Chapter 1
Intelligent Manufacturing and Manufacturing Intelligence

Manufacturing is a prime generator of wealth and is critical in establishing a sound basis for economic growth. Manufacturing is also the cornerstone of all economic activities, and efforts to continuously advance manufacturing technology are therefore vital to a richer and more stable future. Intelligent Manufacturing (IM), believed to be the next generation advanced manufacturing paradigm is extensively investigated by industry and academia. In this chapter, we firstly recall the course of manufacturing development and summarize the characteristics of the four revolutions in this course. Subsequently, the broad sense of ‘manufacturing’ is articulated and the characteristics of manufacturing activities in the operation of manufacturing processes are depicted. The differences and relationships between Artificial Intelligence (AI) and Manufacturing Intelligence (MI) are then presented. The background of intelligent manufacturing, the attributes of intelligent manufacturing technology and the future development of intelligent manufacturing system are described. Lastly, a summary of this chapter is given.

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INTRODUCTION

Manufacturing has played, and continues to play, a vital role in the world economy. In recent years, manufacturing has undergone profound changes because of the development of science and technology, the requirements of global manufacturing and the changing manufacturing environment. Changes have to be made in order to satisfy the increasingly changing and diversified demands of customers. These changes are bringing manufacturing from a resource-based centralized paradigm to a knowledge-intensive, innovation-based, adaptive, digital and networked one. Integration and intelligence are two vital factors of modern manufacturing. Looking at the history and the present state of manufacturing, it is clear that there have been four revolutions according to the four stages of manufacturing industrial development (Wang, 2005). These are the age of craftsmanship, the age of machines and hard automation, the age of information and flexible automation, and the age of knowledge and intelligent automation.

In the age of craftsmanship, all manufacturing activities from raw materials to finished products
were entirely performed by physical labor, in which a person with hand tools was used to make objects. The quality of products relied very much on individual skills. As technology progressed, such as animal, wind and water power were gradually employed, and more sophisticated tools were developed, but the basic structure of craft-based production remained unchanged.

The industrial revolution that dates back 200 years brought manufacturing to the age of machines and hard automation, and machinery has played an increasingly prominent role since then. In the early days, the mechanization of manual procedures was the first step towards automation. In the later stage of the period of mechanization, the total process of production was analyzed and subdivided into a number of simpler production functions as products were becoming increasingly complex. Workers were carefully but rather narrowly trained to operate their own tools and specialized machines. Such a manufacturing pattern is well suited to mass production.

In the age of information and flexible automation, information processed by computers and automatic control has led to significant changes in manufacturing patterns and technologies. At the early stage of this period, a great deal of emphasis was placed on the development and application of ‘hardware’ and on the search for hard automation. In the later stage of this period, information and flexible automation have been the primary focus of development. In order to improve production efficiency, considerable effort has been placed on the development and application of new manufacturing techniques in programmable equipment (hardware: such as NC, CNC, and robotics,) and the computer-aided systems (software: such as CAD, CAPP, CAE, CAM, and so forth).

In today’s information age, manufacturing is forced to be more intelligent in order to have the power to process escalating manufacturing information and to satisfy dynamical marketing demands. With the rapid development of Artificial Intelligence (AI) and the quick improvement various related enabling technologies, the manufacturing age of knowledge and intelligent automation has already begun. The main focus in this age will be on manufacturing flexibility and adaptability in the various aspects of manufacturing, such as automatic and intelligent design, production planning and control, configuration management, intelligent decision support, automatic and intelligent failure detection and maintenance, and so on. Furthermore, Manufacturing systems’ self-organization, self-learning and adaptation according to the conditions of outside environments will also be of paramount importance. One of the developing trends of future manufacturing systems will be intelligent and knowledge-intensive systems, which focus on the integration of knowledge available from various manufacturing domains and the combination of human-computer intelligence.

**MANUFACTURING ACTIVITIES**

The word ‘manufacturing’ includes much more than the basic fabrication techniques. It involves diverse activities from raw materials to finished products during the processes of manufacturing, including marketing prediction, procurement, design, plan, fabrication, distribution, as well as recycling and services. Customer needs or marketing predictions are the beginning of manufacturing activities. Products are designed according to customer needs. Product design is a complicated process, involving conceptual design, configuration, parametrization, and manufacturable analysis. Product design is normally made accessible to a planning subsystem, including process planning, scheduling and manufacturing resource planning, which transforms product design into production plan and manufacturing resource plan. After the plans are developed, the product can then be manufactured. With the rapid development of manufacturing intelligence and information technology, the process of pro-
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