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.

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