GROUP TECHNOLOGY AND FLEXIBLE MANUFACTURING SYSTEMS

Group Technology

Flexible Manufacturing Systems and Cells

Overview of Group Technology (GT)

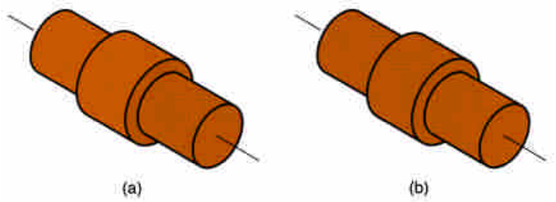
- Parts in the medium production quantity range are usually made in batches
- Disadvantages of batch production:
    - Downtime for changeovers
    - High inventory carrying costs
- GT minimizes these disadvantages by recognizing that although the parts are different, there are groups of parts that possess similarities
- GT exploits the part similarities by utilizing similar processes and tooling to produce them
- GT can be implemented by manual or automated techniques
- When automated, the term *flexible manufacturing system* is often applied

Group Technology Defined

- An approach to manufacturing in which similar parts are identified and grouped together in order 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

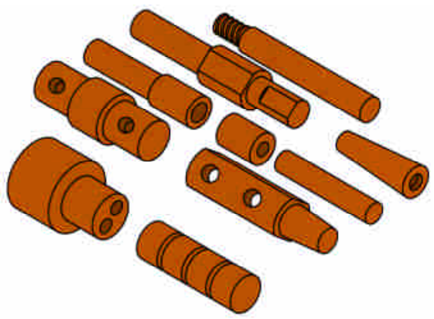
- A group of parts that possess similarities in geometric shape and size, or in the processing steps used in their manufacture
- Part families are a central feature of group technology
- There are always differences among parts in a family
- But the similarities are close enough that the parts can be grouped into the same family



- 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 CR steel, nickel plate

(b)100/yr, tolerance = ±0.001 inch, 18-8 stainless steel



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

Ways to Identify Part Families

1.Visual inspection - using best judgment to group parts into appropriate families, based on the parts or photos of the parts

2.Production flow analysis - using information contained on route sheets to classify parts

3.Parts classification and coding - identifying similarities and differences among parts and relating them by means of a coding scheme

Parts Classification and Coding

Most classification and coding systems are one of the following:

- Systems based on part design attributes
- Systems based on part manufacturing attributes
- Systems based on 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

Three structures used in classification and coding schemes

- Hierarchical structure, known as a mono-code, in which the interpretation of each successive symbol depends on the value of the preceding symbols
- Chain-type structure, 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
- Mixed-mode structure, which is a hybrid of the two previous codes

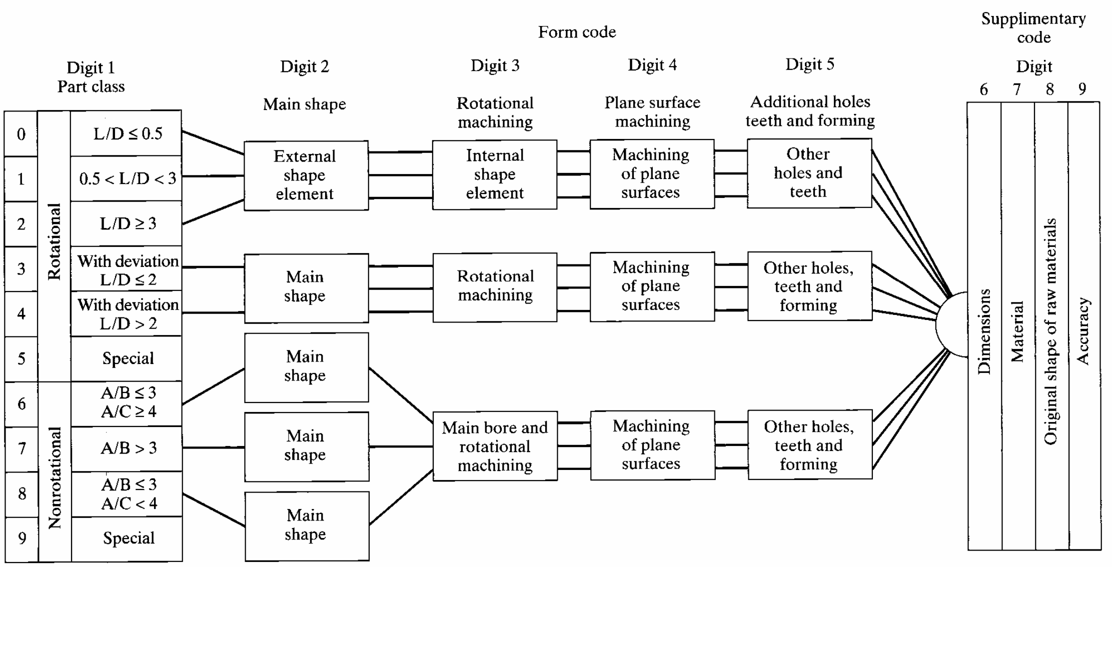
Some of the important systems

- Opitz classification system – the University of Aachen in Germany, nonproprietary, Chain type.
- Brisch System – (Brisch-Birn Inc.)
- CODE (Manufacturing Data System, Inc.)
- CUTPLAN (Metcut Associates)
- DCLASS (Brigham Young University)
- MultiClass (OIR: Organization for Industrial Research), hierarchical or decision-tree coding structure
- Part Analog System (Lovelace, Lawrence & Co., Inc.)

Basic Structure of the Opitz Parts Classification and Coding System

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 Opitz system of parts classification and coding



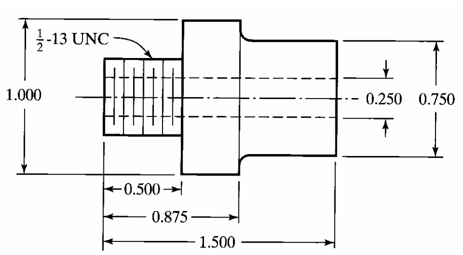
Form code (digits 1-5) for rotational parts in the Opitz coding system

	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 ≤ 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: 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

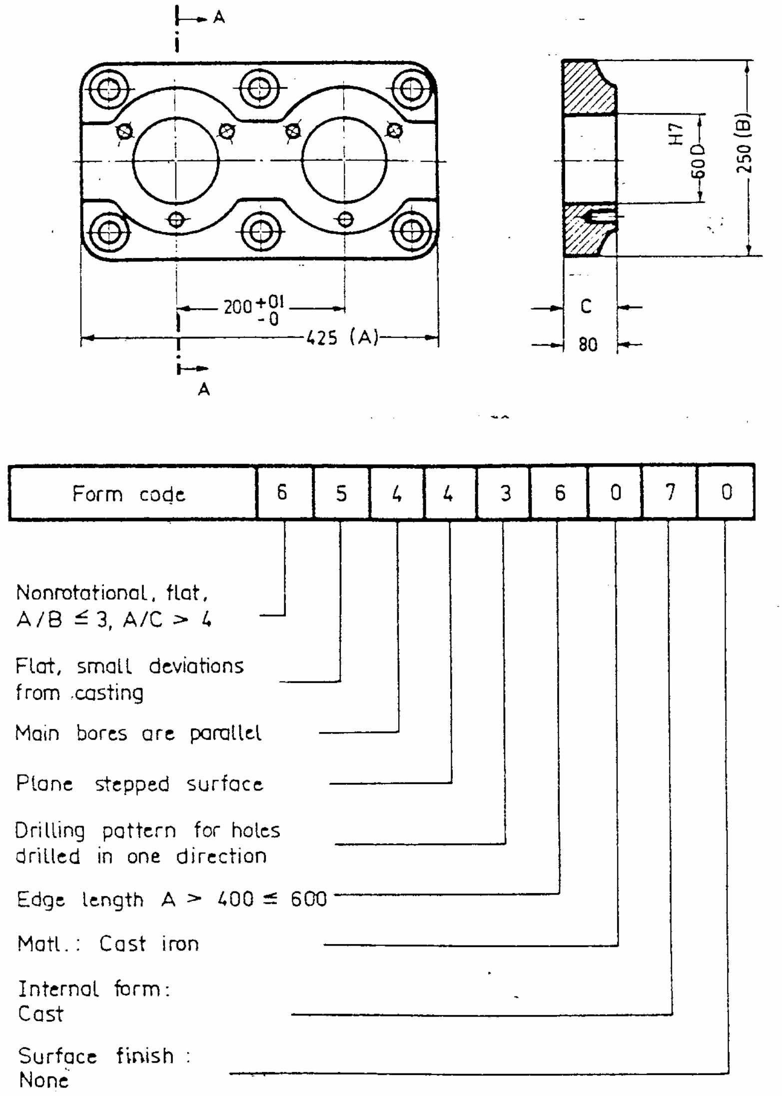
with one thread (code 5)

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



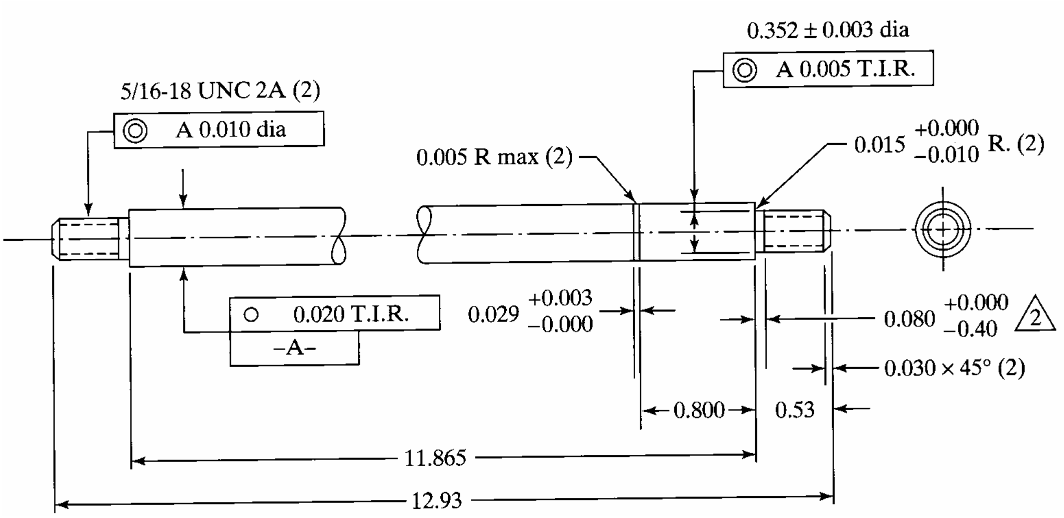
Square cast-iron flange classified by the Opitz system.

MultiClass – developed by the Organization for Industrial Research (OIR)

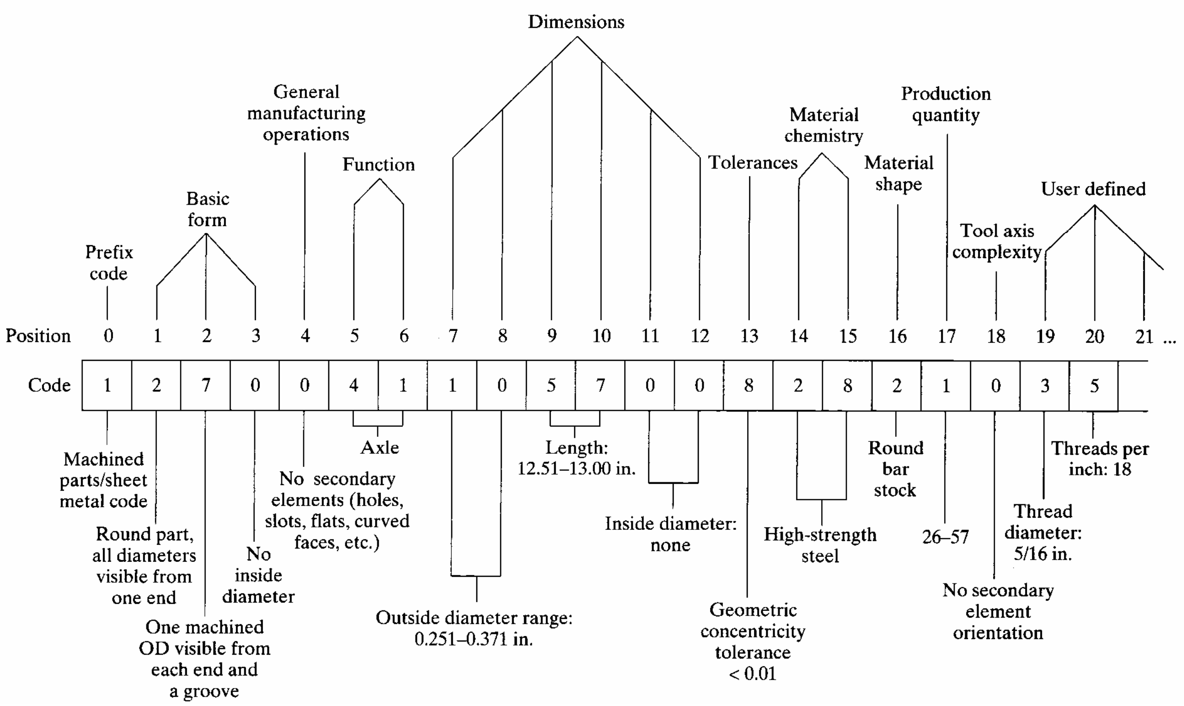
- First 18 digits of the Multiclass Classification and Coding System

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

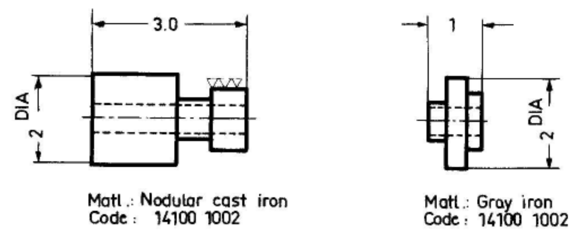
MultiClass Coding System example – the rotational part design



MultiClass code number for the rotational part



Possible ambiguity with a coding system



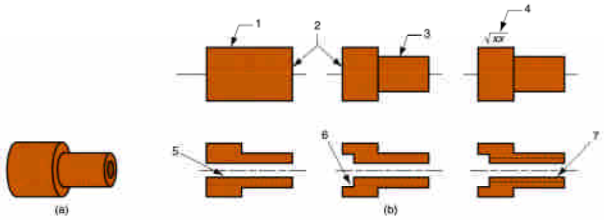
Benefits of a Well-Designed Classification and Coding System

- Facilitates formation of part families
- Permits quick retrieval of part design drawings
- Reduces design duplication
- Promotes design standardization

- Improves cost estimating and cost accounting
- Facilitates NC part programming by allowing new parts to use the same part program as existing parts in the same family
- Computer-aided process planning (CAPP) becomes feasible

Composite Part Concept

- A *composite part* for a given family is a hypothetical part that includes all of the design and manufacturing attributes of the family
- In general, an individual part in the family will have some of the features of the family, but not all of them
- A production cell for the part family would consist of those machines required to make the composite part
- Such a cell would be able to produce any family member, by omitting operations corresponding to features not possessed by that part



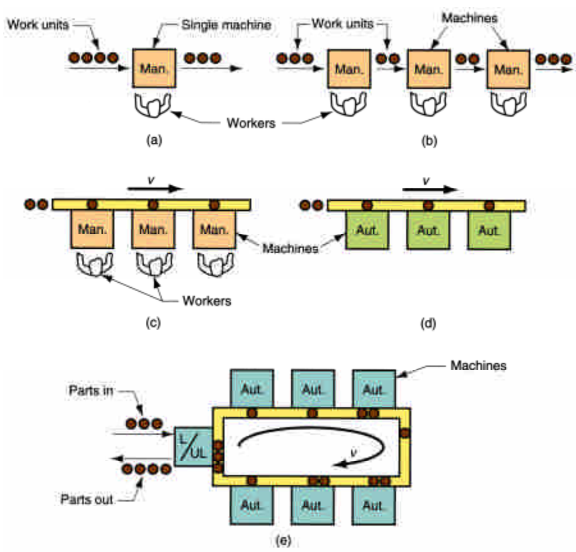
- Composite part concept: (a) the composite part for a family of machined rotational parts, and (b) the individual features of the composite part

Composite Part Features and Corresponding Manufacturing Operations

<u>Design feature</u>	<u>Corresponding operation</u>
1.External cylinder	Turning
2.Face of cylinder	Facing
3.Cylindrical step	Turning
4.Smooth surface	External cylindrical grinding
5.Axial hole	Drilling
6.Counterbore	Counterboring
7.Internal threads	Tapping

Machine Cell Designs (Types of GT cells:)

(a) Single machine
(b) Multiple machines with manual handling
(c) Multiple machines with mechanized handling
(d) Flexible manufacturing cell
(e) Flexible manufacturing system



Benefits of Group Technology

- Standardization of tooling, fixtures, and setups is encouraged
- Material handling is reduced
  - Parts are moved within a machine cell rather than 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

Problems in Group Technology

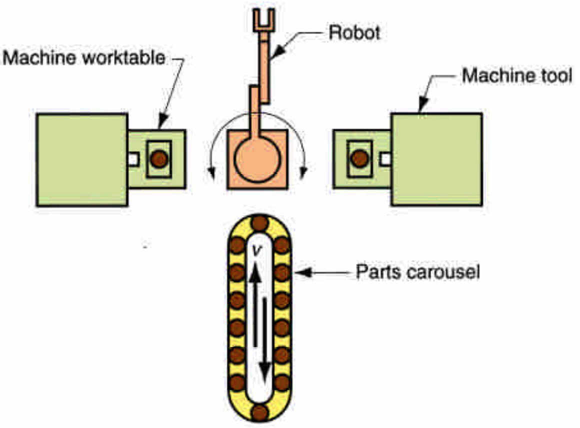
- Identifying the part families (the biggest problem)
  - If the plant makes 10,000 different parts, reviewing all of the part drawings and grouping the parts into families is a substantial task
- Rearranging production machines in the plant into the appropriate machine cells
  - It takes time to plan and accomplish this rearrangement, and the machines are not producing during the changeover

Flexible Manufacturing System

- A highly automated GT machine cell, consisting of a group of processing stations (usually CNC machine tools), interconnected by an automated material handling and storage system, and controlled by an integrated computer system
- The FMS relies on the principles of GT
  - No manufacturing system can produce an unlimited range of products
  - An FMS is capable of producing a single part family or a limited range of part families

Flexibility Tests in an Automated Manufacturing System

- Automated manufacturing cell with two machine tools and robot. Is it a flexible cell?



- To qualify as being flexible, a manufacturing system should satisfy the following criteria ("yes" answer for each question):

1.Can it process different part styles in a non-batch mode?

2.Can it accept changes in production schedule?

3.Can it respond gracefully to equipment malfunctions and breakdowns?

4.Can it accommodate introduction of new part designs?

If the automated system does not meet these four tests, it should not be classified as a flexible manufacturing or cell.

Is the Robotic Work Cell Flexible?

1.Can it machine different part configurations in a mix rather than in batches?

2.Can production schedule and part mix be changed?

3.Can it operate if one machine breaks down?

- Example: while repairs are being made on the broken machine, can its work be temporarily reassigned to the other machine?

4.As new part designs are developed, can NC part programs be written off-line and then downloaded to the system for execution?

This fourth capability also requires that the tooling in the CNC machines as well as the end effecter of the robot are suited to the new part design.

FMS Components

- Hardware components

  Workstations - CNC machines in a machining type system

  Material handling system - means by which parts are moved between stations

  Central control computer - to coordinate the activities of the components so as to achieve a smooth overall operation of the system
- Software and control functions
- Human labor

Five Types of FMS Layouts

1.In-line

2.Loop

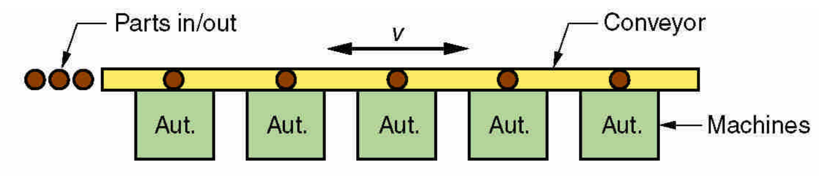
3.Ladder

4.Open field

5.Robot-centered cell

- The basic layout of the FMS is established by the material handling system

Three of the five FMS layout types: (a) in-line



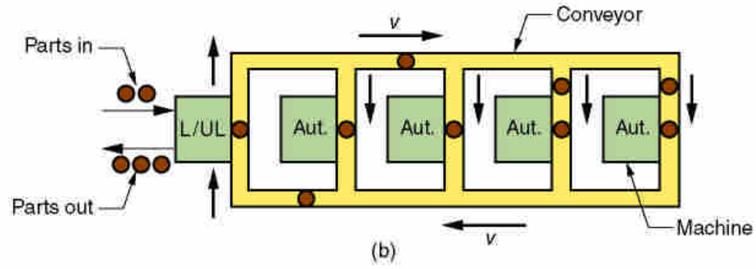
(a)

Key: Aut = automated station; L/UL = load/unload station;

Insp = inspection station; AGV = automated guided vehicle;

AGVS = automated guided vehicle system

(b) Ladder layout



Key: Aut = automated station; L/UL = load/unload station;
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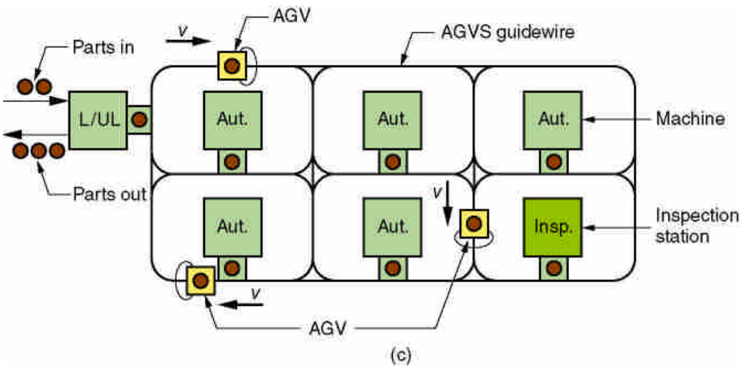
(c) open field



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Typical Computer Functions in a FMS

NC part programming - development of NC programs for new parts introduced into the system

Production control - product mix, machine scheduling, and other planning functions

NC program download - part program commands must be downloaded to individual stations

Machine control - individual workstations require controls, usually CNC

More Computer Functions in a FMS

Workpart control - monitor status of each workpart in the system, status of pallet fixtures, orders on loading/unloading pallet fixtures

Tool management - tool inventory control, tool status relative to expected tool life, tool changing and resharpening, and transport to and from tool grinding

Transport control - scheduling and control of work handling system

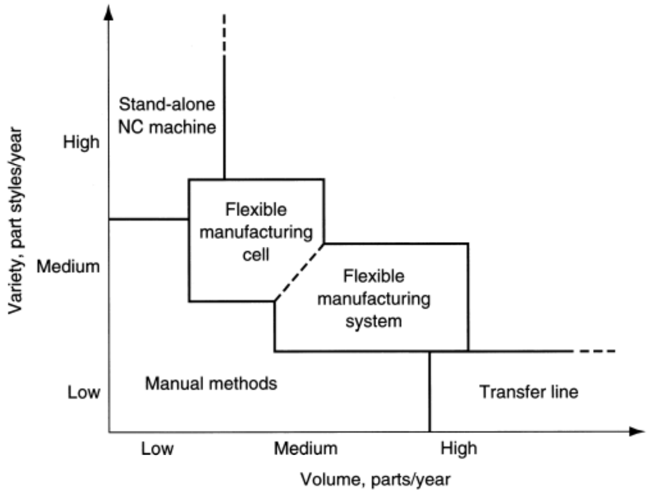
System management - compiles management reports on performance (utilization, piece counts, production rates, etc.)

Duties Performed by Human Labor

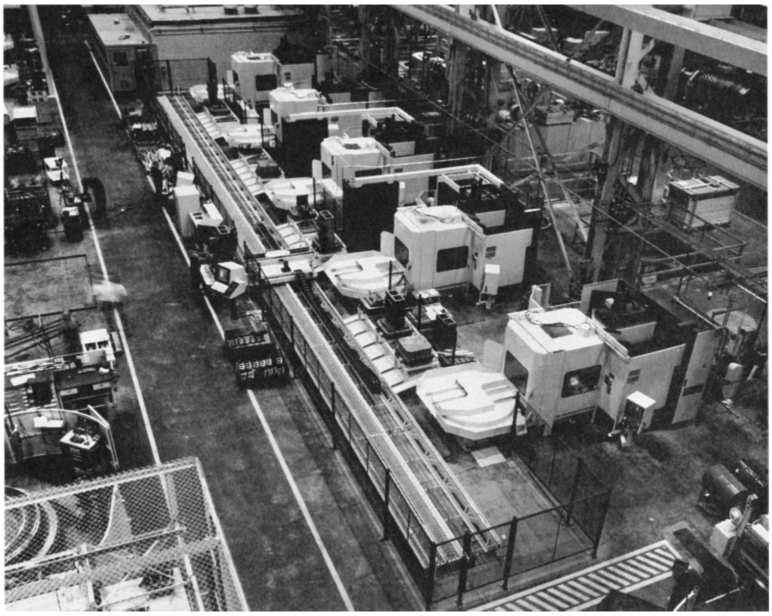
- Loading and unloading parts from the system
- Changing and setting cutting tools
- Maintenance and repair of equipment
- NC part programming
- Programming and operating the computer system
- Overall management of the system

FMS Applications

- Machining – most common application of FMS technology
- Assembly
- Inspection
- Sheet metal processing (punching, shearing, bending, and forming)
- Forging



Application characteristics of flexible manufacturing systems and cells relative to other types of production systems



A five station FMS (courtesy of Cincinnati Milacron)

Typical FMS Benefits

- Higher machine utilization than a conventional machine shop due to better work handling, off-line setups, and improved scheduling
- Reduced work-in-process due to continuous production rather than batch production
- Lower manufacturing lead times
- Greater flexibility in production scheduling