高等学校教材

Mechanical Engineering English Course

机械工程英语教程

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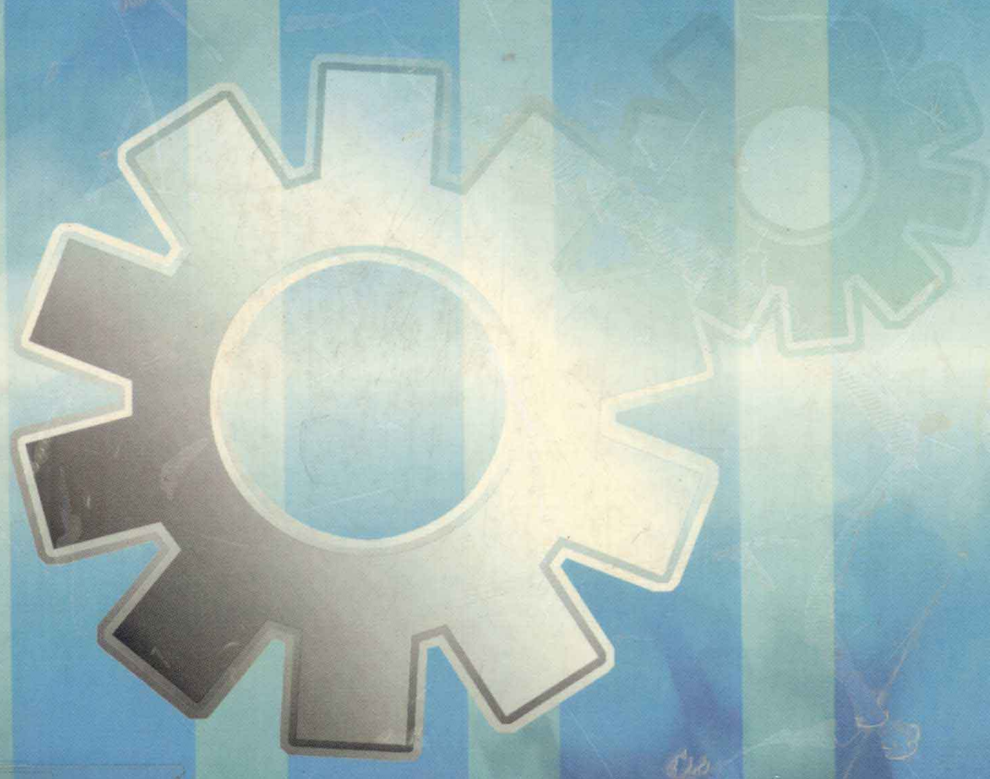

兵器工业出版社

内容简介

本教程在选材方面力求知识面广、信息量大、内容新颖，既包括制造技术与生产系统，又包括工业工程基础和人因工程方面的内容。其主要内容为：生产系统简介、生产方法、工业控制、工业机器人、数控技术、检测技术、物料搬运及存储系统、制造单元与制造系统、制造支持系统、系统仿真、资源管理、管理系统设计、项目管理、劳动强度与等级、噪音、微气候、照明、人因工程在系统设计中的应用等，本教程内容全部取材于英文原版教材，每单元后均有词汇、短语与表达、疑难句子结构分析，方便读者自学。本教程适合作为大专院校学生和有关科技人员的专业英语教材或阅读材料。

图书在版编目(CIP)数据

机械工程英语教程/李梦群等编著．—北京:兵器工业出版社,2003.5

ISBN 7-80172-128-4

Ⅰ.机…　Ⅱ.李…　Ⅲ.机械工程-英语-教材　Ⅳ.H31

中国版本图书馆 CIP 数据核字(2003)第 040308 号

出版发行：兵器工业出版社
责任编辑：郭春临
责任技编：魏丽华
邮编社址：100089　北京市海淀区车道沟 10 号
经　　销：各地新华书店
印　　刷：兵器工业出版社印刷厂
版　　次：2003 年 5 月第 1 版第 1 次印刷
印　　数：1—1050

封面设计：底晓娟
责任校对：武文革　刘春美
责任印制：莫丽珠
开　　本：787×1092　1/16
印　　张：28.5
字　　数：699 千字
定　　价：45.00 元

序

信息时代的机械制造业正面临着新的挑战与机遇,主要的挑战是:机械制造业所处的环境是不断改变与难以预测的环境。信息时代人们对产品的需求有如艺术品,变化莫测,各不相同;人们对产品的认识是:产品是在原始资源(物质、能量与数据)上赋予信息的产物,制造过程则是这种赋予信息与知识的过程,认识的变化与深入产生了新的概念,创造了新的方法,得到了突破性的新成果,先进制造系统(Advanced Manufacturing System)就是这一过程的产物。

信息时代的技术是千变万化,日新月异的,为了适应这种环境,人们从不同的角度提出了许多机械制造的新概念和新思想,例如美国提出的对产品开发及相关过程组成多功能协调小组工作模式为特征的并行工程(Concurrent Engineering),以简化组织和强调人的能动性为核心的精益生产(Lean Production),以动态多变的组织结构和充分发挥技术、组织人员的高度柔性集成为主导的敏捷制造(Agile Manufacturing);日本提出的以提高决策自动化为目的并在整个制造过程中贯穿智能活动的智能制造(Intelligent Manufacturing),此外,还有从计算机仿真角度提出的虚拟制造(Virtual Manufacturing),从仿生角度提出的仿生制造(Bionic Manufacturing),从环境保护角度提出的绿色制造(Green Manufacturing)等等。

工业工程(Industrial Engineering)就是在人们致力于提高工作效率和生产率,降低生产成本的实践中产生的一门工程学科,就是把技术和管理有机地结合起来,去研究如何使生产要素组成生产力更高和更有效运行的系统,是实现提高生产率目标的工程学科。

科学发展和技术进步导致新的生产技术和科学管理原理与方法不断出现,为工业工程的应用和发展创造了条件。工业工程的应用极大地推动了生产发展和经济的增长。实现工业化早和经济发达国家的年人均生产总值已经高达数万美元,而许多发展中国家的年人均产值只有数百美元。这种差别除了历史和物质基础等方面的原因以外,工业发达国家重视发展和应用工业工程这一提高生产率的技术是一个重要因素。

为信息时代培养制造工程师和工业工程师的机械设计制造及其自动化、工业工程的本科教学,必须使学生打下扎实的专业基础,使其能牢牢掌握制造技术和工业工程的最新动向。专业英语教学的目的是使学生能将英语作为工作的工具熟练应用,阅读英文版的专业书刊,快速地获取第一手国外资料,时刻掌握国际动态。《机械工程英语教程》一书,是一本为数不多的适应这种需求的专业英语教材。

该书编者长期致力于先进制造技术的教学科研工作,是我系年富力强的青年骨干教师。编者本着知识面广、信息量大、内容新颖这一原则编写了本书,其内容既包括制造技术与生产系统,又包括工业工程基础和人因工程,全部取材于英文原版教材,每单元后均附有词汇、短语与表达、疑难句子结构分析,方便读者自学。本书可以作为大专院校学生和有关科技人员的专业英语教材和阅读材料。

祝贺该教程的出版,并希望编者百尺竿头更进一步。

教授、博士生导师 王爱玲

2003 年 3 月

前　言

对于理工科大学生来说，一般都经历了八到十年的英语学习。学习的目的在于能够将英语作为工具在工作中熟练应用，阅读英文版的专业书刊，快速地获取第一手国外科技资料，时刻掌握本专业国际动态。因此，在掌握了一定专业知识后，英语学习必须要从“基础”阶段过渡到“应用”阶段。这个过渡是一个飞跃，成功则随心所欲，受益无穷；失败则十年寒窗付诸东流。本教程作者的意图就是要帮助读者在较短的时间内完成这一飞跃。

本教程可供机械工程、工业工程高年级学生作为专业英语教程使用。全教程共计 48 个单元，第一篇 24 个单元，第二篇、第三篇均为 12 个单元。本教程按讲授与课外自学 1：2 的比例配置，根据不同专业的需要选择不同单元进行讲授，其余作为课外自学，如按每周讲授一单元的进度恰好为一个学期的阅读量。

编者本着知识面广、信息量大、内容新颖的原则选择教程内容。由于现代工程技术领域的飞速发展，很多的高新技术知识一时难于通过专业课程向学生传授，而本教程内容的选题将有助于学生了解机械工程、工业工程高新技术的发展现状。

本教程所选择的文章全部取材于英文原版教材，第一篇为制造技术及生产系统，内容包括生产系统简介、生产方法、工业控制、工业机器人、数控技术、检测技术、物料搬运及存储系统、制造单元与制造系统、制造支持系统等。第二篇为工业工程基础，内容包括工业工程的发展历史、资源管理、仿真、管理系统设计、项目管理等。第三篇为人因工程，内容包括人因工程的定义及研究方法、劳动强度与等级、噪音、微气候、照明、人的错误与事故、人因工程在自动化中的应用、人因工程在系统设计中的应用等。本教程尽量保持原著的语言风格，为每单元编写了词汇、短语与表达以及疑难句子结构分析，以方便读者自学。对原版教材作者、出版者表示由衷的感谢。

本教程由华北工学院李梦群、庞学慧、刘兆华、樊旭梅共同编著，李梦群编写第一篇的 Unit 1、Unit2、Unit 8 ~ Unit 11、Unit 13 ~ Unit 20，庞学慧编写第二篇全部及第一篇的 Unit 21、Unit 22，刘兆华编写第三篇全部及第一篇的 Unit 23、Unit 24，樊旭梅编写第一篇的 Unit 3 ~ Unit 7、Unit 12。在本教程的编写过程中，华北工学院博士生导师王爱玲教授给予了多方面的指导，并为该教程作序。太原理工大学机械工程学院副院长高创宽教授，太原重型机械学院副院长徐格宁教授、太原重型机械学院阎献国教授审阅了全稿，并给予了热忱的指导。本教程的编写得到了华北工学院机械工程系领导及教研室同仁的支持和无私帮助。本教程的出版受华北工学院“十五”教材建设规划的资助，得到了院教材建设委员会、教务处领导、教材科领导的鼎力支持。在此向他们致以衷心的感谢。

由于编者水平所限，本教程不足或纰漏之处在所难免，恳请读者给予批评指正，编者将不胜感激。

作　者

2003 年 3 月

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PART Ⅰ MANUFACTURING TECHNOLOGY AND PRODUCTION SYSTEM

PART Ⅱ INDUSTRIAL ENGINEERING

PART Ⅲ HUMAN FACTORS

Unit 1 Introduction to Manufacturing Systems

We define a *manufacturing system* to be a collection of integrated equipment and human resources, whose function is to perform one or more processing and/or assembly operations on a starting raw material, part, or set of parts. The integrated equipment includes production machines and tools, material handling and work positioning devices, and computer systems. Human resources are required either full time or periodically to keep the system running. The manufacturing system is where the value-added work is accomplished on the part or product.

1.1 COMPONENTS OF A MANUFACTURING SYSTEM

A manufacturing system consists of several components. In a given system, these components usually include:

- production machines plus tools, fixtures, and other related hardware
- material handling system
- computer systems to coordinate and/or control the above components
- human workers

1.1.1 Production Machines

In virtually all modern manufacturing systems, most of the actual processing or assembly work is accomplished by machines or with the aid of tools. The machines can be classified as (1) manually operated, (2) semi-automated, or (3) fully automated. *Manually operated machines* are directed or supervised by a human worker. The machine provides the power for the operation and the worker provides the control. Conventional machine tools (e.g. lathes, milling machines, drill presses) fit into this category. The worker must be at the machine continuously.

A *semi-automated machine* performs a portion of the work cycle under some form of program control, and a human worker tends to the machine for the remainder of the cycle, by loading and unloading it or performing some other task each cycle.[1] In these cases, the worker must attend to the machine every cycle, but continuous presence during the cycle is not always required. If the automatic machine cycle takes, say, 10 min, while the part unloading and loading portion of the work cycle only takes 1 min, then there may be an opportunity for one worker to tend more than one machine.[2]

What distinguishes a *fully automated machine* from its semi-automated cousin is its capacity to operate for extended periods of time with no human attention. By extended periods of time, we generally mean longer than one work cycle. A worker is not required to be present during each cycle. Instead, the worker may need to tend the machine every tenth cycle or every hundredth cycle.

In manufacturing systems, we use the term *workstation* to refer to a location in the factory where some well-defined task or operation is accomplished by an automated machine, a worker-and-machine combination, or a worker using hand tools and/or portable powered tools.[3] A given manufacturing system may consist of one or more workstations. A system with multiple stations is called a production line, or assembly line, or machine cell, or other name, depending on its configuration and function.

1.1.2 Material Handling System

In most processing and assembly operations performed on discrete parts and products, the following ancillary functions must be provided: (1) *loading and unloading* work units and (2) *positioning* the work units at each station. In manufacturing systems composed of multiple workstations, a means of (3) *transporting* work units between stations is also required. These functions are accomplished by the material handling system. In many cases, the units are moved by the workers themselves, but more often some form of mechanized or automated material transport system is used to reduce human effort. Most material handling systems used in production also provide (4) *a temporary storage* function. The purpose of storage in these systems is usually to make sure that work is always present for the stations, that is, that the stations are not starved.

Loading, Positioning, and Unloading. These material handling functions occur at each workstation. *Loading* involves moving the work units into the production machine or processing equipment from a source inside the station. For most processing operations, especially those requiring accuracy and precision, the work unit must be *positioned* in the production machine. Positioning provides for the part to be in a known location and orientation relative to the workhead or tooling that performs the operation. Positioning in the production equipment is often accomplished using a workholder. A *workholder* is a device that accurately locates, orients, and clamps the part for the operation and resists any forces that may occur during processing. Common workholders include jigs, fixtures, and chucks. When the production operation has been completed, the work unit must be unloaded, that is, removed from the production machine and either placed in a container at the workstation or prepared for transport to the next workstation in the processing sequence.

When the production machine is manually operated or semi-automatic, loading, positioning, and unloading are performed by the worker either by hand or with the aid of hoist. In fully automated stations, a mechanized device such as an industrial robot, part feeder, coil feeder (in sheet metal stamping), or automatic pallet changer is used to accomplish these material handling functions.

Work Transport Between Stations. In the context of manufacturing system, *work transport* means moving parts between workstations in a multi-station system. The transport function can be accomplished manually or by the most appropriate material transport equipment.

In some manufacturing systems, work units are passed from station to station by hand. Manual work transport can be accomplished by moving the units one at a time or in batches. Manual work transport is limited to cases in which the parts are small and light, so that the manual labor is ergonomically acceptable. When the load to be moved exceeds certain weight standards, powered hoists and similar lift equipment are used. Manufacturing systems that utilize manual work transport include manual assembly lines and group technology machine cells.

Various types of mechanized and automated material handling equipment are widely used to transport work units in manufacturing systems. We distinguish two general categories of work transport, according to the type of routing between stations: (1) variable routing and (2) fixed routing. In *variable routing*, work units are transported through a variety of different station sequences. This means that the manufacturing system is processing or assembling different work units. Variable routing transport is associated with job shop production and many batch production operations. Manufacturing systems that use variable routing include group technology machine cells and flexible manufacturing systems. In *fixed routing*, the 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. Fixed routing transport is used on production lines. The difference between variable and fixed routing is portrayed in Figure 1.1.

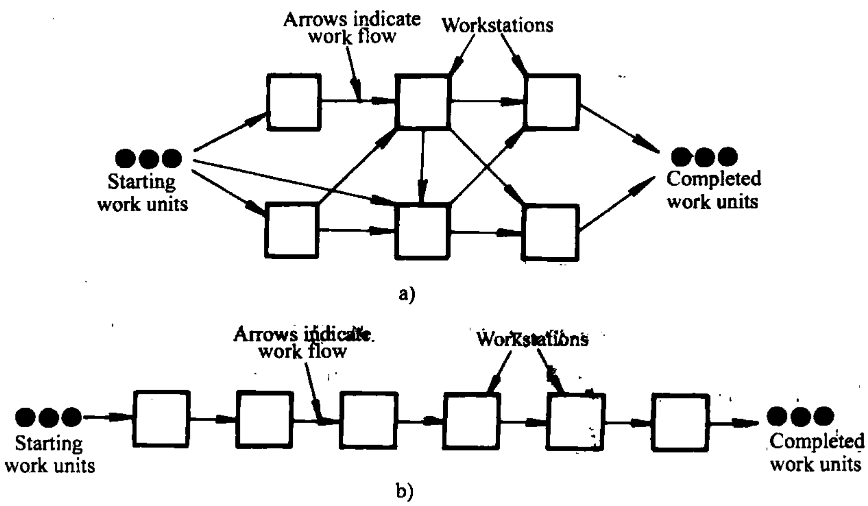

Figure 1.1 Types of routing in multiple station manufacturing systems
a) variable routing b) fixed routing

Pallet Fixtures and Work Carriers in Transport Systems. Depending on the geometry of the work units and the nature of the processing and/or assembly operation to be performed, the transport system may be designed to accommodate some form of pallet fixture. A *pallet fixture* is a workholder that is designed to be transported by the material handling system. The part is accurately attached to the fixture on the upper face of the pallet, and the under portion of the pallet is designed to be moved, located, and clamped in position at each workstation in the system. Since the part is accurately located in the fixture, and the pallet is accurately clamped at the station, the part is therefore accurately located at each station for processing or assembly. Use of pallet fixtures is common in automated manufacturing systems, such as single machine cells with automatic pallet changers, transfer lines, and automated assembly systems.

The fixtures can be designed with modular features that allow them to be used for different workpart geometries. By changing components and making adjustments in the fixture, variations in part sizes and shapes can be accommodated. These *modular pallet fixtures* are ideal for use in flexible manufacturing systems.

Alternative methods of workpart transport avoid the use of pallet fixtures. Instead, parts are moved by the handling system either with or without work carriers. A *work carrier* is a container that holds one or more part can be moved in the system. Work carriers do not fixture the part(s) in an exact position. Their role is simply to contain parts during transport. When the parts arrive at the desired destination, any locating requirements for the next operation must be satisfied at that station.

An alternative to using pallet fixtures or work carriers is *direct transport*, in which the transport system is designed to move the work unit itself. The obvious benefit of this arrangement is that it avoids the expense of pallet fixtures or work carriers as well as the added cost of providing for their return to the starting point in the system for reuse. In manually operated manufacturing systems, direct transport is quite feasible, since any positioning required at workstations can be accomplished by the worker. In automated manufacturing systems, in particular systems that require accurate positioning at workstations, the feasibility of direct transport depends on the part's geometry and whether an automated handling method can be devised that is capable of moving, locating, and clamping the part with sufficient precision and accuracy. Not all part shapes allow for direct handling by a mechanized or automated system.

1.1.3 Computer Control System

In today's 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. Even in manually driven manufacturing systems, such as a completely manual assembly line, a computer system is useful to support production. Typical computer system functions include the following:

- *Communicate instructions to workers.*
- *Download part programs to computer-controlled machines (e.g. CNC machine tools)*
- *Material handling system control.*
- *Schedule production.*
- *Failure diagnosis.*
- *Safety monitoring.*
- *Quality control.*
- *Operations management.*

1.1.4 Human Resources

In many manufacturing systems, humans perform some or all of the value-added work that is accomplished on the parts or products. In these cases, the human workers are referred to as *direct labor*. 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 labor is still needed to perform such activities as loading and unloading parts to and from the system, changing tools, resharpening tools, and similar functions.[4] Human workers are also needed for automated manufacturing systems to manage or support the system as computer programmers, computer operators, part programmers for CNC machine tools, maintenance and repair personnel, and similar *indirect labor* tasks. In automated systems, the distinction between direct and indirect labor is not always precise.

1.2 CLASSIFICATION OF MANUFACTURING SYSTEMS

In this section, we explore the variety of manufacturing system types and develop a classification scheme based on the factors that define and distinguish the different types. The factors are: (1) types of operations performed, (2) number of workstations and system layout, (3) level of automation, and (4) part or product variety.

1.2.1 Types of Operations Performed

First of all, manufacturing systems are distinguished by the types of operations they perform. At the highest level, the distinction is between (1) *processing operations* on individual work units and (2) *assembly operations* to combine individual parts into assembled entities. Beyond this distinction, there are the technologies of the individual processing and assembly operations.

Additional parameters of the product that play a role in determining the design of the manufacturing system include: type of material processed, size and weight of the part or product, and part geometry.

1.2.2 Number of Workstations and System Layout

The number of workstations is a key factor in our classification scheme. It exerts a strong influence on the performance of the manufacturing system in terms of production capacity, productivity, cost per unit, and maintainability. Let us denote the number of workstations in the system by the symbol n. The individual stations in a manufacturing system can be identified by the subscript i, where $i = 1, 2, \cdots, n$. This might be useful in identifying parameters of the individual workstations, such as operation time or number of workers at a station.

The number of workstations in the manufacturing system is a convenient measure of its size. As the number of stations is increased, the amount of work that can be accomplished by the system increases. This translates into a higher production rate, certainly as compared with a single workstation's output, but also compared with the same number of single stations working independently. There must be a synergistic benefit obtained from multiple stations working in a coordinated manner rather than independently; otherwise, it makes more sense for the stations to work as independent entities. The synergistic benefit might be derived from the fact that the totality of work performed on the part or product is too complex to engineer at a single workstation. There are too many individual tasks to perform at one workstation. By assigning separate tasks to individual stations, the task performed at each station is simplified.

More stations also mean that the system is more complex and therefore more difficult to manage and maintain. The system consists of more workers, more machines, and more parts being handled. The logistics and coordination of the system becomes more involved. Maintenance problems occur more frequently.

Closely related to number of workstations is the arrangement of the workstation, that is, the way the stations are laid out. This, of course, applies mainly to systems with multiple stations. Are the stations arranged for variable routing or fixed routing? Workstation layouts organized for variable routing can have a variety of possible configuration, while layouts organized for fixed routing are usually arranged linearly, as in a production line. The layout of stations is an important factor in determining the most appropriate material handling system.

Our classification scheme is applicable to manufacturing systems that perform either processing or assembly operations. Although these operations are different, the manufacturing systems to perform them possess similar configurations. According to number of stations and the layout of the stations, our classification scheme has three levels:

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.

1.2.3 Level of Automation

The level of automation is another factor that characterizes the manufacturing system. As defined above, the workstations (machines) in a manufacturing system can be manually operated, semi-automated, or fully automated.

Manning Level. Closely correlated with the level of automation is the proportion of time that direct labor must be in attendance at each station. The *manning level* of a workstation, symbolized M_i, is the proportion of time that a worker is in attendance at the station. If $M_i = 1$ for station i, it means that one worker must be at the station continuously. If one worker tends four automatic machines, then $M_i = 0.25$ for each of the four machines, assuming each machine requires the same amount of attention. On portions of an automobile final assembly line, there are stations where multiple workers perform assembly tasks on the car, in which case $M_i = 2$ or 3 or more. In general, high values of M_i ($M_i \geqslant 1$) indicate manual operations at the workstation, while low values ($M_i < 1$) denote some form of automation.

The average manning level of a multi-station manufacturing system is a useful indicator of the direct labor content of the system. Let us define it as follows:

$$M = \frac{w_u + \sum_{i=1}^{n} w_i}{n} = \frac{w}{n}$$

where M = average manning level for the system; w_u = number of utility workers assigned to the system; w_i = number of workers assigned specifically to station i, for $i = 1, 2, \cdots, n$; and w = total number of workers assigned to the system. *Utility workers* are workers who are not specifically assigned to individual processing or assembly stations; instead they perform functions such as: (1) relieving workers at stations for personal breaks, (2) maintenance and repair of the system, (3) tool changing, and (4) loading and/or unloading work units to and from the system. Even a fully automated multi-station manufacturing system is likely to have one or more workers who are responsible for keeping it running.

Automation in the Classification Scheme. Including automation in our classification scheme, we have two possible automation levels for single stations and three possible levels for multi-station systems. The two levels for single stations (type I) are: M = manned station and A = fully automated. The manned station is identified by the fact that one or more workers must be at the station every cycle. This means that any machine at the station is manually operated or semi-automatic and that manning is equal to or greater than one ($M \geqslant 1$). However, in some cases, one worker may be able to attend more than one machine, if the semi-automatic cycle is long relative to the service required each cycle of the worker (thus, $M < 1$). A fully automated station requires less than full-time attention of a worker ($M < 1$). For multi-station systems (types Ⅱ and Ⅲ), the levels M and A are applicable, and a third level is possible: H = hybrid, in which some stations are manned and others are fully automated. Listing the alternatives, we have the following:

Type ⅠM *Single-station manned cell.* ($n = 1$, $w = 1$)

Type ⅠA *Single station automated cell.* ($M < 1$)

Type ⅡM *Multi-station manual system with variable routing.*

Type ⅡA *Multi-station automated system with variable routing.* ($n > 1$, $w_i = 0, M < 1$)

Type ⅡH *Multi-station hybrid system with variable routing.*

Type ⅢM *Multi-station manual system with fixed routing.* ($n > 1, w_i \geqslant 1$)

Type ⅢA *Multi-station automated system with fixed routing.* ($n > 1$, $w_i = 0$, $M < 1$)

Type ⅢH *Multi-station hybrid system with fixed routing.* ($n > 1$, $w_i \geqslant 1$ *for some stations*, $w_i = 0$ *for other stations*, $M > 0$)

1.2.4 Part or Product Variety

A fourth factor that characterizes a manufacturing system is the degree to which it is capable of dealing with variations in the parts or products it produces.[5] Examples of possible variations that a manufacturing system may have to cope with include:

- variations in type and/or color of plastic of molded parts in injection molding
- variations in electronic components placed on a standard size printed circuit board
- variations in the size of printed circuit boards handled by a component placement machine
- variations in geometry of machined parts
- variations in parts and options in an assembled product on a final assembly line.

In this section, we borrow from the terminology of assembly lines to identify three types of manufacturing systems, distinguished by their capacity to cope with part or product variety. ,We then discuss two ways in which manufacturing systems can be endowed with this capability.

Model Variations: Three Cases. Manufacturing systems can be distinguished according to their capability to deal with variety in the work units produced. Terminology used in assembly line technology can be applied here. Three cases of part or product variation in manufacturing systems are distinguished: (1) single model, (2) batch model, and (3) mixed model. The three cases can be identified by letter, S, B, and X, respectively. The typical level of product variety can also be correlated with the three categories.

In the *single model case*, all parts or products made by the manufacturing system are identical. There are no variations. Fixed automation in single model systems is common.

In the *batch model case*, 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. Changeover of the manufacturing system is required because the differences in part or product style are significant enough that the system cannot cope unless changes in tooling and programming are made. It is a case of hard product variety. The time needed to accomplish the changeover requires the system to be operated in a batch mode, in which a batch of one product style is followed by a batch of another, and so on.

In the *mixed model case*, 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. This means that the mixture of different styles can be produced continuously rather than in batches. The requirement for continuous production of different work unit styles is that the manufacturing system be designed so that whatever adjustments need to be made from one part or product style to the next, these adjustments can be made quickly enough that it is economical to produce the units in batch sizes of one.[6]

Flexibility in Manufacturing Systems. Flexibility is the term used for the 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. Flexibility is generally a desirable feature of a manufacturing system. Systems that possess it are called flexible manufacturing systems, or flexible assembly systems, or similar names. They can produce different part styles or can readily adapt to new part styles when the previous ones become obsolete. To be flexible, a manufacturing system must possess the following capabilities:

- *Identification of the different work units*.
- *Quick changeover of operating instructions*.
- *Quick changeover of physical setup*.

Reconfigurable Manufacturing Systems. In an era when new product styles are being introduced with ever-shortening life cycles, the cost of designing, building, and installing a new manufacturing system every time a new part or product must be produced is becoming prohibitive, both in terms of time and money.[7] One alternative is to reuse and reconfigure components of the original system in a new manufacturing system. In modern manufacturing engineering practice, even single model manufacturing systems are being built with features that enable them to be changed over to new product styles when this becomes necessary. These kinds of features include:

- *Ease of mobility*. Machine tools and other production machines designed with a three-point base that allows them be readily lifted and moved by a crane or forklift truck. The three-point base facilitates leveling of the machine after moving.

- *Modular design of system components*. This permits hardware components from different machine builders to be connected together.

- *Open architecture in computer controls*. This permits data interchange between software packages from different vendors.

● *CNC workstations*. Even though the production machines in the system are dedicated to one product, they are nevertheless computer numerical controlled to allow for upgrades in software, engineering changes in the part currently produced, and changeover of the equipment when the production run finally ends.[8]

Vocabulary:

virtually adv.事实上，实质上

coordinate n.同等者，同等物，坐标（用复数）adj. 同等的，并列的 vt. 调整，整理

supervise v.监督，管理，指导

cousin n.堂兄弟姊妹，表兄弟姊妹

workstation n.工作站

well-defined adj.定义明确的，明确的

portable adj.轻便的，手提（式）的，便携式的

discrete adj.不连续的，离散的

ancillary adj.补助的，副的

loading n.装载，装填

positioning n.定位（法）

workholder n.工件夹具，工件夹持装置

jig n.夹具，钻模

fixture n.夹具，卡具，定位器

chuck n.钻轧头，夹盘

hoist n.绞起，卷扬

ergonomic adj.人机工程学的

accommodate vt.供应，供给，使适应，调节，和解，向……提供，容纳，调和 vi. 适应

layout n.布置，定位，草图

exert vt.尽（力），施加，努力 v. 发挥，竭尽全力

denote vt.指示，表示

synergistic adj.协合的，复合的，协同的

relieving adj.救助的，救援的

terminology n.术语学

changeover n.（生产方法、装备等的）完全改变，（方针的）转变

setup n.机构，设置，装备，组织，计划，调整

dedicated adj.专注的，献身的

prohibitive adj.禁止的，阻碍的，阻止的；非常高的，昂贵的，抑制性的（价格）

Phrases and Expressions:

material handling system 物料搬运系统

production line 生产线，流水线，装配线

parts feeder 送料器，拾取定向料斗

coil feeder 卷料进料装置

automatic pallet changer 自动托盘交换装置

in the context of 在……情况下

in batches 分批地，成批地

group technology machine cell 成组生产单元

flexible manufacturing system 柔性制造系统

pallet fixture 托盘夹具，随行夹具

transfer line 连续生产线

schedule production 生产计划

failure diagnosis 故障诊断

translate into 翻译成，转化为

injection molding 喷射造型法；喷射模塑法

printed circuit board 印刷电路板

forklift truck 叉式装卸车，铲车

production run 生产（性）运行

Notes:

1. A semi-automated machine performs a portion of the work cycle under some form of program control, and a human worker tends to the machine for the remainder of the cycle, by loading and unloading it

or performing some other task each cycle.

在工作循环的一部分（时间里），半自动机器在某种程序的控制下运行，而在工作循环剩余（时间里），工人操作机器，完成每一工作循环的上下料及一些其他的任务。

此句中 performs 和 tends to 为并列谓语，by loading and unloading it or performing some other task each cycle 在句中做方式状语。

2. If the automatic machine cycle takes, say, 10 min, while the part unloading and loading portion of the work cycle only takes 1 min, then there may be an opportunity for one worker to tend more than one machine.

假设一台自动机器一个工作循环花费的时间比如为十分钟，而一个工作循环中上下料仅花一分钟时间，那么就有机会一个工人照管一台以上机器。

此句为条件状语从句，say 在句中的意思为举例说明，可理解为"比如，暂定为"，句中 while 的意思为"而"。

3. In manufacturing systems, we use the term workstation to refer to a location in the factory where some well-defined task or operation is accomplished by an automated machine, a worker-and-machine combination, or a worker using hand tools and/or portable powered tools.

在制造系统中，使用工作站这一术语，它指的是在工厂的某一特定区域内由自动机器；或者是工人和机器的联合；或者是由工人采用手动工具和（或）便携式动力工具来完成明确的任务或操作。

此句中"refer to"意思为"指的是，意思为"，"where"引出定语从句，句后"an automated machine"，"a worker-and-machine combination"和"a worker using hand tools and/or portable powered tools"为并列成分，在句中做方式状语。

4. In manufacturing systems that are fully automated, direct labor is still needed to perform such activities as loading and unloading parts to and from the system, changing tools, resharpening tools, and similar functions.

在全自动制造系统中，仍然需要直接劳动，完成如下活动：给系统上料或从系统上卸料、更换刀具、刀具重磨以及类似的活动。

此句中的主干成分为"direct labor is still needed"，句中，"that are fully automated,"做"systems"的定语，"to perform…"在句中做目的状语，其中，"loading and unloading" "changing"和"resharpening"为并列成分。

5. A fourth factor that characterizes a manufacturing system is the degree to which it is capable of dealing with variations in the parts or products it produces.

说明制造系统特色的第四个因素是制造系统能应付它所生产的零件或产品变化的程度。

此句的主干为"A fourth factor is the degree"，句中，"that characterizes a manufacturing system"做 factor 的定语，句中 to which it is capable of dealing with variations in the parts or products it produces. 为定语从句修饰 the degree。

6. The requirement for continuous production of different work unit styles is that the manufacturing system be designed so that whatever adjustments need to be made from one part or product style to the next, these adjustments can be made quickly enough that it is economical to produce the units in batch sizes of one.

连续生产不同机件类型的要求是制造系统按如下目标进行设计，从一种零件或产品类型转换到另一种时所要进行的各种调整必须足够快，这样按批量进行生产才是经济的。

整个句型为表语从句“The requirement is that…”，在表语从句中 so that 又引出目的状语从句。

7. In an era when new product styles are being introduced with ever-shortening life cycles, the cost of designing, building, and installing a new manufacturing system every time a new part or product must be produced is becoming prohibitive, both in terms of time and money.

当引入的新产品类型的生命周期越来越短的时候，每生产一种零件或产品就要重新设计、建造、安装一个新的制造系统，在时间和金钱方面的代价都正变得昂贵（起来）。

此句中 when 引出定语从句，做 era 的定语，整个句形的主干为“the cost is becoming prohibitive, both in terms of time and money.”句中“every time”相当于“when”。

8. Even though the production machines in the system are dedicated to one product, they are nevertheless computer numerical controlled to allow for upgrades in software, engineering changes in the part currently produced, and changeover of the equipment when the production run finally ends.

尽管系统中的机器专用于某一产品，然而它们仍然是计算机数控的，考虑到软件的升级、正在生产的零件的工程更改以及生产运行最终完成后的装备更换。

此句话为让步状语从句，由 Even though 引出，句中“to allow for…”为不定式做目的状语，意思是“把……考虑进去”，句后“upgrades in software”，“engineering changes in the part currently produced”，“changeover of the equipment”为并列成分。