

AGILE MANUFACTURING:
THE 21ST CENTURY
COMPETITIVE STRATEGY

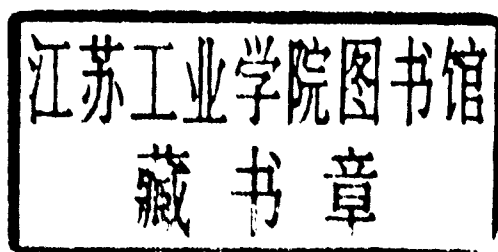
A. Gunasekaran

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2001

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First edition 2001

Library of Congress Cataloging in Publication Data

A catalog record from the Library of Congress has been applied for.

British Library Cataloguing in Publication Data

A catalogue record from the British Library has been applied for.

ISBN: 0-08-043567-X

Ⓢ The paper used in this publication meets the requirements of ANSI/NISO Z39.48-1992 (Permanence of Paper).
Printed in The Netherlands.

**AGILE MANUFACTURING:
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PREFACE

Manufacturing has undergone many evolutionary stages and paradigm shifts. The paradigm shifts in going from a craft industry to mass production, then to lean manufacturing, and finally, to agile manufacturing (AM). The concept of agility (flexible and quick responsive manufacturing) will reduce time to reach market with appropriate products/services.

Businesses are restructuring and re-engineering themselves in response to the challenges and demands of the 21st century. The businesses of the 21st century will have to overcome the challenges of demanding customers who will seek high-quality, low-cost products that are relevant to their specific and rapidly changing needs. The time during which many companies competed based primarily on price tag has gone. Now is the time for companies to compete in the global marketplace, and “push the envelope” in delivery-response, product quality, and overall excellence in customer service and customer satisfaction. Agility addresses new ways of running companies to meet these challenges.

Agile manufacturing is defined as the capability of surviving and prospering in a competitive environment of continuous and unpredictable change by reacting quickly and effectively to changing markets, driven by customer-designed products and services. Critical to successfully accomplishing AM are a few enabling technologies such as the standard for the exchange of products (STEP), concurrent engineering, virtual manufacturing, component-based hierarchical shop floor control system, information and communication infrastructure, etc.

The aim of the book is to help the students at the undergraduate and graduate levels, senior managers and researchers in understanding and appreciating the concepts, design and implementation of Agile Manufacturing systems (AMS). One should be able to understand, develop and implement appropriate agile manufacturing strategies after reading this book.

The scope of the book is to present the undergraduate and graduate students, senior managers and researchers in manufacturing systems design and management, industrial engineering and information technology with the conceptual and theoretical basis for the design and implementation of AMS. The book emphasizes on systems methodology approach for the design and implementation of AMS. Also, the book focuses on broad policy directives and plans of agile manufacturing that guide the monitoring and evaluating the manufacturing strategies and their performance. A problem solving approach is taken throughout the book, emphasizing the context of agile manufacturing and the complexities to be addressed.

This book provides a much needed comprehensive coverage of materials required developing and implementing agile manufacturing strategies and systems. The book includes the concept, theory, modelling, and architecture of agile manufacturing system. It covers the state-of-the-art, concepts and methodologies of manufacturing strategy development taking into account the current development in information technologies and the overall trend in agile manufacturing. The book is expected to assist the companies in formulating 21st century manufacturing strategies to flourish in the competitiveness of manufacturing.

The book presents original works and interesting case studies arising from research with the evolving technologies and production concepts of agile manufacturing. The book aims to promote the ideas and technologies that promote agile manufacturing as company wide strategies to reduce the lead times at all stages of manufacturing. The chapters offer ideas on lowering manufacturing costs, increasing market share, satisfying the customer requirements, rapid introduction of new products, eliminating non-value added activities and enhancing manufacturing competitiveness. The book is organized into six parts to cover the introduction, design and development, information technology/systems, supply chain management, operations management and strategies of agile manufacturing. The chapters deal with the following areas as a part of agile manufacturing system development: concepts, strategies and enablers of agile manufacturing, virtual enterprise, managing people in agile organizations, product development in agile environment, application of Information Technology/Systems in agile manufacturing, supply chain management in agile environment, operations planning and control in agile manufacturing enterprise and some strategic approach for the development of agile manufacturing.

The Editor of this book acknowledges Dr. Martin Ruck, Publishing Editor for Industrial Engineering and Control and the staff of Elsevier Science Ltd (UK) for their great support in completing this book.

I am most grateful to my wife, Latha Parameswari and my son Rangarajan for their generous support and permission for staying away during family time in order to complete this edited book. I appreciate the countless hours spent by my wife for proof reading of all the chapters. My heartfelt thanks go to all the authors who have contributed chapter(s) to this book. Without their contribution and overall support, this book should have been hardly realized.

A. Gunasekaran
Editor
June 6, 2000

CONTENTS

<i>Preface</i>	v
 PART I - INTRODUCTION TO AGILE MANUFACTURING	
Agile Manufacturing as the 21st Century Strategy for Improving Manufacturing Competitiveness <i>Henrique Luiz Corrêa</i>	3
Agile Manufacturing: Concepts and Framework <i>A. Gunasekaran, R. McGaughey and V. Wolstencroft</i>	25
 PART II - DESIGN AND DEVELOPMENT OF AGILE MANUFACTURING SYSTEMS	
A Strategic Approach to Develop Agile Manufacturing <i>Jens O. Riis and John Johansen</i>	53
BM_Virtual Enterprise Architecture Reference Model <i>G.D. Putnik</i>	73
Integrated Product/Process Development (IPPD) Through Robust Design Simulation (RDS) <i>Daniel P. Schrage and Dimitri N. Mavris</i>	95
Developing the Agile Enterprise <i>John Bessant, David Knowles, David Francis and Sandra Meredith</i>	113
Towards Building of Knowledge-Base in Indian Corporations: Some Strategic Directions <i>R.P. Mohanty</i>	131
Enhancing Agility in Manufacturing: The Role of QFD <i>David Ginn, Mohamed Zairi and P.K. Ahmed</i>	157
Product Development Strategies for Agility <i>Sudi Sharifi and Kulwant S. Pawar</i>	175
Managing People in Agile Organisations <i>David Francis</i>	193

PART III - INFORMATION TECHNOLOGY/SYSTEMS IN AGILE MANUFACTURING

Application of Information Technology in Agile Manufacturing <i>Henry C.W. Lau and Eric T.T. Wong</i>	205
Information Systems for Agile Manufacturing Environment in the Post-Industrial Stage <i>S. Subba Rao and A. Nahm</i>	229
Management of Complexity and Information Flow <i>E. Szczerbicki</i>	247
An Object-Oriented Optimization-based Software for Agile Manufacturing in Process Industries <i>M. Draman, I.K. Altinel, N. Bajgoric, A.T. Unal and B. Birgoren</i>	265
Application of Multimedia in Agile Manufacturing <i>Ronald E. McGaughey</i>	279
Computational Intelligence in Agile Manufacturing Engineering <i>Kesheng Wang</i>	297
Computer Applications in Agile Manufacturing <i>M.A. Pego Guerra and W.J. Zhang</i>	317
Secure Communication in Distributed Manufacturing Systems <i>István Mezgár and Zoltán Kincses</i>	337

PART IV - SUPPLY CHAIN MANAGEMENT IN AGILE MANUFACTURING

Agile Supply Chain Management <i>J. Sarkis and S. Talluri</i>	359
Engineering the Agile Supply Chain <i>Denis R. Towill</i>	377
Information Technologies for Virtual Enterprise and Agile Management <i>Nijaz Bajgoric</i>	397
Early Supplier Involvement: A Design-Based Sourcing <i>Shad Dowlatshahi</i>	417
Information Technologies in Supply Chain Management <i>Alexander V. Smirnov and Charu Chandra</i>	437
Enterprise Integration and Management in Agile Organizations <i>F.B. Vernadat</i>	461

Agility, Adaptability and Leanness: A Comparison of Concepts and a Study of Practice <i>Hiroshi Katayama and David Bennett</i>	483
---	-----

PART V - OPERATIONS OF AGILE MANUFACTURING SYSTEMS

Computer Control of Agile Manufacturing Systems <i>Robert W. Brennan</i>	499
Computer Aided Process Planning for Agile Manufacturing Environment <i>Neelesh K. Jain and Vijay K. Jain</i>	515
Aggregate Capacity Planning and Production Line Design/Redesign in Agile Manufacturing <i>Z. -S. Hua and P. Banerjee</i>	535
The Control Problems of Agile Manufacturing <i>B. Ilyasov, L. Ismagilova and R. Valeeva</i>	559
Contingency-Driving Autonomous Cellular Manufacturing - Best Practice in the 21st Century <i>S.-J. Song</i>	583
Role of IT/IS in Physically Distributed Manufacturing Enterprises <i>Walter W.C. Chung and Michael F.S. Chan</i>	601
The Method of Successive Assembly System Design Based on Cases Studies within the Swedish Automotive Industry <i>T. Engström, D. Jonsson and L. Medbo</i>	621

PART VI - STRATEGIC APPROACH FOR AGILE MANUFACTURING

Reengineering and Agile Manufacturing Development <i>G. Doumeingts, H. Kromm, Y. Ducq and S. Kleinhans</i>	645
Corporate Knowledge Management in Agile Manufacturing <i>Michael Thie and Dragan Stokic</i>	665
Agile Manufacturing Strategic Options <i>Vicky Manthou and Maro Vlachopoulou</i>	685
Virtual Enterprise Engineering in Support of Distributed and Agile Manufacture <i>R.H. Weston, R. Harrison and A.A. West</i>	703
Putting the Pieces Together Using Standards <i>Ricardo Jardim-Gonçalves and Adolfo Steiger-Garção</i>	735
Enterprise Integration and Management <i>R.H. Weston and A. Hodgson</i>	759

Gaining Agility Through Supply Chain Management <i>Tareq Suleman and Mohamed Zairi</i>	785
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AUTHOR INDEX	809
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Part I

INTRODUCTION TO AGILE MANUFACTURING

Agile Manufacturing as the 21st Century Strategy for Improving Manufacturing Competitiveness

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1. DEFINITION OF MANUFACTURING STRATEGY

Manufacturing strategy has increasingly been regarded by academics and practitioners as having an important contribution to make to enhance competitiveness. The growth of the literature in manufacturing strategy has matched the growth of interest in the area. Within the literature three main reasons are identified for this newly found importance.

The first is the increased pressure owing to the growing international manufacturing competitiveness made more intense by the recent movement towards globalisation. The second is the increased potential to be gained from the development of new manufacturing technologies, the potential of which grows much faster than our ability to use it for competitive benefits and, the third is the development of a better understanding of the strategic role of manufacturing. Five characteristics can be listed to help understand the need for a strategic management of the manufacturing function:

- Manufacturing in general involves the bulk of the company's assets and human resources
- Many decisions regarding manufacturing resources require a long time to take effect therefore requiring a long term outlook of the future to support them
- Once made, many of these decisions will normally take a long time and substantial amounts of resources to revert
- Manufacturing decisions directly affect the way companies can compete in the market place because it is increasingly accepted that there is not such a thing as a "best way" to manage manufacturing resources - different configurations of manufacturing resources will result in different levels of manufacturing performance in different aspects (e.g. delivery, flexibility, quality and cost)
- Manufacturing decisions have to support and be supported by other functions in order to properly support the business strategy of the company, therefore requiring strategic orientation

Manufacturing strategy can be defined as a framework whose objective is the increased competitiveness of the organisation: to achieve this it should aim at designing, organising, managing and developing the company's manufacturing resources and shape a consistent pattern of manufacturing decisions in order that they can result in an adequate mix of

performance characteristics which will allow the company to compete effectively in the future.

2. THE CHANGING INTERNATIONAL MANUFACTURING COMPETITION IN THE '60s, '70s AND '80s

During the 60s, 70s and 80s, the relative competitive positions occupied by the formerly leading industrial countries changed substantially. Some traditional industrial nations were outperformed by other countries, of which Japan was the most evident example. The United States and the United Kingdom had their leading positions challenged and in many cases lost them, e.g. in the automobile market, long dominated by American companies.

Considering the Japanese manufacturing industry, Buffa (1984) notices that the industries in which they excelled during that period - motor cycles, domestic appliances, automobiles, cameras, hi-fi, and steel production - there were, already developed markets with established market leaders. According to the author, Japanese companies may have succeeded, partially because of their Finance and Marketing related skills, but largely because of the high quality and low cost which they achieved through a sharp manufacturing practice which most of the Western manufacturers initially were not able to match. Japanese companies were using the improvements which they had been achieving in manufacturing as their main competitive advantage, as opposed to the Western companies, which had considered manufacturing as a 'solved problem', focusing their attention on getting competitive advantage through achieving excellence in marketing their products and managing their financial issues.

Not only were Japanese companies on average more cost efficient than most Western companies (though there were many exceptions of Western companies which had maintained or improved their competitive position in the world market during those decades), but they were competing and winning based also on their better quality and reliability performance as well as on their better responsiveness to the market needs and opportunities. In the introduction of new products, for instance, Japanese car manufacturers had cut their product development times (the period between the earliest stages of design and the manufacture of a new model) to an average of less than four years compared to six to eight years in Europe and America of the '70s.

There is, in general, agreement that (initially, at least) Western companies lacked an effective response to the Japanese challenge. According to the literature, the reasons behind this lack of an effective response are various. Hayes and Wheelwright (1984), in their now classic book, summarize some of them in five main points:

Financial considerations The assessment of companies and their manager's performance based predominantly on short term considerations may have induced managers to avoid long term investments which might have resulted in a more effective manufacturing. Managers may not have decided to invest in improvements whose results would only show in the long term because they needed short term performance.

Technological considerations Western managers would have been less sophisticated, imaginative and even less interested in dealing with technological considerations than the overseas competitors, focusing attention predominantly on financial and marketing issues.

Excessive specialization and/or lack of proper integration Western managers would have tended to separate complicated issues into simpler, specialized ones to a greater degree than their foreign counterparts without having developed proper integration to pull the differentiated responsibilities together and to be able to deal with the total picture.

Lack of focus The separating and specializing mentality would have led many Western firms to diversify away from their core technologies and markets. They would have tended to adopt the *portfolio* approach, used by stocks and bonds investors. This approach considers that diversifying is the best way to hedge against random setbacks. Manufacturing, however, would not be subject only to random setbacks but, more significantly, to carefully orchestrated attacks from competitors who focus their resources and energy on one particular set of activities. Focused manufacturing is based on the idea that simplicity, repetition, experience and homogeneity in manufacturing tasks breed competence (Skinner, 1974).

Inertia Skinner (1985) observed that most factories in the Western world were not managed very differently in the 1970s from the way they were in the 1940s or 1950s. Such practices might have been adequate when production management issues centered largely on efficiency and productivity. However, the problems of operations managers moved far beyond mere physical efficiency. On top of this, managers considered that the production problems were solved, directing attention and resources toward other issues such as distribution, packaging and advertising. According to Hill (1995), there had been a failure, conscious or otherwise, of Western industries and the society at large to recognize the size of the foreign competitive challenge, its impact on their way of life, and consequently to recognize the need for change.

The result of the concurrence of the five factors above is that Western plants and equipment were allowed to age in all senses. What one day had been technological advantage, was eroded by the decline in expenditure and attention to issues such as new products research and development and new process technologies (Hayes and Wheelwright, 1984). Then, Hayes and Wheelwright conclude, "in the beginning of the 1970s, US companies found themselves pitted against companies that did compete on dimensions such as defect-free products, process innovation and delivery dependability. Increasingly, they found themselves displaced first in international markets and then in their home market as well".

2.1. The development of a better understanding of the strategic role of manufacturing

Since the seminal work of Skinner (see e.g. Skinner, 1969), a number of authors have addressed the strategic role of the manufacturing function. Hayes and Wheelwright (1984) and later Hayes et al. (1988) called attention to the need to transform the manufacturing role from being primarily reactive to being *proactive*, where the manufacturing function contributes actively to the achievement of competitive advantage.

Another point which some authors make, e.g. Slack (1991) refers to the fact that the complexity of the manufacturing function calls for strategic management. According to Slack, manufacturing is almost certainly the largest (both in terms of people and capital employed), and probably the most complex and arguably the most difficult of all the functions within the organization to manage.

Hill (1995) argues that the need for a manufacturing strategy to be developed and shared by the business has to do not only with the critical nature of manufacturing within the corporate strategy but also with a realization that many of the decisions in manufacturing are structural in nature. Therefore, unless the issues and consequences are fully appreciated by the business, then it can be locked into a number of manufacturing decisions, which may take years to change. Changing them is costly and time consuming, but even more significantly, the changes will possibly come too late.

More recently some authors (Hayes and Pisano, 1996; Teece and Pisano, 1994; Pisano, 1997; Alher, 1998) have added to the debate by arguing that the recently developed resource-based view of strategic management should play an important role in the development of

manufacturing strategy - the resource-based view would help manufacturing strategies to be more difficult to copy resulting in more sustainable competitive advantages. This concept will be further developed later in this chapter.

2.2. Focused manufacturing: a controversial concept

Although the manufacturing function is regarded as one of the most complex to manage within the organization, what creates the complexity is not the technology dimension but the number of aspects and issues involved, the interrelated nature of these and the level of fit between the manufacturing task and its internal capability (Hill, 1995). The level of complexity involved depends largely on corporate and marketing strategy decisions, made within the business, where the competitive priorities are established. These competitive priorities are established because a manufacturing system cannot excel in all aspects of performance at the same time. Trade-offs must be made. Different types of performance demand different manufacturing resources organized in different ways (Slack, 1991; Skinner, 1996). An organization which competes predominantly on cost efficiency, for instance, by manufacturing in high volumes, would need different resources (possibly more dedicated machines) in order to compete effectively if compared to an organization competing on product customization, making products to order (which would possibly call for more general purpose flexible equipment).

This is the rationale behind the concept of *focused manufacturing*. According to this view, for the effective support of competitive business strategy the manufacturing function should focus each part of its manufacturing system on a restricted and manageable set of products, technologies, volumes and markets so as to limit the manufacturing objectives in which it is trying to excel. This means that if an organization has different products or product groups competing in different ways, then its manufacturing function should reflect this in the way it is subdivided and organised so as to maintain focus on what is most important for its competitiveness in the market place.

If a company competes on a broad range of products, the decision to adopt the concept of focused manufacturing can have the disturbing implication of calling for major investments in new plants and new equipment to break down the existing complexity. One alternative approach, which helps to avoid major investments, is a solution that does not involve selling big multipurpose facilities and decentralizing them into small ones. The solution could be the more practical approach of the 'plant-within-a-plant', where the existing facility is divided both organizationally and physically into plants within the original plant. Each of them would have its own facilities. Each plant-within-the-plant can in this way concentrate on its particular manufacturing task, using its own work force management approaches, production control systems, organizational structure and so forth. Each plant-within-the-plant would quickly gain experience by focusing and concentrating every element of its work on those limited essential objectives which constitute its manufacturing task or focus.

The idea of focus should thus permeate all the process of formulation and execution of the business and manufacturing strategies. The establishment of competitive priorities and the decision making process should also take the idea of focus into consideration, in order to make sure that the manufacturing function can really excel in what it is expected to.

Although it is intuitive and appealing, having gained broad support among academics and practitioners, a number of authors (see e.g. Schonberger, 1986) have challenged the idea of focus in manufacturing strategy. Inspired by the Toyota-developed Japanese just-in-time system, the "lean production" system advocates argue that trade-offs do not exist (since at a