SKEM4153
ROBOT TECHNOLOGY FOR AUTOMATION

CHAPTER 5
Automated Work Cells and CIM Systems

Prof. Dr. Shamsudin H.M. Amin
Ir. Dr. Mohd Ridzuan Ahmad
(mdridzuan@utm.my)

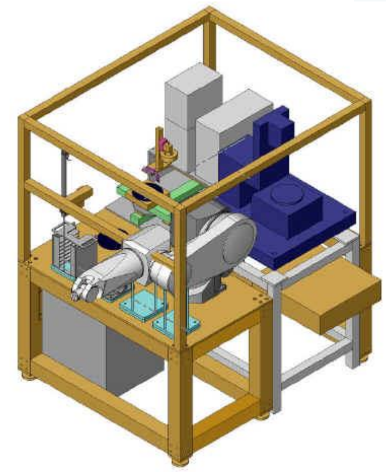
AUTOMATED WORK CELLS AND CIM SYSTEMS

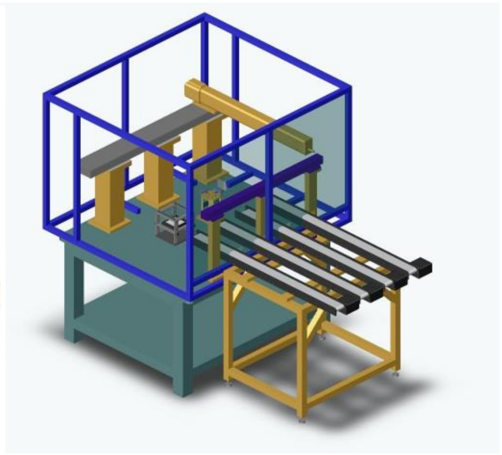
Objectives:

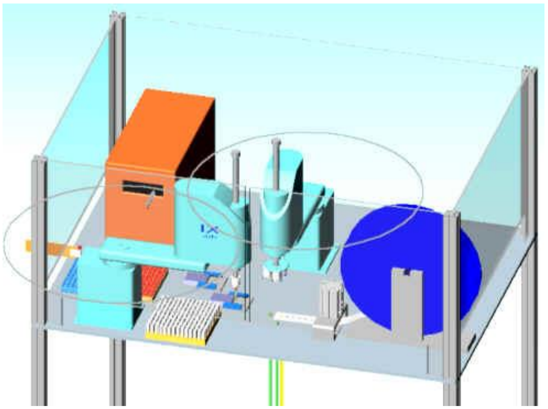
- Description of 3 steps to implement CIM
- Identification of value-added and non-value-added manufacturing operations
- Description and evaluation of 6 manufacturing performance measures
- Description of difference between flexible manufacturing and fixed(hard) automation
- Description of the difference between flexible manufacturing cells and systems
- Application of the work cell design checklist to the design of an automated system

5.1 Performance Measures:

- Lower Manufacturing Costs
- Higher Productivity
- Better Production Control
- Better Customer Responsiveness
- Reduced Inventories
- Greater Flexibility
- Higher Product Quality
- Smaller Lot-Size Production







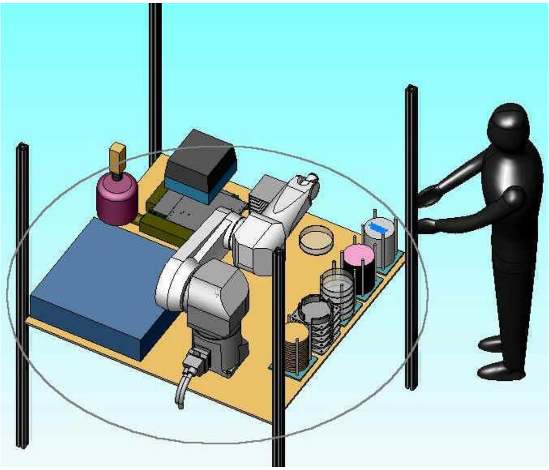
Some sources of disappointing performance:

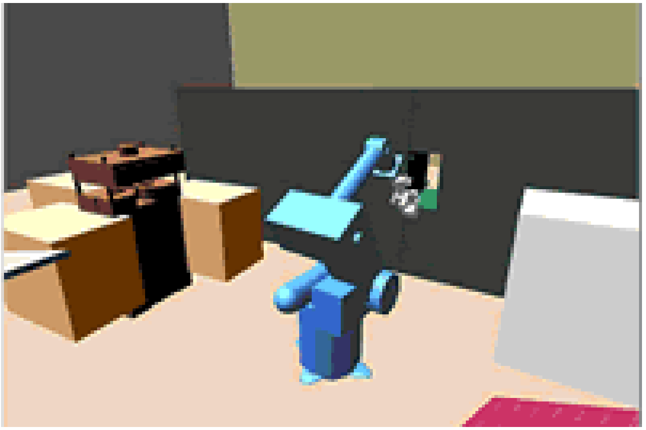
- Isolated automated cell from production system
- Deficiencies in work cell design
- Insufficient human resource training

5.2 The CIM (Computer-Integrated Manufacturing) Implementation Process

Three-step process:

- *Assessment*
- *Simplification*
- *Implementation*





Step 1: Assessment of Enterprise Technology, Human Resources and Systems

Assessment: to have a thorough understanding

Conduct a study of capabilities, strengths, weaknesses and limitations of:

- Current level of technology and process sophistication in manufacturing
- Degree of readiness of employees (both in educational and psychological aspects)
- Functions of workings and operations of production systems

Step 1: Assessment of Enterprise Technology, Human Resources and Systems, cont.

A survey of 139 CEOs, presidents, and vice-presidents of companies planning a CIM implementation is given in Figure 5.1 below:

Lack of in-house technical expertise	55%
Top management does not grasp benefits	48%
Inadequate planning or lack of vision	45%
Inadequate cost-justification methods	43%
Unavailability of funds	36%
Fear of poor implementation	25%

Figure 5.1: Obstacles to a CIM Implementation

Note that 55% of the respondents listed lack of in-house technical expertise as a major obstacle to CIM implementation.

Step 1: Assessment of Enterprise Technology, Human Resources and Systems, cont.

To overcome the limitations, the education and training of employees have to focus on the following aspects:

- The need to change to remain competitive nationally and globally
- The need to support new order in enterprise operations (teamwork, total quality, improved productivity, reduced waste, continuous improvement, common databases, and openness to new ideas)
- The hardware and software necessary for CIM implementation, and the management strategy required to run the system successfully.

CIM is not hardware and software; CIM is a way to manage the new technologies for improved market share and profitability. From the start of the implementation, all members of an organization must understand how CIM relates to their jobs.

Therefore, assessment and education must be done first.

Step 2: Simplification- Elimination of Waste

- **Building automated systems without eliminating operations that produce waste just automates the waste-production process.**
- ***Simplification – is a process that removes waste from every operation or activity before that operation is implemented in the CIM solution.***

Step 2: Simplification- Elimination of Waste, cont.

What is waste and where is it found ?

Waste is every possible operation, move, or process that does not add value to the final product. Value is added if the material or part is worth more after the production process is performed.

E.g. Moving, Waiting in queue, Waiting for process set-up, Being processed*, Being inspected

*only this activity adds value, the rest are cost-added (need to pay overhead cost). However, not all wastes can be removed, but all avoidable cost-added processes must be eliminated.

Step 2: Simplification- Elimination of Waste, cont.

Three-Step Rule for Eliminating Waste

Reduction	Total (%)
Reduce by 50%	50
Reduce by 50% again	75
Make it 10% of what it originally was	90

A world class company works the three-step rule to arrive at a 90 percent reduction in waste.

Figure 5.2 Rules for Elimination of Cost-added Operations

Step 3: Implementation with Performance Measures

- Focuses on the design and implementation of a system based on the results of Step 1 and Step 2; however, the performance of the new system must be compared with past performance.

Step 3: Implementation with Performance Measures, cont.

The key performance measurement parameters are:

- **Product cycle time :** the actual time from the release of a manufacturing order to its final completion. This includes the set-up time, queue time, move and transportation time, run time and lot size.

Example 5.1: A product with a lot size of 100 parts requires two work cells to complete the machining operation. Determine the cycle time in minutes for each part using the following data.

First machine: set-up time is 2.5 hours per 100 parts; queue, move, and transport time is 0.9 hours per 10 part pallets; and run time is 22 minutes per part.

Second machine: setup time is 1.25 hours per 100 parts; queue, move, and transport time is 0.7 hours per 10 part pallets; and run time is 13 minutes for every two parts.

Solution to Example 5.1

a) Find time for first machine:

Setup time = 2.5 hours per 100 parts

Queue, move and transport time =[(0.9h/10 parts) x 100 parts]

= 9 h per 100 parts

Run time = [(22 min / 1 part) x (1 h / 60 min) x 100 parts] = 37 h

Total time = 48.5 h

Cycle time = total production time for lot size / lot size

= (48.5 h / 100) x (60 min / h) = 29.1 min

b) Find time for second machine

Setup time = 1.25 hours per 100 parts

Queue, move and transport time =[(0.7h/10 parts) x 100 parts]

= 7 h per 100 parts

Run time = [(13 min / 2 parts) x (1 h / 60 min) x 100 parts] = 10.83 h

Total time = 19.08 h

Cycle time = total production time for lot size / lot size

= (19.08 h / 100) x (60 min / h) = 11.45 min

Step 3: Implementation with Performance Measures, cont.

The key performance measurement parameters are (cont.):

- **Inventory :** this is a measure of either material resident time (the time raw material or parts spend in manufacturing) or product velocity (the number of inventory turns by product). Inventory costs must be clearly defined if the savings are to be used as performance measure. Inventory turns are defined by the following expression:

$$\text{Inventory turns} = \frac{\text{annual cost of goods sold}}{\text{average annual inventory investment}}$$

Example: Cost of goods sold = RM200,000

Average inventory investment = RM50,000

Inventory turns = (200,000 / 50, 000) = 4

(Here, the RM50,000 could have been used for other financial investment that could generate cash returns. Therefore inventory is a cost for the company. If the inventory turns of the product can be increased to 10 with the same annual sales, the inventory cost will be only RM20,000 and the savings of RM30,000 can be invested elsewhere).

Step 3: Implementation with Performance Measures, cont.

The key performance measurement parameters are: (cont.)

- **Set-up times :** this is part of the product cycle time. However, improvement in set-up is a key factor in being competitive. Most companies use setup time as a measurement parameter apart from the cycle time.
- **Quality :** two areas of interest are the *first-time good parts* and *reduction of scrap and rework*. First-time good parts is a measure of how often the first part produced in a production run is within specifications.

  The reduction of scrap and rework is a measure of production quality in two areas: scrap (unuseable production that must be discarded), and rework (parts that are out of tolerance but that can be fixed with additional manufacturing operations)

Step 3: Implementation with Performance Measures, cont.

The key performance measurement parameters are: (cont.)

- **Employee output/productivity :** this is a measure of amount of output of goods and services per unit of input. (Total employee hours worked divided into total units of output).
- **Continuous improvement :** this is the most important activity in CIM. A measurement could be in the form of the number of improvement suggestions per employee per week or per month.

Example of improvement after CIM implementation

Pump manufacturer's performance report card case history (pump housings)			
Measurement parameters	**Baseline**	**12 months**	**18 months**
Cycle time	18 weeks	6 weeks	1 week
Inventory turns	4	8	48
Scrap(percentage of lot size)	13%	5%	0.06%
First time good parts	45%	85%	93%
Floor space	1200sq ft	500 sq ft	150 sq ft

Figure 5.3 Results of Improved Business Operations

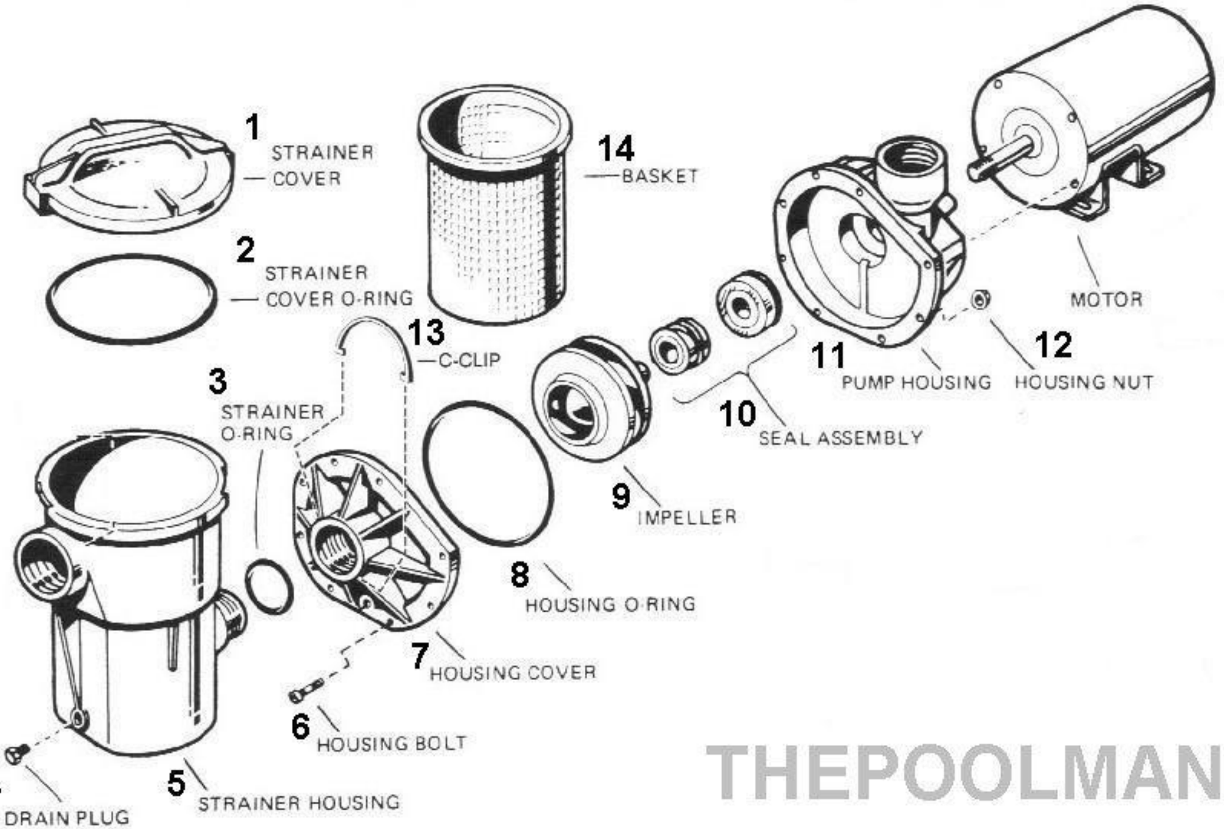
Totally Hayward

Power-Flo LX™

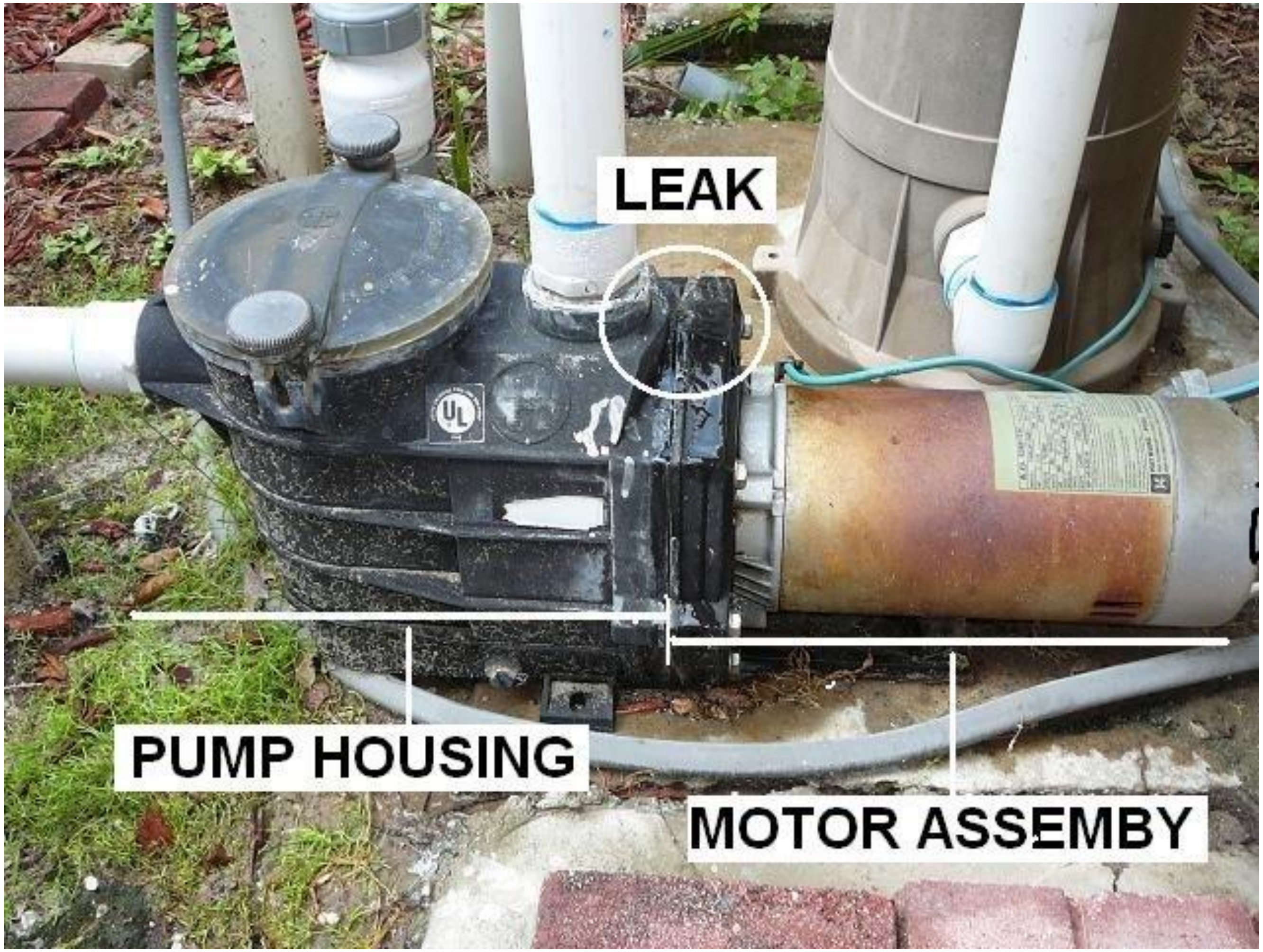
SP1580 PUMP SERIES REPLACEMENT PARTS

Pumps

Parts for Pump Models: SP1575LX, SP1580, SP1580X15 [redacted] THEPOOLMAN



THEPOOLMAN


LEAK
PUMP HOUSING
MOTOR ASSEMBY

Analysis - 1

- Figure 5.3 showed the changes achieved over 18 months by a pump manufacturer with RM75 million in sales. The remarkable improvements in floor space are as a result of a shift from job shop (Figure a) and repetitive production (Figure b) environments to a structured product flow system (Figure c).

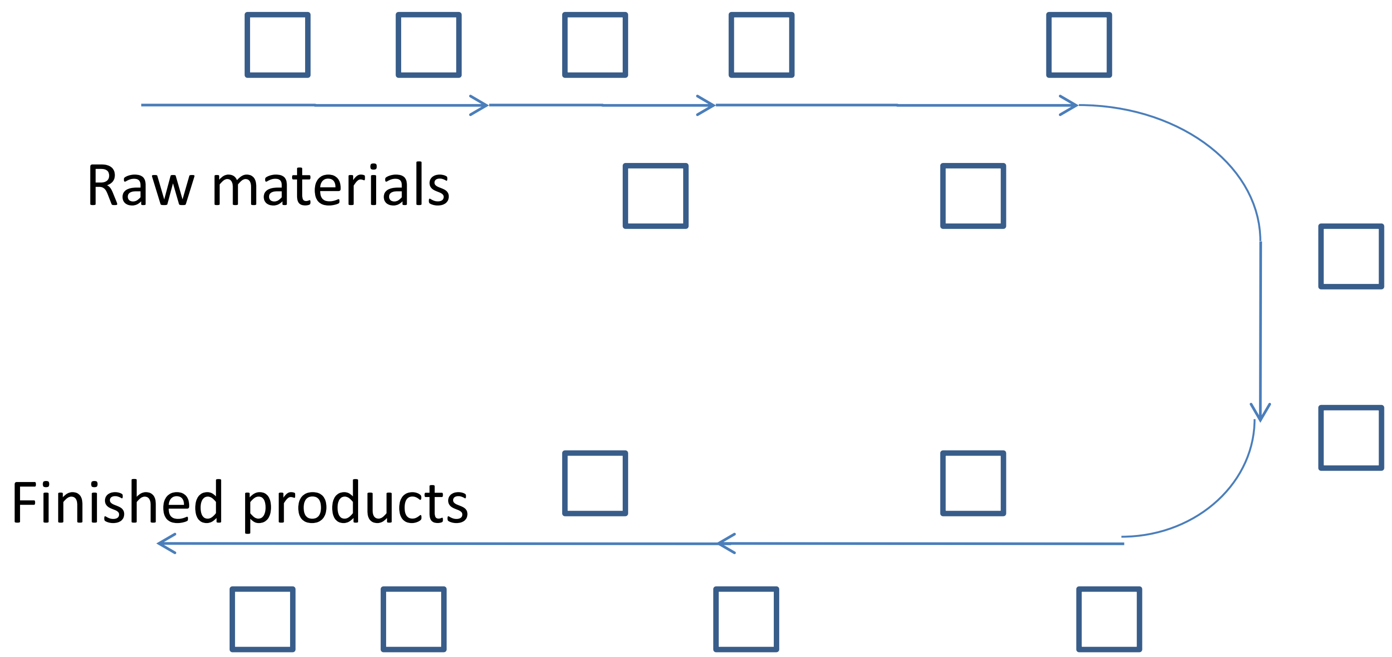
office	**Milling**	**Lathe**	**Grinding**	**Heat treatment**
	Assembly	Finishing	Drilling	Shipping and receiving

- Figure a: Process flow

Figure b: Manufacturing system characteristics

	Project	Job shop	Repetitive	Line	Continuous
Process speed	Varies	Slow	Moderate	Fast	Very fast
Labour content	High	High	Medium	Low	Very low
Labour skill level	High	High	Moderate	low	Varies
Order quantity	Very small	Low	Varies	high	Very high
Unit quantity cost	Very large	Large	Moderate	Low	Very low
Routing variations	Very high	High	None	Low	Very low
Product options	Low	Low	None	Very high	Very low
Design component	Very large	large	Very small	moderate	small

Figure c: product flow layout



5.3 Making the CIM Process Work

Depending on the conditions present in the company and the corporate culture, there are various processes used.

Some elements for successful CIM implementations:

- Use of a program name other than CIM
- Support for the program beginning with the CEO
- Use of multifunctional employee teams at all levels in the process
- A willingness to look at all processes and products for potential productivity gains
- A willingness to accept recommendations for process and product improvement from every employee
- A willingness to accept a 3- to 5-year payback time for the investment

5.4 Automated Production

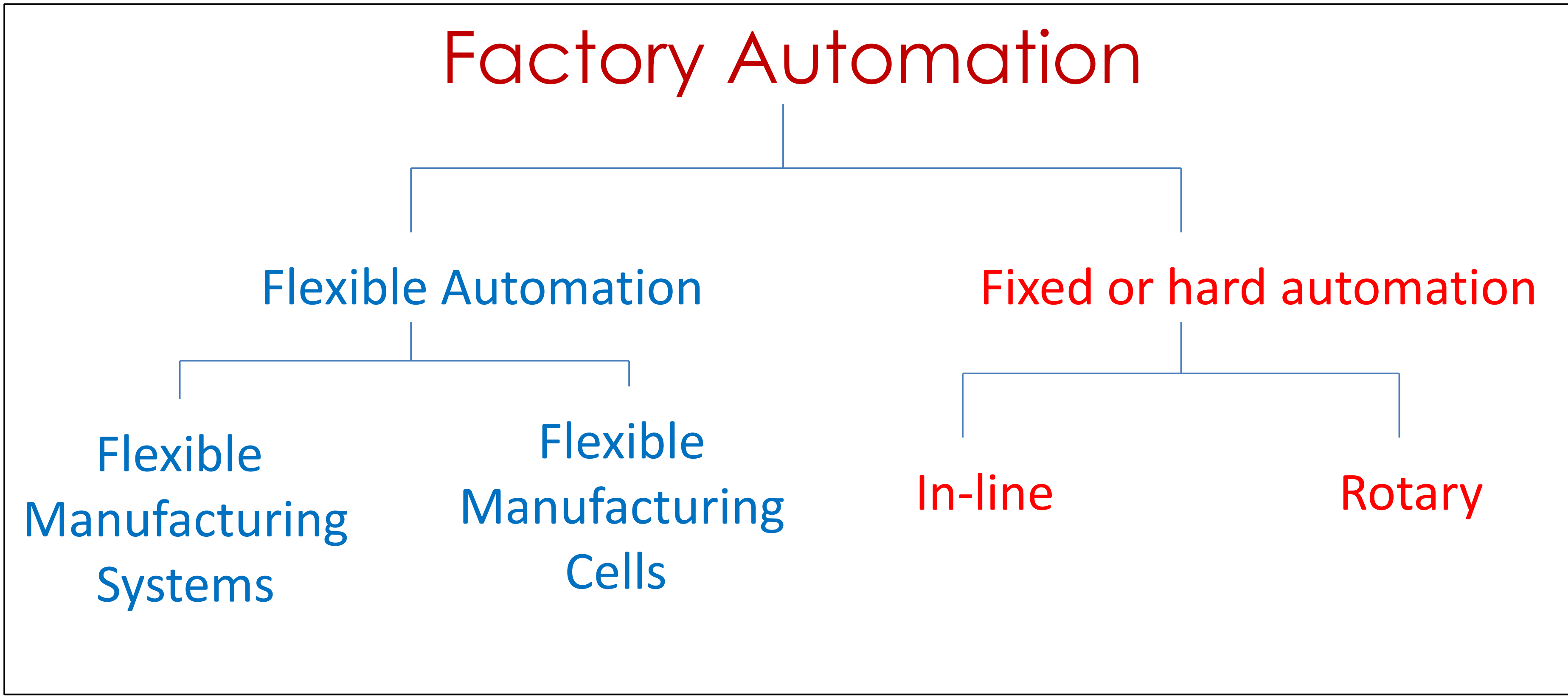


Figure 5.4 : Types of Factory Automation

5.4 Automated Production

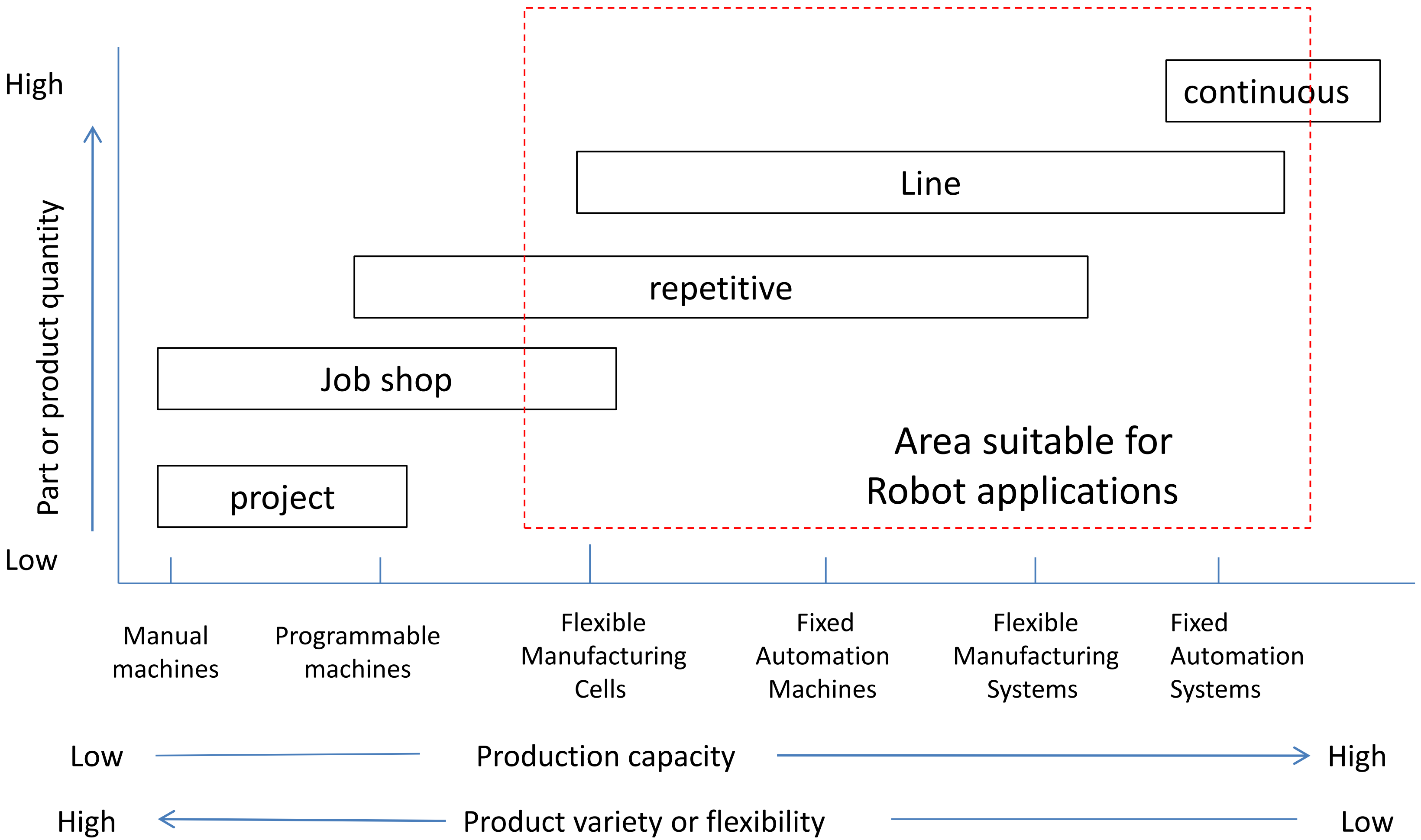


Figure 5.5: Production systems

The Manufacturing Product-Process Matrix

PROCESS PATTERN	**PRODUCT MIX** One of a kind	Low volume custom products	High volume standard products	Very high volume commodity products	**MANAGEMENT CHALLENGES**
Very jumbled flow, process segments loosely linked	PROJECT				Scheduling, material handling, shifting bottlenecks
Jumbled flow with dominant line		JOB SHOP			Worker motivation, maintaining capacity balance and flexibility
			BATCH FLOW		
Process built around a pacing line			LINE FLOW		
Highly automated, continuous process flow with tightly linked segments				CONTINUOUS FLOW	Capital expenses for big chunk capacity, technological change, vertical integration
MANAGEMENT CHALLENGES	Bidding, delivery, product customization		Product differentiation, volume flexibility	Price	

5.5 Work Cell Design Checklist

The work cell check list shows the manufacturing variables that should be addressed during the design process. Depending on the function of the cell and the type of automation proposed, the variables most critical to a successful design change.

The data gathered by the checklist element questions contain sufficient details to make design decisions.

Table 5-1 Work Cell Design Checklist (pp 1/4)

Performance Requirements **Cycle times** **Part-handling specifications** **Feed rate of tools** **Product mix** **Equipment requirements** **Human backup requirements** **Future production requirements**	Tolerance of parts Dwell time of robots Pressure on tools Maximum repair time Malfunction routines Allowable downtime

Table 5-1 Work Cell Design Checklist (pp.2/4)

Layout Requirements **Geometry of the facility** **Environmental considerations** **Accessibility for maintenance** **Equipment relocation requirements**	Service availability Floor loading Safety for machines and people
Product Characteristics **Part orientation requirements** **Surface characteristics** **Unique handling requirements**	Gripper specifications Part size, weight and shape Inspection requirements

Table 5-1 Work Cell Design Checklist (pp.3/4)

Equipment Modifications **Requirements for unattended operation** **Requirements for increased throughput**	Max/min machine speed Requirements for auto operations
Process Modifications **Lot-size changes** **Process variable evaluation**	Routing variations Process data transfer

Table 5-1 Work Cell Design Checklist (pp.4/4)

System Integration **Data interfaces and networks** **Hardware integration requirements** **Data integration requirements**	Integration requirement Software integrating requirements

TEXT AND REFERENCE BOOKS

- **Textbook:**

1. James A. Rehg: Introduction to Robotics in CIM Systems. Fifth Edition, Prentice-Hall. 2003.

- **Reference book:**

1. Mikell P. Groover: Automation, Production Systems, and Computer Integrated Manufacturing, Second Edition. 2004.
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3. Farid M. L. Amirouche: Computer-Aided Design and Manufacturing. Prentice-Hall.
4. Richard K. Miller, Industrial Robot Handbook. Van Nostrand Reinhold, N.Y. (1987).