Manufacturing Systems Design and Analysis

Manufacturing Systems Design and Analysis

B. Wu

Department of Manufacturing and Engineering Systems, Brunel University, Middlesex, UK

CHAPMAN & HALL
London · New York · Tokyo · Melbourne · Madras

Published by Chapman & Hall, 2–6 Boundary Row, London SE1 8HN

Chapman & Hall, 2–6 Boundary Row, London SE1 8HN, UK

Van Nostrand Reinhold Inc., 115 5th Avenue, New York NY10003, USA

Chapman & Hall Japan, Thomson Publishing Japan, Hirakawacho Nemoto Building, 7F, 1-7-11 Hirakawa-cho, Chiyoda-ku, Tokyo 102, Japan

Chapman & Hall Australia, Thomas Nelson Australia, 102 Dodds Street, South Melbourne, Victoria 3205, Australia

Chapman & Hall India, R. Seshadri, 32 Second Main Road, CIT East, Madras 600 035, India

First edition 1992

© 1992 B. Wu

Typeset in Times by Best-set Typesetter Ltd, Hong Kong

Printed in Great Britain by Page Bros, Norwich

ISBN 0 412 40840 6 0 442 31475 2 (USA)

Apart from any fair dealing for the purposes of research or private study, or criticism or review, as permitted under the UK Copyright Designs and Patents Act, 1988, this publication may not be reproduced, stored, or transmitted, in any form or by any means, without the prior permission in writing of the publishers, or in the case of reprographic reproduction only in accordance with the terms of the licences issued by the Copyright Licensing Agency in the UK, or in accordance with the terms of licences issued by the appropriate Reproduction Rights Organization outside the UK. Enquiries concerning reproduction outside the terms stated here should be sent to the publishers at the London address printed on this page.

The publisher makes no representation, express or implied, with regard to the accuracy of the information contained in this book and cannot accept any legal responsibility or liability for any errors or omissions that may be made.

A catalogue record for this book is available from the British Library

Library of Congress Cataloging-in-Publication data
Wu, B. (Bin), 1957–
Manufacturing systems design and analysis/B. Wu.

p. cm.
Includes bibliographical references and index.
ISBN 0–412–40840–6. — ISBN 0–442–31475–2 (USA)
1. Production engineering. 2. Manufacturing processes.
I. Title.
TS176.W8 1992
670.42'7—dc20 91–30683
CIP

Preface

A technological book is written and published for one of two reasons: it either renders some other book in the same field obsolete or breaks new ground in the sense that a gap is filled. The present book aims to do the latter. On my return from industry to an academic career, I started writing this book because I had seen that a gap existed. Although a great deal of information appeared in the published literature about various technical aspects of advanced manufacturing technology (AMT), surprisingly little had been written about the systems context within which the sophisticated hardware and software of AMT are utilized to increase efficiency. Therefore, I have attempted in this book to show how structured approaches in the design and evaluation of modern manufacturing plant may be adopted, with the objective of improving the performance of the factory as a whole. I hope this book will be a contribution to the newly recognized, multidisciplinary engineering function known as manufacturing systems engineering. The text has been designed specifically to demonstrate the systems aspects of modern manufacturing operations, including: systems concepts of manufacturing operation; manufacturing systems modelling and evaluation; and the structured design of manufacturing systems.

One of the major difficulties associated with writing a text of this nature stems from the diversity of the topics involved. I have attempted to solve this problem by adopting an overall framework into which the relevant topics are fitted. This, I hope, will provide a panoramic view of the subject areas. However, the reader may find that some of the topics mentioned are only treated at a superficial level, or even omitted altogether. This is inevitable due to the broad-based nature of this book. Fortunately, most of these topics have been discussed in detail in a number of texts, which are listed as further reading materials at the end of the relevant chapter.

Although the text has been written over a relatively short time, the book builds on my work and research experience of manufacturing industry over some eight to ten years. I would like to thank Professor Ray Wild for his help and encouragement, without which the completion of this book would have been impossible. In addition, I am indebted to all of my colleagues in the Department of Manufacturing and Engineering Systems at Brunel University, from whom I have received tremendous help in many ways. In particular, I wish to thank Dr P.H. Lowe and Professor N. Slack for their invaluable advice; Mr S. Harrington for reading the draft and for making suggestions; Dr R.J. Grieve, Mr F. Schmid, Mr H. Maylor and Professor M. Sarhadi for many inspirational discussions. Sincere appreciation is also extended to the contributions made by my former students, Mr D. Harrison and Miss K.R. Matthews.

Grateful thanks are due to a number of special friends: to Mrs K. Cawsey of Cheltenham, who taught me how to use the English language 'properly', indeed, without whose teaching I would not have been in a position to start writing this book; to Mr E. Thompson and Dr D.H.R. Price, whose help during the early stages of my professional career is greatly appreciated.

I would also like to thank my editor at Chapman and Hall, Mr M. Hammond, for his professionalism and effort in putting this book together. His deadlines have taught me some new aspects of the 'just-in-time' concept! The criticisms and comments received on the manuscript of this book have been very helpful and constructive. I would like to thank the reviewers, especially Professor D.J. Williams of Loughborough University of Technology and Professor A.S. Carrie of the University of Strathclyde.

Finally, I thank my family for their continuous support and encouragement.

B. Wu

试读结束：需要全本请在线购买： www.ertongbook.com

Contents

Part One
Systems

1 Overview of manufacturing systems analysis in the technological age

1.1 Introduction

This chapter is an introduction to the background and scope of manufacturing systems engineering (MSE), a recently recognized multidisciplinary engineering function. It is the result of a new approach to manufacturing modernization and represents the core of this book.

Unlike traditional forms of engineering concerned with production, MSE adopts a systems approach to the design and operation of modern manufacturing systems. It incorporates the new manufacturing technologies and techniques into the manufacturing processes, so that manufacturing systems can efficiently support the wider company objectives.

Understanding the context and problems of modern manufacturing is the first step to appreciating the need and potential role of MSE. In this first chapter, therefore, some real-life cases will be presented, at both corporate and operational levels, to highlight the key problem areas that are being faced by today's engineers and manufacturers: the impact of accelerating technology and the impact of increasing competition. The first half of the chapter will provide those with no prior knowledge of the structure and operation of manufacturing systems with an understanding and appreciation of the background and development of manufacturing. The second half will provide an overview of the potential of manufacturing systems analysis and the interrelationships of the topics to be covered.

After studying this chapter, the reader should be able to:

1. explain the nature and context of manufacturing;
2. outline the need for and importance of manufacturing industry;
3. highlight the characteristics of new developments in manufacturing technology development;
4. describe the environmental pressures on today's manufacturing firms;
5. have a preliminary appreciation of the potentials and limitations of the newly developed manufacturing technologies;
6. recognize the need for a systems approach in manufacturing modernization; and
7. outline the content of manufacturing systems analysis, and the interrelationships of the topics involved.

1.2 Manufacturing industry in context

To understand manufacturing systems, it is first essential to appreciate the context of manufacturing, that is, the nature of manufacturing and its economic and social significance. This section does not provide a full account of these topics, which are discussed extensively elsewhere. However, the context of manufacturing will be briefly considered in an overall sense, to highlight what is involved in manufacturing and how it affects our everyday lives. It is hoped that this brief discussion will help the reader to appreciate the importance of the topic. More detailed description and analysis of the structures and functions of manufacturing systems will be given later in the book.

1.2.1 *Manufacturing defined*

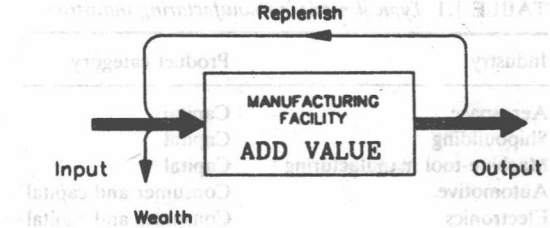
Manufacturing is the organized activity devoted to the transformation of raw materials into marketable goods. In the terminology of economics, these marketable goods are known as *economic goods*; they cannot be obtained without expenditure. This is in contrast to *free goods*, which are available in unlimited quantities at no cost. Manufacturing industry is also called a *secondary* industry, because this is the sector of a nation's economy that is concerned with the processing of raw materials supplied by the *primary* industry (agriculture, forestry, fishing, mining, extraction of minerals, and so on) into the end products. It is one of the most basic and important functions of human activity in modern industrial societies.

A *manufacturing system* usually employs a series of value-adding *manufacturing processes* to convert the raw materials into more useful forms and eventually into finished products. For example, in the process of manufacturing a machine-tool, pieces of metal are machined into parts; various parts and other items are assembled into sub-assemblies; iron ore is smelted and converted into castings; steel plates are cut into various sizes and shapes and then welded into fabrications; and finally, these are assembled into the machine-tools.

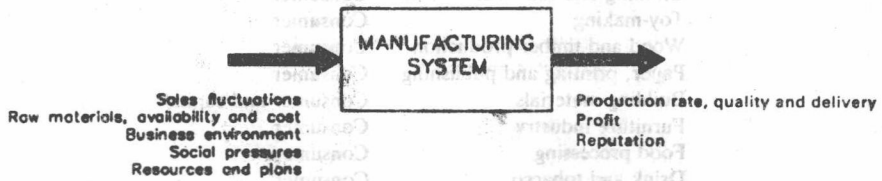
The outputs from one manufacturing system may be utilized as the inputs to another. For example, in the United States, approximately 20 per cent of steel production and about 60 per cent of rubber products are used by the automotive manufacturing industry. The automotive industry is also one of the major consumers of machine-tools, paints and glass, and so on. A manufacturing system is, therefore, a typical input–output system which produces outputs (economic goods) through activities of transformation from inputs (which are also called *factors of manufacturing*). This is why many authors in this field have adopted an input–output approach to represent a manufacturing system in an overall sense. Figure 1.1 gives three such examples.

Although the systems in general may be represented in a homogeneous manner, as illustrated in Fig. 1.1, the actual manufacturing activities are in fact highly diversified – more than 450 separate manufacturing industries have been identified with their products classified into about 20 major groups. These belong to two principal categories: *consumer goods* and *capital goods*. Some examples of typical modern manufacturing industries are listed in Table 1.1.

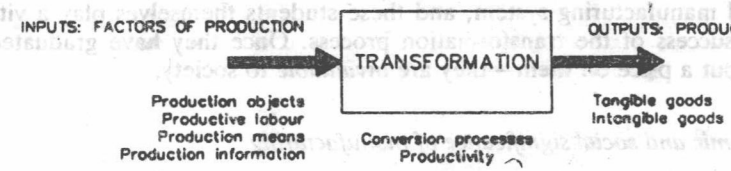
试读结束：需要全本请在线购买： www.ertongbook.com



a) Wealth creation by manufacturing (Source: Lupton [1986])



b) Overall view of manufacturing system (Parnaby [1978])



c) Basic meaning of manufacturing (Hitomi [1979])

Fig. 1.1 *Input–output models of manufacturing*

It is interesting to note that even a university system is analogous to a manufacturing organization, where fresh students are taken into the system and through a series of educational processes transformed into highly valuable professionals. The lectures, seminars, tutorials, and laboratory work are all designed to carry out the transformation process – equivalent to the manufacturing processes involved in an actual manufacturing system. The quality of the transformation process is continuously monitored by tests, assessments and examinations. In the end, for those who have passed the final exams and other assessments, a degree certificate is issued to indicate that the individual con-

TABLE 1.1 *Typical modern manufacturing industries*

Industry	Product category
Aerospace	Capital
Shipbuilding	Capital
Machine-tool manufacturing	Capital
Automotive	Consumer and capital
Electronics	Consumer and capital
Computer manufacturing	Consumer and capital
Computer software	Consumer and capital
Metal, coal, oil	Consumer and capital
Chemical industry	Consumer and capital
Textile industry	Consumer
Leather and fur	Consumer
Clothing and footwear	Consumer
Toy-making	Consumer
Wood and timber production	Consumer
Paper, printing and publishing	Consumer
Building materials	Consumer and capital
Furniture industry	Consumer
Food processing	Consumer
Drink and tobacco	Consumer

cerned has successfully completed the transformation process – analogous to the 'pass' certificate of a product. The difference is, of course, that the manufacturing factors here are the students rather than the actual materials involved in a conventional manufacturing system, and these students themselves play a vital part in the success of the transformation process. Once they have graduated, you cannot put a price on them – they are *invaluable* to society.

1.2.2 *Economic and social significance of manufacturing*

In an industrialized country, manufacturing industries may be viewed as the backbone of the nation's economy, because it is mainly through their activities that the real wealth is created. It has been estimated that in such a country on average about a quarter of the population is involved in some form of manufacturing activity, and the rest of the population benefits from the products (Harrington, 1984). In the United Kingdom, for example, manufacturing industries (process industries, plus capital and consumer products manufacturers) generate approximately 30 per cent of the nation's wealth and employ 32 per cent of the working population. Furthermore, the jobs of half of those employed in non-manufacturing sectors of the country depend on the close links that exist between these sectors and the manufacturing industries.

To any industrialized country, manufacturing is important internally as well as externally. The internal significance factors are continued employment, quality of life, and the creation and preservation of skills. The external factors are national defence, and the nation's position and strength in world affairs.

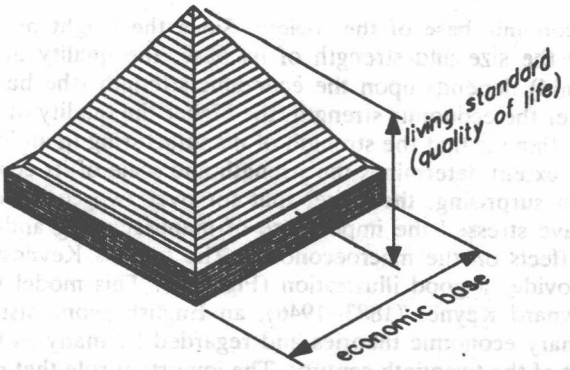


Fig. 1.2 *Relationship between upper structure and economic base*

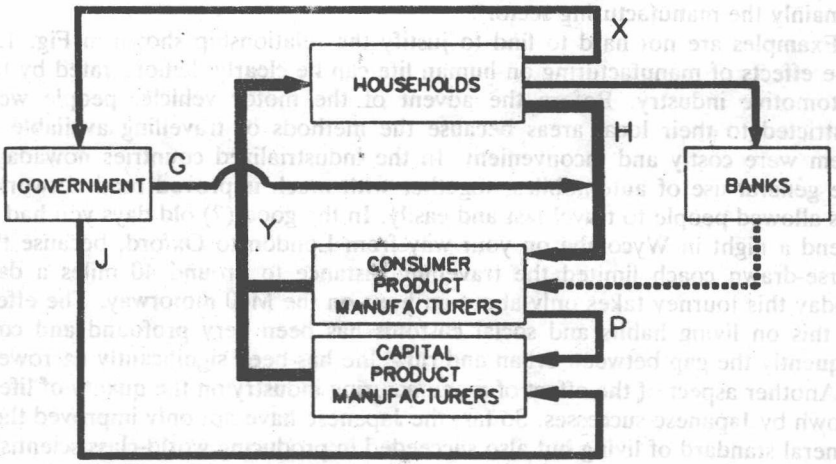


Fig. 1.3 *Simplified Keynesian macroeconomic model illustrating the important role of manufacturing firms*

The internal significance of manufacturing in a society may be demonstrated by Fig. 1.2. In this figure the various aspects of a social structure (whether based on capitalism or socialism) are represented by a pyramid. The upper structure of the society, representing the quality aspects of life, must be built up

on the economic base of the society. Since the height of a pyramid is determined by the size and strength of its base, the quality of life (the height of the pyramid) depends upon the economic strength (the base of the pyramid). The greater the economic strength, the higher the quality of life may reach. The important thing is that the strength of manufacturing in an industrialized society to a great extent determines the strength and scale of its economic base.

It is not surprising, therefore, that for over two centuries many prominent people have stressed the importance of manufacturing and attempted to evaluate its effects on the macroeconomy. The famous Keynesian macroeconomic model provides a good illustration (Fig. 1.3). This model was popularized by John Maynard Keynes (1883–1946), an English economist best know for his revolutionary economic theories and regarded by many as the most influential economist of the twentieth century. The important role that manufacturing plays in the macroeconomy is clearly demonstrated in this model. Kaldor (1966), for example, summarized the relationship very well: 'Fast rates of economic growth are associated with fast rate of growth of the "secondary" sector of the economy – mainly the manufacturing sector'.

Examples are not hard to find to justify the relationship shown in Fig. 1.2. The effects of manufacturing on human life can be clearly demonstrated by the automotive industry. Before the advent of the motor vehicle, people were restricted to their local areas because the methods of travelling available to them were costly and inconvenient. In the industrialized countries nowadays, the general use of automobiles, together with much improved road networks, has allowed people to travel fast and easily. In the good (?) old days you had to spend a night in Wycombe on your way from London to Oxford, because the horse-drawn coach limited the travelling distance to around 40 miles a day. Today this journey takes only about an hour on the M40 motorway. The effect of this on living habits and social customs has been very profound and consequently the gap between urban and rural life has been significantly narrowed.

Another aspect of the effect of manufacturing industry on the quality of life is shown by Japanese successes. So far, the Japanese have not only improved their general standard of living but also succeeded in producing world-class scientists, economists, managers, engineers, athletes and artists – partly because the success of their manufacturing industries has created enduring wealth and enabled the country to afford the extensive training needed for the talented.

To summarize, the development, prosperity, welfare and living standards of a nation depend to a great extent upon the success of its manufacturing industries. Hence the internal importance of manufacturing to the people of a society cannot be overstressed.

The external significance of manufacturing industry is well summarized by Hall (1987):

> National defence depends on production. High-tech or low-tech, weapons must be produced. Nations with little production capability must use scarce resources to buy them from others, and what they buy is seldom the latest model. A nation that is able to design weapons, but not produce them with quality and quantity, also has a major weakness. . . .

During World War II, production capability was obviously a very big factor. How much this has continued . . . is subject to debate, but there is less question that political weight in the world is substantially affected by manufacturing capability.

1.3 The new environment

In section 1.2, the context of manufacturing was outlined briefly in terms of its nature and its economic and social value. It is clear that for an industrial nation such as the United Kingdom, it is of vital importance continuously to improve the performance of manufacturing industry.

Both the means and structures of manufacturing and the environment within which manufacturing systems operate have changed radically. For modern manufacturing industry to be successful in terms of both immediate profit and long-term competitiveness in today's business environment it is essential for everyone involved to have a sound understanding of these changes.

1.3.1 *History of manufacturing development: the three revolutions*

Looking back at history, and at the present state of manufacturing industry, it is clear that there have been three revolutions corresponding to the three stages of industrial development.

The Neolithic Revolution: the age of craftsmanship

Manufacturing industry has its origins in the neolithic period (also called the New Stone Age, between the age of chipped-stone tools and the early period of metal tools about 10000–20000 years ago) when men became herdsmen and cultivators. Archaeological investigation has shown that neolithic man had techniques for grinding corn, baking clay and weaving textiles. In fact new techniques were developed for both primary and secondary industries. Trade in manufactured products also developed between different communities. This period is regarded by many as the age of the Neolithic Revolution – the revolution which marked the beginning of the age of craftsmanship. In this stage of industrial development, each individual craftsman was responsible for a total production process, from raw material to finished product, and manufacturing activities were entirely powered by human muscle – this is reflected by the fact that the word 'manufacturing' itself derives from two Latin words meaning literally 'hand-making'. As technology progressed, more sophisticated tools were developed. Animal, water and wind power were gradually employed in certain areas, but the basic structure of craft-based production remained unchanged.

The Industrial Revolution: the age of mechanization

The age of craftsmanship lasted for centuries until the Industrial Revolution took place in England and other countries in the eighteenth century. The

changes in production techniques from the sixteenth to the eighteenth century laid the foundations of modern industrial production – changes from an agriculture- and craftsman-based economy to one dominated by industry and machine manufacture.

The Industrial Revolution marked the beginning of the age of mechanization. In a machine-dominated factory, the worker obtained new and distinctive skills and his profession changed – from that of craftsman working with hand-tools to that of machine operator subject to factory discipline.

The later stages of the period of mechanization in the early years of the twentieth century were characterized by the analytical study of the production process and the development of scientific management. As the production process became more complex, the total process was analysed and subdivided into a number of simpler production functions. Workers were carefully but rather narrowly trained to operate their own tools and specialized machines with much improved efficiency. The car assembly line at Ford's automobile factory was a classical example of such a production organization – a manufacturing system particularly suited for mass production. Until recently, 'mechanization' has been the key word in manufacturing industries. The concept of mass production was characterized by certain factors such as:

- a stable and 'monochromatic' market;
- long product life cycles and production runs;
- stabilized engineering designs;
- industrial engineering based on breaking a job down into its parts; and
- repetitive operations carried out by each worker.

The New Industrial Revolution: the age of information and automation

The manufacturing industries are now in the midst of a new technological revolution. This revolution, characterized by the increasing application of computers for both information processing and automatic control, has led to significant changes in the techniques of manufacturing. During the first two stages of industrial development, the key issues related to either hand-tool creation and refinement, or machine innovation and power utilization, that is to say, the emphasis was on the development and application of 'hardware'. The latest revolution in manufacturing is different – it has been brought about by advances in computer and information technologies which put more emphasis on information and control than on hardware refinement. The similarity is that just as tools and machines increased the physical abilities of man, so the application of computer and information technologies are heightening his mental abilities.

The third age of industrial development has been accompanied by the evolution of powerful and cheap data-processing systems. This process is taking place in the majority of today's manufacturing organizations.

This development of advanced manufacturing technology (AMT) has attracted much attention. Much recent interest in improving production efficiency has focused upon the development and application of new manufacturing techniques in the following areas:

试读结束：需要全本请在线购买： www.ertongbook.com