Process Planning and Concurrent Engineering

L-32

Contents

1) Process Planning

- Process planning involves determining the most appropriate manufacturing and assembly processes and the sequence in which they should be accomplished to produce a given part or product according to specifications set forth in the product design documentation.

Following is a list of the many decisions and details usually included within the scope of process planning.

a) Interpretation of design drawings
b) Processes and sequence
c) Equipment selection
d) Tools, dies, molds, fixtures and gages
e) Methods analysis
f) Work standards
g) Cutting tools and cutting conditions

a) Process Planning for Parts

For individual parts, the processing sequence is documented on a form called route sheet.

Route Sheet	XYZ Machine Shop, Inc.				
Part no. **081099**	Part name **Shaft, generator**	Planner MPGroover	Checked by: N. Needed	Date 08/12/XX	Page 1/1
Material 1050 H18 Al	Stock size 60 mm diam., 206 mm length	Comments:			

No.	Operation description	Dept	Machine	Tooling	Setup	Std.
10	Face end (approx. 3 mm). Rough turn to 52.00 mm diam. Finish turn to 50.00 mm diam. Face and turn shoulder to 42.00 mm diam. and 15.00 mm length.	Lathe	L45	G0810	1.0 hr	5.2 min.
20	Reverse end. Face end to 200.00 mm length. Rough turn to 52.00 mm diam. Finish turn to 50.00 mm diam.	Lathe	L45	G0810	0.7 hr	3.0 min.
30	Drill 4 radial holes 7.50 mm diam.	Drill	D09	J555	0.5 hr	3.2 min.
40	Mill 6.5 mm deep x 5.00 mm wide slot.	Mill	M32	F662	0.7 hr	6.2 min.
50	Mill 10.00 mm wide flat, opposite side.	Mill	M13	F630	1.5 hr	4.8 min.

Figure 25.1 Typical route sheet for specifying the process plan.

TABLE 25.1 Typical Guidelines in Preparing a Route Sheet

- Operation numbers for consecutive processing steps should be listed as 10, 20, 30, etc. This allows new operations to be inserted if necessary.
- A new operation and number should be specified when a workpart leaves one workstation and is transferred to another station.
- A new operation and number should be specified if a part is transferred to another workholder (e.g., jig or fixture), even if it is on the same machine tool.
- A new operation and number should be specified if the workpart is transferred from one worker to another, as on a production line.

Contd. Figure

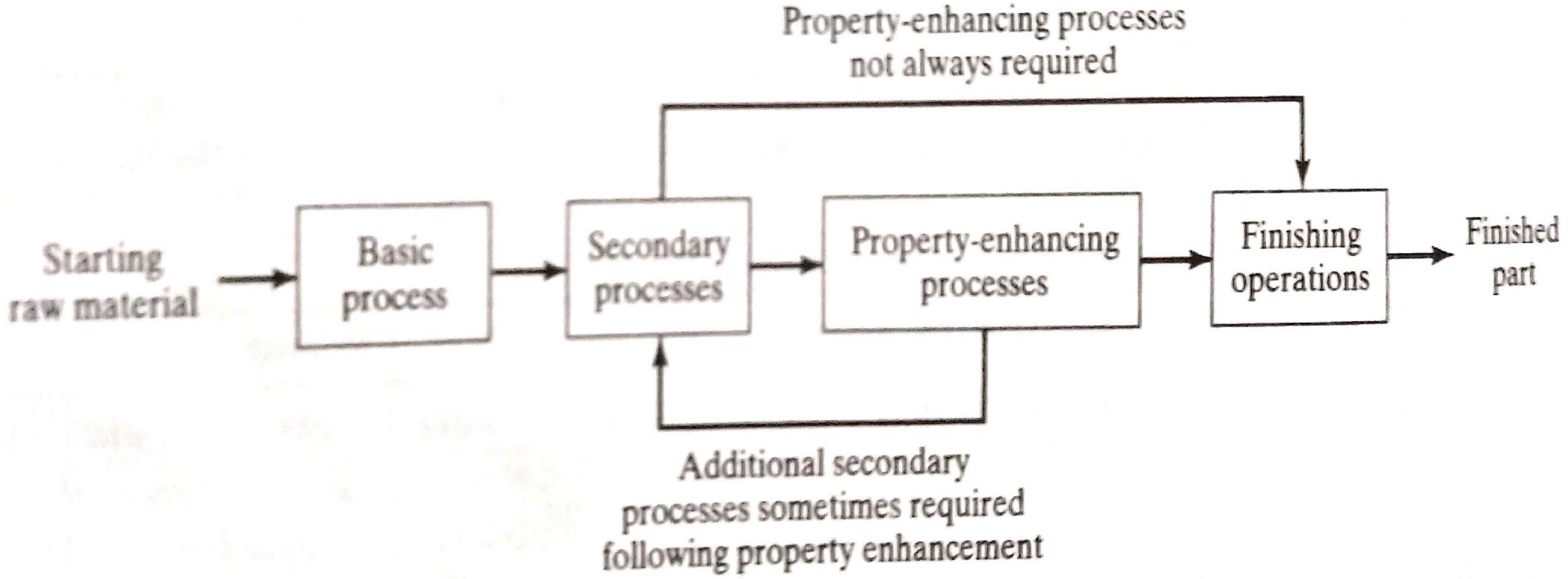

Figure 25.2 Typical sequence of processes required in part fabrication.

Some Typical Process Sequences

TABLE 25.2 Some Typical Process Sequences

Basic Process	Starting Material	Secondary Processes	Final shape	Enhancing Processes	Finishing Processes
Sand casting	Sand casting	Machining	Machined part	(Optional)	Painting
Die casting	Die casting	(Net shape)	Die casting	(Optional)	Painting
Casting of glass	Glass ingot	Pressing, blow molding	Glass ware	Heat treatment	(None)
Injection molding	Molded part	(Net shape)	Plastic molding	(None)	(None)
Rolling	Sheet metal	Blanking, punching, bending, forming	Stamping	(None)	Plating, painting
Rolling	Sheet metal	Deep drawing	Drawing	(None)	Plating, painting
Forging	Forging	(Near net shape) Machining	Machined part	(None)	Plating, painting
Rolling and bar drawing	Bar stock	Machining, grinding	Machined part	Heat treatment	Plating, painting
Extrusion of aluminum	Extrudate	Cutoff	Extruded part	(None)	Painting, anodizing
Atomize	Metal powders	Press	PM part	Sinter	Paint
Comminution	Ceramic powders	Press	Ceramic ware	Sinter	Glaze
Ingot pulling	Silicon boule	Sawing and grinding	Silicon wafer		Cleaning
Sawing and grinding	Silicon wafer	Oxidation, CVD, PVD, etching	IC chip		Coating

castings or forgings, which are purchased from outside vendors. The process plan begins with

b) Process Planning for Assemblies

The type of assembly method used for a given product depends on factors such as:

(1) The anticipated production quantities

(2) Complexity of the assembled product, for example the number of distinct components

(3) Assembly processes used, for example, mechanical assembly versus welding

C) Make or Buy Decision

An important question that arises in process planning is whether a given part should be produced in the company's own factory or purchased from an outside vendor, and the answer to this question is known as the make or buy decision.

TABLE 25.3 Factors in the Make or Buy Decision

Factor	Explanation and Effect on Make/Buy Decision
How do part costs compare?	This must be considered the most important factor in the make or buy decision. However, the cost comparison is not always clear, as Example 25.1 illustrates.
Is the process available in-house?	If the equipment and technical expertise for a given process are not available internally, then purchasing is the obvious decision. Vendors usually become very proficient in certain processes, which often makes them cost competitive in external-internal comparisons. However, there may be long-term cost implications for the company if it does not develop technological expertise in certain processes that are important for the types of products it makes.
What is the total production quantity?	The total number of units required over the life of the product is a key factor. As the total production quantity increases, this tends to favor the make decision. Lower quantities favor the buy decision.
What is the anticipated product life?	Longer product life tends to favor the make decision.
Is the component a standard item?	Standard catalog items (e.g., hardware items such as bolts, screws, nuts, and other commodity items) are produced economically by suppliers specializing in those products. Cost comparisons almost always favor a purchase decision on these standard parts.
Is the supplier reliable?	A vendor that misses a delivery on a critical component can cause a shutdown at the company's final assembly plant. Suppliers with proven delivery and quality records are favored over suppliers with lesser records.
Is the company's plant already operating at full capacity?	In peak demand periods, the company may be forced to augment its own plant capacity by purchasing a portion of the required production from external vendors.
Does the company need an alternative supply source?	Companies sometimes purchase parts from external vendors to maintain an alternative source to their own production plants. This is an attempt to ensure an uninterrupted supply of parts, e.g., as a safeguard against a wildcat strike at the company's parts production plant.

Source: Based on [10] and other sources.

Example : Make or Buy Cost Decision

EXAMPLE 25.1 Make or Buy Cost Decision

The quoted price for a certain part is $20.00 per unit for 100 units. The part can be produced in the company's own plant for $28.00. The cost components of making the part are as follows:

Unit raw material cost	=	$8.00 per unit
Direct labor cost	=	6.00 per unit
Labor overhead at 150%	=	9.00 per unit
Equipment fixed cost	=	5.00 per unit
Total	=	28.00 per unit

Should the component by bought or made in-house?

Solution: Although the vendor's quote seems to favor a buy decision, let us consider the possible impact on plant operations if the quote is accepted. Equipment fixed cost of $5.00 is an allocated cost based on an investment that was already made. If the equipment designated for this job becomes unutilized because of a decision to purchase the part, then the fixed cost continues even if the equipment stands idle. In the same way, the labor overhead cost of $9.00 consists of factory space, utility, and labor costs that remain even if the part is purchased. By this reasoning, a buy decision is not a good decision because it might cost the company as much as $20.00 + $5.00 + $9.00 = $34.00 per unit if it results in idle time on the machine that would have been used to produce the part. On the other hand, if the equipment in question can be used for the production of other parts for which the in-house costs are less than the corresponding outside quotes, then a buy decision is a good decision.

2) Computer Aided Process Planning

- There is much interest by manufacturing firms in automating the task of process planning using computer-aided process planning (CAPP) systems
- The benefits derived from computer-automated process planning include the following:

(i) Process rationalization and standardization
(ii) Increased productivity of process planners
(iii) Reduced lead time for process planning
(iv) Improved legibility
(v) Incorporation of other application programs

a) Retrieval CAPP System

- A retrieval CAPP system, also called a variant CAPP system, is based on the principles of group technology (GT) and parts classification and coding. In this type of CAPP, a standard process plan (route sheet) is stored in computer files for each part code number.
- The standard route sheets are based on current part routings in use in the factory or on an ideal process plan that has been prepared for each family.
- It consists of following steps

(1) Selecting an appropriate classification and coding scheme for the company

(2) Forming part families for the parts produced by the company

(3) Preparing standard process plans for the part families.

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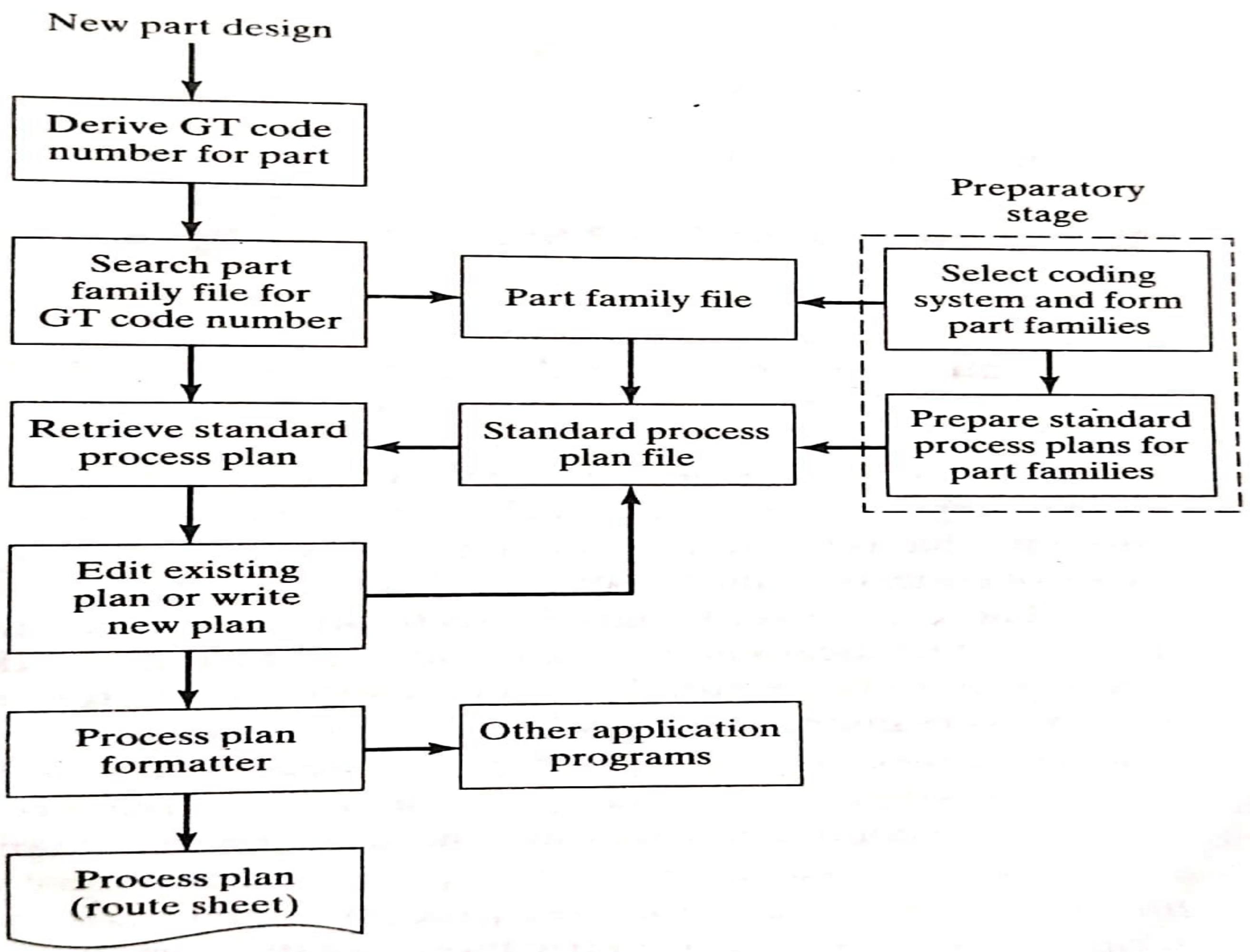

Figure 25.3 General procedure for using one of the retrieval CAPP systems.

b) Generative CAPP System

Organization for Industrial Research, Inc. Facility – F1

Part number: Prob. 15.10.1	Last four orders S/O #	PRJ #	Qty	Minimum Qty	Due dates	PRI #
Part name: Driver VLV Guide						
Plng. rev: 11 DWG Rev: C						
Planner: Fred Sambera						

Change approvals & date			
	#1	#2	#3
MFG		A3	
ENG		E1	E2
Q/A		Q2	

Code #1: 1-3300-07-234901-5-0516-000000000000

Code #2: 5-2120-3654-22-01

Code #3: 6-4032-417

Start: 08/15/8X	T.O.T.D.: 4000	T.R.DOC: 1

Material required:
Special instructions:

Oper. no.	Mach. tool	Operation description–assy instructions	Times S/U	Run	Operator stamp
0010	1258	Set-up 3/4 dia. collet pads Set turrent stop to hold 4.5 length Rough turn .5 dia. to .532 dia. + .01 – .01 Rough turn .375 dia. to .39 + .01 – .01 Hold 1.625 length Finish turn .500 dia. + or – .005 Finish turn .375 dia + or – .005 hold 1.625 Cut-off to 5-7/8 length	1.7	.40	

Figure 25.4 Route sheet prepared by the MultiCapp System (courtesy of OIR, the Organization for Industrial Research).

3) Concurrent Engineering and Design for Manufacturing

- Concurrent engineering refers to an approach used in product development in which the functions of design engineering, manufacturing engineering and other functions are integrated to reduce the elapsed time required to bring a new product to market. Also called simultaneous engineering.

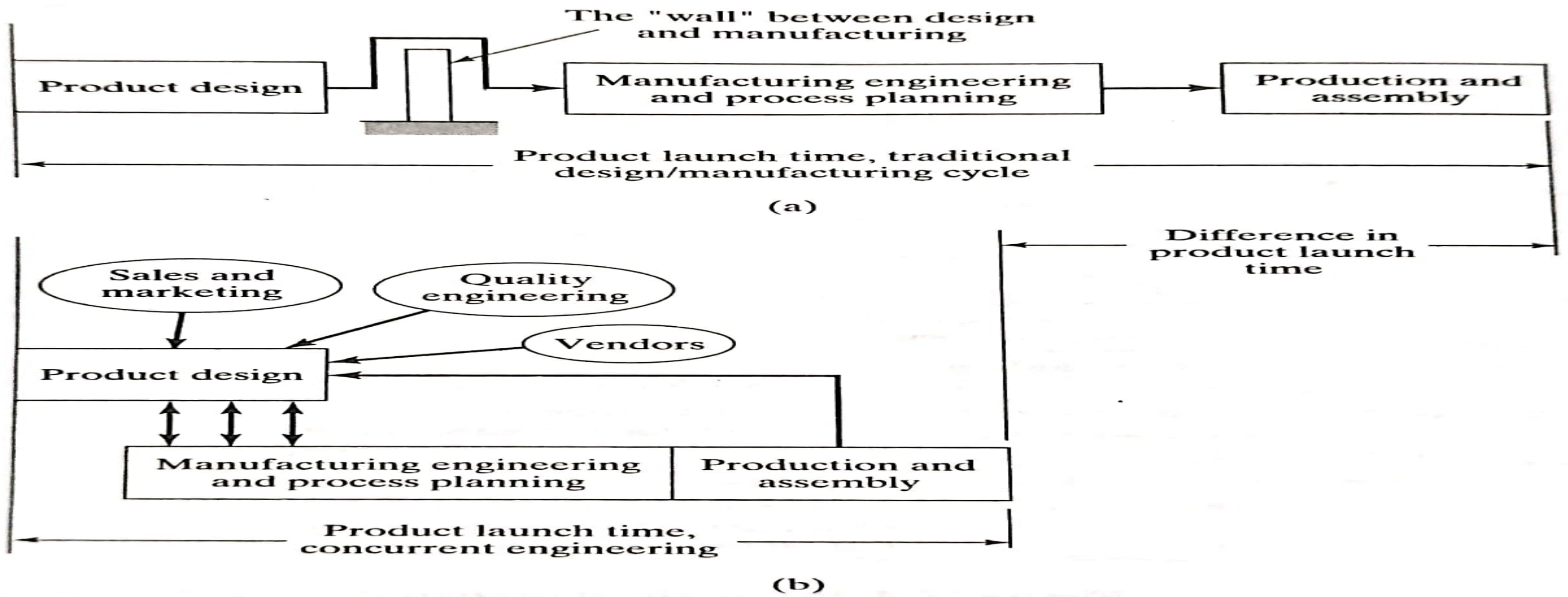

Figure 25.5 Comparison of: (a) traditional product development cycle and (b) product development using concurrent engineering.

a) Design for Manufacturing and Assembly

Design for manufacturing and assembly involves the systematic consideration of manufacturability and assemblability in the development of a new product design.

This includes:

(i) Organizational Changes: Effective implementation of DFM/A involves making changes in a company's organizational structure, either formally or informally, so that closer interaction and better communication occurs between design and manufacturing personnel. This can be accomplished in several ways

a) By creating project teams consisting of product designers, manufacturing engineers and other specialties to develop the new product design

b) Requiring design engineers to spend some career time in manufacturing to witness first hand how manufacturability and assemblability are impacted by product design

c) By assigning manufacturing engineers to the product design department on either a temporary or full time basis as productibility consultants

(ii) Design principles and guidelines

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TABLE 25.4 General Principles and Guidelines in DFM/A

Guideline	*Interpretation and Advantages*
Minimize number of components	Reduced assembly costs. Greater reliability in final product. Easier disassembly in maintenance and field service. Automation is often easier with reduced part count. Reduced work-in-process and inventory control problems. Fewer parts to purchase; reduced ordering costs.
Use standard commercially available components	Reduced design effort. Fewer part numbers. Better inventory control possible. Avoids design of custom-engineered components. Quantity discounts possible.
Use common parts across product lines	Group technology (Chapter 15) can be applied. Quantity discounts are possible. Permits development of manufacturing cells.
Design for ease of part fabrication	Use net shape and near net shape processes where possible. Simplify part geometry; avoid unnecessary features. Avoid surface roughness that is smoother than necessary since additional processing may be needed.
Design parts with tolerances that are within process capability	Avoid tolerances less than process capability (Section 21.1.2). Specify bilateral tolerances. Otherwise, additional processing or sortation and scrap are required.
Design the product to be foolproof during assembly	Assembly should be unambiguous. Components designed so they can be assembled only one way. Special geometric features must sometimes be added to components.
Minimize flexible components	These include components made of rubber, belts, gaskets, electrical cables, etc. Flexible components are generally more difficult to handle.
Design for ease of assembly.	Include part features such as chamfers and tapers on mating parts. Use base part to which other components are added. Use modular design (see following guideline). Design assembly for addition of components from one direction, usually vertically; if mass production, this rule can be violated because fixed automation can be designed for multiple direction assembly. Avoid threaded fasteners (screws, bolts, nuts) where possible, especially when automated assembly is used; use fast assembly techniques such as snap fits and adhesive bonding. Minimize number of distinct fasteners.
Use modular design	Each subassembly should consists of 5-15 parts. Easier maintenance and field service. Facilitates automated (and manual) assembly. Reduces inventory requirements. Reduces final assembly time.
Shape parts and products for ease of packaging	Compatible with automated packaging equipment. Facilitates shipment to customer. Can use standard packaging cartons.
Eliminate or reduce adjustments	Many assembled products require adjustments and calibrations. During product design, the need for adjustments and calibrations should be minimized because they are often time consuming in assembly.

Source: [10]

b) Other Product Design Objectives

(i) Design for Quality

(ii) Design for Product Cost

(iii) Design for Life Cycle

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TABLE 25.5 Typical Product Cost Components

General Area	*Affected Departments*
Product development and design	Marketing research Basic research on new product technologies Engineering analysis and optimization Design drawings and specifications Prototype development Design testing
Manufacturing engineering	Manufacturing process research Process planning Tool design
Materials	Purchased raw materials Purchased components Transportation costs Receiving and inspection
Manufacturing	Parts fabrication (equipment, labor, tooling, etc.) Assembly (tools, assembly lines, labor, etc.) Material handling (equipment and labor) Production planning and control (labor and computer resources)
Inspection	Inspection (inspection plan design, gages, labor) Testing (test design, equipment, labor)
Distribution	Warehousing Shipment Inventory control
Overhead	Factory overhead (plant management, building, utilities, support staff) Corporate overhead (general management, sales, finance, legal, clerical, building, utilities, etc.)

Contd.

TABLE 25.6 Factors in Design for Life Cycle

Factor	*Typical Issues and Concerns*
Delivery	Transport cost, time to deliver, storage and distribution of mass produced items, type of carrier required (truck, railway, air transport)
Installability	Utility requirements (electric power, air pressure, etc.), construction costs, field assembly, support during installation
Reliability	Service life of product, failure rate, reliability testing requirements, materials used in the product, tolerances
Maintainability	Design modularity, types of fasteners used in assembly, preventive maintenance requirements, ease of servicing by customer
Serviceability	Product complexity, diagnostics techniques, training of field service staff, access to internal workings of product, tools required, availability of spare parts
Human factors	Ease and convenience of use, complexity of controls, potential hazards, risk of injuries during operation
Upgradeability	Compatibility of current design with future modules and software, cost of upgrades
Disposability	Materials used in the product, recycling of components, waste hazards

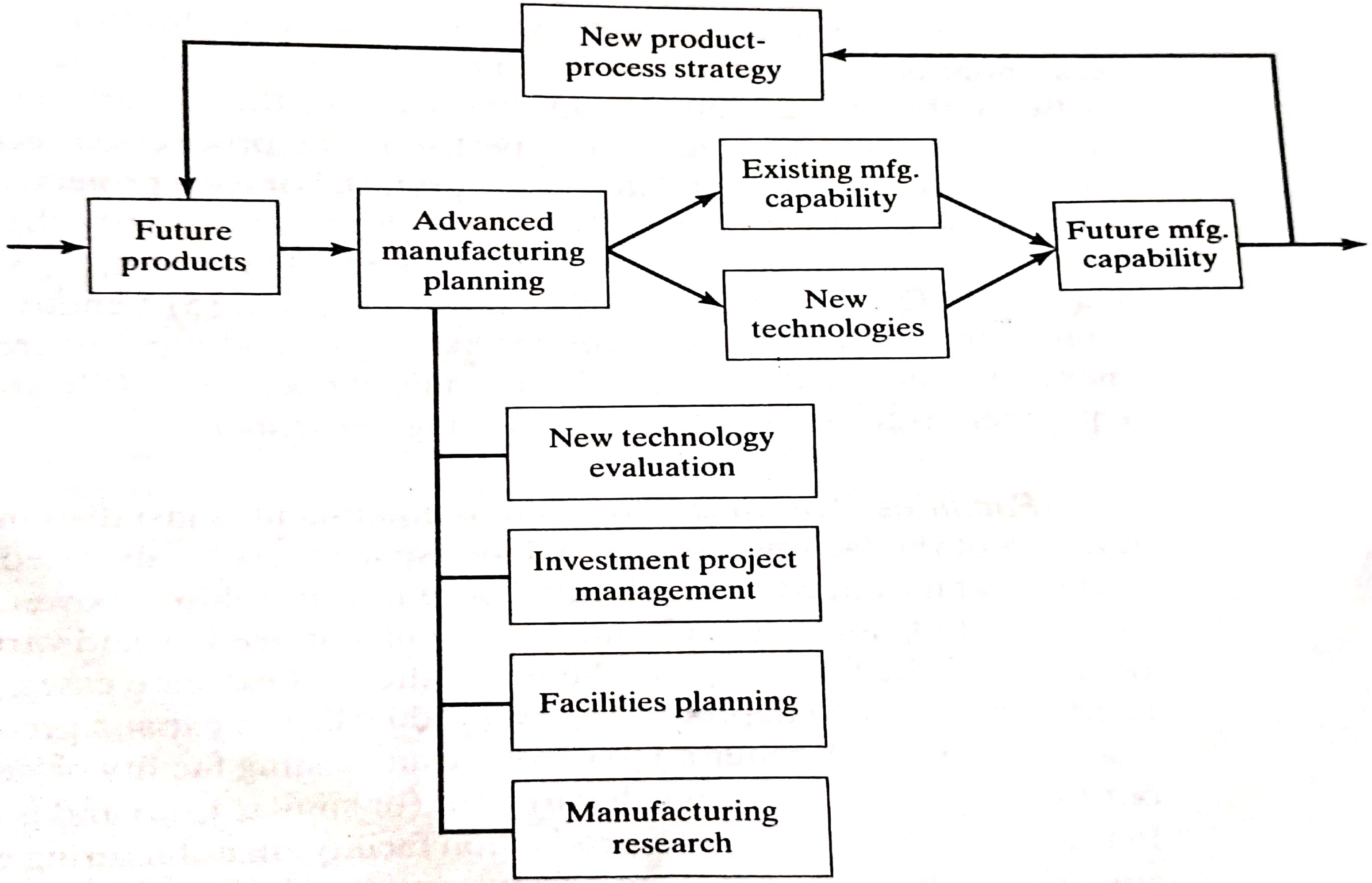
Source: [10].

4) Advanced Manufacturing Planning

Activities in advanced manufacturing planning include:

(i) New technology evaluation
(ii) Investment project management
(iii) Facilities planning
(iv) Manufacturing Research

Advanced manufacturing planning cycle



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Manufacturing Research can take various forms, including

(i) Development of new processing technologies
(ii) Adaptation of existing processing technologies
(iii) Process fine-tuning
(iv) Software systems development
(v) Automation systems development
(vi) Operations research and simulation