Ch 18 Group Technology

- Learning Objectives:

By the end of the lecture the student should be able to:

  - Explain what GT is.
  - Explain the concepts of part families.
  - Explain what parts classification and coding is.
  - Explain what cellular manufacturing is.
  - Perform coding using Opitz.
  - Provide applications and benefits of GT in manufacturing.

Group Technology (GT) Defined

A manufacturing philosophy in which similar parts are identified and grouped together to take advantage of their similarities in design and production

- Similarities among parts permit them to be classified into part families
  - In each part family, processing steps are similar
- The improvement is typically achieved by organizing the production facilities into **manufacturing cells** that specialize in production of certain part families

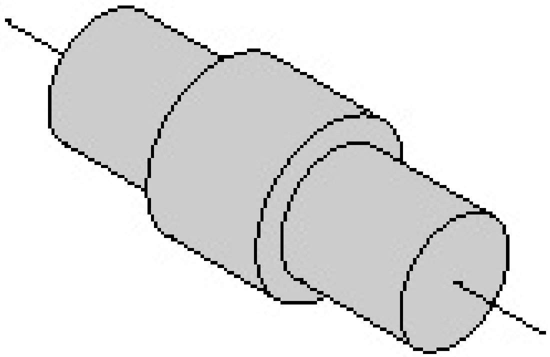
Part Family

A collection of parts that possess similarities in geometric shape and size, or in the processing steps used in their manufacture

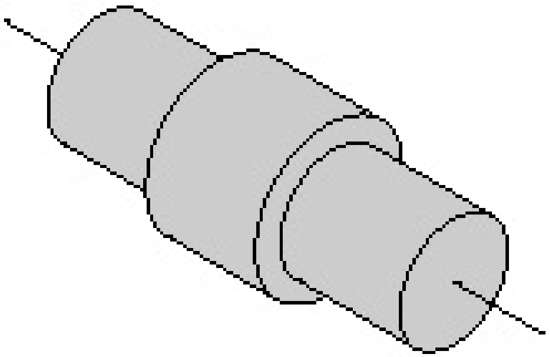
- Part families are a central feature of group technology
  - There are always differences among parts in a family
  - But the similarities are close enough that the parts can be grouped into the same family

Part Families

- Two parts that are identical in shape and size but quite different in manufacturing: (a) 1,000,000 units/yr, tolerance = ±0.010 inch, 1015 steel; (b) 100/yr, tolerance = ±0.001 inch, 18-8 stainless steel



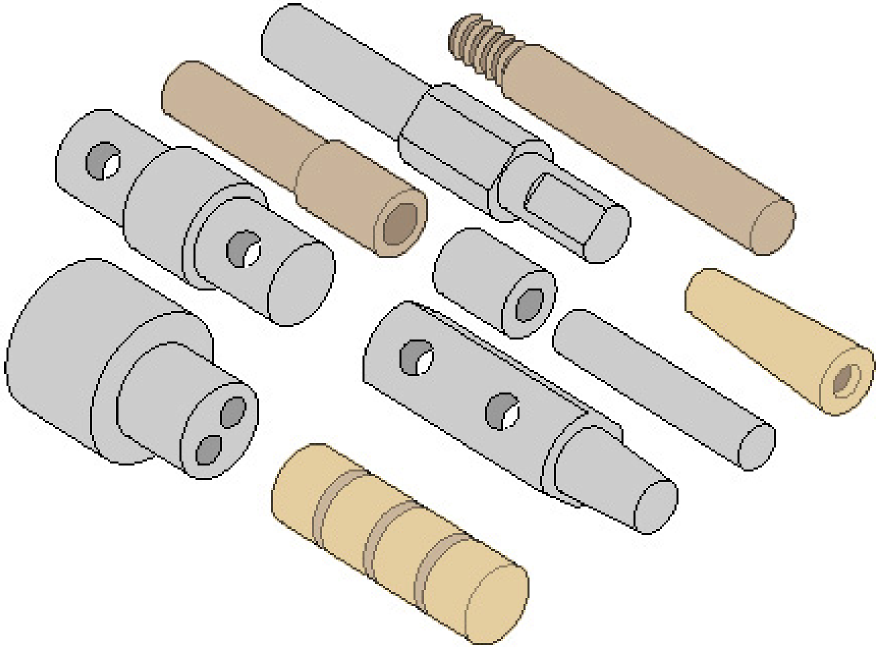
(a)



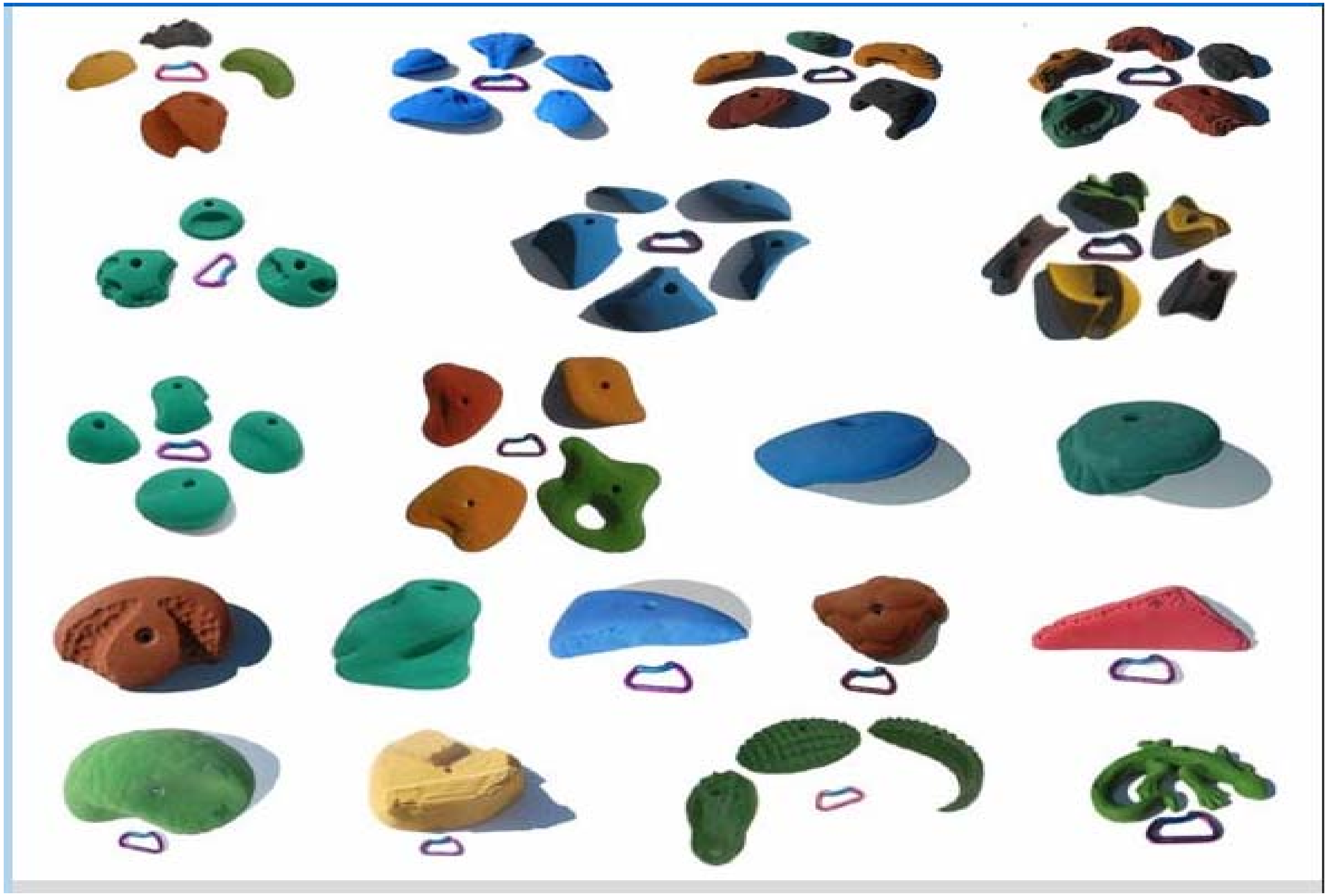
(b)

Part Families

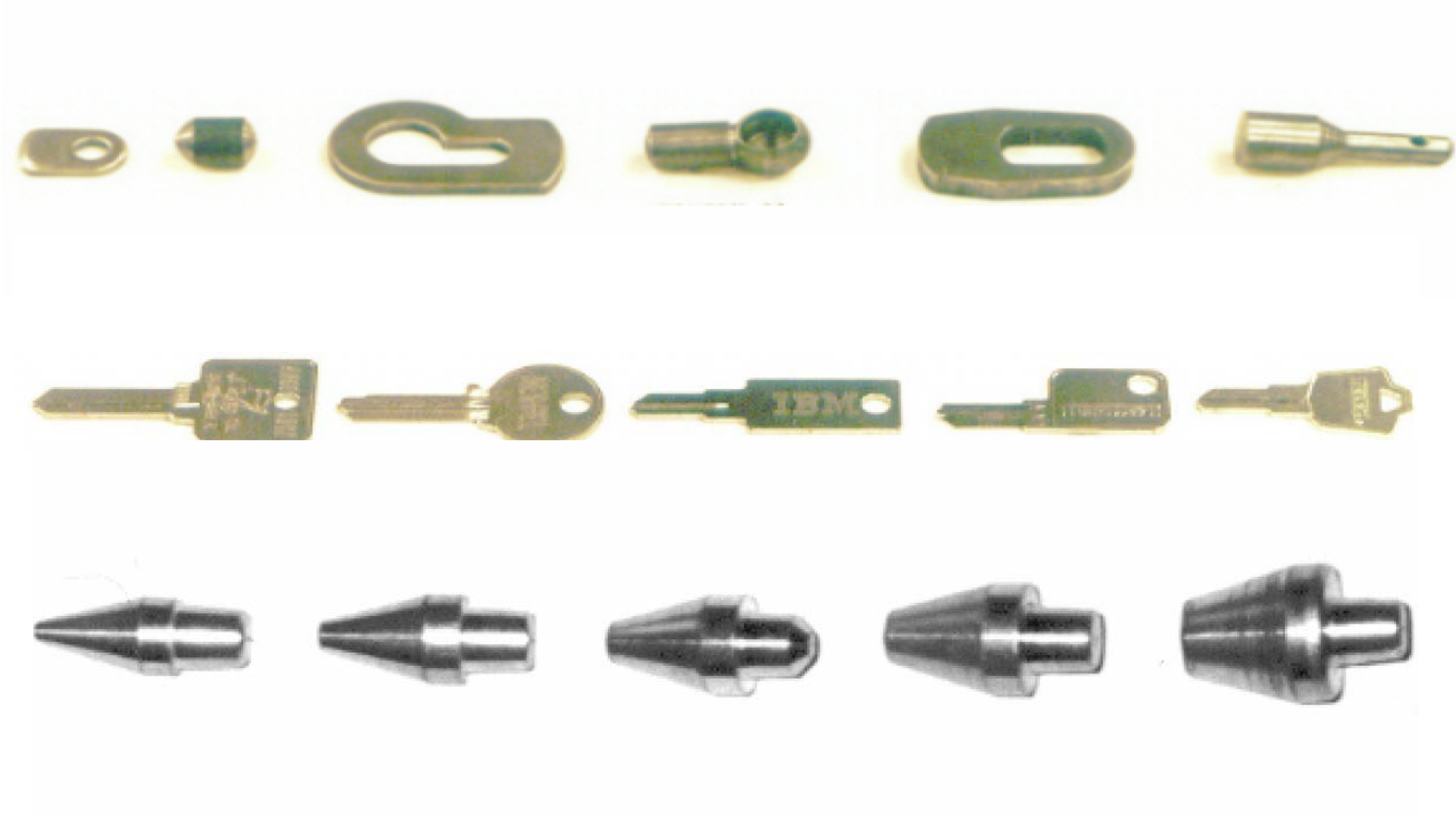
- Ten parts are different in size, shape, and material, but quite similar in terms of manufacturing
- All parts are machined from cylindrical stock by turning; some parts require drilling and/or milling



Exercise 1



Exercise 2



Ways to Identify Part Families

1. Visual inspection
   - Using best judgment to group parts into appropriate families, based on the parts visual inspection
2. Parts classification and coding
   - Identifying similarities and differences among parts and relating them by means of a coding scheme
3. Production flow analysis
   - Using information contained on route sheets to classify parts

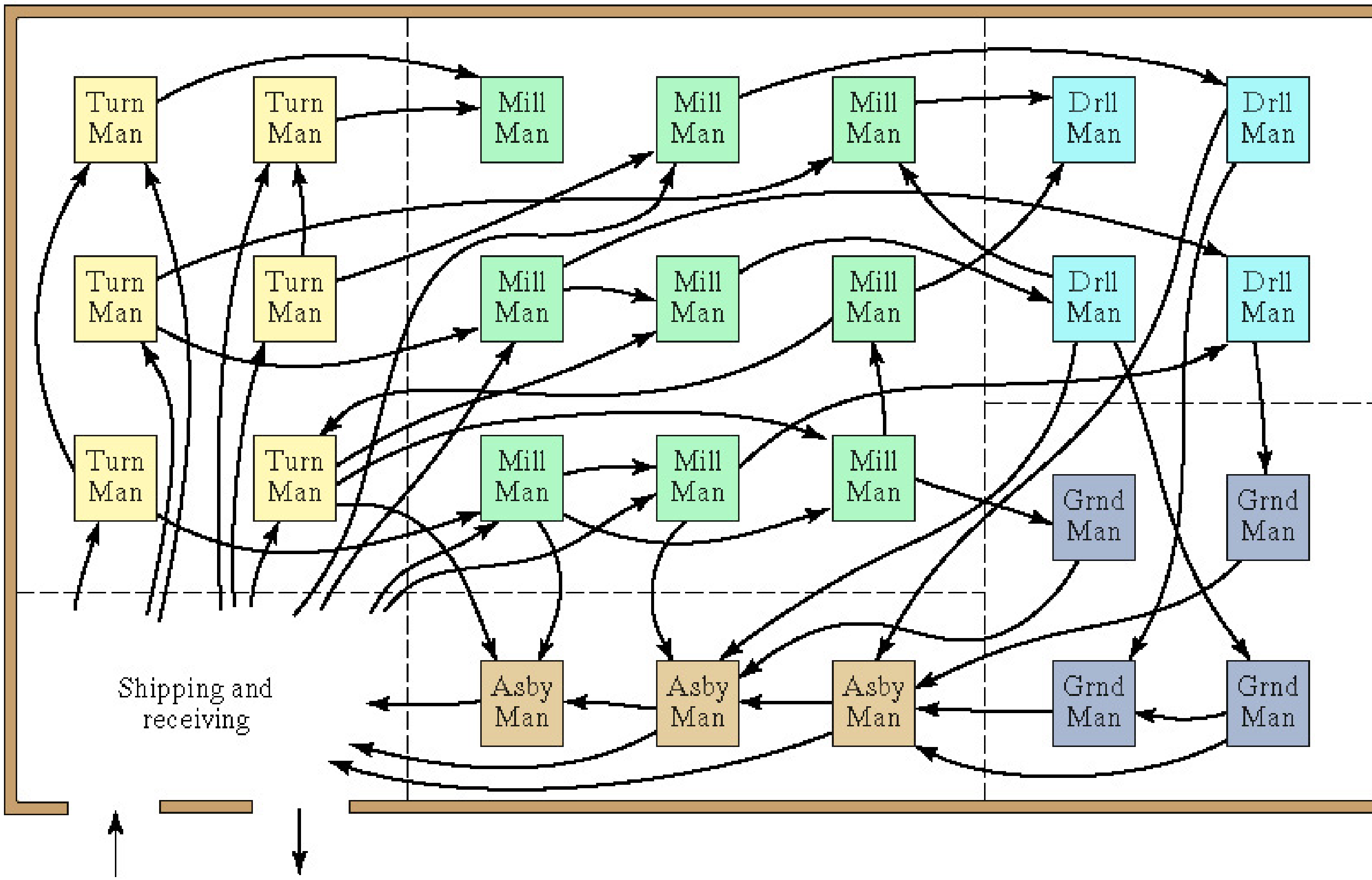
Part Families and Cellular Manufacturing

- GT exploits the part similarities by utilizing similar processes and tooling to produce them
- Machines are grouped into cells, each cell specializing in the production of a part family
  - Called *cellular manufacturing*
- Cellular manufacturing can be implemented by manual or automated methods
  - When automated, the term *flexible manufacturing system* is often applied

When to Use GT and Cellular Manufacturing

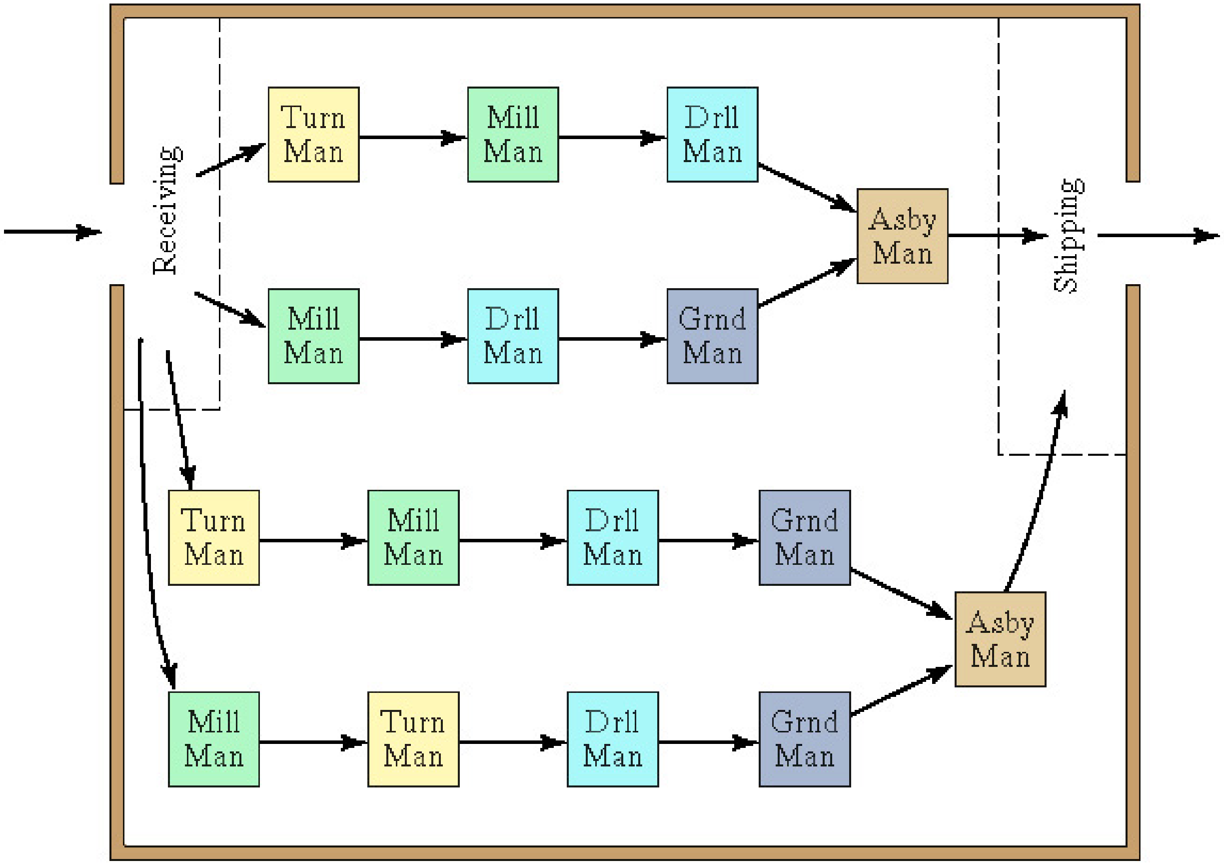
1. The plant currently uses traditional batch production and a process type layout
   - This results in much material handling effort, high in-process inventory, and long manufacturing lead times
2. The parts can be grouped into part families
   - A necessary condition to apply group technology
   - Each machine cell is designed to produce a given part family, or a limited collection of part families, so it must be possible to group parts made in the plant into families

Traditional Process Layout



Cellular Layout Based on GT

- Each cell specializes in producing one or a limited number of part families



Problems in Implementing GT

1. Identifying the part families
   - Reviewing all of the parts made in the plant and grouping them into part families is a substantial task
2. Rearranging production machines into GT cells
   - It is time-consuming and costly to physically rearrange the machines into cells, and the machines are not producing during the changeover

Parts Classification and Coding

Identification of similarities among parts and relating the similarities by means of a numerical coding system

- Must be customized for a given company or industry
- Reasons for using a coding scheme:
  - Design retrieval
  - Automated process planning
  - Machine cell design

Features of Parts Classification and Coding Systems

- Most classification and coding systems are based on one of the following:
  - Part design attributes
  - Part manufacturing attributes
  - Both design and manufacturing attributes

Part Design Attributes

- Major dimensions
- Basic external shape
- Basic internal shape
- Length/diameter ratio
- Material type
- Part function
- Tolerances
- Surface finish

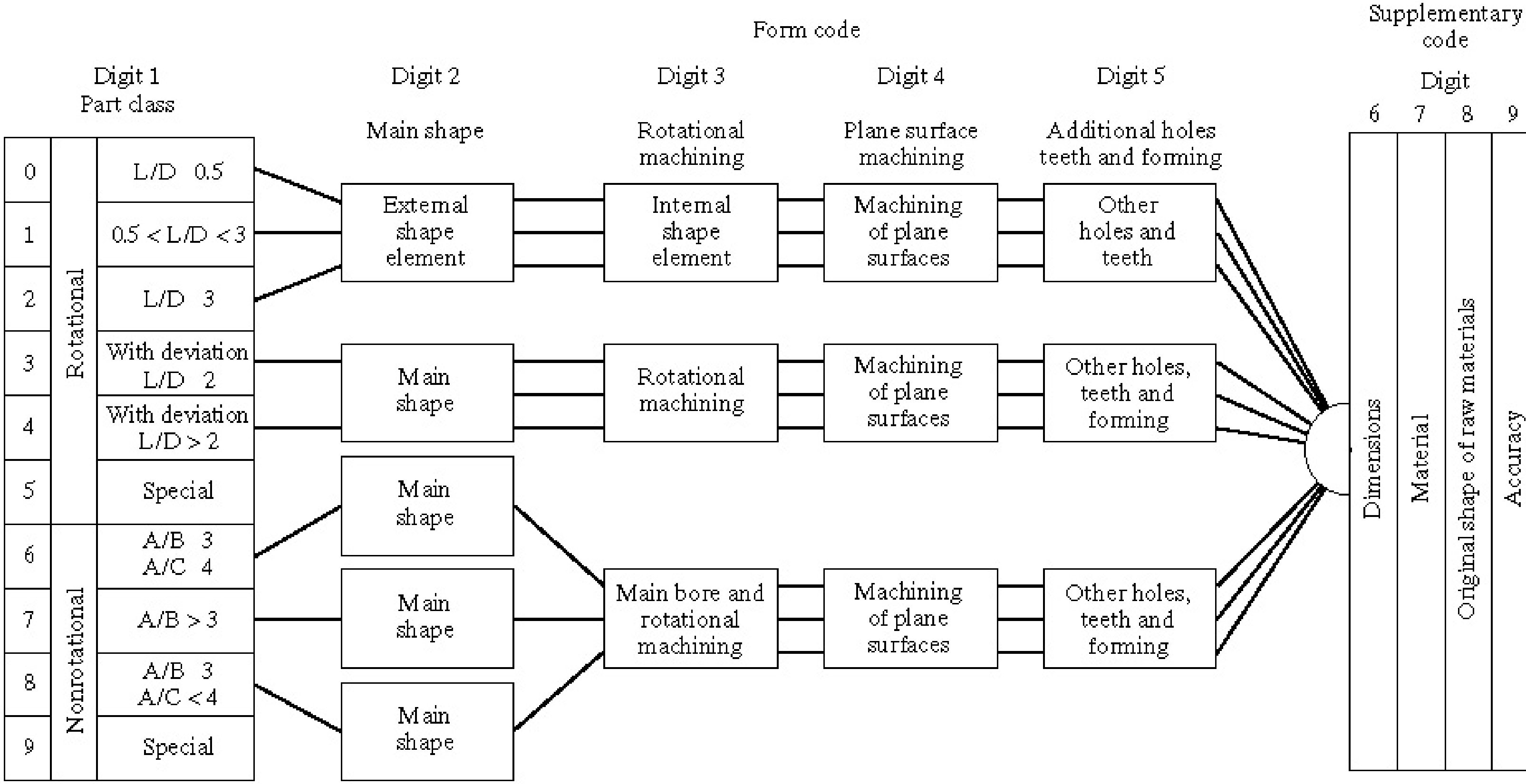
Part Manufacturing Attributes

- Major process
- Operation sequence
- Batch size
- Annual production
- Machine tools
- Cutting tools
- Material type

Opitz Classification System

- One of the first published classification and coding schemes for mechanical parts
- Basic code = nine (9) digits
  - Digits 1 through 5 = 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 = secondary code – production operation type and sequence

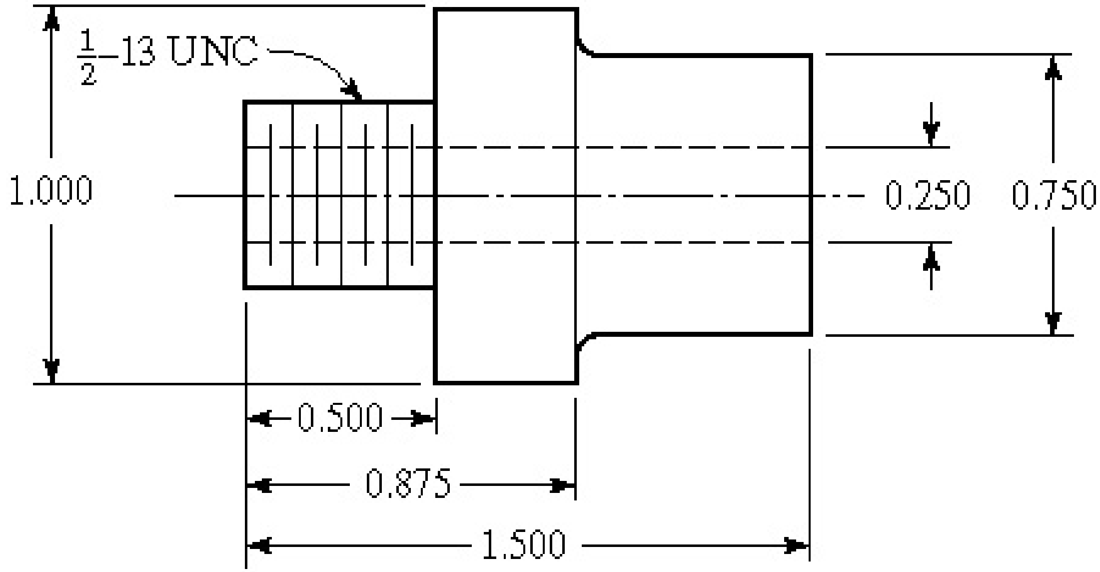
Basic Structure of Opitz System



Opitz Form Code (Digits 1 through 5)

	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 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 the 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	With gear teeth	All others

Example 1: Opitz Form Code



Form code in Opitz system is ________

Benefits of Group Technology in Manufacturing

- Standardization of tooling, fixtures, and setups is encouraged
- 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

Product Design Applications of Group Technology

- Design retrieval systems
  - Industry survey: For new part designs,
    - Existing part design could be used - 20%
    - Existing part design with modifications – 40%
    - New part design required – 40%
- Simplification and standardization of design parameters such as tolerances, chamfers, hole sizes, thread sizes, etc.
  - Reduces tooling and fastener requirements in manufacturing

Clustering Methods

- Using Process Similarity methods:
  - Create Machine – Part Matrices
  - Compute machine 'pairwise' Similarity Coefficient comparisons:

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

here:

x_{ij} **is # of parts (in matrix) visiting both machines of the pair**

x_{jj} **is # of parts visiting one but not both machines**

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Example:

	Part 'Number'						
Machine ID	X	1	2	3	4	5	6
	A			1		1	
	B		1	1			
	C	1			1		
	D		1	1		1	
	E	1			1		1

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Computing Similarity Coefficients:

- Total Number is:
  - [(N-1)N]/2 = [(5-1)5]/2 = 10
  - For 25 machines (typical number in a small Job Shop): 300 S_{ij}'s
- Here they are:

$$S_{AB} = \frac{1}{1+2} = .33$$

$$S_{AC} = \frac{0}{0+4} = 0$$

$$S_{AD} = \frac{2}{2+1} = .67$$

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Continuing:

$$S_{AE} = \frac{0}{0+5} = 0$$

$$S_{BC} = \frac{0}{0+4} = 0$$

$$S_{BD} = \frac{2}{2+1} = .67$$

$$S_{BE} = \frac{0}{0+5} = 0$$

$$S_{CD} = \frac{0}{0+5} = 0$$

$$S_{CE} = \frac{2}{2+1} = .67$$

$$S_{DE} = \frac{0}{0+6} = 0$$

- Here, if the similarity coefficient is <= .33 consider clustering
- This criteria means clustering:
  - A&D, A&B, B&D
  - C & E
- Declustering:
  - A&C, A&E, B&C, B&E and C&D, D&E

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Continuing:

- Examining our Matrix and our freshly clustered 'machine cells,' we develop 2 part families:
  - For the Cell A/D/B: Part Numbers 2, 3 & 5
  - For the Cell C/E: Part Numbers 1, 4 & 6
- Care must be taken (in most cases) to assure that each cell has all the machines it needs – sometimes a couple of families need a key machine
  - In this case, the manager must decide to either replicate the common machine or share it between the cells creating a bottleneck and scheduling problem for each cell
  - This is typically one of the major cost problems

Summarizing:

- Make Machine/Part Matrix
- Compute Similarity Coefficients
- Cluster Machines with positive (□ .33) S_{ij}’s
- Determine Part Families for the clusters (cells)
- Decide if machine replication is cost effective
- Re-layout facility and Cross Train workforce

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