Group Technology and Cellular Manufacturing

L-16

Contents

- Group technology is a manufacturing philosophy in which similar parts are identified and grouped together to take advantage of their similarities in design and production.
- Similar parts are arranged into part families, where each part family possesses similar design and/or manufacturing characteristics
- The efficiencies are generally achieved by arranging the production equipment into machine groups or cells, to facilitate work flow.
- Grouping the production equipment into machine cells, where each cell specializes in the production of a part family, is called cellular manufacturing.

Conditions where GT is most appropriately applied

a) The plant currently uses traditional batch production and a process type layout

b) The parts can be grouped into part families

The task which represent significant obstacles to application of GT

a) Identifying the part families

b) Rearranging production machines into machine cells

Group technology benefits

1) GT promotes standardization of tooling, fixturing and setups
2) Material handling is reduced because parts are moved within a machine cell rather than within the entire factory
3) Process planning and production scheduling are simplified
4) Setup times are reduced, resulting in lower manufacturing lead times
5) Work-in-process is reduced
6) Worker satisfaction usually improves when workers collaborate in a GT cell
7) Higher quality work is accomplished using group technology

Part Families

- A 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.
- The parts within a family are different, but their similarities are close enough to merit their inclusion as members of the part family

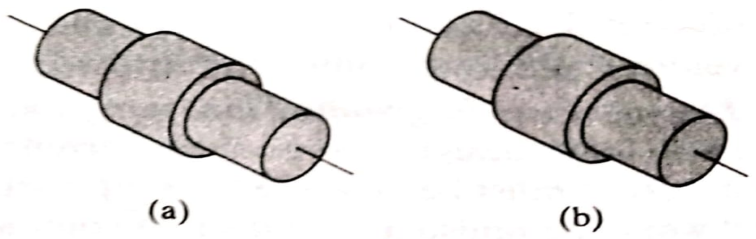


Figure 15.1 Two parts of identical shape and size but different manufacturing requirements: (a) 1,000,000 pc/yr, tolerance = ±0.010 in, material = 1015 CR steel, nickel plate; and (b) 100 pc/yr, tolerance = ±0.001 in, material = 18 − 8 stainless steel.

Diagram- A family of parts with similar manufacturing process requirements but different design attributes

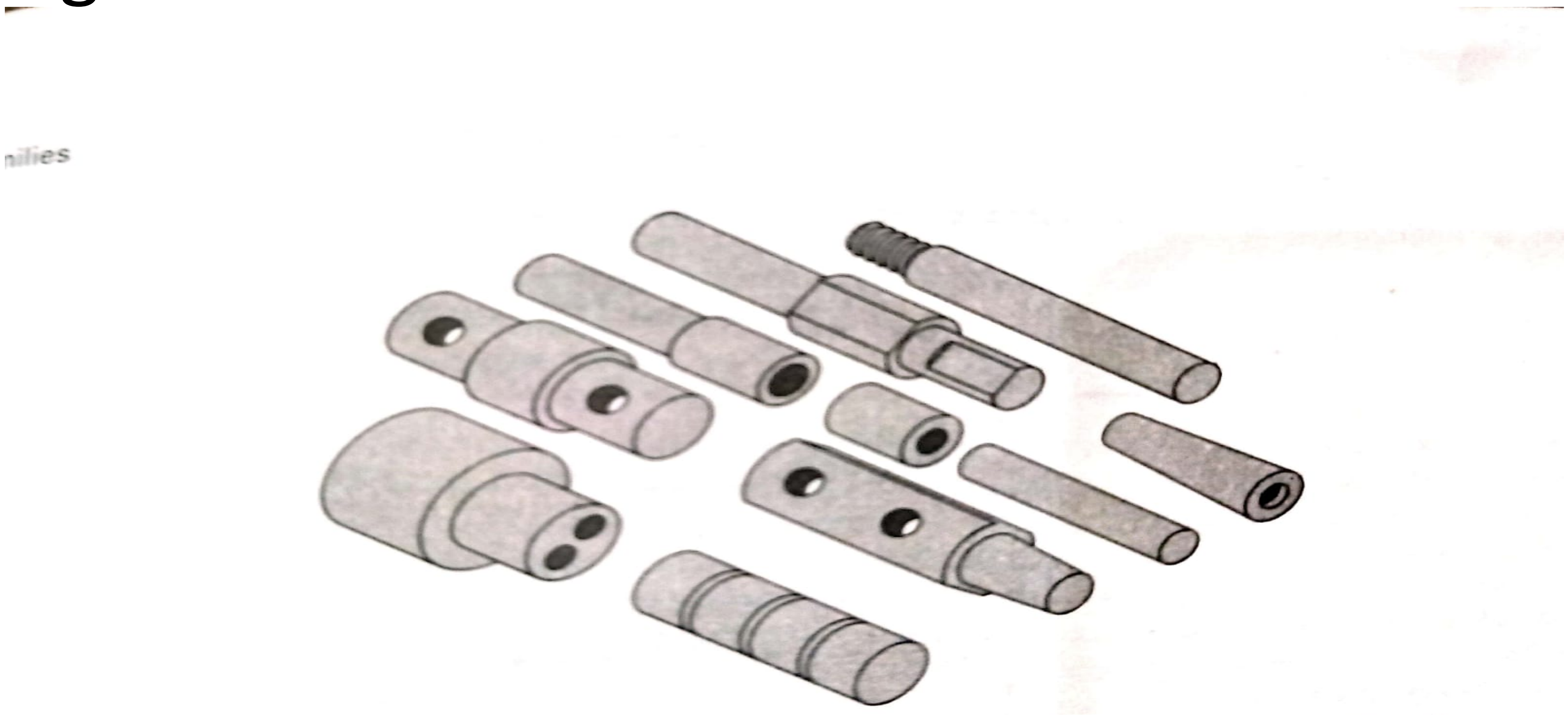


Diagram- Process type plant layout

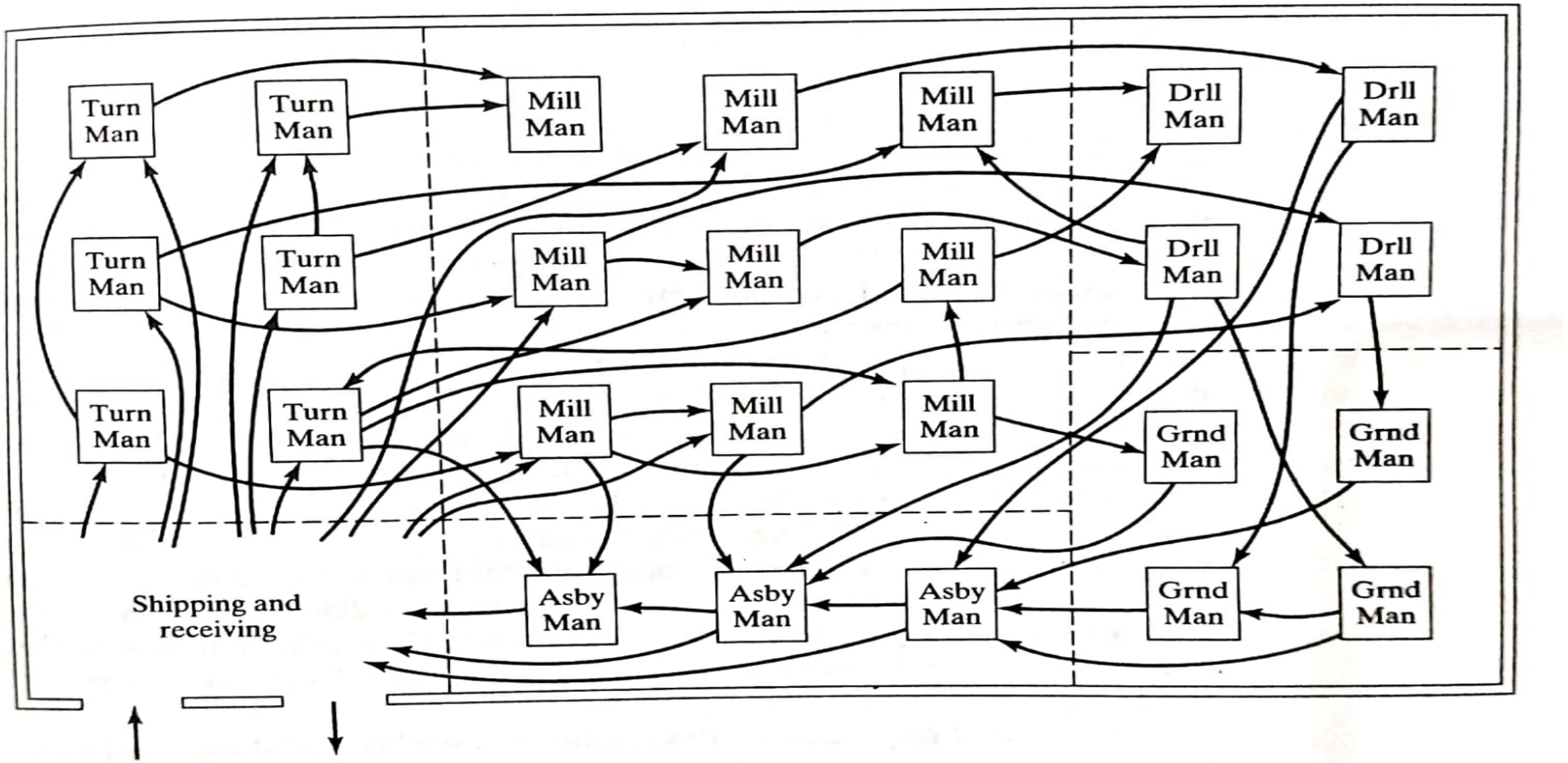
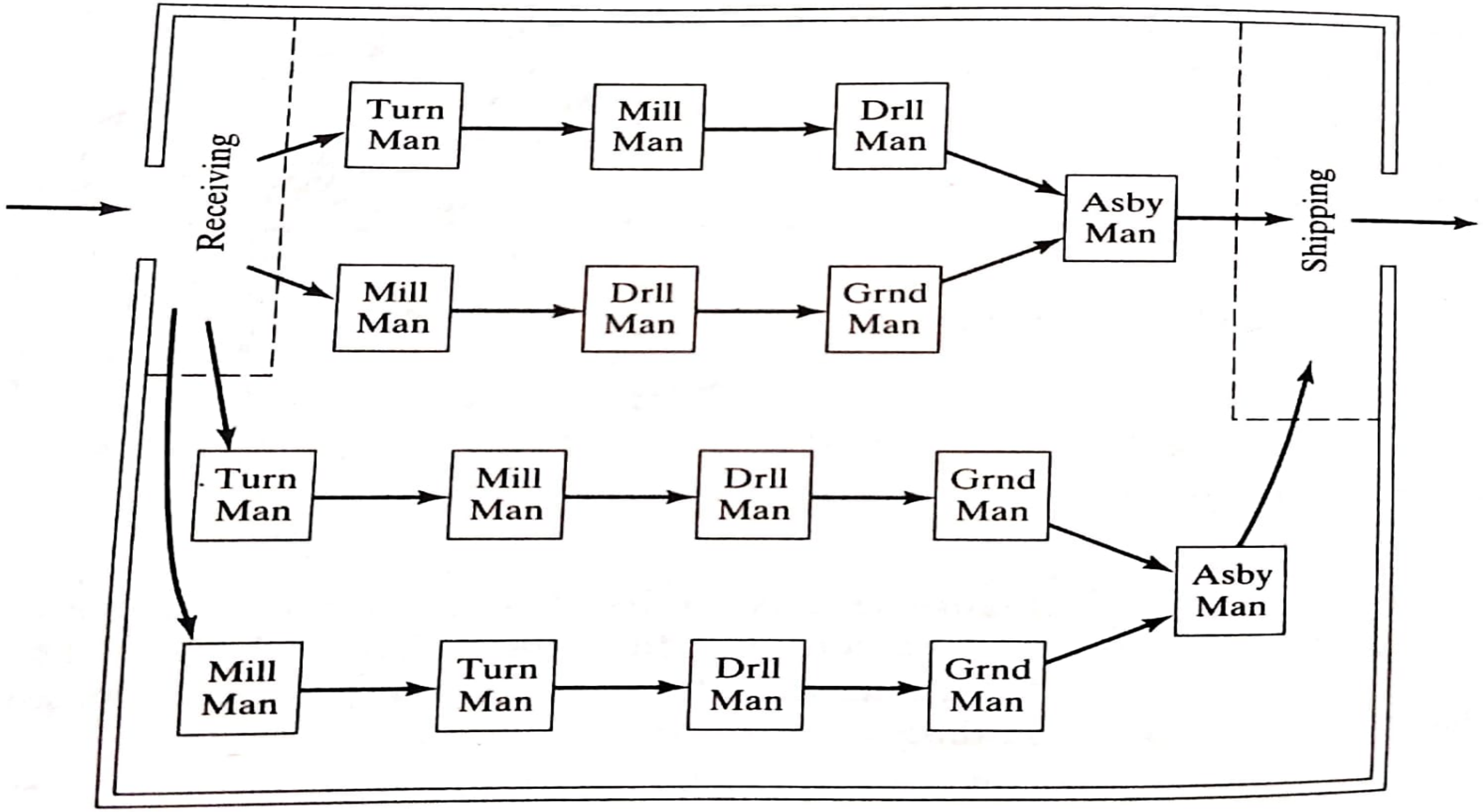


Diagram- Group technology layout



Problems faced to convert conventional production shop in group technology and three methods used :

a) Visual inspection
b) Parts classification and coding
c) Production flow analysis

Two categories of part similarities can be distinguished as

1) Design attributes which are concerned with part characteristics such as geometry, size and material
2) Manufacturing attributes which consider the sequence of processing steps required to make a part

Accordingly, classification and coding systems are devised to include both a part’s design attributes and manufacturing attributes. Reasons for using a coding scheme include:

a) Design retrieval
b) Automated process planning
c) Machine cell design

Features of Parts Classification and Coding Systems

The principal functional areas that utilize a parts classification and coding system are design and manufacturing. Accordingly, parts classification systems fall into one of three categories

(i) Systems based on part design attributes

(ii) System based on part manufacturing attributes

(iii) Systems based on both design and manufacturing attributes

Three structures used in classification and coding schemes

(i) Heirarchical structure, also known as a monocode, in which the interpretation of each successive symbol depends on the value of the preceding symbols

(ii) Chain-type structure, also known as a polycode, in which the interpretation of each symbol in the sequence is always the same,it does not depend on the value of preceding symbols

(iii) Mixed-mode structure, which is a hybrid of the two previous codes

Table showing Design and Manufacturing Attributes typically included in a Group Technology Classification and Coding System

Part Design Attributes	*Part Manufacturing Attributes*
Basic external shape	Major processes
Basic internal shape	Minor operations
Rotational or rectangular shape	Operation sequence
Length-to-diameter ratio (rotational parts)	Major dimension
Aspect ratio (rectangular parts)	Surface finish
Material type	Machine tool
Part function	Production cycle time
Major dimensions	Batch size
Minor dimensions	Annual production
Tolerances	Fixtures required
Surface finish	Cutting tools

Examples of Parts Classification and Coding Systems

(1) Opitz classification

12345 = form code , It describes the primary design attributes of the part, such as external shape (rotational vs rectangular) and machined features (e.g holes, threads, gear teeth etc)

6789 = supplementary code, It indicates some of the attributes that would be of use in manufacturing (e.g dimensions, work material, starting shape and accuracy)

ABCD = Secondary code, It is intended to identify the production operation type and sequence

Diagram- Basic structure of the opitz system of parts classification and coding

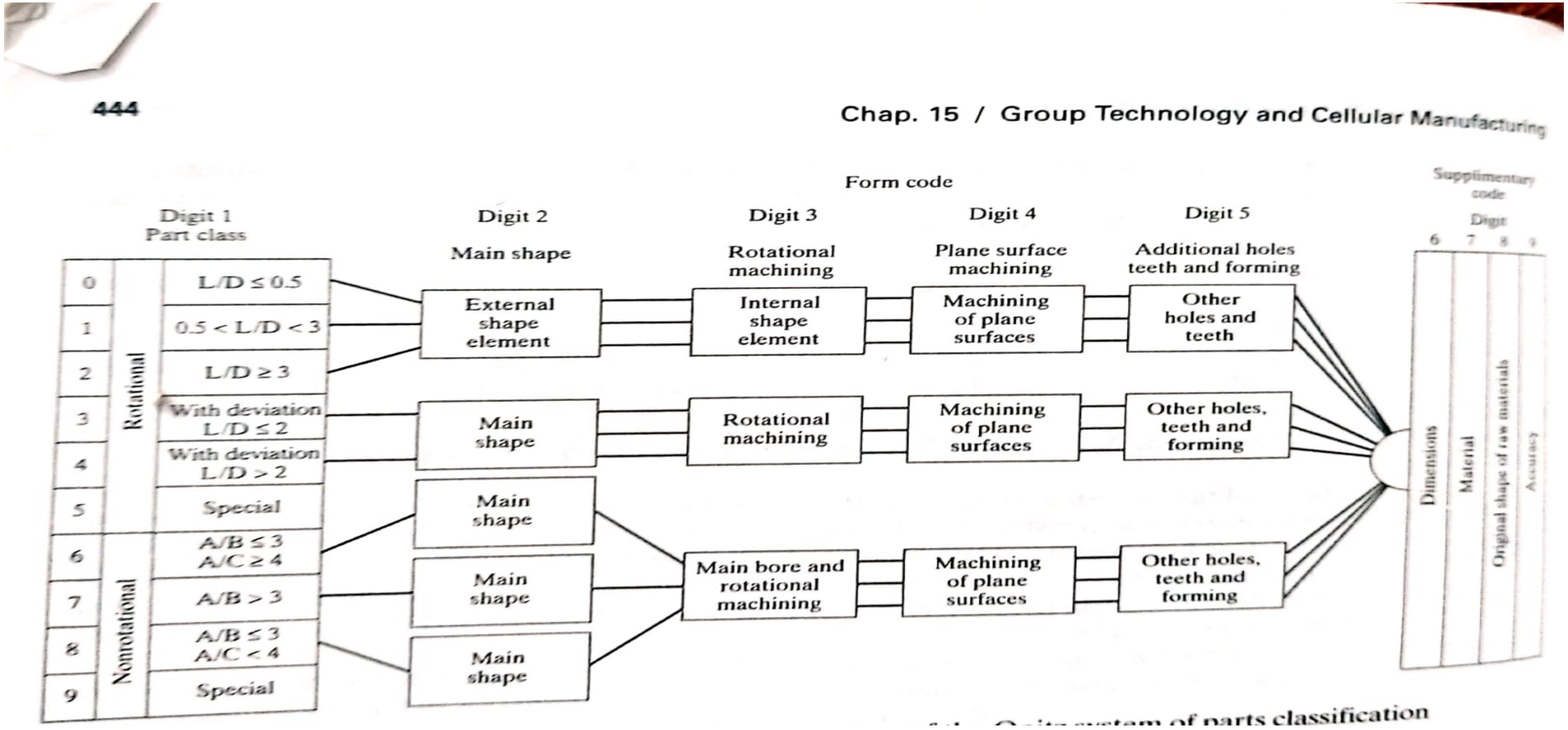


Diagram –Form code(opitz coding system)

Digit 1		Digit 2		Digit 3		Digit 4	Digit 5	
Part class		External shape, external shape elements		Internal shape, internal shape elements		Plane surface machining	Auxiliary holes and gear teeth	
0 Rotational parts	$L/D \le 0.5$	0	Smooth, no shape elements	0	No hole, no breakthrough	0 No surface machining	0 No gear teeth	No auxiliary hole
1	$0.5 < L/D < 3$	1 Stepped to one end or smooth	No shape elements	1 Smooth or stepped to one end	No shape elements	1 Surface plane and/or curved in one direction, external	1	Axial, not on pitch circle diameter
2	$L/D \ge 3$	2	Thread	2	Thread	2 External plane surface related by graduation around the circle	2	Axial on pitch circle diameter
3		3	Functional groove	3	Functional groove	3 External groove and/or slot	3	Radial, not on pitch circle diameter
4		4 Stepped to both ends	No shape elements	4 Stepped to both ends	No shape elements	4 External spline (polygon)	4	Axial and/or radial and/or other direction
5		5	Thread	5	Thread	5 External plane surface and/or slot, external spline	5	Axial and/or radial on PCD and/or other directions
6 Nonrotational parts		6	Functional groove	6	Functional groove	6 Internal plane surface and/or slot	6 With gear teeth	Spur gear teeth
7		7	Functional cone	7	Functional cone	7 Internal spline (polygon)	7	Bevel gear teeth
8		8	Operating thread	8	Operating thread	8 Internal and external polygon, groove and/or slot	8	Other gear teeth
9		9	All others	9	All others	9 All others	9	All others

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2) Multiclass: The classification and coding system is developed by organization of industrial research (OIR). The system is relatively flexible, allowing the user company to customize the classification and coding scheme to large extent to fit its own production and applications.

Digit	Function
0	Code system prefix
1	Main shape category
2, 3	External and internal configuration
4	Machined secondary elements
5, 6	Functional descriptors
7–12	Dimensional data (length, diameter, etc.)
13	Tolerances
14, 15	Material chemistry
16	Raw material shape
17	Production quantity
18	Machined element orientation

3) Production Flow Analysis

It is a method for identifying part families and associated machine groupings that uses the information contained on production route sheets rather than on part drawings.

The procedure of PFA consists of the following steps:

(i) Data collection

(ii) Sortation of process routings

(iii) PFA chart

(iv) Cluster analysis

Table –Possible code Numbers indicating Operations and/or Machining for Sortation in PFA

Operation or Machine	Code
Cutoff	01
Lathe	02
Turret lathe	03
Mill	04
Drill: manual	05
NC drill	06
Grind	07

PFA chart and Rearranged PFA chart

TABLE 15.4 PFA Chart, Also Known as a Part-Machine Incidence Matrix

Machines	Parts: 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		

TABLE 15.5 Rearranged PFA Chart, Indicating Possible Machine Groupings

Machines	Parts: 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

Cellular manufacturing

Cellular manufacturing is an application of group technology in which dissimilar machines or processes have been aggregated into cells, each of which is dedicated to the production of a part or product family or a limited group of families.

Typical objectives of cellular manufacturing are similar to those of group technology:

(i) To shorten manufacturing lead times
(ii) To reduce work-in-process inventory
(iii) To improve quality
(iv) To simplify production scheduling
(v) To reduce setup times

Machine Cell Design

Design of the machine cell is critical in cellular manufacturing. The cell design determines to a great degree the performance of the cell.

Types of Machine cells and Layouts

(i) Single machine cell (type 1 M)

(ii) Group machine cell with manual handling (type IIM generally, type III M less common

(iii) Group machine cell with semi-integrated handling (type IIM generally, type III M less common)

(iv) Flexible manufacturing cell or flexible manufacturing system (type II A generally, type III A less common)

Diagram- Machine cell with manual handling between machines

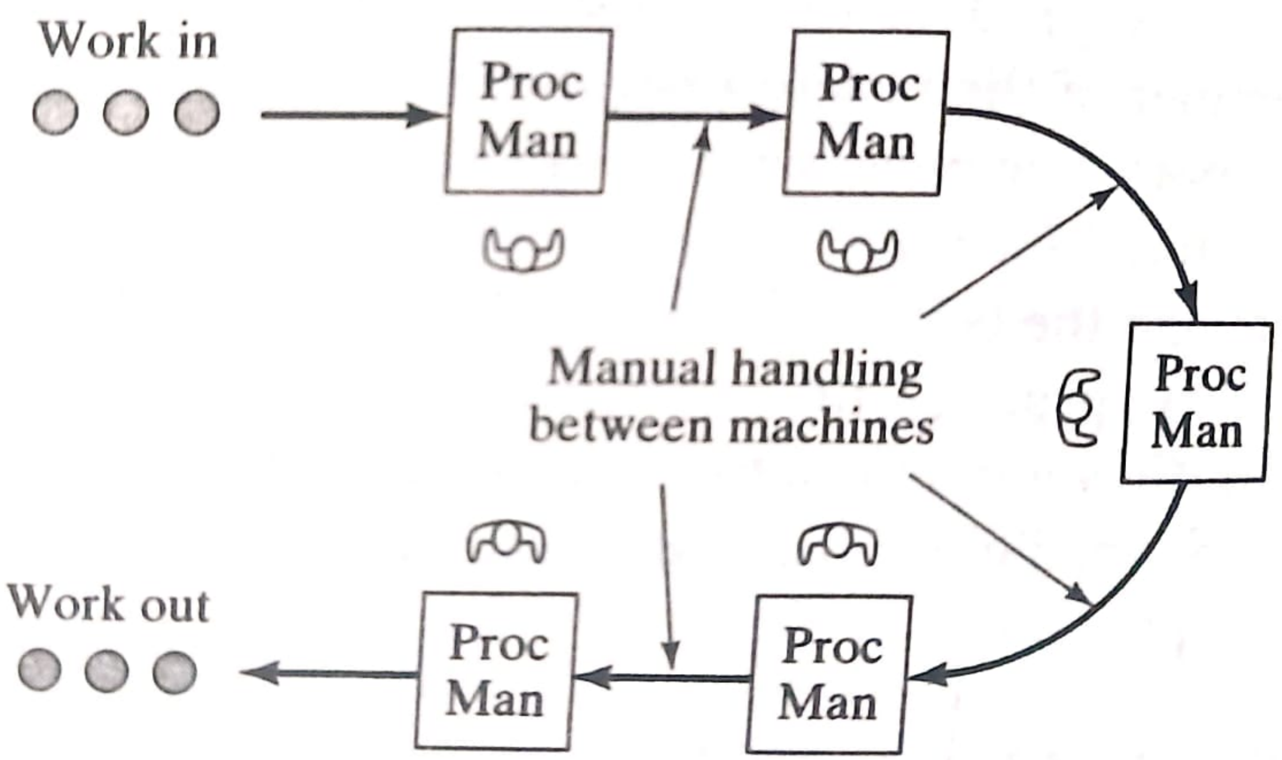
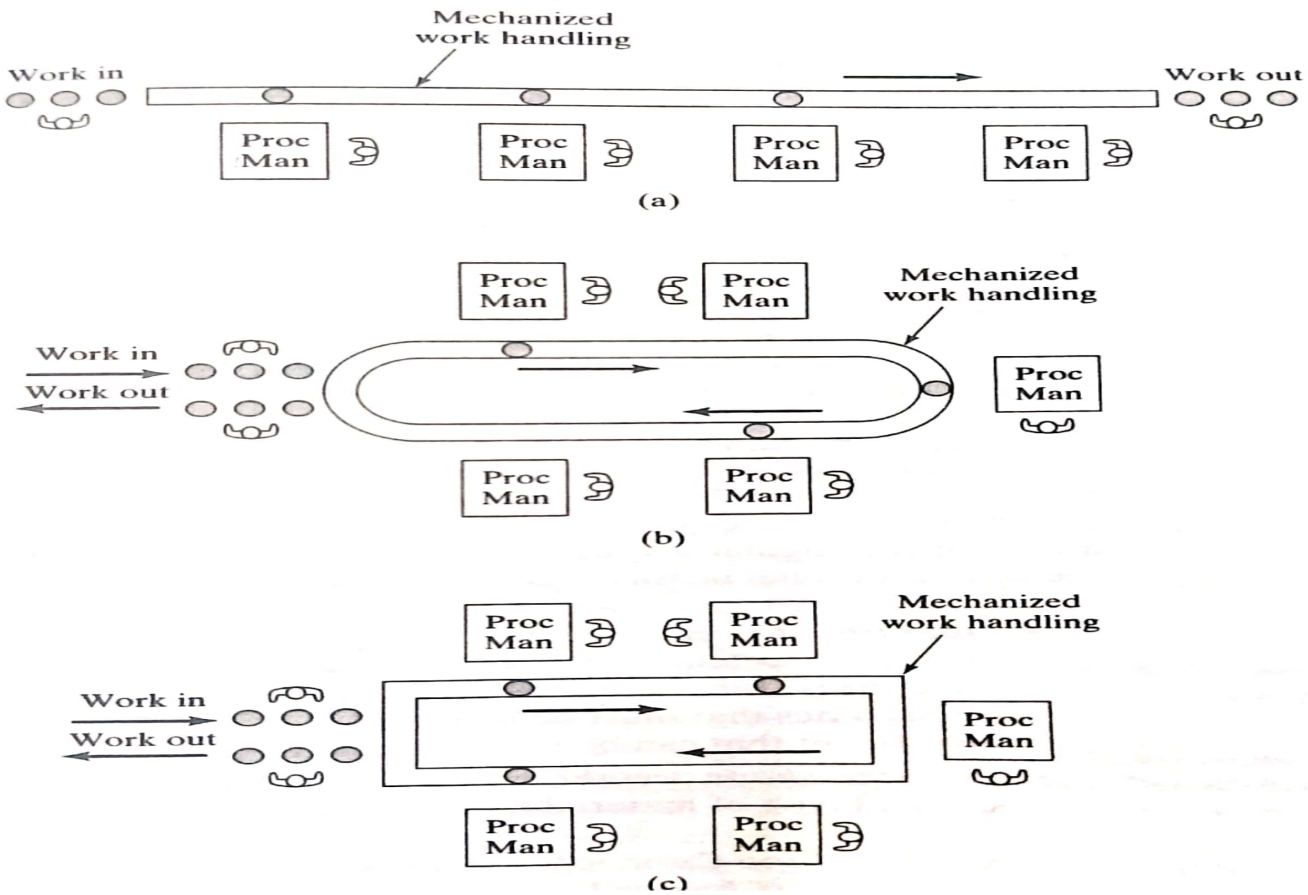


Figure 15.11 Machine cell with manual handling between machines.

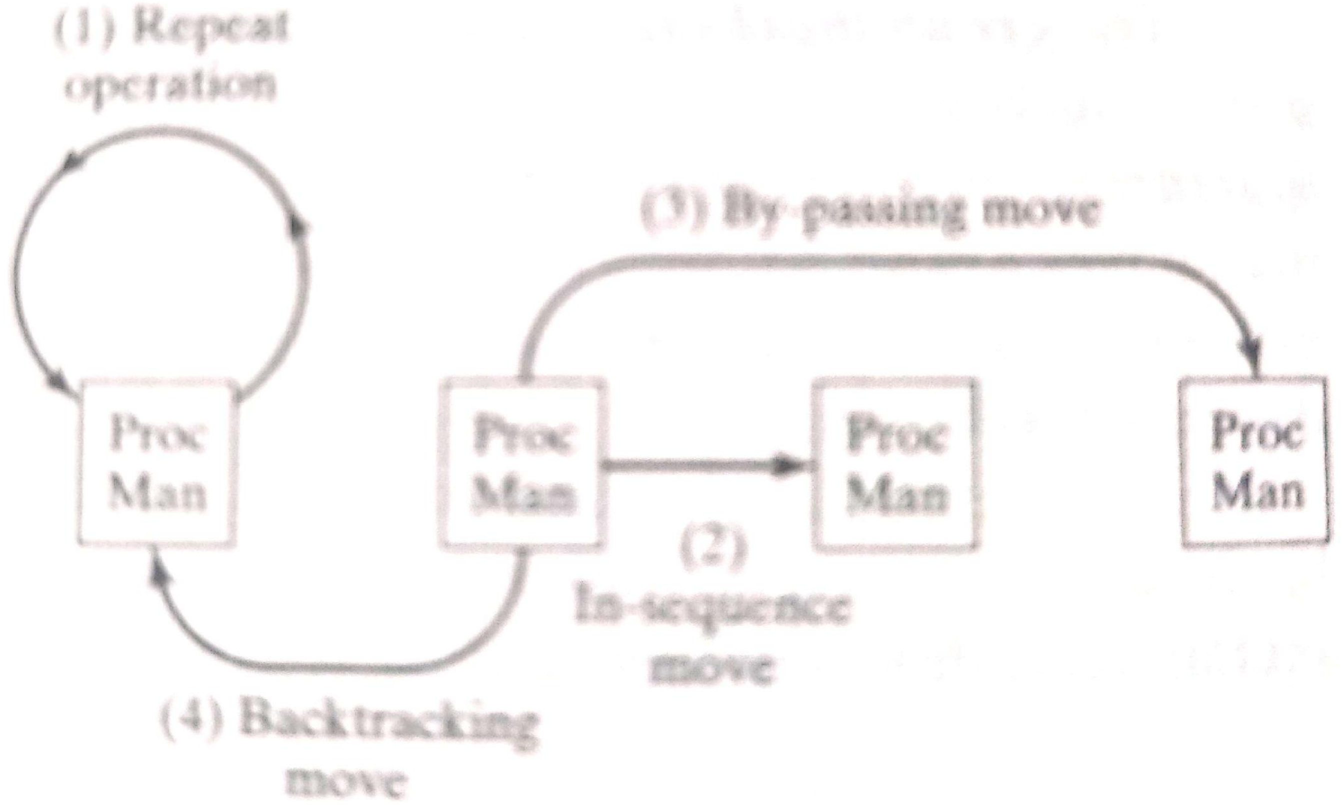
Diagram- Machine cells with semi-integrated handling



Factors determining most appropriate cell layout and cell design

(i) Repeat operation
(ii) In-sequence move
(iii) By-passing move
(iv) Backtracking move
(v) Quantity of work to be done by the cell
(vi) Part size, shape, weight and other physical attributes

Four types of part moves in a mixed model production system. The forward flow of work is from left to right



Applications of Group Technology

1) Manufacturing Applications

(a) Informal scheduling and routing of similar parts through selected machines

(b) Virtual machine cells

(c) Formal machine cells

2) Product Design Applications

Benefits of Cellular Manufacturing

TABLE 15.7 Benefits of Cellular Manufacturing Reported by Companies in Survey

Rank	*Reason for Installing Manufacturing Cells*	*Average Improvement* (%)
1	Reduce throughput time (Manufacturing lead time)	61
2	Reduce work-in-process	48
3	Improve part and/or product quality	28
4	Reduce response time for customer orders	50
5	Reduce move distances	61
6	Increase manufacturing flexibility	
7	Reduce unit costs	16
8	Simplify production planning and control	
9	Facilitate employee involvement	
10	Reduce setup times	44
11	Reduce finished goods inventory	39

Source: Wemmerlov and Johnson [38].

Quantitative analysis in cellular manufacturing

1. Rank order clustering

TABLE 15.10(a) First Iteration (Step 1) in the Rank Order Clustering Technique Applied to Example 15.3

Binary Values	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0		
	Parts									Decimal	
Machines	A	B	C	D	E	F	G	H	I	Equivalent	Rank
1	1			1				1		290	1
2					1				1	17	7
3			1		1				1	81	5
4		1				1				136	4
5	1							1		258	2
6			1						1	65	6
7		1				1	1			140	3

TABLE 15.10(b) Second Iteration (Steps 3 and 4) in the Rank Order Clustering Technique Applied to Example 15.3

	Parts									
Machines	A	B	C	D	E	F	G	H	I	Binary Values
1	1			1				1		2^6
5	1							1		2^5
7		1				1	1			2^4
4		1				1				2^3
3			1		1				1	2^2
6			1						1	2^1
2						1			1	2^0
Decimal Equivalent	96	24	6	64	5	24	16	96	7	
Rank	1	4	8	3	9	5	6	2	7	

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TABLE 15.10(c) Solution of Example 15.3

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