Computers in Manufacturing Enterprises

Group Technology: Automation, production systems & CIM
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Production Flow Analysis (PFA)

- method of grouping part into families
- used to analyze the operation steps and machine routes for the parts produced
- groups parts with similar or identical routings together
- these groups can be used to form logical machine cells in a GT layout
- uses manufacturing data rather than design data to make groups, so takes care of the problem of:
  - parts whose basic geometry may differ but might take same or similar process routes
  - parts whose basic geometry may be same or similar but require different process routings
- disadvantage:
  - takes the route details the way they are, no check for optimal, consistent or logical routing

Production Flow Analysis: Procedure

Data Collection

--define the population of the parts to be analyzed

-- study a sample or the whole population ?

-- minimum data needed is the part number and routing sequence of each part (route sheets)

-- additional data as lot size, annual production rate, can be used to design cells of the desired productivity

Sorting of Process Routings

-- arrange the parts according to the similarity of their process routings

-- sorting procedure is used to arrange the parts into "packs"

-- "pack: is a group of parts with identical process routings

--each pack is given a pack identification number or letter

PFA Chart

-- processes used for each pack are displayed graphically on a PFA chart

-- plot of the process code numbers for all the packs that have been determined

Analysis

-- most difficult and crucial step

-- from the PFA chart, similar groups are identified

-- minimum data needed is the part number and routing sequence of each part (route sheets)

-- additional data as lot size, annual production rate, can be used to design cells of the desired productivity

Example (Matrix Form)

Before Grouping

Pump Machining Production Flow Analysis		Broach	HMC	Lathe-Chuck	Hob	Lathe-Manual	Hob	Lathe-Bar	Lathe-Vert
61354	Cover Bearing			X					
70852	Gear Driven 8P,56T, RH	X		X	X		X		
52594	Spacer,cplg Shaft							X	
81357-T	Impellor	X		X					
50547-D	Gland, MU, 6"					X			
70935	Gear,Driven,8P,26T,LH	X		X	X		X		
51171	Retainer Bushing							X	
81176	Body Volute		X						X
72298	Elbow, Relief Valve		X						
50763	Spacer, Bearing							X	
71972-8	Adapter, Intake, 8"		X			X			X
62575	Shaft Shift							X	
63160	Seat, Spring							X	
62968	Generator, Tach Pulse			X	X				
71928	Head, Pump					X			X

Pump Machining Production Flow Analysis		Lathe-Manu	Lathe-Vert	HMC	Lathe-Chuck	Broach	Hob	Lathe-Bar
50547-D	Gland, MU, 6"	X						
71928	Head, Pump	X	X					
71972-8	Adapter, Intake, 8"	X	X	X				
81176	Body Volute		X	X				
72298	Elbow, Relief Valve			X				
81357-T	Impellor				X	X		
62968	Generator, Tach Pulse				X		X	
70852	Gear Driven 8P,56T, RH				X	X	X	
70935	Gear,Driven,8P,26T,LH				X	X	X	
61354	Cover Bearing				X			
52594	Sp[acer,cplg Shaft							X
62575	Shaft Shift							X
63160	Seat, Spring							X
51171	Retainer Bushing							X
50763	Spacer, Bearing							X

Turn-Mill Cell

Chucking Lathe Cell

Barfeed Lathe Cell

http://www.strategosinc.com/gt-production_flow_analysis.htm

Production Flow Analysis: Procedure

- there will be packs that do not fit into similar groupings
- these parts can be analyzed to determine if a revised process sequence can be developed which fits into one of the groups
- if not possible, then these parts continue to be manufactured through a conventional process-type plant layout
- weakness of PFA is that the data used in the analysis is derived from route sheets, prepared by different process planners

=> routings may contain unnecessary and non-optimal steps

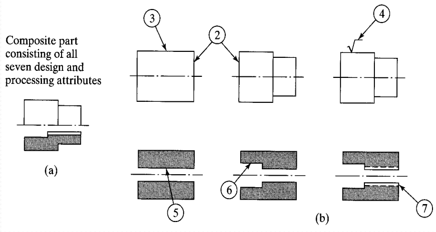
=> final groupings may be sub-optimal

- requires less time to perform than a complete parts classification and coding procedure

Group Technology: Machine Cell Design

Composite Part Concept

- *A Composite Part* for a given family, which includes all of the design and manufacturing attributes of the family
- an individual part in the family will have some of the features that characterize the family but not all of them
- composite part possesses all of the features



Label	Design Feature	Corresponding Manufacturing Operation
1	External cylinder	Turning
2	Cylinder face	Facing
3	Cylindrical step	Turning
4	Smooth surface	External cylindrical grinding
5	Axial hole	Drilling
6	Counterbore	Counterboring
7	Internal threads	Tapping

http://www.atilim.edu.tr/~mfgecourses/MFGE404/Lecture-Notes/Group_Technology_and_Cellular_Manufacturing-II.ppt

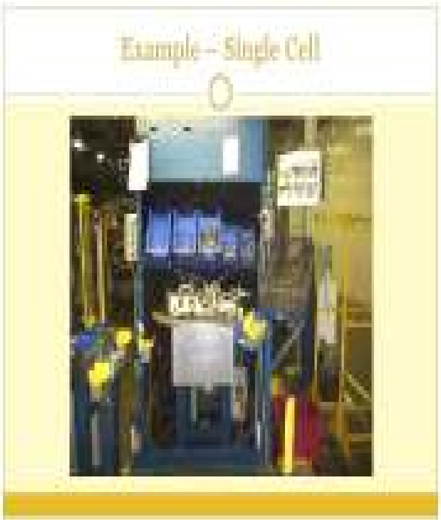
Machine Cell Designs: Types

- term "cellular manufacturing" is used to describe the operations of a GT machine cell
- can be classified, based on number of machines and the degree to which the material flow is mechanized between the machines:
  - single machine cell
  - group machine cell with manual handling
  - group machine cell with semi-integrated handling
  - flexible manufacturing system (FMS)

Machine Cell Designs: Type 1

Single machine cell

- consists of 1 machine plus supporting fixtures and tooling to make one or more part families
- can be applied to work parts that is made by one type of process, such as turning or milling

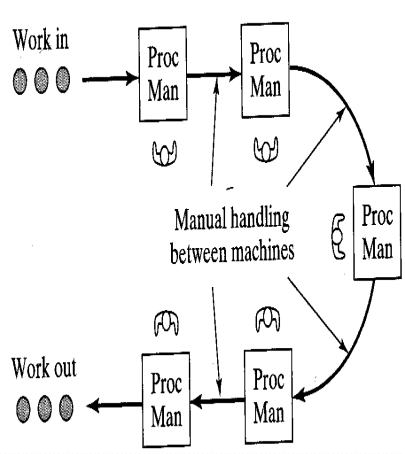


http://www.slideshare.net/jros46/cellular-manufacturing-flexible-operations

Machine Cell Designs: Type 2

group machine cell with manual handling using a U-shaped layout

- consists of more than one machine used collectively to make one or more part families
- no provision for mechanized part movement between machines
- human operators running cell, perform material handling ; if size of the part is huge or arrangement of machines in cell is large, regular handling crew may be required
- often organized in a U-shape layout when there is variation in work flow in parts; also useful in movement of multi functional workers
- design is often achieved without rearranging the process-type layout; simply include certain machines in group and restrict their work to specified part family
- saves cost of rearranging but many material handling benefits of GT are not realized

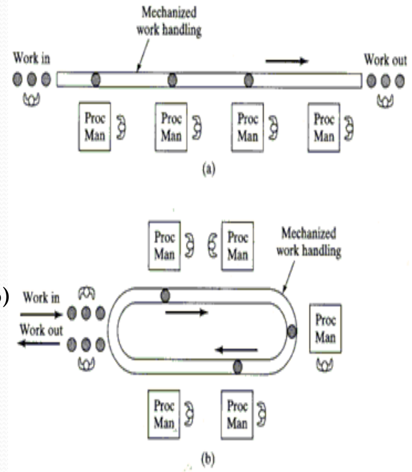


http://www.atilim.edu.tr/~mfgecourses/MFGE404/Lecture-Notes/Group_Technology_and_Cellular_Manufacturing-II.ppt

Machine Cell Designs: Type 3

group machine cell with semi-integrated handling

- uses a mechanized handling system, such as a conveyor, to move parts between machines in the cell
- parts made in the cell have identical or similar routing – ***in-line layout (a)***
  - machines are laid along a conveyor to match the processing sequence
- process routings vary in parts – **loop layout (b)**
  - allows parts to circulate in the handling system
  - permits different processing steps in the different parts in the system



http://www.atilim.edu.tr/~mfgecourses/MFGE404/Lecture-Notes/Group_Technology_and_Cellular_Manufacturing-II.ppt

Machine Cell Designs: Type 4

Flexible Manufacturing System (FMS)

- highly automated machine cells in GT
- combines automated processing stations with a fully integrated material handling system

Best Machine Arrangement

- depends on the work processing requirements
- important factors are:
  - *volume of the work to be done by the cell*
    includes the number of parts per year and the work required per part – influences number of machines to be used in cell, cost of operating a cell, amount of money to be spent in establishing a cell
  - *variations in process routings of the part*
    determines the work flow; for identical routings- in-line flow, significant variation in routing – a U-shape or loop layout
  - *part size, shape, weight, and other physical attributes*
    determine the size and type of material handling and processing equipment that can be used

Arrangement of Machines in GT – Hollier Method

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

Arrangement of Machines in GT - Hollier Method

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

Arrangement of Machines in GT – Hollier Method

- to/from ratios can be calculated:

Machine	To:	from:	To/From ratio
1	50	30	1.67
2	45	45	1.00
3	0	50	0.00
4	40	10	4.00

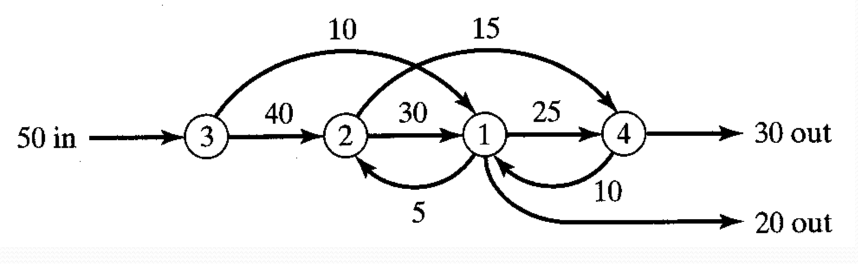
based on the relative values, the machines in the cell should be arranged:

$3 \longrightarrow 2 \longrightarrow 1 \longrightarrow 4$

(value of to/from ratio in ascending order)

Arrangement of Machines in GT - Hollier Method

flow diagram of machine layout



Parts Classification and Coding

- most time consuming of the three methods
- must be customized for a given company or industry
- some benefits of using a coding scheme:
  - helps in formation of part families and machine cells
  - quick retrieval of designs, drawings and process plans
  - reduces design duplication by providing work piece statistics
  - allows improvement in tool design, production panning and scheduling procedures
- Reasons for using a coding scheme:
  - design retrieval: access to a part that already exists

Types of Classification and Coding Systems

- falls into 3 categories, based on:
  - part design attributes
  - part manufacturing attributes
  - both design and manufacturing attributes
- certain overlapping in design and manufacturing attributes

Design and Manufacturing Attributes Typically Included in a GT Classification System

Part Design Attributes	
Major dimensions	Part function
Basic external shape	Tolerances
Basic internal shape	Surface finish
Length/diameter ratio	Material type
Minor dimensions	
Part Manufacturing Attributes	
Major process	Major dimensions
Operation sequence	Length/diameter ratio
Batch size	Surface finish
Annual production	Production time
Machine tools	Fixtures needed
Cutting tools	Minor operations

Coding Scheme Structures

- consists of sequence of numerical digits, designed to identify part's design and manufacturing attributes

advantage: more info is contained in the code

- 2 basic structures:
  - **Hierarchical structure (monocode)**
    interpretation of each successive digit depends on the value of the preceding digit
  - **Chain-type structure (polycode)**
    interpretation of each symbol is fixed and no dependence on previous digits

- example: 2 digit part code 15 or 25
  First digit is general part shape, say, 1 for round work part and 2 for flat rectangular geometry
  Hierarchical structure: preceded by 1, 5 might indicate some length/diameter ratio and if
  preceded by 2, 5 might be interpreted to specify overall length
  Chain-type structure : whether preceded by 1 or 2, 5 might indicate overall part length

Coding Scheme Structures

- sometimes combination of hierarchical and chain-type structures are used
- required number of digits vary from 6 to 30
- coding requiring design characteristics need fewer digits
- modern classification and coding systems incorporate both design and manufacturing data -> code numbers with 20-30 digits may be needed

Opitz Classification System

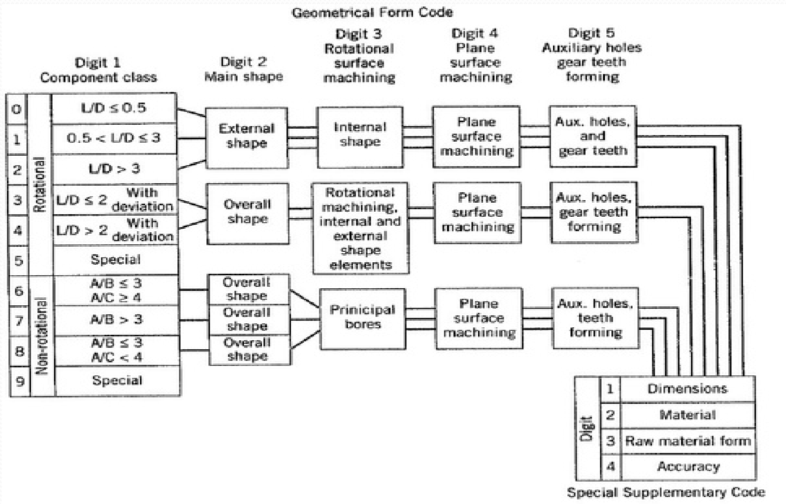
- one of the first published and best known classification and coding schemes for mechanical parts
- uses the following digit sequence

  12345 6789 ABCD

- basic code consists of 9 digits
  - digits 1 through 5 (12345) -> *form code* – primary shape and design attributes (hierarchical structure)
  - digits 6 through 9 -> *supplementary code* – attributes that are useful in manufacturing (e.g., dimensions, starting material)
  - digits 10 through 13 (ABCD) ->*secondary code* – identify production operation type and sequence
- very complex system

Opitz Classification System

Basic structure of Opitz System



http://www.quora.com/Mechanical-Engineering/What-is-OPITZ-classification-system-in-Group-Technology

Opitz Classification System

form code (digits 1 to 5) for rotational parts. Part classes 0, 1, 2

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

Primary Digits: Explained

Opitz Classification System - example

- **Example 1: A part coded 20801**
  - 2 - Parts has L/D ratio >= 3
  - 0 - No shape element (external shape elements)
  - 8 - Operating thread
  - 0 - No surface machining
  - 1 - Part is axial
- **Example 2: given the part design shown define the "form code" using the Opitz system**
  - Step 1: The total length of the part is 1.75, overall diameter 1.25 -> L/D = 1.4 (code 1)
  - Step 2: External shape - a rotational part that is stepped on both with one thread (code 5)
  - Step 3: Internal shape - a through hole (code 1)
  - Step 4: By examining the drawing of the part (code 0)
  - Step 5: No auxiliary holes and gear teeth (code 0)
  - **Code: 15100**

http://www.slideshare.net/NoumanKhan2/9-oct-2013-lec-13-1415161718

Benefits of Group Technology

- Product design
  - derived from coding and classification
  - if new part design is required -> code of the required part is figured out -> matched with the existing part designs
  - design standardization
- material handling is reduced
  - parts are moved within a machine cell rather than the entire factory
- process planning and production scheduling are simplified
- Work-in-process and manufacturing lead time are reduced
- improved worker satisfaction in a GT cell
- higher quality work

Important Announcements!

- Syllabus for Minor 1 exam:
  - All the work done till August 24