Automated Manufacturing

Leonard B. Gardner
editor

ASTM STP 862

AUTOMATED MANUFACTURING

A symposium
sponsored by ASTM
Committee E-31 on
Computerized Systems
San Diego, Calif., 5–6 April 1983

ASTM SPECIAL TECHNICAL PUBLICATION 862
Leonard B. Gardner, Automated Integrated
Manufacturing, editor

ASTM Publication Code Number (PCN)
04-862000-32

1916 Race Street, Philadelphia, Pa. 19103

Library of Congress Cataloging in Publication Data

Automated manufacturing.

(ASTM special technical publication; 862)
"Papers ... presented at the First International Symposium on Automated Integrated Manufacturing held in San Diego, California, on 5-6 April 1983"—Introd.
"ASTM publication code number (PCN) 04-862000-32."
Includes bibliographies and index.
1. Automation—Congresses. I. Gardner, Leonard B. II. ASTM Committee E-31 on Computerized Systems. III. International Symposium on Automated Integrated Manufacturing (1st: 1983: San Diego, Calif.) IV. Series.
T59.5.A79 1985 670.42'7 85-1243
ISBN 0-8031-0422-7

Library of Congress Catalog Card Number: 85-1243

NOTE

The Society is not responsible, as a body, for the statements and opinions advanced in this publication.

Printed in Baltimore, Md.
April 1985

Resolution

By the Honorable Larry Stirling
Seventy-seventh Assembly District; Relative to

THE FIRST INTERNATIONAL SYMPOSIUM ON AUTOMATED MANUFACTURING

WHEREAS, Industry is faced with increasing obsolescence, decline of productivity, and decreased market percentage, and the need to turn these trends around in order to maintain a health production base is well recognized by industrial nations of the world; and

WHEREAS, Although motivation factors are an important part of productivity, there is a limit to production increase based soley on motivation and a bottom-up implementation of the modernization plan for older factories provides the key to this required turnaround; and

WHEREAS, Standardization is one way to effectively implement the rapidly expanding technology available for manufacturing modernization and in support of this activity, academia provides management with research and education, while government provides resources and a climate conducive to modernization through standardization; and

WHEREAS, The First International Symposium on Automated Integrated Manufacturing was held April 5 and 6, 1983, at the Town and Country Hotel in San Diego, the purpose of which was to focus on both application of available standards and requirements for additional standards; and

WHEREAS, The symposium forum offered participants an opportunity to consider an integrated approach to standardization structure in support of computer controlled manufacturing; and

WHEREAS, ASTM, an organization which operates on a voluntary consensus basis through its members, both users and producers, is interested in the applicable portions of this symposium topic; and

WHEREAS, ASTM Committee E-31 has displayed concern for the development of standards for various computerized systems, while its Subcommittee, E31.08 on Computerized Manufacturing Processes, is interested in computer-controlled manufacturing; and

WHEREAS, The pioneering effort and forum for discussions of innovative concepts are improtant means to increase the applications of factory automation in Southern California, and its benefits include conservation of resources and improvement of environmental working conditions; now, therefore, be it

RESOLVED BY ASSEMBLYMAN LARRY STIRLING, That he takes great pleasure in applauding the contributions which the First International Symposium on Automated Integrated Manufacturing provided to the industry, commends ASTM Committee E31.08 on Computerized Manufacturing Systems, Dr. Leonard B. Gardner, Chairman, on its efforts in addressing specific issues, and extends best wishes for continued success in future symposiums; and be it further

RESOLVED, That a suitably prepared copy of this resolution be transmitted to the author for appropriate distribution.

CALIFORNIA · STATE ASSEMBLY · LEGISLATORUM · EST JUSTAS LEGES CONDERE

Members Resolution No. 1927

Dated: May 10, 1983

Signed

Larry Stirling

Honorable Larry Stirling
77th Assembly District

Foreword

The ASTM Symposium on Automated Integrated Manufacturing was held in San Diego, California, on 5–6 April 1983. Leonard B. Gardner, Automated Integrated Manufacturing, served as symposium chairman and has also edited this publication.

Related ASTM Publications

ASTM Standards on Computerized Systems (1983), 03-531083-32

Computer Automation of Materials Testing, STP 710 (1980), 04-710000-32

Computerized Testing, STP 578 (1974), 04-578000-34

A Note of Appreciation to Reviewers

The quality of the papers that appear in this publication reflects not only the obvious efforts of the authors but also the unheralded, though essential, work of the reviewers. On behalf of ASTM we acknowledge with appreciation their dedication to high professional standards and their sacrifice of time and effort.

ASTM Committee on Publications

ASTM Editorial Staff

Contents

Introduction

The papers in this publication were presented at the First International Symposium on Automated Integrated Manufacturing held in San Diego, California, on 5–6 April 1983. Sponsored by ASTM Committee E-31 on Computerized Systems, the symposium offered participants an opportunity to consider an integrated approach to standardization structures involving batch machines, continuous processes, interfaces, languages, protocol, and networking in support of computer-controlled manufacturing. The sponsorship of this symposium by ASTM was particularly significant because the name ASTM has long been synonymous with standards for testing and materials. Appropriately the main subjects discussed at the meeting were standards for the materials comprising an automated manufacturing facility and standards for the testing of these materials. Materials were broadly defined as the individual pieces of manufacturing equipment and their control systems. Automated integrated manufacturing (AIM) presents a method for achieving factory automation that is being developed by consensus. The participants in this symposium were brought together from diverse backgrounds to contribute to this development.

The importance of standardization for factory automation is such that the symposium came to the attention of the Honorable Larry Stirling, member for the 77th Assembly District of California where the symposium was held. After reviewing the program he noted that there is a limit of what can be achieved by bottom-up modernization of older factories. Stirling cited standardization as a method to "effectively implement the rapidly expanding technology" of automation and commended ASTM Subcommittee E31.08 on Computerized Manufacturing Processes for its efforts in addressing specific issues. A copy of the Resolution that he introduced to the Assembly is reproduced in this volume.

Computerized manufacturing encompasses computer-controlled manufacturing and computer integrated manufacturing (CIM), the latter differing from AIM only in that with AIM computer control of the plant has been more fully developed and automation has been spread throughout the plant. The following explanation will further clarify the differences.

Today's exchange of data between individual pieces of computer-controlled industrial equipment is achieved by hard-wired point-to-point cables, custom electronics, and special computer application programs that are slow to debug and difficult to expand. These are the islands of automation. The best present implementation of automation only resembles loosely connected chains of these islands. Exchange of data between the islands is costly, clumsy, and slow, causing a premature cap to be placed on productivity.

Productivity can be further increased only by bridging the islands of automation. These bridges take the form of a hierarchically structured wide-area computer network (WAN) consisting of interconnected local area computer networks (LANs). These networks join the data paths between individual computer-controlled industrial equipment and provide access to engineering information. The appropriate computer application programs bring together these networks to integrate industrial automation throughout all management, engineering, support, and manufacturing operations. This method for increasing productivity is what we term CIM.

Implementation of CIM is being planned around the variant method whereby the operations for manufacturing an item are determined by varying (i.e., slightly changing) operations previously used for manufacturing a similar item. Today, the variations are accomplished by intervention of human experts whose knowledge is more intuitive and is not accessible to introspection; it is taught by example and not by articulating rules. How to effectively use the variant method for industrial manufacturing remains unclear.

Artificial intelligence can be introduced into the WAN hierarchy of LANs and computer application programs to clear up the fuzziness of the variant method. Its goal is to make the control of manufacturing processes smart enough to react in real-time to the status of machine tools and to the status of the work-in-process (WIP). It must be smart enough to decide which operations are necessary to transform raw materials and purchased parts into the finished item while maximizing production rate and minimizing production cost. In its most developed state of the art this method can produce items that are completely different from any previous item produced. This is the generative method of selecting manufacturing operations.

Implementation of the generative method incorporating artificial intelligence into knowledge base systems for modifying the movement of WIP and achieving truly plant-wide integration of computer control of the machine tools requires a level of information exchange between widely divergent systems that is only now being developed. I have called it AIM to distinguish it from CIM. The main distinction is that AIM merges artificial intelligence and expert systems into CIM control to achieve a true generative manufacturing system. It also provides a cost-effective, straightforward, and fast method of exchanging information between all the manufacturing operations. These factors combine to increase productivity. The papers in this volume are written from a CIM point of view showing the way for technological advancement to AIM.

Labor-intensive industries are faced with increasing obsolescence, decline of productivity, and decreased market percentage. The need to turn around these trends in order to maintain a healthy production base is well recognized by the industrial nations. Although motivation factors are an important part of productivity, there is a limit to production increase based solely on motivation. Upon reaching this limit, managers turn towards automating the more labor-intensive operations. This tends to produce islands of automation. Integration of automation throughout the factory is a very tough problem. It can be made easier if there are standards to follow; this subject is discussed in the first part of this publication. The required standardization for AIM is an heroic effort whose magnitude is enormous. This symposium provided a forum in which the participants could discuss an integrated approach to standardization in support of computer-controlled manufacturing. This publication serves as a record of the information that they exchanged.

A bottom-up implementation of a modernization plan for older factories provides the required turnaround. This modernization, as discussed in the second part of this volume, calls for commitment to considerable resources and to the ordeal of change. An integrated standardization structure, such as described in the Appendix, will provide industry with a method of controlling and tailoring their modernization. To be cost effective, management must assure a maximum of supplier competition, interchangeability, and portability of all manufacturing elements. Voluntary consensus among suppliers and users to standardize procedures, methods, and specification is a recognized tool of achieving these management goals. Standardization therefore becomes an effective way of implementing the rapidly expanding technology available for modernization of manufacturing.

Of the approximately 400 standardizing bodies in the United States, less than ten prepare standards that are applicable to the integration of individual pieces of automation. Even so, it is difficult to determine which parts of the integration of factory automation have already been standardized and which remain to be accomplished. This can be made easier by subdividing the subject. I have selected a subdivision based on the interface that exists between various aspects of factory automation. Such interfaces are important because the data to control the machines and to manage the factory must flow across these interfaces. The standards for the integration of automation must define all aspects of the interface necessary to control the equipment and to obtain the status of machines and work-in-progress. The details that do *not* affect either the content of the data or the characteristics of the digital information need not be standardized for AIM. The interfaces that I have selected are: (*a*) Computer and Communication Systems, (*b*) Production Equipment, (*c*) Production and Plant Management, (*d*) Production System Test and Support, (*e*) Plant Environment, (*f*) Production System Spares and Repairs, and (*g*) Systems Training.

When the symposium was in the planning stages, I prepared the Appendix and attempted to group some of the standards according to the above interfaces. The effort was not intended to be complete but to indicate which of the interfaces was well standardized (as measured by the number of standards available) and where further effort was required. Since that time, PC 2 of ANSI Industrial Automation Planning Panel has published Document A and B, "Industrial Automation Standards and Standard Projects." This document identifies many standards that should be included in the spread sheet; however, it also includes many that relate to the content of the data or the characteristics of the digital information and which therefore would not be included in the spread sheet.

The author of each paper has approached standardization from a different perspective. Collectively they are typical of those approaches used by industrial nations that are facing the very trying conditions brought on by the ever-increasing expense of safely manufacturing finished products. Why do our efforts to spread automation throughout the factory continue to be met with frustration? I submit that it is because insufficient attention has been given to planning the integration of automation. If nothing is done, we will miss the golden opportunities to reap in this decade the benefits of the computer revolution and to apply these benefits to reducing manufacturing cost (i.e., increasing productivity). The industrial world can not afford to lose these opportunities. To prevent this from happening, important decisions have to be made. A strategic plan of spreading automation throughout the factory must be formalized.

ASTM is already involved in the field of industrial automation. Committee E-31 is concerned with the development of standards for various computerized systems, and its Subcommittee E31.08 is interested in computer-controlled manufacturing. Individuals are invited to participate in the future activities of these committees.

I would like to take this opportunity to thank those persons who organized and participated in the symposium. Thanks are due the members of the Organizing Committee, particularly Peter Schilling, chairman of Committee E-31; John Rothrock, ASTM staff liaison member; Joseph Berkley, chairman of the Technical Program Committee; J. R. Robinson, chairman of the Keynote Speech Committee; and Robert Gordon and Ken Merkel, who assisted in chairing the sessions. Messrs. Berkley, Gordon, and Robinson also assisted in reviewing the papers contributed to this publication. Their cooperation and constant encouragement has been very much appreciated.

Leonard B. Gardner

Automated Integrated Manufacturing, P.O. Box 1523, Spring Valley, California: symposium chairman and editor.

W. T. Cavanaugh[1]

Opening Remarks

The existence of this symposium suggests very strongly that we are dealing with a series of technologies poised at a degree of maturity sufficient to warrant extensive standardization. You are the experts and you know the myriad of technical facets covering computer graphics, mechanical CAD/CAM systems, hardware/software, sensor interaction, integrated manufacturing, along with management and systems development. Productivity improvement is a vital target of industries caught up in the economic trauma. Industrial automation is moving into high gear for manufacturing activities to apply more high technology, labor-efficient methods of production. Automated-integrated manufacturing and robotics are the effective tools that will improve productivity in more sophisticated operations such as assembly and inspection. Data extraction, processing, and decision making will play an important role in the control procedures, and improved flexibility of assembly systems will become a reality. Integration of a standardization structure, no matter what the subject or the complexity, is ASTM's skill and forte.

My role today is to bring you some facts and concepts concerning ASTM and the way it can be used by you in the pursuit of your objectives, whatever technically they may be.

It is going to be difficult to do this without appearing to project the image that ASTM is the only standards organization in the world. I could use circumlocutions to avoid this—we often use circumlocutions in dealing with the politics of standards—but I do not intend to do that because it would be a disservice to you. There are many people in the room new to the ASTM experience; it is therefore essential to talk in a very straightforward, even at times blunt, fashion. Keep in mind that I am doing this in a spirit of clarifying your thinking concerning the way in which you perceive ASTM.

As the few of you who have served in ASTM policy councils know, ASTM is an organization that believes in planning. Indeed, we have had an ongoing formal planning function now for about 14 years. We believe in planning not only because it is a useful management tool in theory, but also because for ASTM it

[1]President, ASTM, Philadelphia, PA 19103.

has worked—really worked—in practice. I think it is safe to say that those intimately familiar with the affairs of ASTM for the past 14 years or so would agree that the obvious and pervasive health of this organization today is the direct and traceable result of its ability to anticipate events through planning and to set in motion in a timely fashion policies to accommodate those events.

Let me give you a few examples that relate to your specific interests. In our 1969 Long Range Plan, the following paragraph appears:

> Our national system of standardization has emerged from the cloistered surroundings of the testing laboratory into the bright glare of social and political concern. Our system for producing standards—for both industry and the consumer—has been and is being closely scrutinized by government, especially at the federal level, to see whether it is in the public interest.

Every move made from a policy point of view since that time has been made to a large extent in the light of that perception. Thus re-emerged ASTM's reputation for fairness, integrity, and statesmanship in the standards process and in the atmosphere—political, economical, and social—in which our standards process operates. Our planning function has been characterized by a biannual reassessment of the most fundamental assumptions upon which ASTM bases its view of itself and the things that it does. In 1972, it became very obvious in our planning discussions that, while basic standards in the area of materials would increase as an arena of importance, there would emerge a growing and ultimately tremendous need for standards for products, systems, and services. In fact, ASTM had for at least 15 years been moving slowly and almost without notice into those areas.

Our analysis indicated that, in deciding who should do what in the standards area, the concept of technical benchmarks was rapidly becoming obsolete in large part because of the trend toward product and systems standards. ASTM discovered that process not only makes standards development as efficient and cost effective as possible, but also makes it legally safe and publicly acceptable. ASTM in responding to these stimuli and new realities changed its scope to indicate its willingness to make its process available for any standards activity the advocates felt would yield to the ASTM process. The process is the machinery that produces interface and integration, not to make a pun, but it works automatically. We then began to refer to ASTM as an organization that was really a management system for the development of voluntary consensus standards and the assembly of related technology. Here again the events, since that decision was made, have clearly justified our anticipation.

ASTM relates and interfaces in many ways with government, industry, and academia. ASTM is already involved in many phases of the materials/production aspects that interface with systems and automation. Here are a few examples of areas where standards are involved with multiple technologies and numerous disciplines: shipbuilding, nuclear technology and its applications, space simulation and technology, fire standards, electronics, solar energy, waste disposal, spill control, product safety standards, medical devices, and systems.

I have read that the failure rate of interactive CAD/CAM systems is over 35% of installations. The complexity is obvious (even to a layman as myself) in trying to integrate architecturally and functionally heterogeneous systems that are usually geographically dispersed and politically imbedded into large organizations which have historically separated responsibilities. There are hundreds of vendors offering computer technology and systems, even turnkey systems. Some of these problems will be solved through standardization and a partnership between you and the ASTM standardization process. You will have your own opinions, but it is certainly felt by many that a lack of standards is impeding the use and growth of computer-controlled manufacturing systems.

It has been clearly demonstrated time and time again that the ASTM process works with systems, that it is cost effective, and that it is legally, economically, and politically acceptable. It is only a matter of a little more time for those in leadership positions to realize that this process can also be used, indeed has a history of being used, in the development of value standards which is my way of describing those public decisions which we have found so difficult to make where technology interfaces with public policy.

One of the reasons, perhaps the principal reason, that ASTM has been able to track, indeed predict, changes in the world in which it lives is the very simple one that the development of standards and the assembling of their supporting technology in available form is the Society's only concern. If one looks at the agendas for any ASTM policy or control committee from the Board on down, one will be hard put to find any subject on those agendas that does not bear directly on standards, their development, and their worldwide acceptance and availability.

Your fine meeting and symposium is a validation of another fundamental but immensely important part of ASTM's view of itself. ASTM is marketplace driven. One of its basic assumptions is that in a properly organized and managed standards development situation what needs to happen, if anything needs to happen, will happen. You provide the technical activity and develop the needed standards. We help you organize an efficient, cooperative standards program and organization, and support your standards writing through coordinated balloting and due process consensus procedures.

In other words, you are in charge of what is done, we are in charge of how it is done. ASTM can do nothing that you do not want to do technically. ASTM is an upsidedown organization in the sense that the major product decisions are made not at the core but in the supportive satellites. We call those satellites technical committees; sometimes we call them semi-independent tribal groups. We have long known that whole fields of technology are covered by ASTM standards that are the *de facto* standards of the world, just as ASME's Boiler Code is the *de facto* standard of the world.