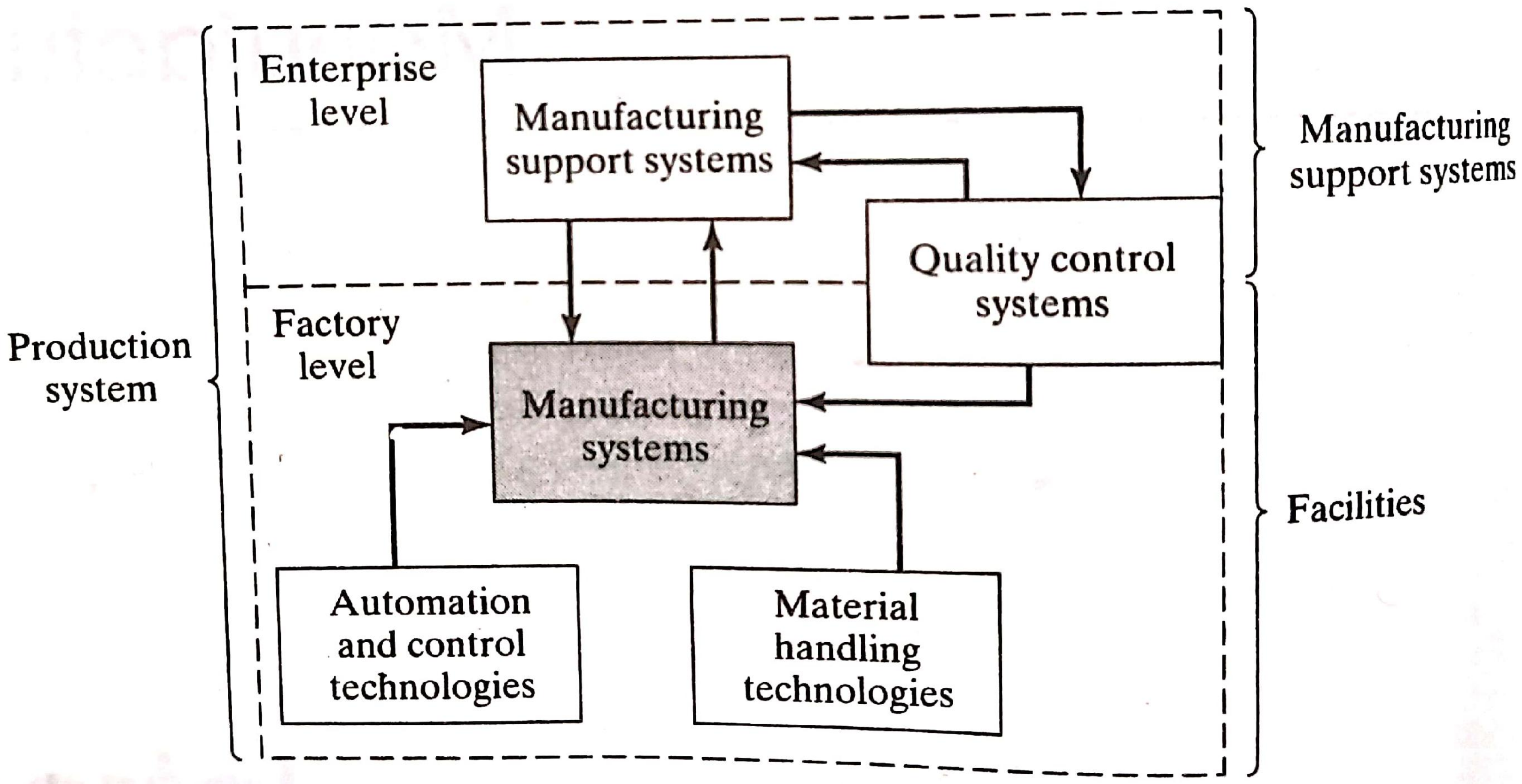
Introduction to Manufacturing Systems

L-14

Contents

Manufacturing System



1) Components of manufacturing systems

a) Production machines:

The machines can be classified as

(i) manually operated – lathe, milling machines and drill presses

(ii) semi-automated : performs the portion of the work cycle under some form of program control and human worker tends to machine for the remainder of the cycle, by loading and unloading it or performing some other task each cycle.

(iii) Fully automated : It has the capacity to operate for extended periods of time with no human attention.

b) Material handling system

(i) Loading and unloading
(ii) Positioning
(iii) Transporting
(iv) Temporary storage

- Loading, positioning and unloading

- Loading involves moving the work units into the production machine or processing equipment from a source inside the station.
- For the operations the work units must be on known location and orientation
- The workholder devices are used include jigs, fixtures and chucks.
- When the production operation has been completed, the work unit must be unloaded.

Contd.

- Work transport between stations:

The work transport is distinguished in two general categories of work transport, according to the type of routing between stations

(i) Variable routing: In this, work units are transported through a variety of different station sequences. This means that the manufacturing system is processing or assembling different work units

(ii) Fixed routing: In this, work units always flow through the same sequence of stations. This means that the work units are identical or similar enough that the processing sequence is identical.

Contd.

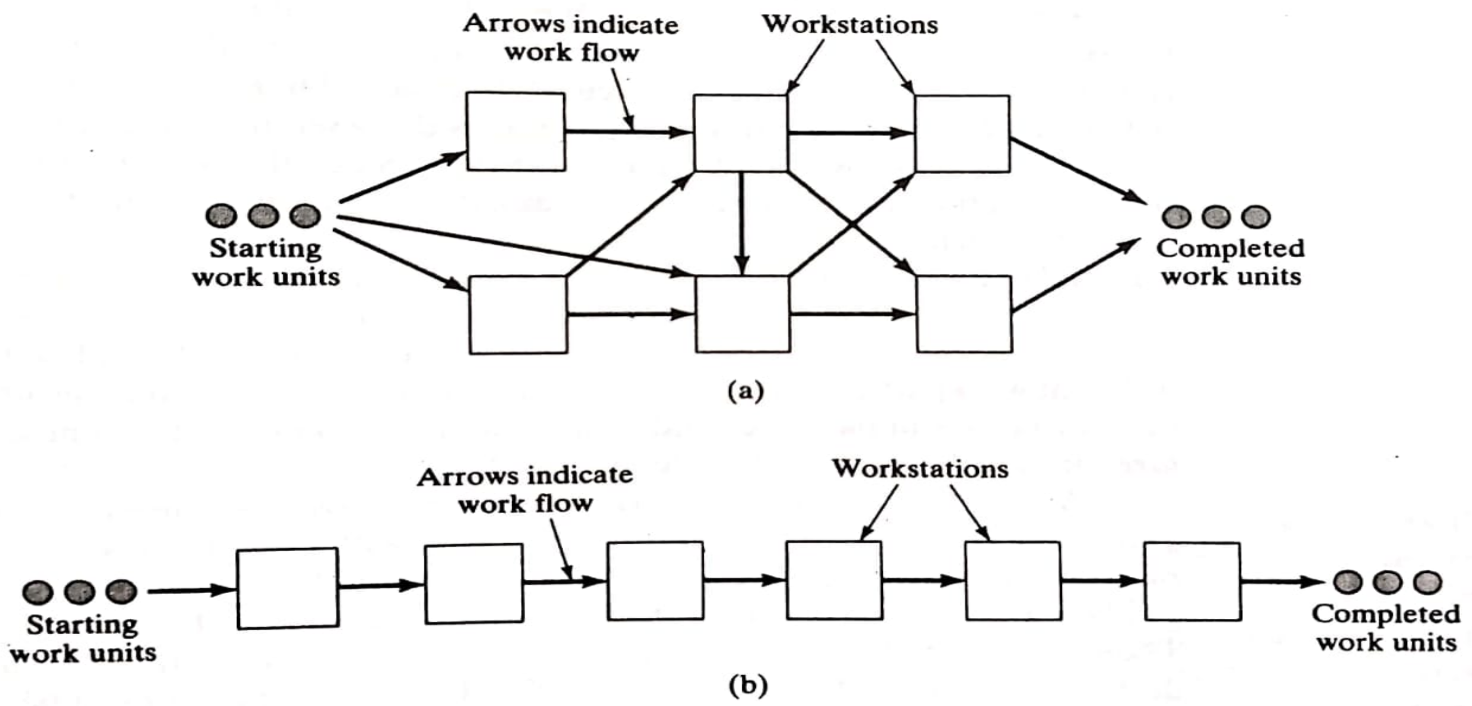


Figure 13.2 Types of routing in multiple station manufacturing systems: (a) variable routing and (b) fixed routing.

Contd.

Types of Part Routing	Material Handling Equipment
Variable routing	Automated guided vehicle system Power and free overhead conveyor Monorail system Cart-on-track conveyor
Fixed routing	Powered roller conveyor Belt conveyor Drag chain conveyor Overhead trolley conveyor Rotary indexing mechanisms Walking beam transfer equipment

Contd.

 Pallet fixtures and work carriers in transport systems:

(i) A pallet fixture is a workholder that is designed to be transported by material handling system

(ii) Alternate methods of workpart transport without pallet fixture includes the tote box, flat pallet and wire basket.

(iii) Alternate to using pallet fixtures or work carriers is direct transport, in which the transport system is designed to move the work unit itself.

C) Computer Control System

- In automated manufacturing systems, a computer is required to control the automated and semi-automated equipment and to participate in the overall coordination and management of the manufacturing system. Typical computer system functions include the following:

(i) Communicate instructions to workers
(ii) Download part programs
(iii) Material handling system control
(iv) Schedule production
(v) Failure diagnosis
(vi) Safety Monitoring
(vii) Quality Control
(viii) Operations management

d) Human Resources

- Human worker are referred to as direct labour
- Through their physical labor, they directly add to the value of the work unit by performing manual work on it or by controlling the machines that perform the work
- In manufacturing systems that are fully automated, direct labour is still needed to perform such activities as loading and unloading parts to and from the system, changing tools, resharpening tools, and similar functions.

2) Classification of manufacturing system

a) Types of operation performed:

(i) Processing operations

(ii) Assembly operations

b) Number of Workstations and System Layout

Type I Single station: This is the simplest case, consisting of one workstation (n=1), usually including a production machine that can be manually operated, semi-automated or fully automated.

Type II Multiple stations with variable routing: This manufacturing system consists of two or more stations (n> 1) that are designed and arranged to accommodate the processing or assembly of different part or product styles.

Type III Multiple stations with fixed routing: This system has two or more workstations (n>1), which are laid out as a production line.

C) Level of automation:

--The level of automation is another factor that characterizes the manufacturing system.

M= Manning level, the portion of time that the worker is in attendance at the station

W = Number of workers assigned specifically to station.

A = fully automated

H = Hybrid

Contd.

Automation in the Classification Scheme:

Type I M (Single station manned cell): The basic case is one machine and one worker (n=1, w =1). The machine is manually operated or semi-automated, and the worker must be in continuous attendance at the machine

Type I A (Single station automated cell): This is a fully automated machine capable of unattended operation (M<1) for extended periods of time (longer than one machine cycle). A worker must periodically load and unload the machine or otherwise service it.

Type II M (Multi-station manual system with variable routing): This has multiple stations that are manually operated or semi-automated. The layout and work transport system allow for various routes to be followed by the parts or products made by the system. Work transport between stations is either manual or mechanized.

Contd.

Type II A(Multi-station automated system with variable routing): This is same as the previous system, except the stations are fully automated ($n<1$, $w_i = 0$, $M<1$). Work transport is also fully automated.

Type II H (Multi-station hybrid system with variable routing): This manufacturing system contains both manned and automated stations. Work transport is manual, automated, or a mixture (hybrid).

Type III M (Multi-station manual system with fixed routing): This manufacturing system consists of two or more stations ($n>1$), with one or more workers at each station ($wi>1$). The operations are sequencial, thus necessitating a fixed routing, usually laid out as a production line. Work transport between stations is either manual or mechanized.

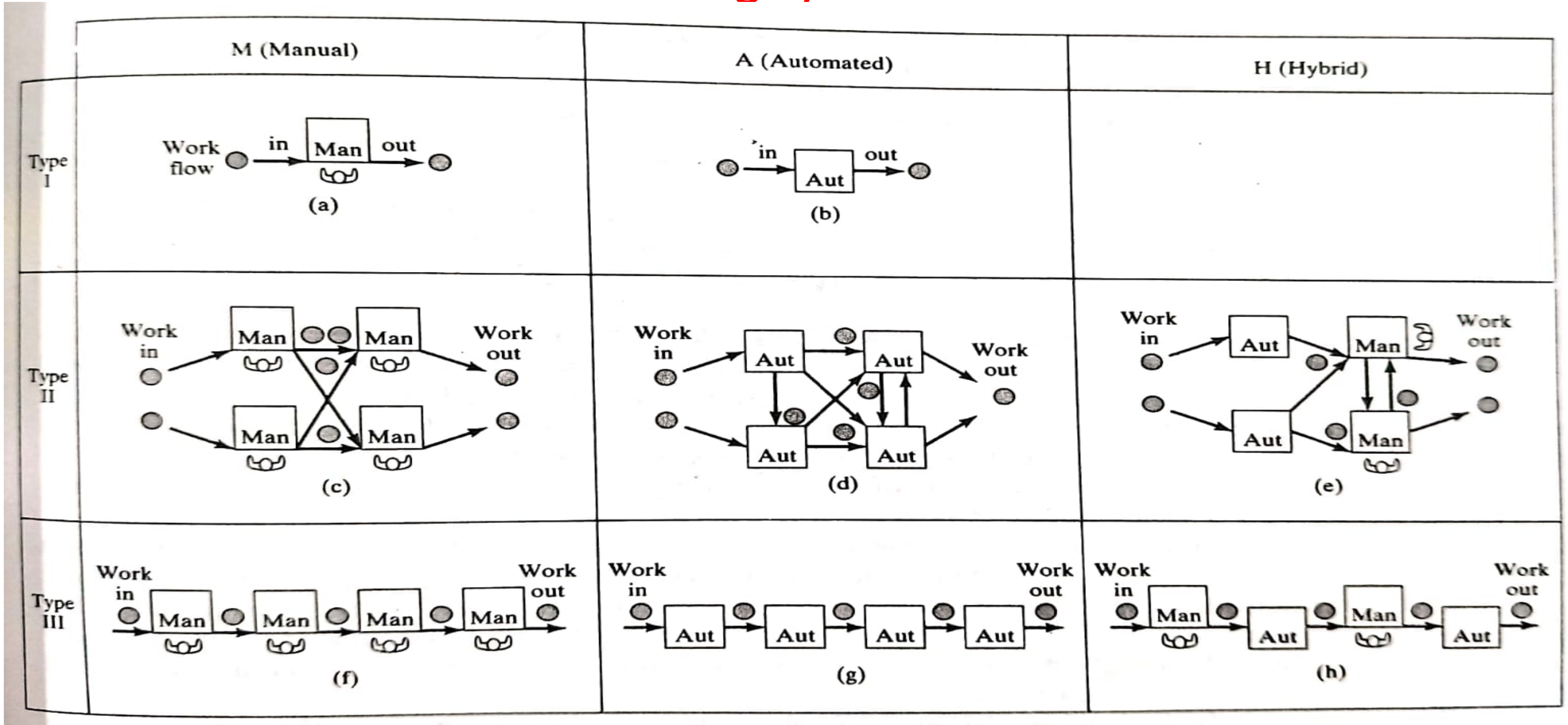
Contd.

Type III A(Multi-station automated system with fixed routing): This system consists of two or more automated stations ($n>1$, $W=0$, $M<1$) arranged as production line or similar configuration. Work transport is fully automated.

Type III H(Multi-station hybrid with fixed routing): This system includes both manned and automated stations ($n>1$, $w>1$ for some stations, $w=0$ for other stations, $M>0$). Work transport is manual, automated, or a mixture (hybrid).

Contd.

Classification of manufacturing system:



d) Part or Product Variety

- The fourth factor which characterizes a manufacturing system is the degree to which it is capable of dealing with variations in the parts or products it produces. Variations in type and/or colExamples of possible variations that a manufacturing system may have to cope with include:

(i) or of plastic of molded parts in injection molding

(ii) Variations in electronic components placed on a standard size printed circuit board

(iii) Variations in the size of printed circuit boards handled by a component placement machine

(iv) Variations in geometry of machined parts

(v) Variations in parts and options in an assembled product on a final assembly line.

Contd:

Model Variations (Three cases):

a) Single model: In this case, all parts or products made by the manufacturing system are identical. There are no variations. In this case, demand for the item must be sufficient to justify dedication of the system to production of that item for an extended period of time, perhaps several years.

b) Batch model: Different parts or products are made by the system, but they are made in batches because a changeover in physical setup and/or equipment, programming is required between models

c) Mixed model: In this different parts or products are made by the manufacturing system, but the system is able to handle these differences without the need for a changeover in setup and/or program.

Table showing three manufacturing systems

System Type	Symbol	Typical Product Variety	Flexibility
Single model	S	No product variety	None required
Batch model	B	Hard product variety typical*	Most flexible
Mixed model	X	Soft product variety typical*	Some flexibility

Contd.

Flexibility in Manufacturing Systems: Flexibility is the term used for attribute that allows a mixed model manufacturing system to cope with a certain level of variation in part or product style without interruptions in production for changeovers between models.

To be flexible, a manufacturing system must possess the following capabilities:

(i) Identification of the different work units

(ii) Quick changeover of operating instructions

(iii) Quick changeover of physical setup

Contd.

Reconfigurable Manufacturing Systems:

(i) Ease of mobility
(ii) Modular design of system components
(iii) Open architecture in computer controls
(iv) CNC workstations

3) Overview of classification Scheme

a) Type I Manufacturing systems :Single Stations– It is distinguished in two categories (i) type M: manned workstations in which a worker must be in attendance either continuously or for a portion of each cycle. (ii) type A: automated stations, in which periodic attention is required less frequently than every cycle.

It has been applied in single model, batch model and mixed model.

Reasons for popularity of the single model workstation include:

(i) It is the easiest and least expensive manufacturing method to implement, especially the manned version (ii) It is most adaptable, adjustable and flexible manufacturing system (iii) The manned single workstation can be converted to an automated station if demand for the parts or products made in the station justifies this conversion.

b) Type II Manufacturing Systems: Multi-Stations Cells

- A multiple station system with variable routing is a group of workstations organized to achieve some special purpose. It is typically intended for production quantities in the medium range (annual production = 100 -10000 parts or products), although its applications some-times extend beyond these boundaries. The special purpose may be any of the following:

(i) Production of a family of parts having similar processing operations

(ii) Assembly of a family of products having similar assembly operations

(iii) Production of the complete set of components used in the assembly of one unit of final product. By producing all of tha parts in one product, rather than batch production of the parts, work-in-process inventory is reduced.

c) Type III Manufacturing Systems: Production Lines

- A multi-station manufacturing system with fixed routing is a production line. A production line consists of a series of workstations laid out so that the part or product moves from one station to the next, and a portion of the total work is performed on it at each station. Production lines are generally associated with mass production (10000-1000000 parts or products per year). Conditions that favor the use of a production line are:

(i) The quantity of parts or products to be made is very high (up to millions of units)

(ii) The work units are identical or very similar. (Thus They require the same or similar operations to be performed in the same sequence)

(iii) The total work can be divided into separate tasks of approzimately equal duration that can be assigned to individual workstations

4) Manufacturing Progress Function (Learning curve)

(i) The learning curve phenomenon occurs when the cycle time required to perform a given activity decreases as the number of cycles increases. When a given task is performed repeatedly by the worker, it is gradually learned so that the time required to perform it decreases with each successive work unit.

(ii) Although it is easier to envision learning when applied to individual humans, the same kind of cycle time reduction occurs in the repetitive operations of work teams, large organizations and manufacturing systems. In these cases, the phenomenon is called the manufacturing progress function.

Contd.

(iii) For the case of an automated manufacturing system, one might think that since the cycle is set by the machine, then cycle time reduction is not possible. However, it must be realized that in all but the simplest of systems, there is invariably a beginning period after the system is first installed during which bugs in the system are being worked out, and the people responsible for operating the system are learning what makes it work. This is often called the break-in period.

(iv) Production tends to be very low during this break-in period. But repairs are made, the bugs are fixed, the system is tuned so that the production rate increases. Learning has taken place. After the break-in period, if learning and fine tuning are allowed to proceed in the spirit of continuous improvement that encouraged by many organizations, the learning curve will continue.

Example:

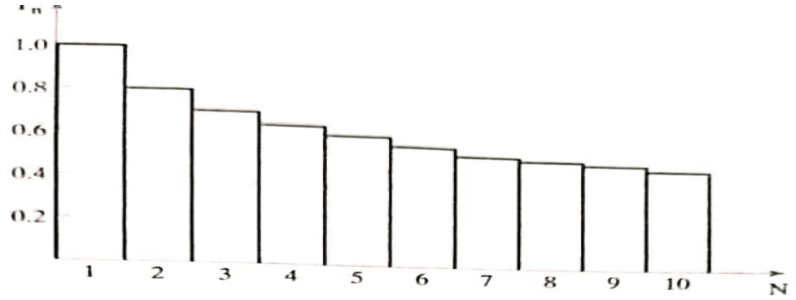


Figure 13.6 The learning curve phenomenon for a learning rate of 80%.

According to learning curve theory, there is a constant learning rate that applies to a given task. Different learning rates are associated with different types of tasks. And different workers have different learning capabilities that affect the learning rate. Whatever the learning rate, its effect is most identifiable every time the number of units doubles. This doubling effect can be seen in our hypothetical plot in Figure 13.6. Assuming a learning rate of 80%, as in our figure, the time to produce the second unit is 80% of that for the first unit; the time to produce the fourth unit is 80% of that for the second; and so forth. Every time the number of units doubles, the task time per unit has been reduced to 80% of its previous value. Between these points, the unit task times gradually decrease. We can calculate the expected time for the Nth work unit by means of the following equation:

$$T_N = T_1(N)^m \tag{13.4}$$

where T_N = task time for the Nth unit of work; T_1 = task time for the first work unit; N = the number of the unit produced in the series; and m = an exponent that depends on the learning rate. The value of m can be determined as follows:

$$m = \frac{\ln(LR)}{\ln(2)} \tag{13.5}$$

where LR = learning rate, expressed as a decimal fraction, such as 0.80. The natural logarithm of 2 in the denominator manifests the doubling effect of the learning rate. This causes the curve to plot as a straight line in a log-log graph, as in Figure 13.7. Typical values of the learning rate for various types of work are compiled in Table 13.5. The following example demonstrates the effect of learning in assembly line work.

EXAMPLE 13.3 The Learning Curve

A certain mechanical assembly task required 3.75 min to complete when a skilled worker did it for the first time. The task will be performed on an assembly line used to produce 1000 units of a particular product. The line is currently operating on a pilot basis, while workers are learning their respective tasks. The line will run on this basis for 50 units, after which it will go into reg-

Contd.

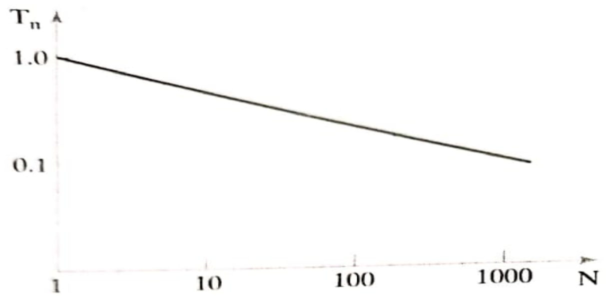


Figure 13.7 The learning curve plots as a straight line on a log-log graph.

TABLE 13.5 Typical Learning Rates for Various Types of Work

Type of Work	*Typical Learning Rate (%)*
Assembly, electrical harness	85
Assembly, electronic	85
Assembly, mechanical	84
Assembly of prototypes	65
Inspection	86
Machining	90–95
Sheet metal working	90
Welding	85

Source: [6], [8].

ular production. (a) If the learning rate for tasks of this type is 84% (Table 13.5), what will the task time be for the 50th unit and (b) for the 1000th unit?

ution: (a) To determine the task time for any numbered unit, we need to compute the exponent m from Eq. (13.5).

$$m = \frac{\ln(0.84)}{\ln(2)} = -0.2515$$

The task time for the 50th unit is found from Eq. (13.4):

$$T_{50} = 3.75(50)^{-0.2515} = 3.75(0.3738) = 1.402 \text{ min}$$

(b) The task time for the 1000th unit:

$$T_{1000} = 3.75(1000)^{-0.2515} = 0.660 \text{ min}$$

This example demonstrates the ... (manufacturing ...