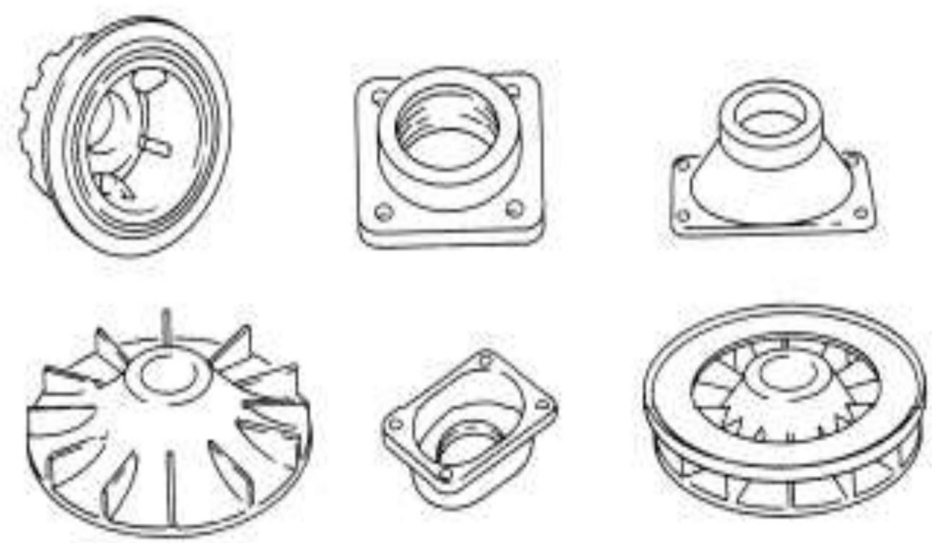
Part Families

A part family is a collection having similar:

Design Characteristics
(Geometrical Features)







Manufacturing Processes (Process Similarity)

ADVANTAGES OR BENEFITS OF GROUP TECHNOLOGY:-

1. Standardization of tooling, fixtures, and setups is encouraged

2. Material handling is reduced Parts are moved within a machine cell rather than the entire factory

3. Process planning and production scheduling are simplified

4. Work-in-process and manufacturing lead time are reduced

5. Improved worker satisfaction in a GT cell

6. Higher quality work

7. Group technology allows similar designs to be easily modified from the existing designs from the database instead of starting from scratch.

8. Improvement in quality and reduction in scrap results in increase in production.

9. There is improved utilization of machines and as result lesser number of machines are required. This increase the floor space available.

10. There is improved ability to respond to market changes.

REDUCTIONS:-

1. Setup times
2. Inventory
3. Material handling cost
4. Direct and indirect labour cost.

IMPROVEMENTS:-

1. Quality
2. Material flow
3. Machine and operator utilization
4. Space utilization
5. Employee morale

LIMITATIONS:-

1. **The cost of implementation is generally high with an outside consultant often being necessary since in house expertise on GT is rarely available. It requires a long setup times and painful debugging.**

2. It may not be suitable for a factory with a very large variety of products.

3. There are too many GT codes in use and there is no one GT code that suits all applications.

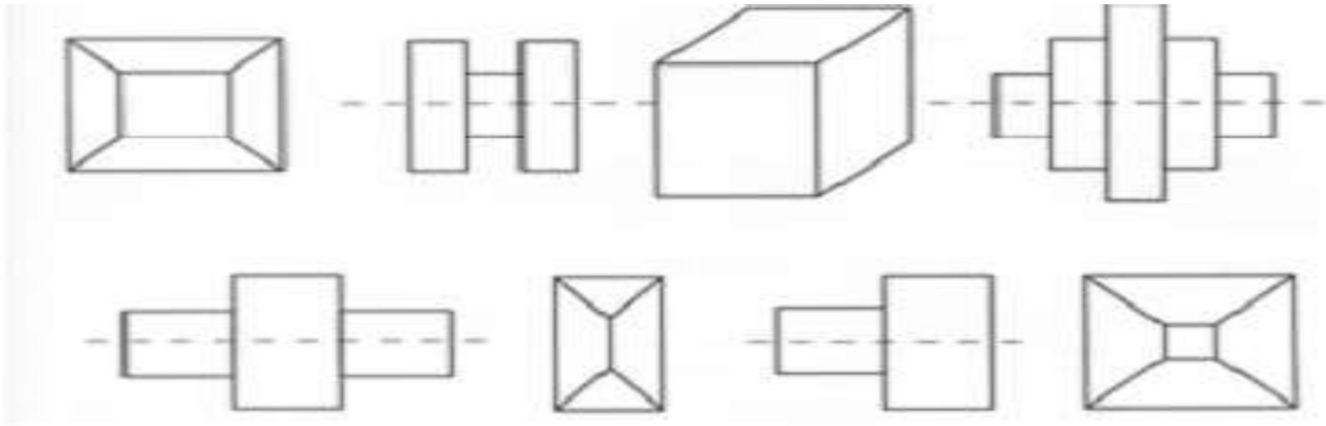
4. The range of product mix in a plant may be under constant change in which case, the GT cells may need constant revision which is impractical.

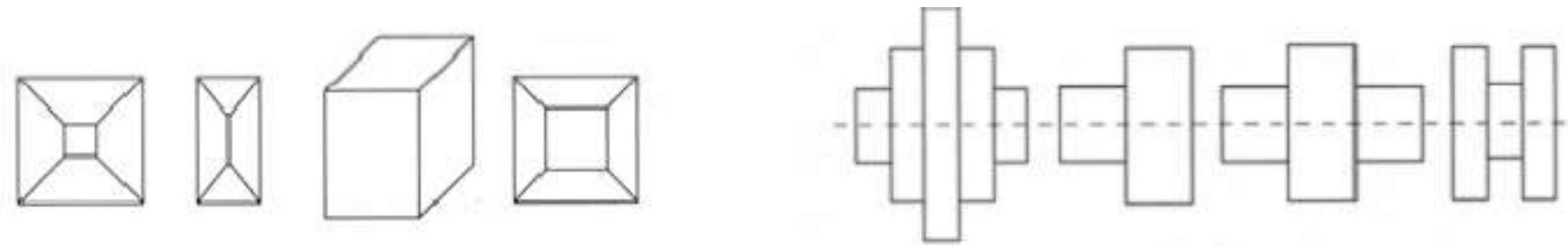
PART FAMILY FORMATION:-

Three methods for identifying parts families

- **Visual inspection**
- **Classification and coding**
- **Production flow analysis**

Forming Part Families – 1. Visual Inspection Method





Prismatic parts Rotational parts

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

Forming Part Families – 1. Visual Inspection Method

- incorrect results
- human error
- different judgment by different people
- inexpensive
- least sophisticated
- good for small companies having smaller number of parts

Forming Part Families – 2. Classification and Coding

Coding:

- The process of assigning symbols to the parts. Where the symbols represent design attributes of parts, manufacturing features of parts, or both

Classification:

- The process of categorization of a set of parts into part families

The OPITZ classification system:

- it is a **mixed** (hybrid) coding system
- developed by **OPTIZ**, Technical University of Aachen, 1970
- it is widely used in industry
- it provides a basic framework for understanding the classification and coding process
- it can be applied to machined parts, non-machined parts (both formed and cast) and purchased parts
- it considers both **design** and **manufacturing** information

Mixed-mode

- Optiz Classification System:

12345	6789	ABCD
Form code	Supplementary code	Secondary code

Form code:

- Focus on part geometry dimensions and features relevant to part design

Supplementary code

- Includes information relevant to manufacturing, such as raw material, tolerance, and surface roughness

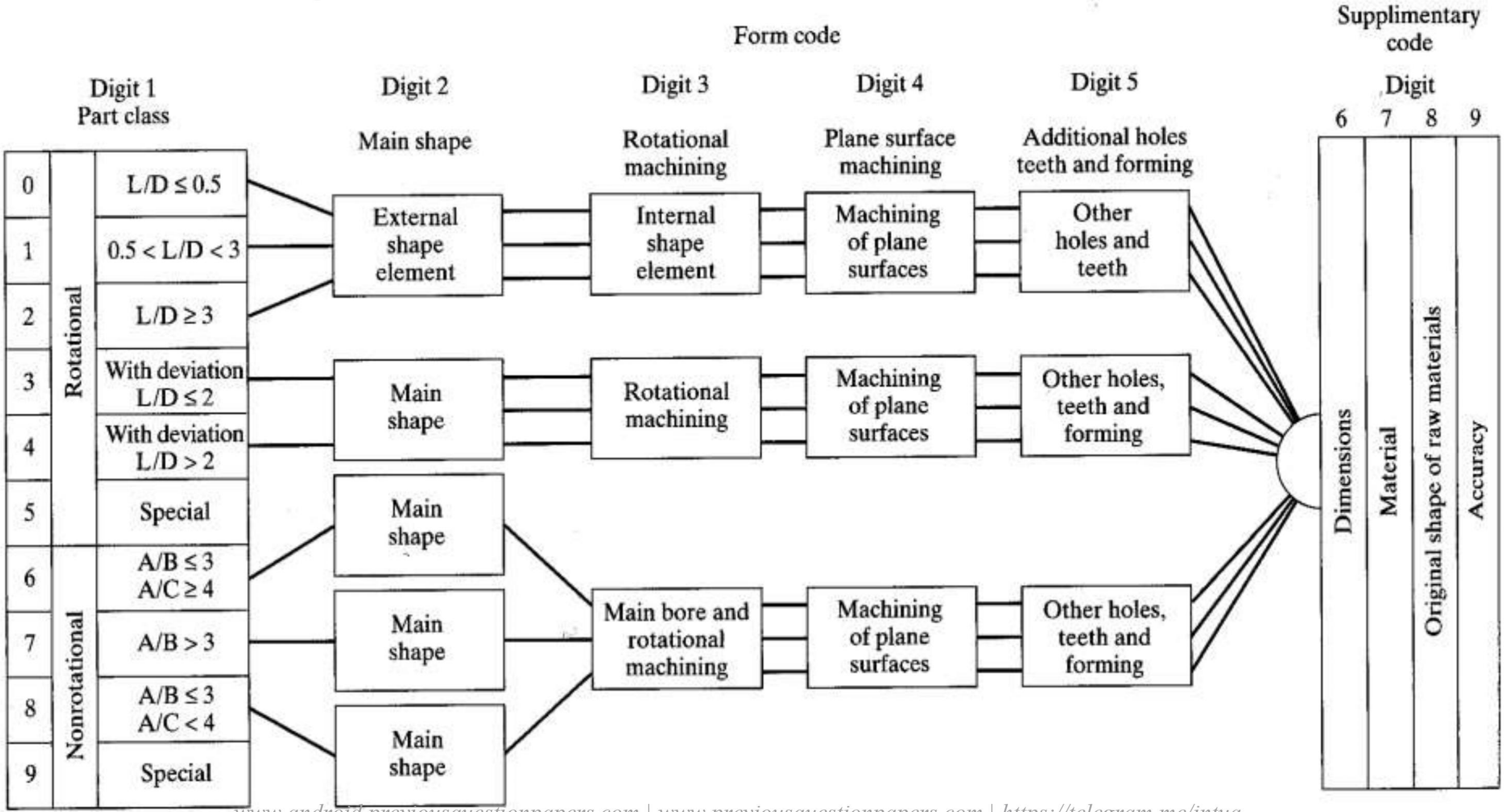
Secondary code

- Intended to identify the production operation type and sequence.
- It can be designed by the user firm to serve its own needs

Basic Structure of the OPTIZ

Digit	Description
1	Part shape class: rotation versus nonrotational (Figure 22.1). Rotational parts are classified by length-to-diameter ratio. Nonrotational parts by length, width, and thickness.
2	External shape features; various types are distinguished.
3	Rotational machining. This digit applies to internal shape features (e.g., holes, threads) on rotational parts, and general rotational shape features for nonrotational parts.
4	Plane machined surfaces (e.g., flats, slots).
5	Auxiliary holes, gear teeth, and other features.
6	Dimensions—overall size.
7	Work material (e.g., steel, cast iron, aluminum).
8	Original shape of raw material.
9	Accuracy requirements.

Basic Structure of the OPTIZ System



Form Code (digits 1 – 5)

Digit 1

	Part class	
0	Rotational parts	$L/D \leq 0.5$
1	Rotational parts	$0.5 < L/D < 3$
2	Rotational parts	$L/D \geq 3$
3	Rotational parts	
4	Rotational parts	
5	Rotational parts	
6	Nonrotational parts	
7	Nonrotational parts	
8	Nonrotational parts	
9	Nonrotational parts	

Digit 2

	External shape, external shape elements	
0		Smooth, no shape elements
1	Stepped to one end or smooth	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

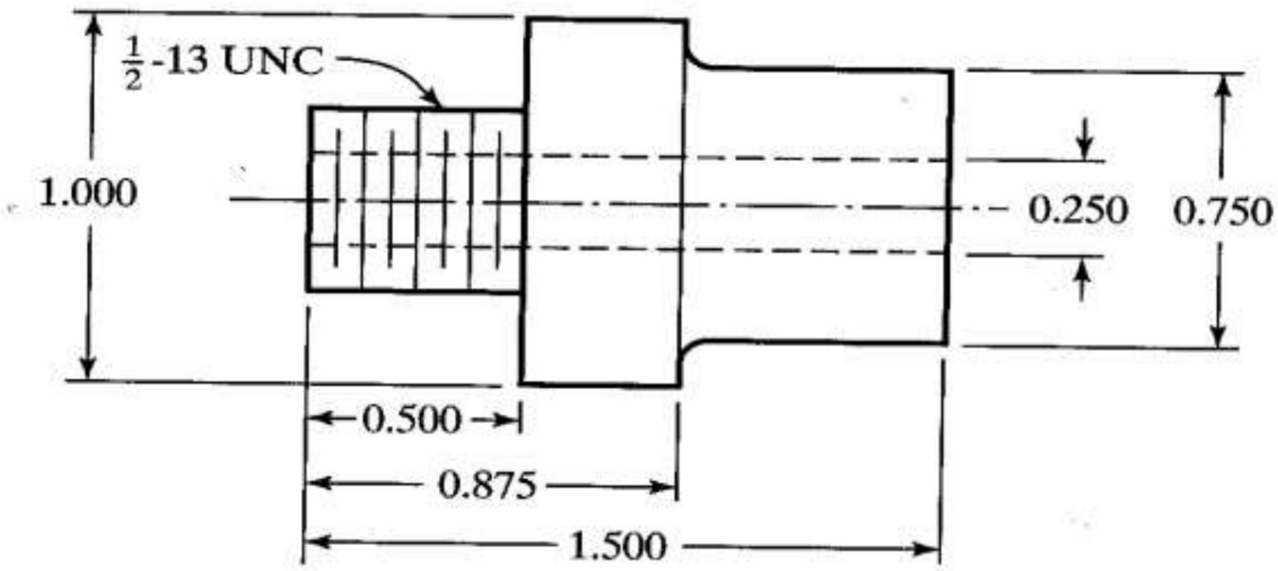
	Plane surface machining
0	No surface machining
1	Surface plane and/or curved in one direction, external
2	External plane surface related by graduation around the circle
3	External groove and/or slot
4	External spline (polygon)
5	External plane surface and/or slot, external spline
6	Internal plane surface and/or slot
7	Internal spline (polygon)
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 direction
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.**



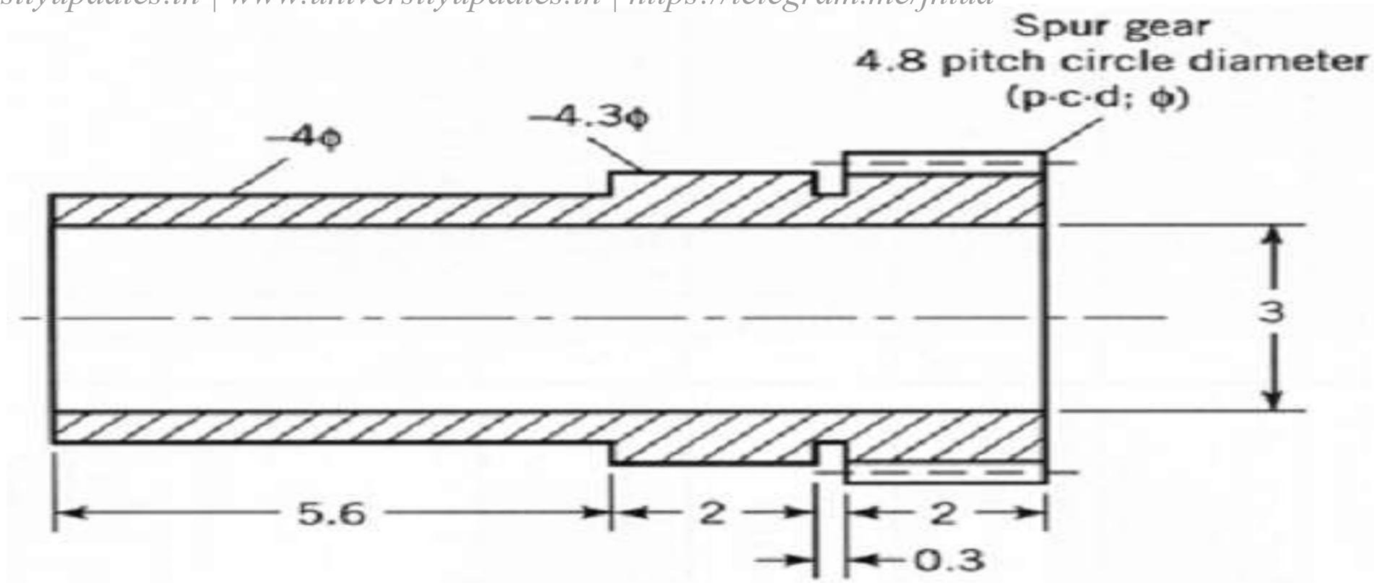
Solution

- ***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

Example

Form Code	1	3	1	0	6



- Part class:

Rotational part, L/D = 9.9/4.8 ≈ 2.0 based on the pitch circle diameter of the gear, so the first digit = 1

- External shape:

The part is stepped on one side with a functional groove, so the second digit is 3

- Internal shape:
- The third digit is 1 because of the through hole
- Plain surface machining:
- The fourth digit is 0 because there is no plain surface machining
- Auxiliary holes and gear teeth:
- The fifth digit is 6 because there are spur gear teeth on the part

Forming Part Families – Classification and Coding: 3.Production Flow Analysis (PFA)

Method for identifying part families and associated machine groupings based on production route sheets rather than part design data

- Work parts with identical or similar route sheets are classified into part families
- Advantages of using route sheet data
  - Parts with different geometries may nevertheless require the same or similar processing
  - Parts with nearly the same geometries may nevertheless require different processing

Steps in Production Flow Analysis

1. Data collection – operation sequence and machine routing for each part
2. Sortation of process routings – parts with same sequences and routings are arranged into "packs"
3. PFA chart – each pack is displayed on a PFA chart
   – Also called a *part-machine incidence matrix*
4. Cluster analysis – purpose is to collect packs with similar routings into groups
   – Each machine group = a machine cell

Machines	A	B	C	D	E	F	G	H	I
1	1			1				1	
2					1				1
3			1		1				1
4		1				1			
5	1							1	
6			1						1
7		1				1	1		

	Parts								
Machines	C	E	I	A	D	H	F	G	B
3	1	1	1						
2		1	1						
6	1		1						
1				1	1	1			
5				1		1			
7							1	1	1
4							1		1

BENEFITS OF GROUP TECHNOLOGY

It affects all areas of a company, including:

- engineering
- equipment specification
- facilities planning
- process planning
- production control
- quality control
- tool design
- purchasing
- service

BENEFITS OF GROUP TECHNOLOGY

Some of the well-known tangible and intangible benefits of implementing GT :

1. Engineering design

- **Reduction in new parts design**
- **Reduction in the number of drawings through standardization**
- **Reduction of number of similar parts, easy retrieval of similar functional parts, and identification of substitute parts**

BENEFITS OF GROUP TECHNOLOGY

2. Layout planning

- Reduction in production floor space required
- Reduced material-handling effort

BENEFITS OF GROUP TECHNOLOGY

3. Specification of equipment, tools, jigs, and fixtures

- Standardization of equipment
- Implementation of cellular manufacturing systems
- Significant reduction in up-front costs incurred in the release of new parts for manufacture

BENEFITS OF GROUP TECHNOLOGY

4. Manufacturing: *process planning*

- Reduction in setup time and production time
- Alternative routing leading to improved part routing
- Reduction in number of machining operations and numerical control (NC) programming time

BENEFITS OF GROUP TECHNOLOGY

5. Manufacturing: production control

- Reduced work-in-process inventory
- Easy identification of bottlenecks
- Improved material flow and reduced warehousing costs
- Faster response to schedule changes
- Improved usage of jigs, fixtures, pallets, tools, material handling, and manufacturing equipment

BENEFITS OF GROUP TECHNOLOGY

6. Manufacturing: quality control

- Reduction in number of defects leading to reduced inspection effort
- Reduced scrap generation
- Better output quality
- Increased accountability of operators and supervisors responsible for quality production, making it easier to implement total quality control concepts.

BENEFITS OF GROUP TECHNOLOGY

7. Purchasing

- Coding of purchased part leading to standardized rules for purchasing
- Economies in purchasing possible because of accurate knowledge of raw material requirements
- Reduced number of part and raw materials
- Simplified vendor evaluation procedures leading to just-in-time purchasing

BENEFITS OF GROUP TECHNOLOGY

8. Customer service

- Accurate and faster cost estimates
- Efficient spare parts management, leading to better customer service
- Lower lead times

Cellular Manufacturing

Cellular manufacturing

is an application of group technology in manufacturing in which all or a portion of a firm's manufacturing system has been converted into cells

A manufacturing cell

is a cluster of machines or processes located in close proximity and dedicated to the manufacturing of a family of parts

Why cellular manufacturing:

- Reduce setup times: By using part family tooling and sequencing
- Reduce flow times: By reducing setup and move times and wait time for moves and using smaller batch sizes
- Reduce inventories
- Reduce lead time

Cell Design

Design of cellular manufacturing system is a complex exercise with broad implications for an organization.

The **cell design process** involves issues related to both ***system structure*** (Structural Issues) and ***system operation*** (Procedures Issues)

Cell Design

Structural issues include:

- Selection of part families and grouping of parts into families
- Selection of machine and process populations and grouping of these into cells
- Selection of tools, fixtures, and pallets
- Selection of material-handling equipment
- Choice of equipment layout

Cell Design

Procedures Issues include:

- Detailed design of jobs
- Organization of supervisory and support personnel around the cellular structure
- Formulation of maintenance and inspection policies
- Design of procedures *for production planning, scheduling, control*, and *acquisition of related software and hardware*
- Modification of cost control and reward systems
- Outline of procedures for interfacing with the remaining manufacturing system (in terms of work flow and information, whether computer controlled or not)

Evaluation of Cell Design Decisions

The evaluation of design decisions can be categorized as related to either

- ***the system structure***

or

- ***the system operation***.

Evaluation of Cell Design Decisions

Typical considerations related to the ***system structure*** include:

- Equipment and tooling investment (low)
- Equipment relocation cost (low)
- Material-handling costs (low)
- Floor space requirements (low)
- Extent to which parts are completed in a cell (high)
- Flexibility (high)

Evaluation of Cell Design

Evaluations of cell system design are incomplete unless they relate to the ***operation of the system***.

A few typical performance variables related to ***system operation*** are:

- Equipment utilization (high)
- Work-in-process inventory (low)
- Queue lengths at each workstation (short)
- Job throughput time (short)
- Job lateness (low)

Cell Formation Approaches

1. Machine - Component Group Analysis:

Machine - Component Group Analysis is based on ***production flow analysis***

Machine - Component Group Analysis

Production flow analysis involves four stages:

Stage 1: ***Machine classification***.

Machines are classified on the basis of operations that can be performed on them. A machine type number is assigned to machines capable of performing similar operations.

Machine - Component Group Analysis

Production flow analysis involves four stages:

Stage 2: ***Checking parts list and production route information*.**

For each part, information on the operations to be undertaken and the machines required to perform each of these operations is checked thoroughly.

Machine - Component Group Analysis

Production flow analysis involves four stages:

Stage 3: ***Factory flow analysis*.**

This involves a micro-level examination of flow of components through machines. This, in turn, allows the problem to be decomposed into a number of machine-component groups.

Machine - Component Group Analysis

Production flow analysis involves four stages:

Stage 4: ***Machine-component group analysis*.**

An intuitive manual method is suggested to manipulate the matrix to form cells. However, as the problem size becomes large, the manual approach does not work. Therefore, there is a need to develop analytical approaches to handle large problems systematically.

Machine - Component Group Analysis

Example: Consider a problem of 4 machines and 6 parts. Try to group them.

Components

Machines	1	2	3	4	5	6
M1		1		1		1
M2		1		1		1
M3	1		1		1	
M4	1		1		1	

Machine - Component Group Analysis

Solution

Components

Machines	2	4	6	1	3	5
M1	1	1	1			
M2	1	1	1			
M3				1	1	1
M4				1	1	1

Rank Order Clustering Algorithm

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

Rank Order Clustering Algorithm

Step 1: Assign binary weight and calculate a decimal weight for each row and column using the following formulas:

$$\text{Decimal weight for row } i = \sum_{p=1}^{m} b_{ip} 2^{m-p}$$

$$\text{Decimal weight for column } j = \sum_{p=1}^{n} b_{pj} 2^{n-p}$$

Rank Order Clustering Algorithm

Step 2: Rank the rows in order of decreasing decimal weight values.

Step 3: Repeat steps 1 and 2 for each column.

Step 4: Continue preceding steps until there is no change in the position of each element in the row and the column.

Rank Order Clustering Algorithm

Example:

Consider a problem of 5 machines and 10 parts. Try to group them by using *Rank Order Clustering Algorithm.*

Table 1 **Components**

Machines	1	2	3	4	5	6	7	8	9	10
M1	1	1	1	1	1		1	1	1	1
M2		1	1	1					1	1
M3	1				1	1	1			
M4		1	1	1				1	1	1
M5	1	1	1	1	1	1	1	1		

Rank Order Clustering Algorithm

Table 2 **Binary weight**

	2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0

Components

Machines	1	2	3	4	5	6	7	8	9	10	Decimal equivalent
M1	1	1	1	1	1		1	1	1	1	1007
M2		1	1	1					1	1	451
M3	1				1	1	1				568
M4		1	1	1				1	1	1	455
M5	1	1	1	1	1	1	1	1			1020

Rank Order Clustering Algorithm

Table 3 **Binary weight**

		2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0

Components

Binary weight	Machines	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
2^4	**M5**	1	1	1	1	1	1	1	1		
2^3	**M1**	1	1	1	1	1		1	1	1	1
2^2	**M3**	1				1	1	1			
2^1	**M4**		1	1	1				1	1	1
2^0	**M2**		1	1	1					1	1
Decimal equivalent		28	27	27	27	28	20	28	26	11	11

Rank Order Clustering Algorithm

Table 4 **Binary weight**

		2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0

Components

Binary weight	Machines	1	5	7	2	3	4	8	6	9	10	Decimal equivalent
2^4	M5	1	1	1	1	1	1	1	1			1020
2^3	M1	1	1	1	1	1	1	1		1	1	1019
2^2	M3	1	1	1					1			900
2^1	M4				1	1	1	1		1	1	123
2^0	M2				1	1	1			1	1	115
Decimal equivalent		28	28	28	27	27	27	26	20	11	11	

Rank Order Clustering Algorithm

- R/O clustering oscillations indicating need of machine replication (happens often!)
- Presence of Outliers and/or Voids in the finished clusters
- Outliers indicate the need of machine replication
- Voids indicate ‘skipped’ machines in a cell
- Generally speaking, these clustering algorithms are designed to convert existing routes for facility re-organization
- They require a previous engineering study to be performed to develop a series of routers on a core sample of parts that represent most of the production in the shop

Rank Order Clustering Algorithm

- The ROC provides a simple analytical technique that can be easily computerized
- The ROC has fast convergence and relatively low computation time depending on the matrix size
- The fact that ROC uses binary values will impose restrictions on the size of the matrix that can be solved

Rank Order Clustering Algorithm

- Most computers have a maximum of 2^{48}-1 for integer representation, which means that the maximum number of rows and columns is limited to 47 and columns is limited to 47
- The algorithm results depend on the initial matrix arrangement
- The algorithm collects positive entries (1s) in the top left-hand corner, leaving the rest of the matrix disorganized

Cluster Identification Algorithm (CIA)

- Designed to identify disconnected blocks if they exist
- If there are no disconnected blocks (the matrix is not mutually separable), the entire matrix will form one block
- The algorithm begins by masking all columns that have an entry of 1 in any row (selected randomly), then all rows that have an entry of 1 in these columns are masked. This process is repeated until all intersecting columns and rows are masked.

Cluster Identification Algorithm (CIA)

- These masked columns and rows are placed in a block and removed from the matrix removed from the matrix.
- Then the process of masking starts again and another block is identified.
- This will continue until all the entries in the matrix are assigned in blocks and all separable blocks are identified

Cluster Identification Algorithm (CIA)

Example:

Part Number

Machine Number	1	2	3	4	5	6	7	8
1				1				1
2			1		1			
3		1				1	1	
4			1		1			
5	1			1				1
6		1				1	1	
7	1			1				1

Step 1. Select any row i of the incidence matrix and draw a horizontal line hi through it.

Row 3 of the matrix is selected randomly and a horizontal line h3 is drawn.

Cluster Identification Algorithm (CIA)

Step 2. For each entry of 1 crossed by the horizontal line h3 draw a vertical line vj.

Three vertical lines v2, v6, and v7 are drawn

		Part Number								
		1	2	3	4	5	6	7	8	
Machine Number	1				1				1	
	2			1		1				
	3		1				1	1		h_3
	4			1		1				
	5	1			1				1	
	6		1				1	1		
	7	1			1				1	
			v_2				v_6	v_7		

Cluster Identification Algorithm (CIA)

Step 3. For each entry of 1 crossed once by a vertical line vj draw a horizontal line. A horizontal line h6 is drawn through all the crossed-once entries of the matrix:

Part Number

Machine Number	1	2	3	4	5	6	7	8	
1				1				1	
2			1		1				
3		1				1	1		h_3
4			1		1				
5	1			1				1	
6		1				1	1		h_6
7	1			1				1	
		v_2				v_6	v_7		

Cluster Identification Algorithm (CIA)

Step 4. The preceding steps are repeated until no more crossed once entries are left.

• All the crossed-twice entries are grouped in a block and removed from the matrix.

•Parts 2, 6, 7 and machines 3, 6 are grouped in one block.

Machine Number \ Part Number	2	6	7	1	3	4	5	8
3	1	1	1					
6	1	1	1					
1						1		1
2					1		1	
4					1		1	
5				1		1		1
7				1		1		1

Cluster Identification Algorithm (CIA)

The grouped parts and machines are removed from the matrix

	2	6	7
3	1	1	1
6	1	1	1

Cluster Identification Algorithm (CIA)

Step 5: The above procedure is repeated for the remaining matrix entries until all entries are grouped

	1	3	4	5	8
1			1		1
2		1		1	
4		1		1	
5	1		1		1
7	1		1		1

Cluster Identification Algorithm (CIA)

The resulting matrix is as follows:

	2	6	7	8	1	4	3	5
3	1	1	1					
6	1	1	1					
5				1	1	1		
1				1		1		
7				1	1	1		
2							1	1
4							1	1

Arranging Machines in a GT Cell

- **After part-machine grouping have been identified by cell formation approaches, the next problem is to organize the machines into the most logical arrangement.**

- **Hollier Method. This method uses the sums of flow "From" and "To" each machine in the cell. The method can be outlined as follows**

1. ***Develop the From-To chart from part routing data.*** **The data contained in the chart indicates numbers of part moves between the machines in the cell.**

2. ***Determine the "From" and "To" sums for each machine.*** **This is accomplished by summing all of the "From" trips and "To" trips for each machine.**

   - **The "From" sum for a machine is determined by adding the entries in the corresponding row.**
   - **The "To" sum is found by adding the entries in the corresponding column.**

Arranging Machines in a GT Cell

3. *Assign machines to the cell based on minimum "From" or "To" sums.* **The machine having the smallest sum is selected.**

   - **If the minimum value is a "To" sum, then the machine is placed at the beginning of the sequence.**
   - **If the minimum value is a "From" sum, then the machine is placed at the end of the sequence.**

   Tie breaker

   - **If a tie occurs between minimum "To" sums or minimum "From" sums, then the machine with the minimum "From/To" ratio is selected.**
   - **If both "To" and "From" sums are equal for a selected machine, it is passed over and the machine with the next lowest sum is selected.**
   - **If a minimum "To" sum is equal to a minimum "From" sum, then both machines are selected and placed at the beginning and end of the sequence, respectively**

4. *Reformat the From-To chart.* **After each machine has been selected, restructure the From-To chart by eliminating the row and column corresponding to the selected machine and recalculate the "From" and "To" sums.**

5. **Repeat steps 3 and 4 until all machines have been assigned**

Example of Arranging Machines in a GT Cell

- **Suppose that four machines, 1, 2, 3, and 4 have been identified as belonging in a GT machine cell. An analysis of 50 parts processed on these machines has been summarized in the From-To chart presented below. Additional information is that 50 parts enter the machine grouping at machine 3, 20 parts leave after processing at machine 1, and 30 parts leave after machine 4. Determine a logical machine arrangement using Hollier method.**

From-To Chart

	To:	1	2	3	4
From:	1	0	5	0	25
	2	30	0	0	15
	3	10	40	0	0
	4	10	0	0	0

Example of Arranging Machines in a GT Cell

- **First iteration**

	To: 1	2	3	4	"From" Sums
From: 1	0	5	0	25	30
2	30	0	0	15	45
3	10	40	0	0	50
4	10	0	0	0	10
"To" sums	50	45	0	40	135

Example of Arranging Machines in a GT Cell

- **Second iteration with machine 3 removed.**

	To: 1	2	4	"From" Sums
From: 1	0	5	25	30
2	30	0	15	45
4	10	0	0	10
"To" sums	40	5	40	

Example of Arranging Machines in a GT Cell

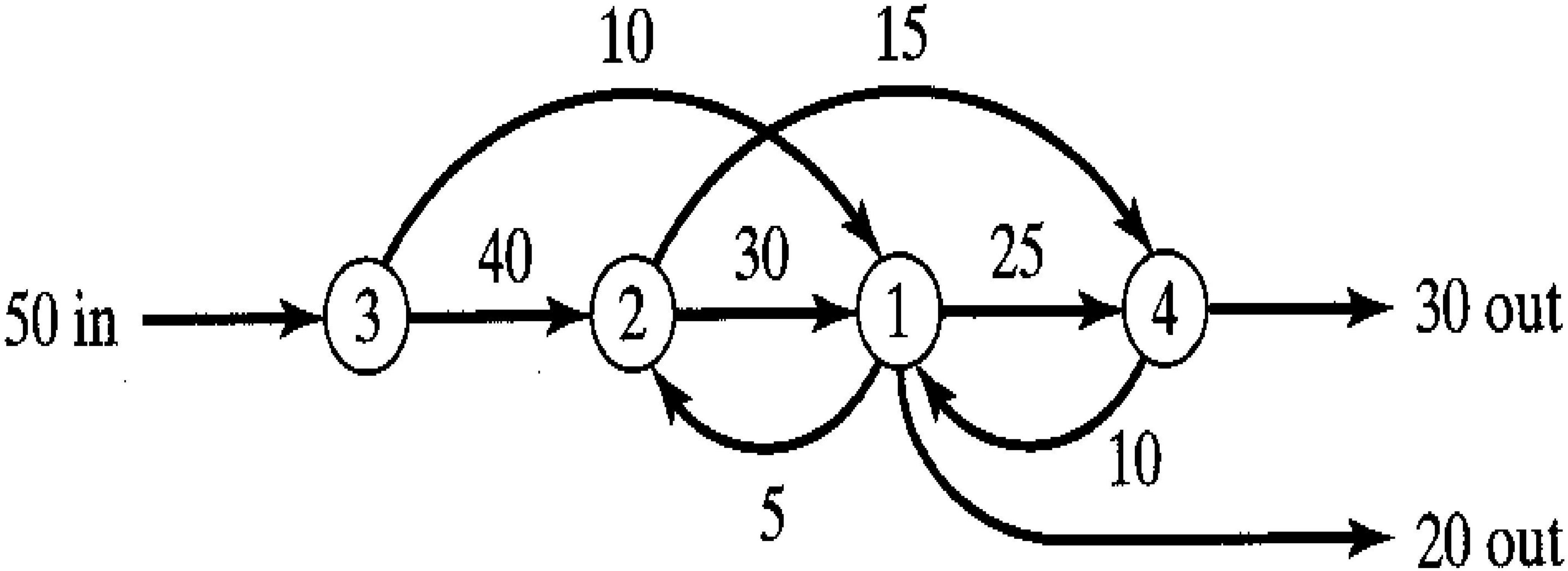
- Third iteration with machine 2 removed.

	To:	1	4	"From" Sums
From:	1	0	25	25
	4	10	0	10
"To" sums		10	25	

- The resulting machine sequence 3 → 2 → 1 → 4

Example of Arranging Machines in a GT Cell

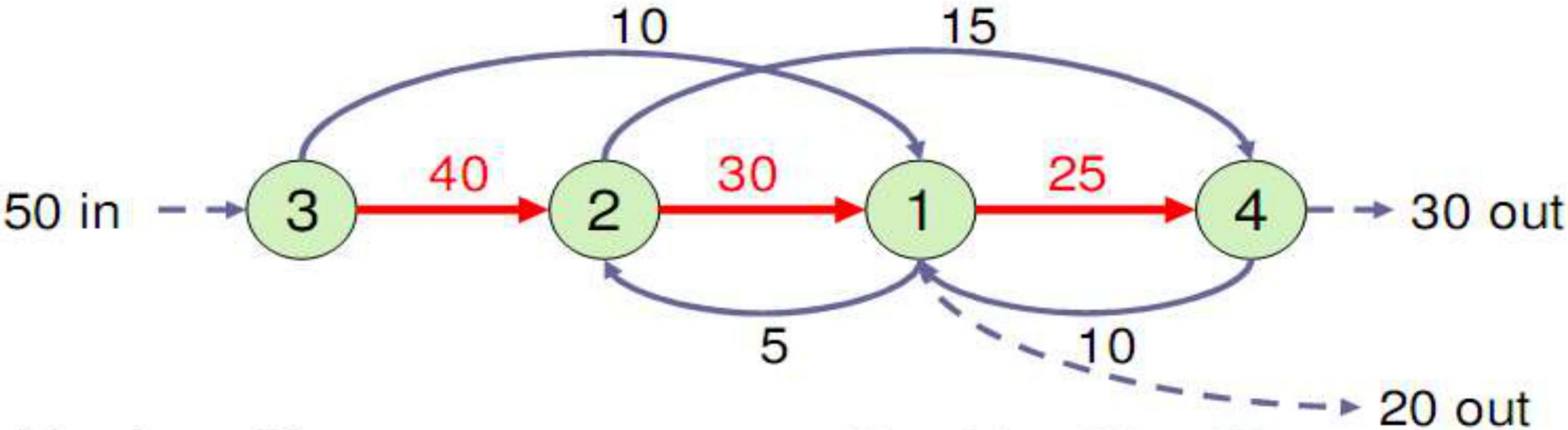
- **The flow diagram for machine cell in the Example is shown below. Flow of parts into and out of the cells has also been included**



Hollier Method

- Percentage of in-sequence moves

(%) which is computed by adding all of the values representing in-sequence moves and dividing by the total number of moves



Number of in-sequence moves = 40 + 30 + 25 = 95

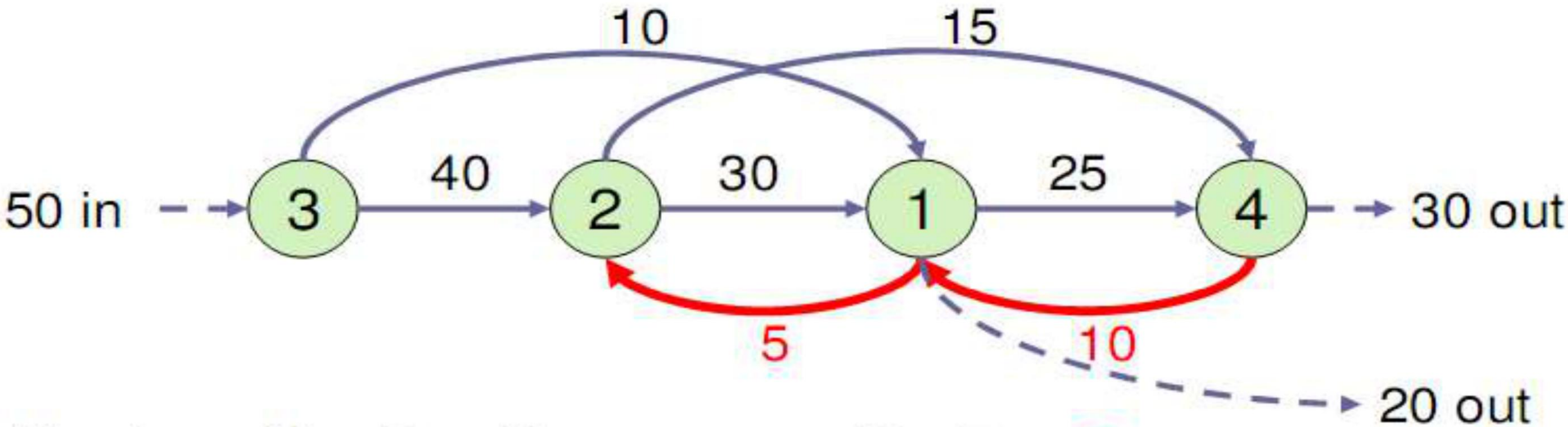
Total number of moves = 95 + 15 + 10 + 10 + 5 = 135

Percentage of in-sequence moves = 95/135 = 0.704 = 70.4%

Hollier Method

- Percentage of backtracking moves

(%) which is computed by adding all of the values representing backtracking moves and dividing by the total number of moves



Number of backtracking moves = 10 + 5 = 15

Total number of moves = 95 + 15 + 10 + 10 + 5 = 135

Percentage of backtracking moves = 15/135 = 0.704 = 11.1%

Hollier Method 2 Example

- From-To sums and From/To ratio

	To: 1	2	3	4	From sums	From/To ratio
From: 1	0	5	0	25	30	0.60
2	30	0	0	15	45	1.0
3	10	40	0	0	50	∞
4	10	0	0	0	10	0.25
To sums	50	45	0	40	135	

Resulting machine sequence 3 – 2 – 1 – 4