

# CHAPTER 26

## Scheduling Manufacturing Systems

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### 26.1 PROBLEM IDENTIFICATION

Scheduling is concerned with determining when, and using which, resources, jobs or orders in a factory when they are competing for the same resources (machines, tools, materials, personnel, etc.). This determination is essential for the operative part of any production planning system.

The importance of scheduling is a consequence of the demand trend to increase product variety which results in decreasing lot size, an adverse side-effect. Behind this trend lies the intention to shoulder the requirements of the market with more flexibility of the production. The main idea behind the JIT philosophy (Just-In-Time). Besides flexibility, cost reduction is also an objective of JIT. JIT aims at the reduction of stock which, traditionally, served not only to provide enough products to satisfy the market demand but also served as a buffer between different production stages (or workcells), with or without drastically reduced buffers, graceful interaction between different production processes becomes a must. This interaction again creates the role of scheduling.

However, scheduling is not a stand-alone process, and a process which is finished once executed. Instead, it is an ongoing process, highly dependent on current data in order to react to unforeseen events that might disturb the current schedule. Figure 26.1 shows scheduling as a part of a closed feedback loop together with production control and production processes. As scheduling takes place in a complex and rapidly changing environment, it is a demanding task. Better method dynamic scheduling. In effect, the efficiency and accuracy of schedules have an important impact on the success of an enterprise. Though not being the only factor, scheduling is one of the key factors used to gain flexibility and to reduce costs.

In literature as well as in the factory, the terms *planning*, *scheduling* and *dynamic scheduling* are often used as synonyms, though each has a different meaning. Therefore, classification of the terminology is necessary. Besides the definition of basic terms, the characterization of scheduling, based upon the three dimensions, *time horizon*, *production scope* and *optimal method*, has proved to be very useful and will be discussed. The final concept of section 26.2 is the representation of decision-making; therefore, GSAI nets are introduced.

Scheduling problems is a highly complex task; for example, for an subsequence of orders,  $n = 8$  to be scheduled for  $m = 3$  sequential machines, the number of possible schedules is, according to  $y = y(n, m) = 8! = 65,000,000,000,000$ . If a computer needs only 9.3 msec to compute a schedule and to evaluate it, about 205 years would be required to review all schedules. In complexity theory, the scheduling problem is known to be NP-complete; it is not likely that there exists an algorithm which can solve the problem with a time requirement not higher than a polynomial on the number of variables. Thus, it is not possible to find the optimal schedule for realistic problems by mere calculation. Instead, the task of a scheduler is to compute a good schedule; that is, a schedule which at least satisfies the most important objectives at hand. A number of methods to reduce the set of possible solutions with respect to certain objectives is commonly used. Sections 26.4 and 26.6 present some OR (Operation Research) and AI (Artificial Intelligence) methods for solving the scheduling problem. Examples of current implementation are given in section 26.5. They illustrate the use of both OR and AI techniques. Finally, section 26.6 discusses some pros and cons of the AI and the OR approach to scheduling.

# Handbook Of Design Manufacturing And Automation

**Ernest Paul DeGarmo,J. T.  
Black,Ronald A. Kohser**



## **Handbook Of Design Manufacturing And Automation:**

Handbook of Design, Manufacturing and Automation Richard C. Dorf, Andrew Kusiak, 1994 Comprehensive detailed and organized for speedy reference everything you need to know about modern manufacturing technology From concurrent engineering to fixture design for machining systems from robotics and artificial intelligence to facility layout planning and automated CAD based inspection this handbook provides all the information you need to design plan and implement a modern efficient manufacturing system tailored to your company s special needs and requirements Handbook of Design Manufacturing and Automation does more than simply present the characteristics and specifications of each technology much more Each technology is discussed both in terms of its own capabilities and in terms of its compatibility with other technologies and the trade offs involved in choosing one option over another are explored at length An entire section is devoted to the business aspects of converting to the new technologies including acquisition of automation managing advanced manufacturing technology and issues of cost and financing The focus is on incorporating these technologies into a cohesive whole an efficient cost effective manufacturing system Other important topics include Design for automated manufacturing Nontraditional manufacturing processes Machine tool programming techniques and trends Precision engineering and micromanufacturing Computer integrated product planning and control Image processing for manufacturing And much more

**DeGarmo's Materials and Processes in Manufacturing** Ernest Paul DeGarmo, J. T. Black, Ronald A. Kohser, 2011-08-30 Now in its eleventh edition DeGarmo s Materials and Processes in Manufacturing has been a market leading text on manufacturing and manufacturing processes courses for more than fifty years Authors J T Black and Ron Kohser have continued this book s long and distinguished tradition of exceedingly clear presentation and highly practical approach to materials and processes presenting mathematical models and analytical equations only when they enhance the basic understanding of the material Completely revised and updated to reflect all current practices standards and materials the eleventh edition has new coverage of additive manufacturing lean engineering and processes related to ceramics polymers and plastics

**Manufacturing Automation Management** Roger W. Bolz, 2012-12-06 Automation has been employed for many years to provide a multitude of reasonably priced products for the American consumer However it has become evident that its real character as a manufacturing systems approach needs to be examined carefully for a better appreciation In this book the purpose is to examine automation technology in its broadest sense and develop not only an understanding but also present some of the engineering and organization know how by which manufacturing management can more effectively utilize automation to improve productivity and combat rising costs in the years ahead Fundamentally this book is addressed to manufacturing managers and the material presented in a manner that will provide the knowledge for assuring success in automating In addition it highlights the manufacturing research and long range planning that will be required for creating the new manufacturing technology so necessary for assuring success in future automation efforts One

of the important facts emphasized in this text is that automation is not merely robotics or another kind or type of machinery. To effect true productivity improvement requires a fresh look at the entire production process or facility as a completely integrated system. With the developments of the past few years, rapid advances in the technology and the tools of automation have brought this imperative goal within the reasonable grasp of manufacturing management in almost every segment of industry. However, to utilize this progress, it is necessary to acquire a working understanding of all facets of automation.

*Encyclopedia of Production and Manufacturing Management* Paul M. Swamidass, 2006-09-21. The Encyclopedia of Production and Manufacturing Management is an encyclopedia that has been developed to serve this field as the fundamental reference work. Over the past twenty years, the field of production and operations management has grown more rapidly than ever, and consequently its boundaries have been stretched in all directions. For example, in the last two decades, production and manufacturing management absorbed in rapid succession several new production management concepts: manufacturing strategy, focused factory, just in time, manufacturing concurrent engineering, total quality management, supply chain management, flexible manufacturing systems, lean production, and mass customization, to name a few. This explosive growth makes the need for this volume abundantly clear. The manufacturing industry thinks and acts more broadly than it did several decades ago. The most notable change has been the need for manufacturing managers to think in technological, strategic, and competitive terms. This is a very favorable development, and it leads to manufacturing success. The entries in this encyclopedia include the most recent technical and strategic innovations in production and manufacturing management. The encyclopedia consists of articles of varying lengths. The longer articles on important concepts and practices range from five to fifteen pages. There are about 100 such articles written by nearly 100 authors from around the world. In addition, there are over 1000 shorter entries on concepts, practices, and principles. The range of topics and depth of coverage is intended to suit both student and professional audiences. The shorter entries provide digests of unfamiliar and complicated subjects. Difficult subjects are made intelligible to the reader without oversimplification. The strategic and technological perspectives on various topics give this Encyclopedia its distinctiveness and uniqueness. The world of manufacturing today is increasingly competitive. It is apparent that manufacturers must respond to these competitive pressures with technical and strategic innovation. This encyclopedia has been developed to help researchers, students, and those in the manufacturing industry to understand and implement these ongoing changes in the field.

**Using the Engineering Literature** Bonnie A. Osif, 2016-04-19. With the encroachment of the Internet into nearly all aspects of work and life, it seems as though information is everywhere. However, there is information, and then there is correct, appropriate, and timely information. While we might love being able to turn to Wikipedia for encyclopedia-like information or search Google for the thousands of links.

**SPS2022** Amos H.C. Ng, Anna Syberfeldt, Magnus Holm, 2022-05-15. The realization of a successful product requires collaboration between developers and producers, taking account of stakeholder value, reinforcing the contribution of industry.

to society and enhancing the wellbeing of workers while respecting planetary boundaries Founded in 2006 the Swedish Production Academy SPA aims to drive and develop production research and education and to increase cooperation within the production area This book presents the proceedings of the 10th Swedish Production Symposium SPS2022 held in Skövde Sweden from 26-29 April 2022 The overall theme of the symposium was Industry 5.0 Transformation Towards a Sustainable Human Centric and Resilient Production Since its inception in 2007 the purpose of SPS has been to facilitate an event at which members and interested participants from industry and academia can meet to exchange ideas The 69 papers accepted for presentation here are grouped into ten sections resource efficient production flexible production humans in the production system circular production systems and maintenance integrated product and production development industrial optimization and decision making cyber physical production systems and digital twins innovative production processes and additive manufacturing smart and resilient supply chains and linking research and education Also included are three sections covering the Special Sessions at SPS2022 artificial intelligence and industrial analytics in industry 4.0 development of resilient and sustainable production systems and boundary crossing and boundary objects in product and production development The book will be of interest to all those involved in the development and production of future products

**Tool and Manufacturing Engineers Handbook: Material and Part Handling in Manufacturing** Philip Mitchell, 1983 Get the expert advice you need to shrink handling costs reduce downtime and improve efficiency in plant operations You will use this comprehensive handbook during post design process selection and planning for establishing quality controls tests and measurements to streamline production and for managerial decision making on capital investments and new automated systems

**Tool and Manufacturing Engineers Handbook: Design for Manufacturability** Thomas J. Drozda, Charles Wick, Philip Mitchell, Ramon Bakerjian, John T. Benedict, Raymond F. Veilleux, 1983 Addresses important topics of DFM including how it relates to concurrent engineering management issues getting started in DFM how to justify using DFM applying quality tools and how DFM is affecting computer technology and vice versa Covers topics starting with the creative thinking process to combining DFM with geometric dimensioning and tolerancing Also includes product design information that designers should know when committing pen to paper or mouse to mat

*Assembly Automation and Product Design, Second Edition* Geoffrey Boothroyd, 2005-06-22 Addressing design for automated and manual assembly processes Assembly Automation and Product Design Second Edition examines assembly automation in parallel with product design The author enumerates the components processes performance and comparative economics of several types of automatic assembly systems He provides information on equipment such as transfer devices parts feeders feed tracks placing mechanisms and robots Presenting detailed discussions of product design for assembly the book contains over 500 drawings tables and equations and numerous problems and laboratory experiments that help clarify and reinforce essential concepts Highlighting the importance of well designed products the book covers design for manual assembly high speed automatic and robot

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Considine, Glenn D. Considine, 2012-12-06 The authors and editors of this Handbook have attempted to fill a serious gap in the professional literature on industrial automation Much past attention has been directed to the general concepts and philosophy of automation as a way to convince owners and managers of manufacturing facilities that automation is indeed one of the few avenues available to increase productivity and improve competitive position Seventy three contributors share their knowledge in this Handbook Less attention has been given to the What and How of automation To the extent feasible and practical within the confines of the pages allowed this Handbook concentrates on the implementation of automation Once the Go signal has been given by management concrete details not broad definitions and philosophical discussions are required To be found in this distinctly different book in the field are detailed parameters for designing and specifying equipment the options available with an evaluation of their relative advantages and limitations and insights for engineers and production managers on the operation and capabilities of present generation automation system components subsystems and total systems In a number of instances the logical extension of current technology into the future is given A total of 445 diagrams and photos and 57 tables augments detailed discussions In addition to its use as a ready reference for technical and management personnel the book has wide potential for training and group discussions at the college and university level and for special education programs as may be provided by consultants or by in house training personnel     **The Circuits and**

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quantitative and analytical approach to manufacturing processes It provides a broad coverage of the major aspects of manufacturing processes and attempts to present a balanced view of the important fundamentals analytical approaches and relevant applications Examples and end of chapter problems are included as well as a summary of formulae for each chapter

Instrument Engineers' Handbook, Volume 3 Bela G. Liptak, Halit Eren, 2018-10-08 Instrument Engineers Handbook Volume 3 Process Software and Digital Networks Fourth Edition is the latest addition to an enduring collection that

industrial automation AT professionals often refer to as the bible First published in 1970 the entire handbook is approximately 5 000 pages designed as standalone volumes that cover the measurement Volume 1 control Volume 2 and software Volume 3 aspects of automation This fourth edition of the third volume provides an in depth state of the art review of control software packages used in plant optimization control maintenance and safety Each updated volume of this renowned reference requires about ten years to prepare so revised installments have been issued every decade taking into account the numerous developments that occur from one publication to the next Assessing the rapid evolution of automation and optimization in control systems used in all types of industrial plants this book details the wired wireless communications and software used This includes the ever increasing number of applications for intelligent instruments enhanced networks Internet use virtual private networks and integration of control systems with the main networks used by management all of which operate in a linked global environment Topics covered include Advances in new displays which help operators to more quickly assess and respond to plant conditions Software and networks that help monitor control and optimize industrial processes to determine the efficiency energy consumption and profitability of operations Strategies to counteract changes in market conditions and energy and raw material costs Techniques to fortify the safety of plant operations and the security of digital communications systems This volume explores why the holistic approach to integrating process and enterprise networks is convenient and efficient despite associated problems involving cyber and local network security energy conservation and other issues It shows how firewalls must separate the business IT and the operation automation technology or AT domains to guarantee the safe function of all industrial plants This book illustrates how these concerns must be addressed using effective technical solutions and proper management policies and practices Reinforcing the fact that all industrial control systems are in general critically interdependent this handbook provides a wide range of software application examples from industries including automotive mining renewable energy steel dairy pharmaceutical mineral processing oil gas electric power utility and nuclear power

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*Handbook of Industrial Robotics* Shimon Y. Nof, 1999-03-02 About the Handbook of Industrial Robotics Second Edition Once again the Handbook of Industrial Robotics in its Second Edition explains the good ideas and knowledge that are needed for solutions Christopher B Galvin Chief Executive Officer Motorola Inc The material covered in this Handbook reflects the new generation of robotics developments It is a powerful educational resource for students engineers and managers written by a leading team of robotics experts Yukio Hasegawa Professor Emeritus Waseda University Japan The Second Edition of the Handbook of Industrial Robotics organizes and systematizes the current expertise of industrial robotics and its forthcoming capabilities These efforts are critical to solve the underlying problems of industry This continuation is a source of power I believe this Handbook will stimulate those who are concerned with industrial robots and motivate them to be great contributors to the progress of industrial robotics Hiroshi Okuda President Toyota Motor Corporation This Handbook describes very well the available and emerging robotics capabilities It is a most comprehensive guide including valuable information for both the providers and consumers of creative robotics applications Donald A Vincent Executive Vice President Robotic Industries Association 120 leading experts from twelve countries have participated in creating this Second Edition of the Handbook of Industrial Robotics Of its 66 chapters 33 are new covering important new topics in the theory design control and applications of robotics Other key features include a larger glossary of robotics terminology with over 800 terms and a CD ROM that vividly conveys the colorful motions and intelligence of robotics With contributions from the most prominent names in robotics worldwide the Handbook remains the essential resource on all aspects of this complex subject



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