AUTOMATION IN THE FOOD INDUSTRY

Edited by C. A. Moore

Blackie

Automation in the Food Industry

Edited by

C.A. MOORE B.Sc., C.Eng., FIEE
Divisional Director – Engineering
AMEC Design and Construction Ltd.
Stratford-upon-Avon

Blackie
Glasgow and London

Published in the USA by
avi, an imprint of
Van Nostrand Reinhold
New York

Blackie and Son Ltd
Bishopbriggs, Glasgow G64 2NZ
and
7 Leicester Place, London WC2H 7BP

Published in the United States of America by
AVI, an imprint of
Van Nostrand Reinhold
115 Fifth Avenue
New York, New York 10003

Distributed in Canada by
Nelson Canada
1120 Birchmount Road
Scarborough, Ontario M1K 5G4, Canada

16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1

First published 1991

British Library Cataloguing in Publication Data

Automation in the food industry.
1. Food. Processing. Use of automatic control systems
I. Moore, C.A. (Colin A.)
664.02

ISBN 0-216-92976-8

Library of Congress Cataloging-in-Publication Data

Automation in the food industry / edited by C.A. Moore.
p. cm.
Includes bibliographical references and index.
ISBN 0-442-31432-9
1. Food industry and trade—Automation. I. Moore. C.A. (Colin Anthony), 1952–
TP372.8.A88 1991
664—dc20 91–164
CIP

Phototypesetting by Thomson Press (India) Limited, New Delhi
Printed in Great Britain by Thomson Litho Limited, East Kilbride, Scotland

Automation in the Food Industry

Preface

This book is designed to be everything its title suggests—a practical guide to automation within the food industry. It is the first book to offer practical advice on what can be a most bewildering subject in an industry where the use of effective automation is of paramount importance. There are many books dealing with the theory and practice of control systems in both the food and other industries. However, these tend to offer too much detail in both areas to be classed as overviews, or cover too much of the more obvious detail and gloss over, or avoid, the elements where the decisions are hard—even though these are the areas which are fundamental to successful and expansive projects.

This book identifies those elements of any automation scheme which have to be considered first, and that form the foundations for any successful project. The editorial introduction outlines the content of the book and is a useful starting point. Examples are used, wherever possible, to show what can be done, how it can be achieved, and what to avoid. A glossary of definitions is included at the end of the book. All the chapters have been written by engineers, with many years' experience in this field, who have been able to express their views freely. The result is a book which covers the key areas of the subject, using a minimum of the technical jargon with which this subject abounds, in a readable, practical manner.

This book is intended for process engineers, electrical engineers and food technologists working in the food industry. It will also serve as an essential source of reference for production managers considering the purchase of new equipment.

Acknowledgements

I would like to pass my sincere thanks to all the contributors who have put in many hours of hard work to make this book not only possible but also useful. It is their breadth of knowledge and real engineering experience which makes their chapters valuable and enables this book to meet the objectives established right at the start.

I must also express my gratitude to AMEC Design and Construction Ltd. who have tolerated the inevitable disturbances that editing this book has created, and I thank them for their support during this venture.

C.A.M

Contributors

Ian M. Baker *AMEC Design and Construction Ltd., Timothy's Bridge Road, Stratford-upon-Avon, Warwickshire CV37 9NJ.*
Ian Baker has gained his wealth of experience in roles directly connected with the design and implementation of electronic or microprocessor based control systems in the food and beverage industry. After completing his engineering apprenticeship with a company in the Marryat Group he became an Application Engineer with them until 1975. He progressed from this to become Chief Application Engineer, then Commercial Manager and Sales Director with Systems Integrators, and Sales Manager for a leading UK programmable controller manufacturer. Projects he has been involved with in the food and beverage industries include milk pasteurisers, kegging and bottling lines, brewhouse automation, chocolate and meat products using programmable controllers and supervisory computers. In addition to food industry experience he has worked on control systems in chemical process, materials handling and has extensive experience in the motor industry.

Tony Dodd *Expert Systems Limited, Unit 12, 7, West Way, Oxford OX2 0JB.*
Tony Dodd read Mathematics and Philosophy at Oxford and then spent the years 1973 to 1978 doing research into set theory, gaining an M.Sc. in 1974 and a D.Phil. in 1978. From 1978 to 1983 he was a research fellow first of New College and then of Merton College in Oxford. He published a monograph on constructible sets in 1982. He first became interested in computing while doing research in logic and developed an interest in the theory of formal languages and compilation. He joined Expert Systems Ltd. (as it then was) in 1983 to work on Prolog-1. In 1984 he designed and led the implementation of Prolog-2, and in 1985 became Technical Director of the company. He led the design team that produced the Prometheus expert system shell, is an active member of the BSI Prolog standardisation committee and secretary of the UK Association for Logic Programming. His book 'Prolog: a logical approach' is due to be published by OUP in 1990. In 1989 Tony joined Chemical Design Ltd. as Expert System Product Manager, and early in 1990, together with three other employees, set up Expert Systems Ltd., of which he is Chairman and Managing Director.

Tom W. Greeves *Cambridge Consultants Limited, Unit 3, Lighting Way, Alvechurch Road, West Heath, Birmingham B31 3TH.*
Tom Greeves is a Director of Cambridge Consultants (Systems Engineering) Ltd. based in Birmingham, UK; a division of Cambridge Consultants Ltd. of Cambridge. Tom has degrees in Mechanical and Electrical Engineering from Queen's University, Belfast, and an Open University degree in Mathematics and Electronics. After a short period with Rolls-Royce in Derby he moved to Cadbury Ltd. in Birmingham where he held a number of senior positions including the management of large projects for the

introduction of new plant and processes, running the facility for the development of new processes for existing and new products, having responsibility for in-house engineering research and development, and setting up and running a corporate systems engineering department with a special remit for packaging systems. In 1987 Tom and a senior colleague completed a buy out which gave Cambridge Consultants majority ownership of the Systems Engineering unit and has enabled the team of mechanical, electrical and software engineers to gain experience of solving production problems in a variety of industries, especially in consumer orientated industries such as food, confectionery, pharmaceutical and health care. Tom is able to draw on some 35 years' industrial experience.

John Holoway *Dowty Systems Integration Ltd., Marshfield, Chippenham, Wiltshire SN14 8NN.*
John Holoway is a Principal Consultant with Dowty Systems Integration Ltd. Current duties include responsibility for IT Strategy Development Feasibility Studies and Integration Consultancy with particular emphasis on the management of information flows within distributed or service critical environments. Formerly a leading Consultant with Logica Energy and Industry Systems Ltd., and the Managing Director of an in-house systems company associated with a major multi-national air express organisation, he has worked within the IT industry for over twenty years. During this time he has been associated with leading edge technology in such diverse applications as graphic arts, office automation, telecommunications, and logistics systems. He has concentrated on developing practical methods of implementing Integration Information Systems in the food and pharmaceutical sectors.

Iain A. Lindsay *Allen Bradley, Denbeigh Road, Bletchley, Milton Keynes MK1 1EP.*
Iain Lindsay graduated from the University of Bath in 1981 where he specialised in Systems Engineering disciplines. During time spent working in various system engineering roles for the Dowty Group and General Electric (USA) he gained experience of automation in a wide range of industries. In 1988 he joined the Systems Engineering Division of Allen Bradley where he is currently Technical Manager.

Derek Mack *GEC Industrial Controls Limited, Kidsgrove, Stoke-on-Trent, Staffordshire ST7 1TW.*
Derek Mack served an apprenticeship from 1960 to 1966 with the English Electric Company which later became one of the constituent companies of the General Electric Company. On completion of his apprenticeship he became a control engineer involved in the design of d.c. variable speed motor control equipment and also a.c. motor starter panels. The applications were concerned mostly with the heavy engineering industries. Following a period in the commercial world of sales and contracts he became a founder member of the GEM 80 Programmable Controller Division of GEC Industries Controls Ltd. concerned with both commercial and applications engineering. In this role he was involved in the engineering of programmable controllers across the whole range of industry including a number of applications in food processing. These covered various aspects of confectionery, brewing including maltings, beverages and milling. He is currently special assignments engineer for GEM 80 programmable controllers and is concerned with all aspects of the application of the range of GEM 80 controllers where unusual conditions exist or where special control activities are being under-

taken. He has special responsibility within the company for the safety and reliability aspects of programmable systems and has presented various papers on the topic at seminars organised by HSE and the IEE.

Colin A. Moore *AMEC Design and Construction Ltd., Timothy's Bridge Road, Stratford-upon-Avon, Warwickshire CV39 9NJ.*
Colin A. Moore graduated in Control Engineering and spent a number of years with the British Steel Corporation engaged on all aspects of the design and construction of multi-discipline projects throughout the Steelworks Division. During this time he expanded his understanding of business operations by gaining a diploma in Accounting and Finance. In 1981 he joined IDC Limited where he became involved with the design and construction of electrical and control systems for major projects. He was directly responsible for the successful completion of these, a large number of which were within the food industry. He was appointed Divisional Director–Engineering in 1985, and in this role has assisted the company to strengthen its standing in the food industry in particular, and in other industries in general. In 1990 he became responsible for all Process, Control and Systems Engineering aspects within IDC Limited (now AMEC Design and Construction Ltd.)

Håkan Morän *SattControl Automation AB, S-20522, Malmö, Sweden.*
Håkan Morän is Marketing Manager for food-processing automation at SattControl AB, a member of the Alfa-Laval Group. He has specialised in applications for the food industry since 1980 and operates as a project manager as well as a systems engineer for a number of major installations. More than 20 years ago, SattControl designed the first PLC to be produced in Europe and has since established an international reputation as a market-driven innovator. The SattGraph operator system has recently been launched together with SattLine, a distributed system for integration of control systems at all levels. SattControl automation systems are used in the food and beverage industry for a wide range of applications, including grain mills, dairies, breweries, fruit-juice lines and meat-processing plants.

Mauro Novaresio *Fata Automation, 10152 Torino, Italy.*
Mauro Novaresio attended the University of Turin, where at the age of 22 he was awarded a degree in Computer Science following a dissertation about simulation. His first working experience was in the offices of Fiat in Turin. He then moved to factory automation and participated in some of the first innovating projects in both Northern and Southern Italy. His main role was the analysis of complex systems using the most advanced hardware/software technology for the automation of material handling lines and AS/RS systems. He has been in charge of the automation projects carried out by the FATA European Group in both the USA and USSR for over four years, and is involved in the preparation of the templates for the CIM projects. Furthermore, he coordinates the activities of the Group Task Force appointed to CAD/CAM development and CAD/simulator interfaces.

Roger Pilkington *AMEC Design and Construction Ltd., Timothy's Bridge Road, Stratford-upon-Avon, Warwickshire CV37 9NJ.*
After graduating from University College of Swansea in Electrical Engineering in 1973, Roger Pilkington joined Crompton Electricals and was involved in the design and

application of d.c. based control systems for electric vehicles. Upon completing four years with that company, he joined Thames Board Mills Ltd. and commenced his career in project engineering. At Thames Board Mills he was involved with the application of d.c. drives, a.c. motor control equipment and general electrical distribution schemes. During this time he was part of a large project team involved with the design and installation of a new card-board machine. He joined IDC Ltd. (now AMEC Design and Construction Ltd.) in 1984 as a Senior Engineer, working on control systems for process applications. He is currently Technical Manager, responsible for all the Control and Systems Engineering operations. Roger Pilkington has had considerable experience on food industry projects involving complex control systems.

Derek J. Spencer *GEC Industrial Controls, Kidsgrove, Stoke-on-Trent, Staffordshire ST7 1TW.*

Derek Spencer joined the English Electric Company as a technician apprentice in 1957, working in the Relay Development Laboratory on electronic distance protection. Later he joined Field Engineering to work on power-station commissioning and then computer-systems commissioning. Since 1968 he has been firmly committed to automation. He became Head of Engineering of the Automation Division at GEC Electrical Projects Ltd. in 1982 and Divisional Manager in 1984. In 1988 he transferred to GEC Industrial Controls Ltd., Kidsgrove as Manager of the newly formed Control and Process Systems Division.

Editorial introduction

The food industry has been a major investor in control systems over recent years and predictably will continue to be so. This investment is driven to a great extent by the need to continually market new product lines, and also by the need to increase throughput and efficiency. In practice this means the industry wants to, or has to, apply sophisticated control techniques to provide repeatable and automatic controls which allow accurate records to be kept and fewer operators to be used to produce the same or an increased amount of product.

This book contains contributions from highly experienced engineers who have spent many years working within and for the food industry. Some have spent their working life with manufacturing companies, others have supported manufacturers for many years as suppliers of control systems. By combining their views on the various topics covered it has been possible to express a highly representative view of the industry in a way which no single author could hope to achieve. This book sets out to be not only factual and useful, but also:

- to be *real*, with the information put forward based on practical experience combined with practical examples;
- to be *readable*, with the minimum of jargon, theory and formulae so that those with a minimum of knowledge, or some understanding and those with a more general interest are able and will want to follow it;
- to improve *opportunity* for people in the industry, by indicating what can be achieved now, what is likely to be possible in the future, and how these goals can and should be achieved.

By meeting these objectives this book is appropriate for readers drawn from a number of different situations. This includes students studying the subject at college or university, who are rarely exposed to practical problems or real life knowledge: there are very few books available which offer a *real* view of controlling a process plant or how to apply the theory which has been learnt. Also there are many practising electrical engineers who know how to design elements of the control scheme but would benefit if they understood how the *total* system might be put together.

Within the project teams implementing these schemes are those who understand the process well enough to know how it works but do not know what computers are capable of, and those who understand computers but do

not have the experience or knowledge required to use them to their full advantage. Furthermore, people such as the plant or production engineers may have a wealth of experience of how the process works or how the product is really made but may not understand how modern controls can help them (and maybe do not want to admit it?). Lastly (but not least) are those who are being asked to invest on average 30% of the total project cost in sophisticated control systems. It is easy to imagine that they might like to know what they will get for their money.

As stated above, the important principle maintained throughout this book is that it is practical and easy to follow. There are many books around which offer pages of formulae and complicated control engineering theory which are rarely used by most practising engineers, let alone those who operate on the fringes of the business, or who have yet to experience the vagaries of a food processing plant for the first time. Of course control theory is very important if you need to study the detailed operations of a process, but most food processes do not require this level of detail. What is required, and most fundamentally so, is a good, common sense, pragmatic view of what can and should be achieved. This book is aimed at developing this by indicating the key areas where attention must be directed if a successful project is to be the result.

It is inevitable within a book covering such a wide subject that not all aspects of automation can be covered. Equally, not all food industries can be represented by example. However, it is fair to say that automation systems are reasonably general in their suitability if the problem is defined correctly. It is this definition which is usually the major contribution to the application of advanced systems, not the systems themselves. Given a meaningful examination and understanding of the processes, and how they relate to the other process stages and the overall factory operation, a full automation strategy can be identified and implemented.

This book identifies those issues which make a fundamental contribution to the success or failure of a project. It is worth noting that few automation schemes 'fail' as such, but all too often they do not deliver the potential they are capable of.

Within this book, therefore, the scene is set in Chapter 1 by examining food processing as an industry, and the role of automation within this. This chapter indicates how, by looking at the stages of food preparation through to final product, this is not such a daunting task, as long as it is considered as several elements.

Whilst it is necessary to identify separate modules or stages within the process itself it is essential to maintain a total view of what is to be achieved. This suggests a 'total systems' approach, where not only the automation of the plant is considered but also the way the factory is run. This may not only require a review of what automation is appropriate, but also how production is scheduled, how management structure their operations and so on. The need for this approach is expanded in Chapter 2.

The next two chapters look at how integrated factories can work, what is possible if this approach is adopted and how one can prepare specifications in such a way as to ensure that the final project achieves the ambitions set.

In order to ensure a good background of understanding, the various types of computers available are examined in Chapter 5, with an insight into what they can achieve and how. This is followed by reference to a most important part of any automation scheme: the interface with the people who will work the plant once built. Operator interfaces must be designed for operators and managers, and not just to satisfy the engineers who design them. This demands a good ergonomic approach and Chapter 6 highlights some of the main features to consider.

Having examined what is possible by adopting the right approach the book then looks at how these objectives can be achieved. Important factors which have to be considered are that the accuracy of the final system must be good enough, and that the components of it must be reliable. Unfortunately the automation industry abounds with loosely defined terminology and these two elements fall within this area. Chapter 7 looks at what these terms mean in practice, and how to assess what is required, and what is achievable. There is a need to include some formulae in this area, which tends to make this chapter appear somewhat mathematical, but as both of these subjects rely heavily on mathematics and statistics some presentation of this was unavoidable. However, to maintain some sanity the formulae presented have been kept brief, and examples have been used to illustrate the point. Furthermore, lengthy proofs of the final formulae have been excluded in the interest of keeping the book readable.

Chapter 8 reviews how food processes can be automated in practice with examples of how, or how not, to approach the problems encountered. It develops the themes established in the earlier chapters and illustrates the fact that automating a food factory need not be a daunting task.

It is essential within any project to keep a realistic view of what needs to be achieved, and this will normally mean using currently available technology—tried and tested—to satisfy this. However, if the plant is to be expandable in the future it is vital to maintain a longer term view, and an understanding of future developments must be retained whilst applying 'today's' technology. In this way updating with new techniques or equipment will be relatively easy. The final two chapters look at the direction in which the industry is moving, and Chapter 10 in particular identifies what could become an advanced technique in creating friendly, controllable process plants within the food industry.

Contents