CONTROL AND PROGRAMMING

IN ADVANCED MANUFACTURING

Edited by: K. Rathmill

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International Trends in Manufacturing Technology

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Control and Programming
in
Advanced Manufacturing

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International Trends in Manufacturing Technology

The advent of microprocessor controls and robotics is rapidly changing the face of manufacturing throughout the world. Large and small companies alike are adopting these new methods to improve the efficiency of their operations. Researchers are constantly probing to provide even more advanced technologies suitable for application to manufacturing. In response to these advances IFS (Publications) Ltd publish a series of books on topics that highlight the developments taking place in manufacturing technology. The series aims to be informative and educational.

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The series is intended for manufacturing managers, production engineers and those working on research into advanced manufacturing methods. Each book is published in hard cover and is edited by a specialist in the particular field.

This, the fourteenth in the series – Control and Programming in Advanced Manufacturing – is under the editorship of Keith Rathmill. The series editors are: Mike Innes and Brian Rooks.

Finally, the Publisher's gratitude is expressed to the authors whose works appear in this book.

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Foreword

Today, computers are to be found in most operations in manufacturing industry. Their influence is being felt in design, planning, production, sales and other functions. Even more important is the way that computers are breaking down these functional barriers, leading to real integrated manufacture.

Developments in computer programs and languages over the last two or three years have followed a similar trend. Now there are programs to control the individual functions, as well as software to provide the means of efficient communication between those functions. This book follows a similar pattern, with some chapters covering primary operations such as programming robots, and others dealing with the integration of those functions.

The aim of the book is to provide the reader with the most important techniques that are currently available. The papers presented have been written by acknowledged experts in their own fields and will provide a ready source of reference for both the software engineer and those responsible for the management of the manufacturing operations.

As the life of a product starts with design, it is appropriate that the first chapter of the book deals with design issues. Particularly important is the conversion of design data into manufacturing instructions – the subject of the first paper in the chapter. How well that conversion is handled will depend on the design of the database, and two papers in the first chapter discuss this problem. And, as the final paper in the section describes, CAD can also be used to plan and evaluate a manufacturing operation.

The programming of robots is the subject of the second chapter. The number of degrees of freedom and the unrestricted movement of the modern-day robot as compared to, say, an NC machine tool have led to much activity in this sphere of programming. The first paper in this chapter identifies and classifies the languages now available to the robot programmer. Even after the language has been chosen, the problem of writing programs still remains. As the second paper explains, automatic programming could be the solution. A macro-assembler technique, as discussed in the next paper, could be another solution. As far as the user is concerned, standardisation in languages would make it much easier to switch from one to another, thus opening up the possibility of better utilisation. The last paper presents some of the steps being taken to achieve standardisation.

The programming of other manufacturing equipment is covered in the third chapter. The first paper discusses the implications of human factors in the programming of flexible manufacturing systems. This is followed by papers on programmable controllers and machining processes with a description of the MPL and AML languages.

Another growth area in the application of computers to manufacturing is modelling and simulation. Simulation can be a cost-effective method of designing systems and of minimising the time and effort to get these systems up and running. Several simulation methods are described for a number of tasks including robot simulation, FMS simulation and transportation. The final paper should guide the reader in the selection and use of simulation languages and provides an overall picture of the characteristics of some of the languages that are currently available, as well as discussing future developments.

One of the drawbacks of current languages and programming methods is their increasing complexity, presenting problems to the user as opposed to the software engineer. The solution could be task-level programs written in a language that is understandable to the user. This topic is discussed in the fifth chapter on high-level programming and control. Assembly is one of the first areas being tackled using task-level programs and the first paper discusses AIM (Assembly and Information Management system) – a task-level language developed by Adept Technology. Another language, TDL, the basis of the second paper, is robot-type independent and allows graphic animation of a robotic workcell. The ADA high-level programming language is discussed in another paper, as is F-Prolog – a top-level robot assembly programming language which has the ability to interface with LISP. Controlling, as opposed to just programming, an advanced manufacturing system is the subject of the final paper in this chapter.

As discussed earlier, the trend in manufacturing industry is towards integration of functions, and software is an enabling development in this process. The subject of the final chapter is how to achieve effective integration and control of the manufacturing systems. The problems of FMS management systems such as MRP, JIT and OPT, as well as CIM, are discussed. In the final paper the influences of new developments such as personal computer and local area networks in the economics of integrated manufacturing are traced.

This compilation of papers on control and programming adds a further volume to the 'International Trends in Manufacturing Technology' series started some four years ago. It represents a major effort by a large number of people, in particular the authors of the individual contributions. In addition, the input of Rory Chase of the IFS Publications staff has greatly assisted the editor in selecting and arranging the papers in this book.

B. W. Rooks, Editorial Director
IFS (Publications) Ltd
December 1987

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1
COMPUTER-AIDED DESIGN ISSUES

Converting design data into manufacturing control instructions is essential to the successful implementation of the computer-integrated manufacturing strategy. The manufacturing database links the sales, design, estimating, process planning, production, assembly, and distribution functions together, reducing operating costs and increasing business competitiveness. This section examines the elements of an integrated manufacturing database, emphasising database design and integrity. A practical example involving the design and simulation of a robotic cell in a flexible manufacturing system is examined.

THE ELEMENTS OF AN INTEGRATED CAD/CAM SYSTEM

CONVERTING DESIGN DATA INTO MANUFACTURING INSTRUCTIONS

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Much publicity has been given to the development and use of computer-based systems for design purposes such as calculation, layout and drawing, as well as for providing user-friendly facilities for the storage, retrieval and editing of such design data. However, before production can commence, it is usually necessary for this data to be processed through other departments with quite different functions; for example, method study, process planning, estimating, tooling, NC programming, scheduling, and so on. For these functions, too, the computer, with appropriate software, can now provide effective aid in terms of time and cost reduction. It is important to link together all these elemental software systems and thus provide the user with a means of automatically converting design data into manufacturing instructions. The extent to which this has been achieved is discussed.

During the evolution of CAD/CAM systems over the past two or three decades, it is interesting to note how independent developments which began at completely opposite ends of the CAD/CAM spectrum have gradually approached each other. Yet it is only in 1987 that a complete link-up over a broad field of engineering is becoming a reality.

Apart from the use of computers for the purpose of calculation, computer-aided design did not come into regular use until the 1960s, when the computer was successfully linked to a graphic display screen, so that under the direction of a trained engineer, and with appropriate software, it became possible to create pictorial models of two- and three-dimensional shapes on the screen. This process was known as interactive computer-aided design.

As a quite separate advance, in the late 1950s and early 1960s, following the introduction of NC machine tools into industrial workshops, came the development of computer-aided NC programming systems, which enabled major reductions to be achieved in the time and cost necessary to write an NC program and prepare an NC tape.

Most of the early developments in both these areas emanated from work undertaken on aerospace, missile, and defence projects. In these types of industry, many of the major problems involved in creating and building a new product, in terms of time and manpower, concern the functions of design and the actual machining of complex components and assemblies. The CAD/CAM applications which were developed to solve such problems do not, however, satisfy the requirements of all types of industry. This is because in the vast majority of engineering companies, particularly those involved in mechanical engineering, the amount of time and effort involved in conceptual, creative design is quite small, and machining cycles on all but a few major components tend to be short – of the order of minutes. Nonetheless, it is very often a matter of some days or weeks before production work can commence on a new order, and possibly even longer before that order is completely manufactured and ready for despatch to the customer.

An analysis of the functional activities in the pre-production and production areas facilitates an assessment of how computer aids can be used to make such activities more cost effective, what type of computer aids are currently available, and how the available computer aids fit together into a coherent CAD/CAM system.

Design and manufacturing functions

The main engineering functions involved in the creation and subsequent conversion of design data into manufacturing instructions are listed in Fig. 1. Clearly the extent, or even the formal existence, of each of these functions depends on a variety of company- and product-related factors, but, with the possible exception of the NC functions (i.e. when no such machines are in use), all the activities have to be undertaken as part of the overall process of design and manufacture.

It may be of some interest and significance for individual companies to calculate how many personnel are now involved directly and indirectly in the pre-production activities (1–8), as opposed to those associated with the actual production processes (9), and to compare this ratio with that which applied to their company 20 years ago. In almost all cases, the ratio of pre-production to production personnel will have increased, mainly as a result of two interacting factors. The first relates to the continuing increase of all types of automation techniques on the shop-floor, with subsequent reductions in the number of direct

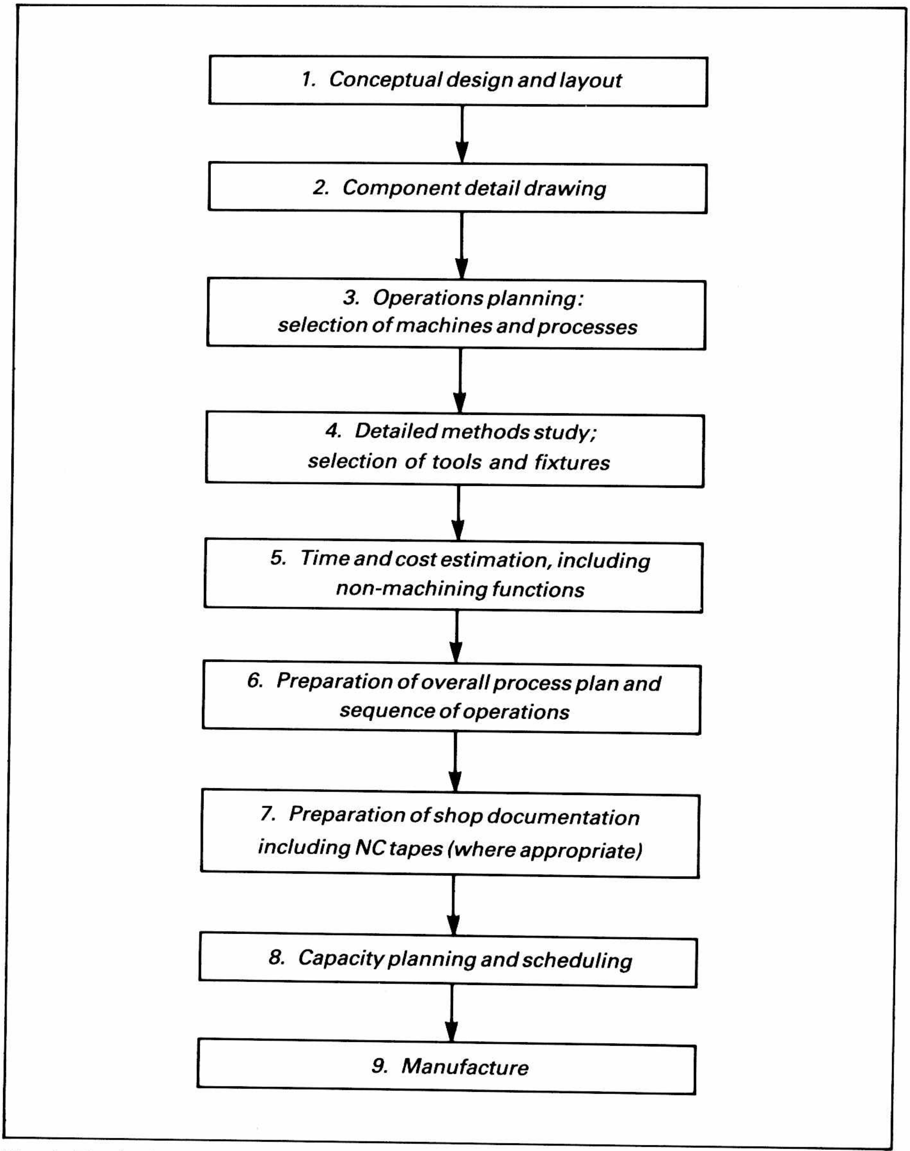

Fig. 1 Typical sequence of engineering activities

operators required. The second factor, mainly consequent upon the first, is that in the desire to improve the efficiency of the directly productive processes, an ever-increasing number and variety of pre-production functions have been created to determine such matters as what should be done on the shop-floor, when it should be done, on what machines and in what sequence, so that when the instructions reach the shop everything can swing into action without delay.