The Impact of Advanced Manufacturing Technology on Major Organizational and Managerial Concern Areas

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Abstract

In today's highly competitive global marketplace, many manufacturers are seeking lower cost, higher quality processes in order to increase productivity and enhance flexibility. Many of these manufacturers seek a solution with lower paid workers by either importing them or moving manufacturing operations to low wage locations. Often this is done with disappointing results. Low labor costs are often offset by high turnover rates, low productivity, poor quality of work, high training costs, and high travel and transportation costs. An alternative solution for many manufacturers is automated manufacturing. However, this solution can be costly, involves many complex risks, and provides the inexperienced manufacturers with many technical and management challenges and there also appear to be number of obstacles in this path to integration.

The objectives of the research are first to examine the issues surrounding the implementation of Advanced Manufacturing Technology and the survey integration benefits, problems, and major areas for concern cited in recent literature. A second objective seeks to examine how AMT enhances the philosophy and implementation of Total Quality Management and establish it as a hypothetically viable framework within which to address and resolve current TQM integration obstacles.

The thesis is divided into Four sections. The first section is a brief history of AMT, followed by a discussion of system benefits and a survey of implementation difficulties cited in the literature. The second section examines the philosophy behind TQM and identifies its basic methodologies. Then examines how AMT enhances the philosophy and implementation of Total Quality Management. The third section

discusses methodology development via case study, and involving a company integrating AMT systems and participating in TQM programs. The fourth section reports the research results obtained through detailed descriptions and comparative summaries. The final section addresses research conclusions.

The case study shows that TQM involvement appeared to be correlated with better production monitoring and control systems and improved production synchronization. Moreover the case study suggests that functional integration of AMT has positive effect on TQM programs. However, there were other variables present which suggest that future studies should more explicitly concentrate on the effects of budget variation and employer-employee relations.

Chapter I

Introduction

In today's highly competitive global marketplace, many manufacturers are seeking lower cost and higher quality processes. Many of these manufacturers seek a solution with lower paid workers by either importing them or moving manufacturing operations to low wage locations. Often this is done with disappointing results. Low labor costs are often offset by high turnover rates, low productivity, poor quality of work, high training costs, and high travel and transportation costs. An alternative solution for many manufacturers is automated manufacturing. However, this solution can be costly, involves many complex risks, and provides the inexperienced manufacturers with many technical and management challenges.

The 1980s saw a steady growth in the use of a number of new manufacturing technologies in industry. Computer Integrated Manufacturing (CIM) is both a set of technologies and a philosophy which seeks to combine computer-based elements so that they may work effectively in concert. CIM is hallmarked by its sophisticated use of computers, which facilitates effective processing and dissemination of information among the elements of the system, as well as control of the processes at the machine level. A distinguishing feature of these manufacturing technologies is the fact that they address the integration and coordination of processes and products in manufacturing rather than simply the processes themselves.

Computer technology will continue to be a source of dramatic change in the manufacturing industries. As more and more processes shift to effective computer control at the machine level, so it will become possible to effectively and predictably co-ordinate the flow of work and information of those machines. The advantages of continuous flow manufacturing are progressively being brought into the "small-batch" arena, as the previously stifling complexity and variety is ordered and controlled by computer systems.

The successful implementation of Computer Integrated Manufacturing (CIM) poses a challenge to the work force not only in terms of the new skills to be learned, but also to the industrial relations system and the managerial and organizational practices.

Technology may be defined as the application of science for a practical purpose. "Armed with his machinery, man can drive, can fly, ... Knock down cities... (Emerson, 1904, p. 103)." Coupled with technological advance is the need to understand how to use it. As Oliver Wendell Holmes (1916) once wrote; "science can be a first-rate piece of furniture for a man's upper-chamber if he has common sense on the ground floor (p.120)." Manufacturers have long sought to take advantage of advance in technology wrought by science to improve their production process: This Thesis discusses certain "common sense" approaches that may be necessary for industry to implement technology more effectively.

Manufacturers, who believe in TQM as a means to their survival and see in innovative technology a means for further TQM enhancement, will benefit from such research. According to Micheal Porter, profitable opportunities are fewer in mature industries, if you do not create a way to dynamize this industry. There are five forces driving industry competition: Relations with suppliers, Relations with buyers, New entrants, Substitute products, and Rivalry amongst established firms. In a highly competing environment, "the goal of competitive strategy… is to find a position in an industry where a company can best defend itself against these competitive forces or can influence them in its favor" (Tidd, p. 64). Advances in technology can influence those forces to one's favor. AMT is one of many of these technologies.

Research Objectives

The objectives of the research are:

- First to examine the issues surrounding the implementation of Advanced Manufacturing Technology, integration benefits, problems, and major areas for concern cited in recent literature.
- Second to examine how AMT enhances the philosophy and implementation of Total Quality Management and establishes it as a hypothetically viable framework within which to address and resolve current TQM integration obstacles. The hypothesis is explored through a case study involving a particular organization who currently uses AMT facilities and is in the process of deploying TQM.

Introduction to Integrated Advanced Manufacturing Technology

Advanced Manufacturing Technology (AMT) can be defined as computer-controlled equipment designed to provide programmable and flexible manufacturing automation (Groover, 1987). Such systems are capable of providing numerous benefits of speed, flexibility, and accuracy in production processing and in process control. However, a variety of articles have highlighted the difficulties facing industrial implementation of AMT. Reviews in journals have cited technological concerns: high capital costs and marginal gains, an inability to integrate single-vendor systems due to incomplete product lines, difficulty of integrating multi-vendor systems due to incompatible program logic and communication protocols, and overall complexity of network operation and maintenance. In addition, AMT vendor sales have been declining and smaller batch manufacturers, those supplying the theoretical "best-fit" for AMT, had previously recognized advantages in AMT but later found that, for such companies, implementing AMT may not only aggravate existing problems, but also create new ones (Groover, 1987).

The literature also cites organizational and managerial difficulties. It is believed that people and organizational constraints are the chief obstacles to integrated manufacturing. Companies have invested in "substitution-innovation" by exchanging automated machines for manual ones, rather than transforming the production process. Apparently, the result is often the automation of already wasteful practices, difficulty in coordinating workflow between machines with varying capabilities, and duplicated data entry. The organization integrating AMT must be concerned with its effect upon work organization and industrial relations, occupational safety, and skill requirements and training needs.

There are numerous areas to consider in factory AMT implementation to assure "first-rate furniture", rather than expensive machinery that fails to deliver as promised. In addition to the technological issues of standardization which need to be addressed is the need for management to take a systems approach, and evaluate not only the needs of the production process to be automated, but also the associated functions of design, data collection and communication, accounting, and personnel. The company must also review management and implementation strategies, as well as the overall goals and objectives of the company.

Overall importance of Total Quality Management

Quality in product and production is a theme that has run concurrently with integration of AMT. A number of authors advocate the integration of traditionally disparate functions to assure quality throughout the manufacturing process. To accomplish this organizational integration, they identify a need for management to take a systems approach to quality. They must evaluate not only process capabilities through SPC, but also design and fabrication considerations, set-up operations, material flows and process linkages, personnel, data collection and communication, management practices and overall company goals and objectives.

Organization of the Research Project

This research is divided into six chapters. The first chapter introduces the basic concepts and construction of the project. The second chapter provides introductory information on Advanced Manufacturing Technology, and is followed by a discussion on system benefits with a survey of current implementation difficulties and concern areas cited by literature. These concern areas are recapped in light of the need for management policy to address functional, as well as physical, process integration. In the third chapter, the research project examines Total Quality Management and then compares its overall objectives with the integration concern areas cited in Chapter II. The fourth chapter discusses the methodology used in developing and implementing a case study involving a company with a number of operational Advanced Manufacturing Technology systems, that is involved in Total Quality Management programs. The fifth chapter presents and summarizes the case study results. The sixth and final chapter integrates these results, discusses the limitations and advantages of the methodology, and then offers some conclusions and implications for future studies.

Chapter II

Advanced Manufacturing Technology

Introduction

This chapter provides background information on Advanced Manufacturing Technology (AMT), as well as its current usage. It begins with a brief discussion of the need for more efficient production, and industrial use of automation to achieve it. Next is a brief recitation of machine-tool history, leading to the flexible-programmable automation of AMT, the need for systems integration, and the role integrating AMT has in computer-integrated manufacturing. A survey of literature follows, concerning the benefits of corporate investment in such flexible automation, and then an examination of articles highlighting difficulties manufacturers are currently experiencing while implementing AMT. These difficulties and problems lead to a need for an integrated systems management approach.

Need for Improved Industrial Productivity

Manufacturers are always in need of producing marketable goods, using more efficient and more effective production methods. The machinery with which the manufacturer produces marketable goods must be more efficient in order to stay profitable in industries with more efficient competitors. The manufacturer must continually and rapidly improve in the eye of a customer who continuously demands higher quality, lower cost, better services, and greater flexibility to provide variety. Manufacturers must reduce defects, lower production costs, assure on time delivery, reduce maintenance and warranty costs in an effort to be able to compete in a global market. One of the means by which industry has endeavored to meet these market needs is through the use of AMT.

Background

The roots of AMT originate in the mechanical guides used to control the jackknife and edges of the free-cutter, unfettered wood and metal working. Some time around the fourth or fifth century BC, mechanical guides began to be used with cutting instruments. This assured precision and repeatability. However much of the flexibility of free cutting was lost. The water-powered cutters of the 1400s brought the first "automation" to the factory. They gave way to steam powered cutters shortly after the invention of the steam engine by Watts In 1769 (Voalker, 1988). In 1801, Jacquard is credited with the first "programmable" machine, a loom (weaving machine) able to reproduce weave patterns in textiles (Groover, 1987). Development of interchangeable parts for guns began in the late 1700s. Metal and material science added further refinements through development of manufacturing parameters, such as "speed and feed" tables, which replaced "cut and try" values. Factory electrification in the early 1900s decentralized the factory floor by freeing machinery from attachment to central steam power via belts, cables, and drive shafts. Individual lathe, drill, press, mill, welding, and assembly machines could then be easily distributed throughout the factory floor (Voalker, 1988)

Manual information system: The mechanic rather than the machine controlled the shop floor production and information flow. The mechanic controlled the physical movements of the machine. His skills, hands, and eyes coordination determined the outcome of the manual operations. Master mechanics often possessed all the information regarding the numbers, machining requirements, and storage of parts being produced. Dimensional information not committed to memory was stored in black books and blueprints. The success of this manual method was assured primarily by the memory, persistence, and long employment of the mechanic. Departmental coordination was often achieved through the same individuals, with the mechanic having memorized and recollected information created by the other departments (Hordeski, 1988)

Need for precision: Continuing manufacturing developments resulted in the need for more precise control of machining. Advances in aircraft architecture, especially jet turbine technology, demanded complex machining geometries and large-scale military orders demanded more quality and reproducibility in the machining than was possible in manually-controlled machining. Some "record-playback" machines were available at this time, however they required a skilled machinist to let the initial "lead-through" of machine tool movements be recorded. The US Air Force wanted to move away from dependence on skills crafts, wanted centralized control over machining, needed to maintain and document component reliability, and wanted to transfer production easily from supplier to supplier. To meet these needs, the USAF heavily subsidized the development of Numeric Control machining (NC). NC machines turned operations by replacing the human operator with a mechanism, which, through electronic instructions encoded in thesis tape, always "operates" the machine tool in exactly the same manner. (Wall, 1987)

Automated information systems: The computer control of machining demanded information flow control developed along with that of machine control. NC information consisted of workers taking tapes from "fluxowriter" tape programmers to the tape readers on NC machines (Groover, 1987). Manual input data devices were attached to machines for on-site editing, but it took the addition of more advanced computer processing and memory to achieve computer-numeric control (CNC) and allow complete part programming to be stored, as well as edited, on the machine (Wall, 1987).

Programmable/ Flexible Automation

Programmable and flexible automation is different from the hard automation of traditional transfer lines. The most common "automated factory" is the one using hard or fixed automation. Hard automation has been integrated with centralized computer control for many years in the continuous processing plants typical to the chemical, petroleum, and food industries. There, the vast majority of processing is under machine control (Groover, 1987). Computer Integrated Manufacturing (CIM), using the definition of CIM as automation throughout the factory, has been considered common for the food and beverage industry. In these industries, information systems are under such complete computer control so personnel is less devoted than any other industry. Fixed automation is incapable, however, of being easily adjusted to changes in product design, product configuration, lot size, or other production area without great expense (Groover 1987). On the other hand, the programmable and flexible automation AMT is capable of not only automating every production step, but is also capable of being re-programmed for a variety of part configurations, shapes, and lot sizes.

AMT can be defined as a computer-controlled equipment designed to provide programmable and flexible manufacturing automation (Groover 1987). There are numerous types of AMT available, such as Automated Storage and Retrieval Systems (AS/RS). Automated Guided Vehicles (AGV), Automated Testing Equipment (ATE). Bar code scanners, Computer Aided Design and Manufacture (CAD/CAM). Computer-Aided Production Management (CAPM), Computer-Numeric Control (CNC) machines, Flexible Manufacturing Systems (FMS), robotics, and Programmable Logic Controllers (PLC). Computer hardware and software processing characterize these systems. Their output is in the form of data or printouts (Groover 1987).

Trend Towards Systems Integration

The intent of the programmable-flexible automation of AMT is to achieve in the discrete production plant the same level of "integrated operation" found in the fixed automation of continuous processors.

The degree of linkage between elements is essential to the overall level of system integration, regardless how the data processing is accomplished. The systems concept lies at the heart of the physical and functional integration of production. In general, a system can be defined as "a set of related elements interacting within an environment and organized to achieve predetermined objectives (White, 1988)." AMT systems can be installed as "islands of automation", as is the case in many industries (Sheridan, 1990). However, just like an island in the Pacific lacking communication with the outside world, the automation may well remain isolated, no "synergy" occurring, and full benefits go unrealized. Process synergy only occurs after having "taken many technologies and blended them together so that the whole is better than the sum of the parts ... synergism of existing and emerging technologies" (Vail, 1988). The literature indicates that the greatest gains from using AMT are derived when they are fully integrated within the plant, in which process synergies are derived from AMT components operating in concert with all other systems (Vail, 1988).

Computer Integrated Manufacturers (CIM)

Integration of AMT can occur on a small or on a large scale. CNC machines can be grouped into cells, and have robotics to automate the material handling function in concert with machining. Computer Aided Design (CAD) functions can be linked to CNC production and information control to create a CAD/CAM facility. Coordinate Measuring Machines (CMM) can be linked to a CAD database. CMM are computerized inspection devices designed to verify, with a great deal of precision, accuracy, and repeatability, the measured component's conformance to specification by comparing the digitized locations of part coordinates with specification database.

The greatest benefit occurs when the CAD specification database is physically integrated to the CMM. CAD, CMM, CNC, and other AMT systems can be linked on a large scale, with database sharing throughout the plant, and all plant activities are under computer controls (Groover, 1987; Hordeski, 1988)

While system elements can be tightly, or loosely connected, and can operate independently, they still have to achieve the objectives collectively, the system must be integrated. "An integrated system is generally one that is tightly connected" where each of "the individual elements in an integrated system are synchronized (White, 1988, p. 47)." When the manufacturing system is integrated through the use of computers, CIM is achieved.

This physical and functional integration is essential to overall AMT systems integration.

In this context CIM is defined with "integrated AMT" as follows. The term " integrated AMT" refers to AMT systems that are both physically and functionally intertwined with production. The physical linkage is achieved through the technical aspects of the AMT system: the hardware, consisting of production related devices (e.g.: lathe, circuit tester, barcode scanner), computer control, and communication media; and the software, consisting of the application, operating system, data and database management, and communication protocol. The functional linkage is the one achieved through departmental interaction affecting AMT system usage, the planning, scheduling, and controlling of activities such as machine operation, material handling, storage, and routing, and involving shop floor communication. The term CIM is defined as managerial philosophy used to provide the necessary corporate framework in order to properly plan and implement the physical linkage of AMT systems. A CIM system is, thus, one in which management has directed the physical integration of AMT subsystems throughout the plant.

Benefits of Advanced Manufacturing technology

There have been numerous benefits ascribed to integrated AMT. These benefits include reductions in power and cost, improved quality, productivity, and flexibility. The literature was unclear on the potential of labor cost reductions. A survey by Huang and Sakurai (1990) indicates that most Japanese industries consider the greatest benefit of fully integrated AMT to be labor cost reductions, having "increased their ability to compete in world markets (p.105)." In the American industry, reductions in direct labor cost were most often offset by increased indirect labor in programming, engineering, and maintenance. Most accounting authors consider labor reductions to be either insignificant, offset by increase indirect labor costs, or secondary to principal benefits (Kaplan, 1986; Cooper, 1989). Potential reductions in labor power and labor expense aside, the greatest benefits appear to be improvements in quality, productivity, flexibility, and strategic planning.

Quality

Integrated AMT facilitates offer the potential benefits of improved quality. The combination of programmable logic and feedback control in an AMT application is designed to repeat machining and assembling movements with extreme precision and accuracy (Groover, 1987). Significant benefits can be derived from CAD operations, including: productivity increase, improved accuracy, reduced lead times, greatly enhanced legibility, easier repeatability and modification from having on-line parts libraries and drawing databases. This ability to consistently achieve much closer tolerance can greatly improve conformance to design and specification, reducing scrap and rework, and enhancing product reliability, as measured through warranty expense and service call rates (Kaplan, 1986). In a study of Japanese companies using CIM, over half ranked the improvement of quality as the most important contribution, vital to assuring total quality control, and attaining zero defects in production (Huang & Sakurai, 1990).

Productivity

As design conformance and quality specification conformance improve, scrap and rework are reduced. Also, since the same amount of raw material is converted into more salable product, productivity increases. A recent study of the United States

Department of Commerce on midwestern companies involved in durable goods manufacture noted 55 per cent median increase in production rates when CNC machines replaced manual machine tools, and 105 per cent median increase when these CNC machines were linked to CAD systems. The speed of production, coupled with the ability to process different parts together and reduce batch and work-in-process size, have the potential to reduce product development time by half, thus paving the way for rapid prototyping and subsequent market entrance (Groover, 1987)

Flexibility

AMT integration can provide flexibility in production lines. CNC and FMS facilities assure economy-of-scope in productions through the ability to process a variety of parts, in a variety of volumes, in a variety of component mixes, using a variety of routing and sequencing procedures, and a variety of materials. Production can thus be customized. In addition, reprogramming capabilities allow one computerized machining center to serve as a backup for other production lines. Use of AMT can reduce factory floor space requirements, as individual multiple-use machines replace a number of older machines dedicated to specific processes, with square footage and the number of shop floor machines often reduced to less than half that originally needed. Freeing up the shop floor space already paid for affords additional facilities flexibility (Groover, 1987). Eighteen of the most well known Japanese manufacturers ranked flexibility as the third most important contribution of "factory automation", a popular Japanese term for plant-wide integrated AMT (Huang & Sakurai, 1990).

Strategy

Integrated AMT can offer strategic benefits. Strategy can be defined as the plan or schemes used to achieve goals (Webster, 1978). In a business sense, strategic goals include: capturing, maintaining, and growing within the desired market; achieving competitive advantages through product quality, cost, design, and service; and optimizing capital usage and cost structures through enhanced facilities capabilities. The production function must be able to support whichever business strategy management decides upon (Hall, 1987). By the same token, the business strategy decided upon must be in the areas where the company has some skill. Since it has been noted that businesses using strategies that adhere to "core skills," but that are still flexible enough to adapt and manage this adaptation, "tend to be superior performers (Peters & Waterman, 1982, p. 295)." Integrated AMT facilities support "core skill" strategic issues through the capability of improving product design and specification conformance quality, and enhancing facilities capabilities. They also support the need for adaptability through inherent systems flexibility. CIM "factories of the future" can give large companies the capability of offering the same level of production flexibility as the one previously enjoyed almost exclusively by the smaller manufacturer. The large manufacturers investing in such systems may thus be able to expand their market. On the other hand, the small firm can benefit strategically by investing in integrated AMT and stay a competitive step ahead of bigger plants (Vail, 1988).

Limitations of Advanced Manufacturing Technology

Experience integrating AMT appears to have been marked more by trial and tribulation than by stellar success. Variety of journals provide circumstantial and survey evidence of the difficulties facing the company, and industry in general, trying to integrate AMT with operations.

Little productivity Gained

AMT has the potential for significant improvements in quality and speed, but industrial users have not been experiencing desired productivity gains. One study found spectacular spending on such systems had no detectable impact on productivity. Some American manufacturers, "after a decade of throwing money at shop floor automation (Horwitt & Booker, 1989, p.1)," are reevaluating their CIM strategies. "The majority of manufacturers have not realized the expected gains...[having] spent heavily in developing computer–integrated manufacturing (Booker, 1990,p.56)." Substitution of AMT for existing machinery has only slightly improved existing operations (Rush & Bessant, 1990). A survey of 5000 North American manufacturers by Roller and Tomback (1990) revealed that, although competitive advantages can be gained using AMT systems such as FMS, unrecoverable high capital costs often eliminated any benefit.

Failure to Integrate

AMT systems demand intensive electronic interaction with other operations, systems such as shop floor coding, robotics, or distributed numeric control. Features of recent technology have greatly enhanced the ability to achieve physical and logical integration. Yet the apparent failure to physically integrate has resulted in most AMT installations operating as unlinked automation islands. Such installations form of "substitution innovation" that slightly improves existing operations, rather that a production transformation (Rush & Bessant, 1990). Small batch manufacturers can not afford the high capital costs associated with production transformation. So they tend to transform step by step each part of the production or sometimes they are not able to integrate single-vendor systems due to incomplete product lines. Multi-vendor systems result in difficulty in integrating due to incompatible program logic and communication protocols, and overall complexity of network operation and maintenance.

Technological and Information Systems Concern Areas

Effective management and integration of communication demands plant-wide access to data collection and distribution systems. When considering the decision-making process necessary to monitor, evaluate, and control production, one conclusion is that good decisions need good data collection. Data collection systems must be both comprehensive and convenient. If automated units can receive and generate all appropriate data, overall integration problems can be resolved.

The technological concerns of AMT revolve around networking. The "timely flow of appropriate information across departmental boundaries (Jones, 1988, p.8)" demands fast and efficient communication between AMT systems. It is impossible to handle manually the reams of data generated by AMT. This impossibility establishes the basis for using data communication networks, electronic, or optical transmission systems. To assure "the timely flow of appropriate information across departmental boundaries (Jones, 1988, p.8)," networks must be able to transmit data to all nodes in a consistent, accurate, timely, economically feasible, and relevant manner.

<u>Goal of networks:</u> The proper network architecture assures that the network attain its goal of facilitating communication between devices. The network should be "user friendly", allowing users to easily define, operate, maintain, modify, and secure the network. The network must also use standardized hardware and software to assure database connectivity and file compatibility, and minimize internal modification and excessive data overhead (FitzGerald).

<u>Distributed processing concerns:</u> This distribution of information processing functions, while benefiting data communication, also affects departmental relations. The move to distributed processing fragments existing information and media reservoirs. Such reservoirs, once entirely under the control of IT departments and libraries, have become distributed throughout the plant. This decentralization and loss of one form of local control may cause gaps in the dissemination of information and knowledge. These gaps in the corporate knowledge base may lead to the need for information resource managers and integrated information centers, as well as strategic information planning (Battaglia, 1991).

<u>Data collection and distribution:</u> Collected data must be properly distributed. To effectively link design, manufacturing, and marketing, information traditionally held by the IT function must be shared, along with the underlying hardware and software resources. Data once viewed as "personal," or internal to the department, is often of broad interest to the corporation. Software standards must be enhanced to provide uniformity in access: the original users, out of necessity, lose control over their own hardware, software, and data.

The loss of control over such things as report creation and distributed computing power has fostered resentment that sometimes precipitates "turf wars with information systems personnel, who restricted the idea of spreading around centralized computer assets (King, 1991, p. 67)." This need to "spread around" computer assets must, however, be weighed against integration concerns. One reason that IT departments press for OSI software is that they are often "aware of the data redundancies and inconsistencies and of the difficulties of pulling together far-flung applications for management reports.

Functional impact of information systems: Design and engineering functions have a significant impact on information system resources. While design engineering accounts for approximately 5% of total product cost, they indirectly control 75 to 85% of total product cost through their effect on production, material, tooling databases. With an estimated 70% of IT time spent on "trucking" data around the company, design activity should therefore be of major concern to management. IT departments do not appear to be working closely with design and engineering. Senior management at many companies may be skirting this issue since, at a time when increasing demand on information resources should have expanded IT resources, IT managers often cite insufficient budgeting and equipment, overworked people, and excessive backlogs and maintenance activity. Survey evidence suggests that the "very narrow shop floor perspective of most respondents may have kept IS in the back room during system development and, rather than being involved, IS departments often feel victimized by users' requests for variety and uniqueness in shop floor systems (Horwitt & Booker, 1989, p. 143)."

Human Resources Challenges Created by AMT

AMT planners must also recognize that there are certain human obstacles to overcome. A survey of problems encountered in American, European, and Japanese CIM installations uncovered instances where total factory integration proved both insufficient and uneconomical because human factor and worker knowledge demands went unnoticed, with numerous difficulties encountered in work reorganization, skill requirements, occupational hazards, and industrial relations.

Major Personnel Management Implications

The human concerns of integrated AMT systems are divided into the areas of installation, operation, maintenance, and safety. The installation phase requires workers to be trained in the manufacturing process and automation. During implementation, management must motivate and support employees, and recognize the need for employee participation. In operation, management needs to also recognize the discretion of human interaction with the Database Management Systems (DBMS); the interface with multiple devices, work area needs, and interaction with other people. System maintenance involves recognizing work space requirements, the need for task analysis, and monitoring and adjustment duties, the need for system programming and engineering, and departmental interaction. Lastly, for system safety, management must consider the hazards of automated machinery, and provide adequate lighting, safety zones, and safety training to heighten worker awareness.

Supervisory scope change: An increase in automation on the shop floor changes shop floor skill needs, as well as the scope and control spans of supervisors. Factory floor automation used to be installed exclusively for its labor-saving potential. A "skill-twist" phenomenon occurs: although direct labor decreases, the ratio of skilled to unskilled workers increasing with the addition of automation. Veteran machinists may initially be replaced by "machine-minders", but difficulties associated with assuring proper part positioning, programming, and maintaining the sophisticated AMT environment demand employees trained in machine software, error in control and in fault diagnosis. Data tend to support a decline in unskilled workers, and a rise in professional engineers and technical support staff. As a result, the company installing AMT often sees a change from task-related training to individual development (Rush & Bessant, 1990).

Supervisory skill change: When AMT is introduced, supervisor skills and control areas shift from concern with people and labor management to machines and technical-systems management. Introduction of CNC introduced complexity to management, contradiction in production requirements, and mismatches between expectations and experience. Managerial complexity developed as engineering managers with machinist backgrounds began aligning themselves with shop floor machinists rather than programmer technicians with strictly computer backgrounds and as small firms coupled programming skills with supervisory roles. Foremen reacted differently to this coupling of programming and supervision. Some welcomed this challenge as an opportunity for technical enhancement. Others felt less confidant about their skills, with some becoming "project assassins," and sabotaging machinery. Beatty and Gordon (1990) found that this sabotage may be quite subtle: an automated welding line that was mothballed due to "poor equipment design," failing after a year deployed adjacent to a manual welding line, was "running perfectly" within sin months in an isolated greenfield site.

Performance Appraisal

Where stand-alone CNC machines are implemented, the operator will be less directly involved than before in the manufacturing process. Instead, they are required to check the machinery, make minor adjustments to machine settings and switch programs according to changes in batch production requirements. Maintenance duties and failure corrections, may also be included in their job. While operators may be able to solve straightforward problems, more complex difficulties may require unscheduled maintenance support.

Thus AMT changes the way performance appraisals are conducted. Whereas the actual production rate and quality was previously controlled by a single skilled worker, CNC has the advantage of being more consistent and the rate at which goods can be produced is more or less constant, therefore output is not the main criteria to consider in evaluating ones performance. MPC allows management to control Work Orders requested by each operator, the reason for the outage and the reaction taken. Thus operators are evaluated on how much preventive actions they take, their ability to work in teams when diagnosing a problem, how they maintain their equipment, and on the ability to control error and diagnose faults.

The main criteria to consider performance are:

- Supervisory Ability
- Analytical Ability
- Resource Utilization
- Sense of Responsibility
- Quality of Work
- Quantity of Work
- Work Relationship

- Judgement
- Emotional Stability
- Punctuality
- Initiative
- Safety Consciousness

Training on Error Control and Fault Diagnosis

Most manufacturing engineers accept that CIM is changing the nature of human work in manufacturing, rather than dispensing with it. The major aspect of human interaction with computer-integrated systems is that of fault diagnosis or troubleshooting. The complexity of the new manufacturing systems has meant that fault diagnosis has become an increasing proportion and an integral part of operators' jobs. Establishing and maintaining high levels of diagnostic accuracy and efficiency is important for a variety of reasons. One is that equipment downtime is expensive, another is that errors of diagnosis might, under some circumstances, be a threat to both safety and quality.

One particular mental skill that must be exercised when system failures occur, is fault diagnosis, or troubleshooting as it is sometimes called. As such, fault-finding ability can be vital to the successful and safe operation of plant installations. Despite the sophisticated nature of CIM, increasing levels of complexity have often been achieved at the cost of decreased levels of reliability, and it has been reported that up to 70% of maintenance operators' time in advanced manufacturing systems is engaged in fault diagnosis.

One difficulty found in many CIM installations concerns the transfer of the system from the engineers who designed and built it, to the day-to-day operators who will run and maintain it. One reason that engineers tend to want to stay close to the system is that failures have not settled into a predictable pattern. Indeed patterns may not arise and there will always be novel failures. It is a crucial issue then, to determine when the system should be handed over and which training should be given to the operators to prepare them for that time.

Developing an accurate picture of what expert diagnosticians actually do during diagnosis is not easy. The most frequently adopted approaches to training on diagnosis skills include training in theory and practice.

It seems that one of the major training problems it seems, is to develop a training method that encourages beginner operators to sample the environment efficiently and to develop appropriate mental models that allow them to put some "top down structure" on what is essentially "bottom up" information.

Operator Selection

The operator selection problem can be broken down into three parts:

- First identify the mental skills necessary for effective diagnosis of novel failures.
- Second devise a series of tests that will indicate those individuals who possess either, the prerequisite mental abilities that will allow them to develop the appropriate skills, or the actual skills themselves.
- Third develop a method of selecting individuals who are likely to retain the benefits of training and/or who have somehow demonstrated that they can exercise such skills even if they have not been required to for some time.

It should be remembered that the greater the number of restrictions that are placed on those who are eligible for employment, the smaller the pool of acceptable personnel from which to select. This point will not be lost on those organizations who are in the process of developing CIM systems as an alternative to traditional manufacturing processes. Many traditionally skilled machine operators may have the potential to be effective in their new roles with advanced technology. It will be unlikely, however, that all of them will be equally capable of making the transition. It should not be forgotten that the original criteria by which they were selected will, in many instances, be different from those against which their performance will be judged with the new technology.

Implications on Organizational Structure

The introduction of CNC had other effects. Production requirements put contradictory pressures on work organization: CNC was an avenue to reducing managerial reliance on skilled machinists.

AMT places different demands on employees than traditional production technologies. AMT decreases the number of routine, specialized jobs by building their activities, and the rules, policies and procedures that govern them, into the hardware and software of the production system itself. The new tasks require different set of skills and job requirements. Organizations change their reward systems to fit these new job requirements. Some has already started rewarding employees on the basis of flexibility and not output.

With AMT jobs tend to be horizontally enlarges because the new technologies increase job complexity. Jobs also tend to become vertically enriched because employees need more discretion to deal with the unexpected.

Because the rules, policies, and procedures that govern standardized jobs are built into the hardware and software of a production process, organizations that employ new technologies have less need for RPPs (rules, regulations, and procedures) to coordinate and control employee behavior. Organizations must develop their cultures to adopt the new technologies effectively and socialize their employees with the new culture.

AMT decentralizes decision making in some areas and centralizes in others. Operating decision-making becomes more decentralized, while strategic decision making becomes more centralized: AMT eliminates the positions of middle managers and staff members whose role was to collect and process information that can now be collected from the system. The removal of managerial layers leave the technical and professional specialists with more authority and autonomy in taking operational decisions. On the other hand, strategic decision making becomes more formally centralized, because people can be linked electronically regardless of their location which will result in greater access to information and sharing of expertise for more effective strategic decision making.

Procedural changes: Management must create new procedures for personnel development and deployment to cope with "job optimization" and re-evaluate the existing departmental engineering, production, and maintenance functions in order to support flexible deployment, enhancing communication to facilitate interdepartmental coordination, as well as to foster skill and knowledge "interchange". The use of high-technology installations demand that "high-tech" training material and aids be readily accessible on the factory floor. Leniency in work regulations may also be a necessary measure to assure flexibility in operations and employee deployment. Integrated AMT replaces the specialized, departmental, and hierarchical factory of the past with one that is interdependent, flexible, and requiring considerably more time to orient, train, and deploy personnel who have an increase range and quality of skills (Rush & Bessant, 1990).

Major Managerial Concern Areas

The literature review reveals numerous corporate activities that must be carefully considered when addressing the particular needs of integrated AMT systems, but what is needed to assure effective integration is a coordination framework, a philosophical superstructure with which to guide all corporate activities. A popular expression is to "think globally and act locally".

The installation and integration of AMT has an effect upon managerial practice. Although there is some subjectivity in the grouping due to an overlap between managerial and organizational aspects, management of AMT concerns can be roughly classified into four areas: the need for system approach, the need for strategic investment management, the need to manage technology, and the need to recognize and confront the changes that technology may impose.

Needs for Systems Approach

Management has begun to recognize the company-wide cooperation inherent in integration of AMT, and especially in CIM implementation. Coordination efforts have even encompassed such traditional IS functions as distribution, customer service, ordering, and accounts receivable. Survey results stressed the importance of joint project teams. The data integration efforts of integrating AMT demands work-flow coordination, elimination of data entry duplication across departmental lines, database sharing, and faster implementation of engineering change notices (Horwitt & Booker, 1989)

Need for Strategic Investment Management

In project analysis, factory automation should be viewed as a strategic investment decision, rather than a budgeting process, with the impact on increased flexibility and lead times (Kaplan, 1986). This strategic investment demands strategic information planning. The company should examine information needs and then align them with corporate strategy when implementing AMT. This is essential to properly assess the issues surrounding communication standards, integration and coordination of distributed data processing systems, database access issues, and future automation plans. Improving quality and production control requires the development of a strategic "vision". This vision necessitates thorough planning, plan implementation, and continuous process measurement. Customer habits should be used to determine production patterns which in turn helps to minimize inventories, lead-time, and costs; and maximize quality. Functional leadership and technical barriers must first be identified and overcome.

Need to Manage Technology

AMT integration is not an issue of technology, but rather the management of technology. Management orientation must change from task and tool installation, to people and process integration, with CIM integrating people and functions across departmental boundaries. Integrating AMT becomes a cross-functional, top-down, and strategic management. System and process optimization across group boundaries is dependent upon top management when functional groups have no charter to initiate change beyond their own departments.

Management needs to address some areas when implementation teams or groups are used, such as: the need to change compensation strategies to reward involvement, empower teams according to level of expertise rather than position of authority, the need for management full support. Teams also need to have a thorough knowledge of both process and management objectives.

The technological expertise of management plays an important part in AMT installation and integration. When upper management has little or no experience with AMT, they will unwittingly force AMT into work environments ill suited and ill equipped to use it. Managerial causes cited included a lack of managerial technical comprehension and expertise, lack of vision, and a general reluctance to tackle the problem (Groover, 1987).

Need to Recognize Effects of Technological Change

The degree of mutual reciprocity and interaction needed to achieve integration may have significant effects upon the existing corporate structure. When implementing a new technology, management must be aware that organizational changes may occur. Organizational changes may be forced by the elementary requirements of particular systems. Companies may have to reorganize departments and implement new methods of network planning in order to accommodate equipment that physically integrate multi-departmental functions on one platform.

The redistribution caused by technological change has an effect upon management practice. Considerable change in both structure and power occurred, following technological change within an organization. This change occurred when: early system adapters acquire more control and more centralized roles as late system adapters turn to them for guidance in using the new system; and workers experience greater self-reliance and control, growing less dependent on outside processing as the system became more integrated. Management can minimize the "shock" that new technology has on an organization: if, once an implementation decision is made, they themselves become the early adapters of the new technology. If they continue their support throughout the life of the technology; and if they make adoption mandatory for all intended users, and train them as early and as closely as possible.

Need for Management Support

Management approach is more important than the compatibility issue itself. Standards, or the lack thereof, are part of the competitive process. A thorough needs analysis must be made of the system to identify the nature of each problem, the capabilities of available devices, and how each device links with the system, and work to minimize the complexity that irritates security, safety, reliability, and cost. Interdepartmental coordination must occur to facilitate the planning, installation, and coordination. Interdisciplinary steering committees can be used for compatibility strategy and cross-functional teams for systems implementation. These teams need complete management support, thorough knowledge of both process and management objectives, compensation strategies to reward involvement, and empowerment based upon experience and technical skill.

Recognition of human factors

Factory integration may prove inefficient and uneconomical when human factor and worker knowledge demands go unnoticed, when work reorganization does not occur, and when skill requirements are not recognized. Integrated AMT systems require workers to be trained in manufacturing process and automation; require management commitment to support and motivate employees; require employee participation; require task analysis, monitoring and adjustment duties; require departmental interaction; and require training to heighten worker awareness. AMT may be purchased to reduce direct labor, however difficulties associated with positioning, programming, and maintaining the sophisticated AMT environment demand employees skilled in error control and fault diagnosis. The company installing AMT may move from task-related training to individual development, with supervision shifting from people and labor to machine and technology management. Management must create new procedures to cope with "job-optimization" and re-evaluate the existing departmental functions to support flexible deployment, enhance communication to facilitate interdepartmental coordination, and foster skills by providing accessible training materials and lenient work regulations, and by spending time orienting, training, and deploying personnel with increased skill range and quality.

Need for comprehensive data system

The decision-making necessary to monitor and control production demands adequate data collection and distribution systems. Data systems must be both comprehensive and convenient. Data is of broad interest to the corporation, and effective linkage of all corporate functions demand sharing of information systems, underlying hardware, and software resources. The distribution of processing fragments existing information reservoirs. Such reservoirs, without the direct control of information systems departments, become dispersed throughout the plant and may cause gaps in information and knowledge dissemination. Some substitute control mechanism is necessary to regain control, and reduce this loss, provide uniformity in system access, while still maintaining control to prevent data redundancies and platform inconsistencies.

Need for quality and productivity improvement

The fundamental functional concern of manufacturing is the production of a saleable good at a profit or the excess of the selling price over their cost. These costs can be reduced by improving efficiency of production, and AMT offers the capability for such improvement. Profits assure that a company survive, what assures profits are sales, and what assures sales are saleable goods. Thus product quality has become more important to ensure that a good is saleable, and consequently, quality management has become more important to ensure product quality.

Overall need for physical and functional integration

Most suggest that AMT operated in isolation provides only a fraction of its potential, that AMT must be integrated with the rest of production, and that the solution includes managerial efforts based upon a systems approach where all activities of interrelated productive elements are coordinated to achieve the specific goals and objectives of the company and are capable of self-regulation and adjustment. This coordination has physical and functional elements. Physical integration problems can be addressed through an accurate assessment of manufacturing needs and available technology. Assessing the latter must take into consideration present and projected inter-operability and connectivity of individual operations, but also an understanding of how they affect the production process plant-wide, and how they work to assure the achievement of plant goals, such as product quality. Trying to achieve physical integration before assessing functional concerns may be analogous to "putting the cart before the horse".

Viability of a Total Quality Management Approach

One approach to assure the functional; objective of quality in production is Total Quality Management (TQM). When implementing TQM, management must focus on such areas as data collection and distribution, process description and diagnosis, personnel training and teamwork, departmental communication and coordination. There is considerable overlap between the commonly cited obstacles to TQM and the problem areas AMT is designed to address.

Chapter III

Total Quality Management and System Integration

Introduction

This chapter provides introductory and background information on Total Quality Management. It begins with a brief discussion of a basic need for quality in production, the changes in industrial organization, and their effect upon quality control. Product quality is defined. The Total Quality Management (TQM) philosophy is explained. This is followed by a survey of TQM tools highlighting the importance placed upon the need for an integrated systems approach to assure quality, process control, and continuous improvement. A TQM implementation is described, as well as changes in managerial practice that must take place for TQM to occur. Detailed discussion is made of how TQM can address AMT integration problem areas. The chapter concludes with a hypothesis.

Quality

To adequately address TQM, attention must be turned to the issue of quality itself. This section briefly describes the evolution of quality control; from its early history in guilds, to the formulation of the "management-centered paradigm" wrought by continuing advances in production technology. This is followed by a brief discourse on renewed consumer demand for product quality, the push for improved production quality through the "Malcolm Baldridge Award".

Quality Background

Prior to the "Industrial Revolution," production and quality control were integrated; individual efforts were responsible for both. By the 13th century, strictly controlled membership in artisan and craftsman guilds and a lengthy apprenticeship assured the skills necessary for proper product design and construction. "The craftsmen knew their trades, their products, and their customers; and they built quality into their goods (Gitlow, 1989, p: 9). The manufacturing process had a "job-shop" orientation, with the number and variety produced limited. Each product was hand-built and unique. This discrete productive process did not lend itself well to mass production methods (Gitlow, 1989).

The industrial revolution resulted in manufacturing changes precipitated by the need to produce in the variety and quantities the marketplace demanded. The manufacturing process became increasingly complex, necessitating differentiation and segmentation of the work effort. Individuals performed their functions separately. Versatile artisans began to be replaced by standard part builders and assemblers, with "gage artisans" acting in the modern capacity of manufacturing planner (Voalker, 1988). "Division of Labor" maximized the efficiency of each process unit. The limited informational requirements within each link assured simplicity in the system, allowing complex products to be assembled by relatively unskilled labor (Gitlow, 1989).

Management Centered Paradigm

Integration of the manufacturing process occurred through the efforts of supervisors and shop-floor managers, with the corporate hierarchy controlling communication and planning. Management developed into the science of Taylor and Weber, who sought to maximize factory efficiency through rigid control and supervision of workers, and through highly structured bureaucratic chains of command. Manufacturing philosophy developed into the "management-centered paradigm." Both the company and employees are assets. Production focuses on scale economies. Companies are vertically organized along distinct departmental boundaries, with the division of labor assuring that "managers manage and workers work". All thinking is based upon short-term profits and cost trade-offs and all operations are company-centered and transaction-driven. Performance measurements are solely for control of existing production, and based upon narrowly defined financial calculations (Hall, 1990). Emphasis is placed on long, high volume production runs, products with long life cycles and few variations, and profit maximization occurring through return on fixed assets.

Lost control: The result of "management-centered" thinking has been a cost-efficient production of goods previously deemed "luxury" items. However, as manufacturing moved further and further from a customer to a production orientation, the quality of these luxury goods suffered. The division of labor changed the worker's concern from that of production quality to that of production quantity. This necessitated the creation of a separate quality control department. Quality assurance was then achieved through such techniques as lot sampling and inspection (Gitlow, 1989).

Need for Quality: In today's market, assuring quality in production is foremost in the minds of most manufacturers. It is common knowledge that today's marketplace has demonstrated significant interest in high-quality goods designed specifically for the customer. Increasingly sophisticated consumers demand design quality, better performance, and greater durability. Companies are realizing that they must be more customer-oriented and more equipped to produce quality goods for the market place. Since quality is the key for securing the satisfaction of the customer and to successful manufacturing.

The Malcolm Baldridge Award

The United States Congress, having recognized the need for government support of product and process quality efforts, established the "Malcolm Baldridge National Quality Award" in 1987. Created by the enacting of Public Law 100-107, the award emphasizes the importance of incorporating quality improvement programs in strategic planning, of management comprehension of shop floor control, of worker involvement, and of statistical process control. The quality improvement program must be "management-led" and "customer-oriented." Selection criteria are based upon point–scores in the areas of leadership, information and analysis, strategic quality planning, human resources utilization, quality assurance, quality results, and customer satisfaction (NIST, 1990). Industry has responded favorably to the award, with reports of improvements in performance and customer satisfaction following company application of the award selection criteria (Wolff, 1990).

Total Quality Management

In order to discuss TQM, one must first define quality, a term subject to certain semantic ambiguity. One particular framework provides a consistent platform upon which to review quality. It classifies quality in three types; design/ redesign, conformance, and performance. Design and redesign qualities are assured through close interaction between customers and marketing, service, and design personnel. This is achieved by consumer surveys to identify present and future needs, sales call analysis to clarify present and future needs, and service call analysis to identify current problems. Conformance quality is assured by striving to meet and exceed customer design specification. Performance quality is assured by determining how the current product/ service mix performs in the marketplace. This is done by analyzing after-sale service, warrantees, maintenance, and support, in addition to analyzing design/redesign quality data. Performance quality is assured by then implementing the changes suggested by this analysis. By assuring conformance to design, specification, and performance, the manufacturing is provided with a means to secure a good fit between market needs, and the product and service combination produced (Gitlow, 1989).

Relationship between Quality and Productivity

In addition to their external analyses of market, an internal analysis of production must also occur. It appears to be common sense that a business should strive to improve productivity and produce more goods using the same, or fewer, resources. There is an implicit relationship between quality and productivity. An increase in productivity can occur by manufacturing more goods, using more resources, and accepting a certain amount of waste in defect and scrap. Alternatively, an increase in productivity can occur by manufacturing the same number of goods, but selling more of what is built by reducing losses due to defect and scrap.

The new manufacturing paradigm

The difference between the two approaches is the difference between the old "management-centered paradigm" and the new manufacturing paradigm. The modern manufacturer faces an international market demanding a wide product variation and high quality. The manufacturer must use short, low volume production runs, minimize waste, and maximize the value-added. The new manufacturing paradigm demands the use of advanced production methods, the advanced technologies that lower labor costs, and raise indirect and overhead expense.

Quality control in this environment is achieved through a managerial philosophy that is based upon preventive, rather than corrective, measures emphasizing continuous process control through statistical analysis. The goal of the manufacturer is then to reach built-in quality, i.e.: doing it right the first time. This is, in essence, Total Quality Management (Hall, 1987).

Philosophy

Much of the foundation for the modern philosophy of TQM is found in the work of a few individuals, principally; George Edwards, Armand Feigenbaum, and W. Edwards Deming. Edwards was the first to coin the term "Quality Assurance," and advocated quality as the responsibility of production management (Gitlow, 1989). Feigenbaum was the first to insist that all business functions be involved in quality assurance and operate in concert to "build quality in" through preventive actions, rather than inspect quality in through detective actions (Feigenbaum, 1983).

W. Edwards Deming: TQM philosophy may be best described through the principles espoused by Deming, an individual commonly regarded as its chief proponent, with some suggesting that Deming helped to pave the way for the quality consciousness and subsequent success of Japanese industry. Japan has bestowed numerous honors upon Deming, and awards "The Deming Prize" to companies achieving the greatest quality gains (Gitlow, 1989).

<u>The Fourteen Points:</u> Deming defines "14 Points" for management to use to accomplish the corporate transformation necessary for TQM. These points include the need to:

- Create constancy of purpose toward improvement of product and service, with the aim to become competitive and to stay in business, and to provide jobs.
- Adopt the new philosophy. Western management must awaken to the challenge, must learn their responsibilities, and take on leadership for change.
- Cease dependence on inspection to achieve quality. Eliminate the need for inspection on a mass basis by building quality into the product in the first place.
- End the practice of awarding business on the basis of price tag. Instead, minimize total cost. Move toward a single supplier for any one item, on a long-term relationship of loyalty and trust.
- Improve constantly and forever the system of production and service, to improve quality and productivity, and thus constantly decrease costs.
- Institute training on the job.
- Institute leadership. The aim of supervision should be to help people and machines to do a better job. Supervision of management is in need of overhaul as well as supervision of production workers.
- Drive out fear, so that everyone may work effectively for the company.
- Break down barriers between departments. People in research, design, sales, and production must work as a team, to foresee problems of production and in use that may be encountered with the product or service.

- Eliminate slogans, exhortations, and targets for the work force asking for zero defects and new levels of productivity. Such exhortations only create adversarial relationships, as the bulk of the causes of low quality and low productivity belong to the system and thus lie beyond the power of the work force.
- Eliminate work standards (quotas) on the factory floor. Eliminate management by numbers, numerical goals. Substitute leadership.
- Remove barriers that rob the worker of his right to pride of workmanship. The responsibility of supervisors must be changed from sheer numbers to quality.
- Institute a vigorous program of education and self-improvement.
- Put everybody in the company to work to accomplish the transformation. The transformation is everybody's job.

The Five Deadly Diseases: In addition to the points which should adhered to, he also identifies five "Deadly Diseases" that, according to Deming (1989) affect most western world companies. They include:

- lacking "constancy of purpose" to assure business survival
- emphasizing short-term profits, rather than long-term goals
- using performance appraisals, merit ratings, and annual reviews based on individual output
- management having excessive mobility
- managing based solely upon visible figures.

The presence or absence of such conditions may be used as a measure with which to evaluate the overall level of TQM policy deployment.

Quality Environment and Corporate Transformation

The "14 Points" and the five "Deadly Diseases" provide the tools and concepts with which to provide the "quality environment" and starts positive corporate cultural change, as well as achieve company-wide total quality control. Management must foster the proper conditions for an atmosphere of continuous improvement by creating partnerships with employees and suppliers, and by concentrating on customer needs. Since it is impossible to know in advance what constitutes "acceptable" quality, management must strive to always exceed existing standards.

The acceptance of TQM, and its subsequent deployment throughout the plant, often is accompanied by a corporate "transformation". The objective of this quality deployment becomes the delivery of a "customer-oriented" product, one which benefits society. Quality control becomes a social responsibility and this value judgement should become part with the company TQM philosophy, and be engrained in all employees through education and training. This transformation must occur in order to promote the "quality environment", vital to achieving quality objectives. The reform of management itself is the real goal of TQM. Management is critical to the success of TQM and in order to succeed, they must: support TQM throughout the company; provide employees with the proper tools and training; provide them with process support; be consistent, never contradictory; never compromise, and always favor quality objectives over other goals.

Chen (1990) provides a summary of the fundamental changes in company perspective, practices, and procedures which occur in the "corporate transformation" to TQM. Management changes:

- From short-term [profit] to long-term [survival] orientation,
- From management by results to management through process improvement,

- From managing averages to managing averages and variations,
- From individual merit only to teamwork,
- From managing based on tangibles to tangibles and intangibles,
- From product-out to market-in,
- From plan only or do only to plan, do, check, act,
- From special causes only to special causes and common causes, from reactive to proactive,
- From competition to cooperation (Chen, 1990, p. 914).

Management practice makes a logical progression to this perspective as more of the "Fourteen Points" of Deming are adhered to. These criteria also provide a useful framework with which to measure the level of TQM policy deployment, and are used as such in the case study results reported in chapter V.

Chen also lists a number of obstacles to comprehensive TQM implementation. Such obstacles include instances when:

- Top managers are not actively participating
- Middle managers and supervisors are not actively promoting TQM
- Functional managers are not actively participating
- Overtraining of rank employees
- TQM coordinator lack clout
- There is no implementation plan
- The reward system is not in line with TQM philosophy
- The required resource is under-estimated
- Unions are not cooperating
- Employees are afraid of statistics

- People are afraid; fearful of losing their jobs because of TQM
- Top and middle managers do not come to quality sessions and presentations
- Suppliers and dealers are not interested in TQM (Chen, 1990, pp. 917-918)

For the case study results, the presence or absence of such obstacles are used in conjunction with the previous criteria as an indication of overall TQM policy deployment.

The transformation of management brought about by such changes in managerial practice is necessary to optimize the effectiveness of TQM, its tools and methods.

TQM Tools and Methods for Improving Quality

There are many TQM tools available which are designed to assure quality. Principal among these, are techniques such as: Design For Assembly and Parameter Design, used to improve product fit; Statistical Process Control, used to measure and diagnose process performance; and the concept of Continuous Process Improvement, the scientific method tying all activities together.

There are instruments in the TQM toolbox designed to tune the production process, they are used to improve the fitness a product has with productive capabilities; by designing assemble-ability into the product, and by optimizing the combination of materials going into the product. There are tools used to improve product flow; by optimizing machinery grouping, by optimizing machine set-ups, and by optimizing material routing and handling.

Product Design and Process Fit

There are TQM tools used to improve the fit a product has with productive capabilities by designing in assemble-ability and by optimizing raw material combinations. Product design and design process are important aspects of manufacturing efficiency and quality improvement. American management often places the focus of improvement efforts "downstream" of the design process, even though most of the manufacturing cost is committed during the initial steps in design.

Materials Handling and Process Flow

The next set of tools are used to improve product flow by optimizing material routing and handling, optimizing machinery grouping, and by optimizing machine set-ups. Material handling is an important element of manufacturing, and cuts across almost all department boundaries. This function is best performed by using the method to provide the right amount of the right material at the right place, at the right time, in the right sequence, in the right condition, and at the right cost.

Material handling systems must be designed with specific objectives and problem–resolving goals in mind. The basic objectives of material handling involve material movement, storage, and control.

Just-in-Time and Process Integration

Ideally, material handling systems provide exactly the right amount of the right material at the right place, and at the right time. Material handling expenditures and delays can be minimized by limiting moved material amounts, move distances, manual moves, container variation and movement methods, and material storage amounts. However, just getting the right material to the right machine at the right time and amount is not sufficient: they must be of the right quality. If the quality of the material is inadequate, meeting all other conditions is in vain. TQM tools and methods are the means by which material quality is assured throughout manufacturing. When all other conditions are met and when material quality is assured, such as system is referred to as Just-In-Time (JIT).

Continuous Process Improvement

The goal of TQM is continuous process improvement, but before improvement can take place, the process must be stabilized. Stabilization is needed to acquire greater control over production activities because problem diagnosis and corrective action is extremely difficult in an "out-of-control" process, one experiencing common and special cause variations. Such a process is exemplified by unpredictable performance, with irregular production rates, varying quality levels, and fluctuating costs. Management can neither accurately assess existing capability or future performance. However, once the process is under control (and experiencing only common cause variation), management can not only accurately assess current capabilities, they can also predict future performance. In addition to being predictable; a stable system is also operating with productivity at a relative maximum, and costs at a relative minimum (Gitlow, 1989). The method of securing process stabilization is analogous to taming a wild animal before training it. Once the process is under control, management can "fine-tune" rather than "fight-fires".

The Plan-Do-Check-Act Cycle: The Shewhart (or Deming) cycle, a derivative of scientific method used in process control, supplies the theoretical foundation for continuous improvement. This cycle has four stages, namely; plan, do, check, and act (PDCA). The plan stage is characterized by thorough analysis of design-conformance-performance quality issues, and is supported by the previously mentioned activities of process description, data collection, data description and charting, and process diagnosis. The outcome of process diagnosis is the plan of attack designed to rectify process problems. The do stage is simply the execution of the plan on a trial basis. The check stage uses, once again, process description, data collection, data description and charting, and process diagnosis to evaluate the trial execution, and answer two questions: Are input variables acting according to plan and improving performance of the specified process, and are there any downstream effects? Answers to these questions determine the next step, to act. If the trial plan has problems of its own, it is modified and submitted for retrial; if it results in improvement, it is fully implemented (Deming, 1986).

TQM Policy Implementation

The authors of TQM and related articles surveyed suggest that management efforts to assure quality should be based upon a system approach, with company-wide involvement. The dictionary definition of a system is "a group of objects or units so combined as to form a whole and work, function, or move interdependently and harmoniously (Webster's, 1978, p. 541)." A more scientific definition involves interrelated elements coordinating activity to achieve specific objectives, such as the manufacture of quality products.

TQM must be implemented company-wide, with QC in the function areas design, management, planning, production, distribution, and service. Integrating components assures that the quality in each step is preserved in subsequent steps. TQM efforts are compromised by departments operating independently, by "sole point performance measure," by inadequate communication, and by differing and conflicting priorities. Only when all process elements work together in a communicative, coordinative, and cooperative fashion is company-wide awareness and control of quality realized.

TQM policy cornerstones: TQM implementation must work to achieve involvement from the top down and from bottom up. Chen's framework consists of TQM policy involvement "cornerstones"; TQM from the top, TQM from the bottom, horizontal TQM, and "cooperating company" TQM. TQM from the top is upper management involvement in policy and guideline formulation, steering committees, QC seminars and presentations, and diagnosis and feedback. Upper management fully supports the effort, providing TQM guidance and leadership across all functional lines. Training for middle management and supervisors is initiated after top management is completely committed to implement TQM. TQM from the bottom is the continuous and comprehensive training of all employees and managers in QC methodology, the development of QC circles tackling immediate problems, and the implementation of action plans. Horizontal TQM is QC deployed across all departments. Remaining TQM efforts are designed to lend corporate encouragement and assistance in QC to both suppliers and purchasers through the elimination of competitive bidding, limiting the number of vendors, formation of long-term contracts, and close cooperation of all parties to assure quality in production (Chen, 1990).

Implementation order: Chen describes a TQM plan to be implemented in the following approximate order: corporate statements of their philosophy regarding quality excellence; organizational and operational plans for TQM implementation; delineation of goals, action, impact measure, and feedback control mechanisms; training and education program implementation plans; selection of initial TQM projects; quality excellence programs for suppliers and vendors; and time-tables for TQM implementation. With the essentials of TQM policy deployment discussed, attention can be turned to how such a policy can affect the implementation and integration of AMT.

AMT as an enhancement for TQM orientation

The trend to automate production with AMT is coupled with a trend to assure quality in production. It seems logical that production and quality control should be integrated. The company pulled by the desire to improve integrated automated productive processes is also pushed by a market demanding quality in its products. Difficulties in achieving integration may exacerbate the difficulties in achieving quality.

If a foundation can be built to support a systematic approach to achieve the desired objectives of successful AMT integration, efficient production, and a market-accepted level of product quality, it can enhance all operations, requiring less effort than individually applied methods. AMT objectives of physical and functional integration may be the way for achieving the TQM deployment.

Addressing Physical Integration Concerns

Physical integration can be addressed through the assessment of both manufacturing needs and available technology. The assessment of available technology must consider network issues; present and projected inter-operability, and the connectivity of individual operations. The accurate assessment of manufacturing needs demands not only an understanding of individual operations, but also an understanding of how they affect plant-wide production and process objectives. Physical integration concerns should be evaluated in conjunction with functional concerns, and it is in this capacity that TQM appears most beneficial.

Providing necessary information: Management must assure timely and appropriate information flows between departments. Network development may be promoted by having already in place an information system transmitting data to all nodes in the consistent, accurate, timely, and relevant manner. Such a system will help assure physical integration of AMT systems. Since many firms are often unable to purchase complete integration "solutions" at one time, the long-term production planning horizon of TQM may aid the systems integration process by focusing company efforts on compatible and potentially compatible components, and avoid the inherent existing system incompatibility.

Developing talent in-house: Since TQM policy emphasizes in-house training and solutions, it may prove advantageous when outside vendors do not have sufficient technical expertise to advise competently on network issues. With TQM, the company may also lessen their desire to resort to systems integrators. When system integrators can not fulfill their acknowledged principal role of technological transfer, and when plant-wide integration of organization and technology is needed and human and organizational considerations are the major obstacles to integration; then the approach the company may need to take is TQM, which is designed to assure departmental coordination and cooperation, and achieve physical and functional integration.

Systems approach reduces complexity: If management plans wisely, the network is less complex to operate and maintain, and less expensive. One direct benefit of coordinated network development is that a common network architecture eliminates much of the need for costly front-end controllers and processors. The long-term systems approach of TQM can help avoid device contention problems through adequate advance planning. Device compatibility is determined by ascertaining plant networking needs and system specifications, which in turn depends upon complete involvement of all users. The objective of TQM is complete employee involvement in production. By integrating the requirements of each department, this approach may facilitate procurement of standardized hardware and software, assure database connectivity and file compatibility, and minimize internal modification and excessive data overhead. This has the added benefit of reducing the network complexity that exacerbates security issues by avoiding the use of dissimilar encryption machines and standards in each department.

<u>Long-term planning and network uniformity:</u> The company needs to purchase to uniform specifications throughout the system. The potential for "platform migration" must be considered, since continued expansion is the goal of most "going concerns." The long time needed to implement a plant network, and the difficulty in forecasting advances in peripheral equipment, force companies to demand fully portable software with standardized functions, adjustable network addressing, standardized instruction sets, and standardized communication protocols. The interdepartmental coordination and long-term planning of TQM may help assure consistency in network operational specifications for network delay, reliability, and availability, and improve overall network connectivity. Such an approach may lessen the possibility that firms will be unwilling to wait for the industry to complete standards for OSI platform, instead investing in non-standardized systems offering immediate access to multi-platform files.

Cooperation with vendors and customers: Part of TQM is the need to work more closely with both suppliers and customers. A comprehensive deployment of TQM using JIT demands coordination with raw material suppliers. This coordination can be used to facilitate the formation of joint ventures with equipment suppliers as well, and focus on improving systems integration through concerted logical and hardware integration. Suppliers must be brought to the "standards table" for platform discussions. TQM deployment also demands cooperation with customers. To learn about product usage, companies can participate in joint ventures with customers using multi-vendor systems to learn ways of coordinating production, as well as integrating AMT systems into networks. TQM involves close interaction with customers and suppliers that can help to determine production patterns to minimize inventories, lead-time, and costs, and maximize quality.

Addressing Functional Integration Concerns

TQM provides a number of techniques that may be used to assure functional integration of AMT systems. Such techniques as DFA and parameter design can further stress the demands AMT places on precision programming, while TQM provides the higher quality input material in order for AMT to perform effectively, and at the same time, works to simplify and streamline the manufacturing process. TQM is devised to accommodate procedural and training revisions to improve production control, as well as improve material routing and handling. TQM is designed to provide information when and where needed, consistency of purpose in goals, proper employee training and orientation, thorough departmental and employee involvement and teamwork, and the coordination with customers and vendors necessary to eliminating waste and inefficiency and improving functional integration.

Assuring adequate information flows: The best theoretical application for integrated AMT involves batch manufacturing, with its need for production speed and efficiency while maintaining flexibility to accommodate customer demands for part variety and changing part configurations. Providing shop-floor coordination and control becomes critical, and fast and efficient information management vital. TQM supports the unit needs assessment, and corporate culture and employee relations considerations as necessary to achieving the increased quality and reductions in labor costs possible using "selective automation." TQM supports that good management decision-making and communication integration demand plant-wide data collection and distribution systems, and avoid the problems associated with gaps in the dissemination of information and knowledge caused by distributed data processing trends.

Assuring uniform corporate goals: AMT equipment has a shortened life cycle and "built-in" obsolescence that must be carefully weighed in project evaluation and subsequent operating cost allocations. TQM provides a uniform corporate need for the longer time spans and planning horizons in AMT project evaluations, especially important when it takes up to seven years for pay-back. Using TQM to focus on overall product goals may assure the objectivity necessary to accurate accounting. If management adheres to TQM, consistency occurs in all practices and procedures. This consistency is necessary for proper accounting following AMT implementation, and avoid project rejection, or abandonment, due to inadequacies in financial analysis. TQM assures a comprehensive, rather than incremental, investment approach since productive decisions are based not upon short-term financial performance, but rather on long-term business survival.

Assuring employee involvement: TQM is designed to assure plant-wide employee involvement. Thorough worker participation lessens the problems encountered in some CIM installations by explicitly addressing the human factor and worker knowledge demands, and confronting work reorganization, skill requirements, occupational hazards, and industrial relations issues. TQM addresses the concerns for workers to be thoroughly trained, for management to commit to support and motivate employees and recognize the need for employee participation, recognizing work space needs, task analysis, monitoring and adjustment duties, to assure departmental interaction, recognizing the need to heighten worker awareness. TQM specifically addresses the concerns that to assure proper part positioning, programming, and maintaining the sophisticated AMT environment, employees must be trained in error control and in fault diagnosis. TQM is designed to change the managerial approach from one of task-related training to individual development.

Assuring adequate training: A cornerstone of TQM policy is comprehensive practical training. Since TQM makes the worker responsible for production and management responsible for adequately training the worker, thus CNC operators are to be fully trained in machine programming. A thoroughly trained machinist may eliminate the creation of inferior programs by technicians with limited practical cutting experience. In general, TQM forces management to cope with the need for "job optimization", by re-evaluating departmental relations to support flexible deployment, enhancing communication to facilitate interdepartmental coordination, and foster skill and knowledge "interchange"; and the need for training material and aids readily accessible on the factory floor. The use of TQM can provide management with thorough process information before decisions are made to provide technical skill and expertise, proper plant-wide vision, and a policy supporting problem resolution; and avoid forcing AMT into the ill-equipped work environs cited by Teresko (1990).

Assuring proper work orientation: TQM appears to address the need for leniency in work regulations to assure flexibility in operations and employee deployment; and the need espoused by Rush and Bessant (1990) for a factory that is flexible, interdependent, democratic, and uses time to orient, train, and deploy personnel who have an increased range and quality of skills. TQM can aid in the development of an organizational strategy for AMT, and avoid the "technification of Taylorism" that might defeat integration efforts. TQM may eliminate much of the organizational and structural redistribution. By requiring management commitment, employee training, and continuous process evaluation, TQM may be able to minimize the "shock" new technology has on an organization. By letting management be the early adapters of new technology once an implementation decision is made, by continuing management support throughout the life of the technology, and by making adoption mandatory for all intended users and training users as early and as closely as possible.

Aiding teamwork: The emphasis TQM places on management support, departmental cooperation, and worker training and empowerment may enhance the results implementation teams achieve by providing the complete management support, the need to empower teams, and the need for thorough team knowledge of process and management objectives. TQM provides necessary institutional support for the interdisciplinary steering committees, used to establish plant-wide compatibility strategy, and the mid-level cross-functional management “implementation teams”.

Assuring proper management orientation: TQM can assist in making the management orientation change from task and tool installation, to people and process integration, using “communication-intensive management” to achieve the integration of people and functions across departmental. TQM is a cross-functional, top-down, bottom-up, management approach that may enhance the performance gains of AMT since it seeks to identify and eliminate the cause of functional transfer losses. TQM can support the changes needed for system and process optimization across group boundaries, where functional groups otherwise have no character, eliminating “shop floor perspectives,” and assuring the managerial “span of control” required to integrate AMT across functions. Lastly, constant process data collection, analysis, evaluation, and adjustment using the scientific methods embodied in the PDCA cycle can help ensure the TQM objective of "continuous process improvement,” and closer coordination, better system synchronization, and greater productivity.

Hypothesis

TQM is a system philosophy, designed to assure superior product quality through management-supervised, employee-lead, coordination and integration of the production process through simplification, optimization, and communication. Survey evidence from the literature suggests that current integration problems may be due to a lack of integration of AMT installations with the production process. Perhaps, by combining physical with functional integration efforts, an ideal approach can be taken to automating process and production control using AMT. This approach first identifies and defines a process, and then determines its state of control; second, strives to maintain stability in production through statistical process control and close departmental interaction and communication; third, once stabilized, the production process can be evaluated for introduction and integration of AMT, so that; fourth AMT can be successfully integrated to fully realize those benefits it is capable of providing.

The factors identified in the literature as impediments to achieving AMT integration embody an underlying need for production process identification, analysis, and evaluation; interdepartmental cooperation and complete employee involvement; thorough employee training; shared information and database; unhindered corporate communication; extensive interaction with key suppliers; and a system for continuous improvement through technological evaluation. These needs are essential elements of TQM. An effective strategy for implementation of TQM may use the same management strategies as that of AMT. Thus, in theory, an integration strategy that uses AMT systems should be more successful in achieving TQM deployment than one without AMT.

Chapter IV

Methodology

This chapter is a discussion of case study methodology. Chapter II surveys existing literature to first define AMT, and then report the problems occurring in the effort to integrate AMT, and then report the problems occurring in the effort to integrate AMT. It also describes possible sources of problems and why they may arise. Chapter III discusses TQM; its tools and methodologies, its philosophy, and the problems it is designed to resolve. Chapter III ends with the hypothesis that AMT is a viable framework with which TQM is enhanced. Chapter IV identifies the characteristics of the research, defines the research problem, and explaining the rationale using the case study approach. The research methods applicable to this study are summarized, and then methods used are described. The chapter concludes with a summary of the research design.

Research Characteristics

According to Yin (1989), the best strategy to use is determined by analyzing the three conditions involved: the type of research question posed; the level of control over events; and the perspective, either contemporary or historical, of the case. This research seeks to answer "how, what, and why" questions: how thoroughly AMT is being integrated with productive processes; what difficulties are being encountered and if they are, why they are occurring; how involved the companies are in TQM, whether this involvement has any bearing on integration and the resolution of these difficulties. Research focuses solely on contemporary events using variety of evidence, in the form of documents, interviews, questionnaires, and observations.

Using the Case Study Approach

Given these conditions, the best research strategy according to Yin (1989) is the case study, since the research seeks to answer "how, what, and why"; research questions are asked about a set of contemporary events; and the investigator has little or no control over these events. As noted by Jenkins (1985), " the case study attempts to capture and communicate the reality of a particular environment at a point in time (p. 112)."

Disadvantages: There are several disadvantages to using the case study approach. The case study has a limited ability to test causal hypotheses and control confounding variables, or alternative explanations. The case study is more adversely affected by artifacts: the potential for a change in researcher expectancy during the course of study; the potential " for the researcher to convey perceptual cues to the subjects about the hypothesis being tested (Jenkins, 1985, p.113)"; and the possibility for "evaluation apprehension," where subject response is based in part on their awareness that they are part of a study (Jenkins, 1985).

Advantages: Although there are disadvantages to the case study, there appear to be numerous advantages. The case study supports the contention of Yin (1989) that such an approach must be used when the research "is an empirical inquiry that investigates a contemporary phenomenon within its real-life context, when the boundaries between phenomenon and context are not clearly evident, and in which multiple sources of evidence are used (p.23)." The case study allows for a range of variables to be examined, assures strength in the independent variable. In addition, costs are comparable with other approaches (Jenkins, 1985).

Case Study Methodology

Candidate Selection: The candidate must have well-established functional departments and can point out the effect of AMT on personnel and other organizational and managerial concern areas.

Case study Components: Once a participant have been chosen, the study seeks to explore issues surrounding how the company has implemented AMT systems, how thoroughly the current systems are integrated, and whether there appears to be any correlation between the level of integration and the level of TQM policy currently deployed at each company. Yin (1989) notes that a formal research methodology is necessary to help assure validity to any case assessment. To that end, the research methodology is discussed in context with the case study protocol presented by Yin, and is broken into several study components; proposition, and criteria for interpreting findings.

Propositions: The current study involves an organizational theory hypothesis, with the intent to explore the relationship between TQM policy deployment and AMT installation and the relative level of integration achieved with AMT systems. The proposition to be evaluated is whether the level of AMT integration has a positive correlation with that of TQM policy deployment.

Study Questions: This research seeks to answer "how, what, and why" questions: how thoroughly AMT is being integrated with productive processes; what difficulties are being encountered and, if they are, why they are occurring; how involved the companies are in TQM, and whether this involvement has any bearing on integration.

Units of Analysis

The units of analysis in the study are the major functional departments within the organization, the Advanced Manufacturing Technologies and the linked systems used in the productive process. According to Yin (1989), these units of analysis are best defined by their ability to answer the "how, what, and why" research questions posed about the level of AMT "integratedness" and of TQM policy deployment.

Level of AMT integration: Integrated AMT can be described in terms of system theory. The dictionary definition of a system as "a group of objects or units so combined as to form a whole and work, function, or move interdependently and harmoniously (Webster, 1978, p. 541)" can be modified to include " to achieve a predetermined objective as they interact within their environment (White, 1988, p. 47)." How tightly connected the hardware and logical linkages are within the system determines the level of physical integration. The board definition of integration used by White (1988) includes any interaction and coordination of manufacturing functions, all component hardware linkages, and communication, occurring throughout the company. The criterion to be measured is the extent, or level, to which this integration reaches. This linkage has both physical and functional elements.

The physical connection is concerned with compatibility issues affecting system integration (e.g., type of AMT systems in use, network protocols, database sharing), however, how management approaches the solutions to integration problems is of more interest that the particular systems or technologies management uses to achieve physical integration. The functional linkage is how tightly connected and closely coordinated the AMT facility is integrated with the other production processes.

Level of TQM deployment: The overall extent of TQM policy deployment can be measured in a number of ways. The principal way in which to measure TQM policy deployment is by observing how closely the "Fourteen Points" of Deming (1989) are adhered to, and how many of his "Five Deadly Diseases" are avoided. A further measure is the necessary corporate transformation and change in management perspective, and the presence and absence of obstacles, as noted by Chen (1990).
Another way is based upon how close the company is to Just-In-Time (JIT). TQM is critical to the success of a JIT system. Without assured material quality at each step of production, some provision has to be made for scrap and rework, buffer storage has to be introduced, and the JIT system fails. The success in achieving JIT material flow may be logically applied as a measure of how far a company has deployed TQM.

Case Study Procedures

This section describes the methods used to acquire information about the research candidate. The case study data is obtained from interviews, observations, and documentation.

Observations

Direct observations of the manufacturing process are necessary to identify the varieties, as well as the orientation, of AMT machinery used at the plant.

Observations are needed to acquire a rough approximation of: the material handling methods used; the basic plant layout of machines and functional departments; storage areas and WIP inventory; and the general plant conditions, cleanliness, orderliness, and condition of the equipment. The more subjective objective of observation is to acquire a "feel" for the facility, its atmosphere and employees.

Documentation

The study documentation evaluated comes in two principal forms; questionnaires and interviews. Representatives from major functional departments (Human Resources, Information Systems, and Production) are to be asked to complete questionnaires (Copies of the questionnaire are in Appendix A).

Interviews

The study protocol begins with informal interviews designed to furnish introductory information on company structure, basic business areas, and productive methods. This is done to determine the company representative through whom all subsequent contact would take place. The formal interviews will be conducted with functional department heads relative to the research. The follow-up interviews to the questionnaires are to provide much of the detail information.

Summary

This chapter discusses the case study methodology. The case study has been posited as a means by which to test the hypothesis presented at the end of Chapter III. The case study approach is chosen the best way to address the research questions. A study methodology is developed to provide a practical and logical foundation for executing the research. Direct observations are then to be made where and when needed. The use of such methodology can help assure study reliability and repeatability. The questionnaires are designed to identify the approximate depth and breadth of TQM policy, the extent to which AMT is used and integrated with other systems and illuminate management practice, communication, and the extent of physical and functional integration.

Chapter V

Case Study Results

This chapter discusses the results of the case study. The research sought to answer "how, what, and why" questions asked about contemporary events over which the investigator had no control. The evidence has been collected from interviews, questionnaires, and observations. The chapter reports this evidence as it relates to the research questions; how the company has implemented its Advanced Manufacturing Technology (AMT) systems, how it has physically and functionally integrated its production systems, and what level of Total Quality Management (TQM) policy it has deployed.

This chapter is divided into two sections. The first section discusses the participant selection process. Then the business and organizational structure, Manufacturing Production Control (MPC) system, and management practice of the participant is discussed. The following section consists of analysis based upon the research questions of AMT integration difficulties; AMT equipment physical linkage; AMT equipment functional linkage, including departmental communication; and TQM policy deployment.

Participant Selection

Choosing a participant for the case study was not an easy fact due to the novelty of AMT among the Lebanese manufacturers. Sohat is one of the few organizations in Lebanon that uses AMT in its production process. Sohat is a prestigious organization whose goodwill and market dominance are the main proofs for its success. Sohat's success is mainly achieved through its strong belief in quality and in being a quality product provider. Sohat's well-established functional departments can point out the effect of AMT on personnel and other organizational and managerial concern areas.

A Brief Introduction to Sohat

Sohat is familiar to every household in Lebanon. It has become a generic product to the point where many identify "bottled natural mineral water" with Sohat.

Sohat's natural source springs from Falougha on an altitude of 1710m. In 1910, during the excavations of the late Habib Zoghzoghy, many Roman coins and a 125m long tunnel were found around the source. That proves that Sohat's source was first discovered and exploited by the Romans. Many centuries later the source's water started to spring and created a "Ain". The inhabitants of Falougha called the water "Ain Sohat"; source of health.

Sohat's water found its way to many surrounding countries and to the royalties of Cairo and Baghdad. People in many Arab countries pilgrimaged to Falougha to spend the summer season there and drink form Sohat's water that was believed to cure many diseases and sicknesses.

In the mid 1960s, Mr. Claude Zoghzoghy had an entrepreneur vision: bottling and selling Sohat's water. This idea was the first in the Middle East. Mr. Zoghzoghy had to abide by laws set by the government concerning the quality of the water and the control over the manufacturing process. Samples from Sohat's water had undergone several consecutive intensive testing in laboratories of Paris, Bordeaux, and Beirut over six years on different times of the year, before launching it on the market in 1971 with a huge marketing campaign. At that time Sohat was displayed next to whisky bottles in the supermarkets because it was the first local bottled water in Lebanon.

The facility was built around 200m lower than the source; thus the water flows to the facility without the help of any pumps.

The tests conducted have been developed as a systematic procedure published in "Annals de L'Institut d'Hydrologie et de Climatologie". This research has been set as an example for studies on exploitation of natural mineral water sources. Sohat's water is characterized by its constant 6.5°C temperature and same composition characteristics all over the year. These constant characteristics enabled Sohat to be a Natural Mineral Water.

Sohat's Case Study

Most of the information about Sohat came from personal interviews, site tours, and questionnaire responses.

- Business and Organizational Structure:

Sohat is one of the main companies of Group Sohat, which includes Meatel (Mobile phones and accessories), Dima (food products), Dima Healthcare (medical products), Slaf (real estates), and Macdonald's Franchise.

By the end of 1997, Sohat went through a joint venture with Perrier Vittel of group Nestle (leader of the global bottled water grouping around 70 international brands). Accordingly a new center of production has been installed that complies with the international Nestle production standards.

AMT was implemented as the means of production after the joint venture. PVC was substituted by PET. PET has been proven to be less harmful to the environment. Bottlers all over the globe are adopting PET due to its advantages over PVC. The change was envisioned by Mr. Claude Zoghzoghy, due to his belief that quality and awareness are the means of competition and survival in the coming millenium.

At the case study inception, Sohat employed around 300 employees. Full time employees are registered in the National Social Security Fund and benefits from private insurance and schooling. The plant operations are under the control of the Technical Manager, Mr. Magdi Batato, who is the liaison between Perrier Vittel and Sohat. The Technical Manager acts under the authority of the General Manager of Sohat. At Sohat, the Quality Control, Operations, Accounting, Inventory, Information Technology, and Human Resources report to the Technical Manager and coordinate activities with the other functional departments of Group Sohat.

Manufacturing Methods and Production Controls

The facility of Sohat consists of a single large building on an area of $14400m^2$. The building consists of two floors and two underground floors. The first floor houses the offices of the administration, personnel, server room, information technology department, accounting, plant manager,.. The ground floor consists of several areas: the blowing area, the filling area, the packing area, quality control laboratory, technical and electrical workshops, stores, and a visitors room. Whereas the warehouse, compressors, shipping area are in the underground floors.

A wide assortment of shop floor machinery is used including: CNC blowers, photocells, conveyors, fillers, and some machines for grinding, and folding. Each CNC equipment is operated in isolation, and numerous platforms and languages are used.

Sohat has its new center of production been installed by vendors of Perrier-Vittel. Even though the management tried to standardize CNC equipment, its vendors couldn't. Although all the PLC in use are Siemens S5, yet each equipment has a built in software that is not compatible with other equipment.

- The Blower: The blowers are produced by Sidel of France. Sohat runs two blowers that can be set for 0.5l or 1.5l preforms. The blowers run almost continuously. The preforms are heated in an infra-red oven at 110^{0}C, then the blown bottles are conveyed with air conveyors. The air is filtered to 99.9%. There are only two laborers in the blower area to control and feed the blowers with the preforms.
- The Filler: The filler is produced by SARCMI of Italy. Sohat runs two fillers for the 0.5l and 1.5l bottles. The bottling area is a hygiene area where everything is sterilized and filter air is continuously fed into the area to assure an overpressure. After being filled with a preset amount depending on the size of the bottle, the bottles are automatically, capped, labeled and ink-jet coded with the production and expiry date. There are three laborers in the filler area. One laborer controls the lines and keeps track of all incidents on a log sheet, while the other two check the physical appearance of label, cap, and date on the bottle.
- Packing: There are four packing lines. Two for the carton and two for the nylon depending on the size of the bottles. Six laborers control the whole packing procedure. After being packed, boxes or packages are palletized. On the 1.5l lines the folding is automated while on the 0.5l line it is manual.

Manufacturing Production Control (MPC) for Sohat is computerized. Maintenance and repair of equipment are processed through Work Orders. Production is controlled with the Management Of Manufacturing Operation (MOMO) software application. MOMO is an Access application used by Perrier-Vittel. Maintenance can be a scheduled preventive maintenance such as cleaning, CIP (cleaning in place), oiling or greasing,.. or it can be an electrical or mechanical failure. Log sheets for filling failures or problems encountered on equipment or lines are given to each laborer controlling the process. The problem, equipment code, down time, action taken, person in charge, parts used, are recorded on the sheets. Those information are fed in the software in order to have an accurate status about the equipment, history, parts costs, down time, failure reasons, and solutions. Thus have an accurate SPC.

Spare Parts are managed and controlled with Nestle International software called MPCS. An Access program developed by the Information Technology department of Sohat runs in parallel with MPCS, in which parts are updated, stock is controlled, parts history is tracked, parts costs are updated and charged on the equipment, budgets are set and controlled on equipment. Moreover Purchase Orders are generated from this system.

Loosely structured morning meetings are convened to address work status; supervisors identify part progress, update scheduling and machine status, report delinquencies, and detail any difficulties encountered during manufacture. Both the management and the production supervisors are responsible for distributing reports; the former distributes monthly customer requirements, detailing vendors, part numbers, and due dates (anticipated, current, and past-due); and the latter distributes machine status reports, detailing machine lines, status, and necessary comments.

Quality Control (QC) is the department with the principal responsibility for assuring product quality conformance. Quality is achieved when the product adheres to specifications via in-process and final inspections, and SPC. The Quality control department of Sohat employs five employees. Sohat has developed detailed inspection standards, methods, and procedures.

The Technical Manager and QC Manager are the key players in the TQM effort, with the basic objectives of TQM to improve quality while reducing cost. QC and upper management is currently trained in SPC.

Quality concern has always been one of the main goals, of Mr. Claude Zoghzoghy, to achieve. Long before the joint venture with Nestle, Sohat was credited for the quality of its water and production process. Sohat's water undergoes regular tests in Lebanon and abroad. The durability of the old PVC bottle was tested and the quality of the cartoon boxes were tested in terms of compression.

After the venture with Nestle, Sohat has developed many new methods and techniques to control quality of its products, production processes, packing and stocking (FIFO).

Work is actively inspected as it flows from one station to the next. In each step defective goods are flagged by machine operators and supervisors.

Moreover the QC conducts Preventive and Reactive tests on all raw materials, semi finished and finished products. Although the 0.5l preforms are imported Valvert of Belgium and the 1.5l prefroms are imported from Vera of Italy, who are both Nestle factories, yet the QC of Sohat conducts on Preventive and Reactive tests on them.

The preventive tests are conducted on a sample of preforms selected randomly. The tests are to measure the thickness, diameter, and perpendicularity of the preform, and to expose it to a polarized light.

The reactive tests are conducted on a sample of blown bottles selected randomly. Where each bottle is cut into several pieces and tested to see if the PET has been well distributed in the bottle during the blowing process.

Management Practice

Management believes that efforts to control costs and improve quality, were mutually beneficial to both plant management and the workers: Quality products sell, and the sales enable the company to survive and thus keep jobs. Management believes in

TQM philosophies of Deming, noting the importance of the good worker relations, open communication, and mutual respect and trust.

The Factory Manager considers quality a state of mind. The Factory Manager has improved productivity and quality. TQM environment is underway. The basic objectives are to reduce waste and increase quality awareness. The Factory Manager considers "all personnel" key players in the TQM efforts. While management, supervisors, and engineers have been trained in the basics of SPC, nearly all other employees have been trained on the usage of computers, in order to control processes. This has occurred principally through seminars conducted by an outside training center and by in house training conducted by the Information Technology staff. Some training for supervisors is being conducted in problem solving and developing "team orientations" to system diagnosis and correction.

AMT project decisions are based upon direct benefits. Proposed investments must have identifiable payback in terms of reduced cost and improved efficiency. Purchase decisions are made by upper management, with departmental input. Project implementations are typically headed by user teams, with upper management maintaining overall control. Management currently considers CIM to be long-term goal and makes AMT equipment investment with integration in mind.

The Technical Manager describes Sohat's employees as competent and dedicated. He has a heavy agenda and has considerable experience in both the office and on the shop floor. He initiated supervisors and interdepartmental meetings, and he pushes communication.

Based upon the overall impact on their resources, the principle role of Information Technology department is to support ERP. IT currently operates a LAN with a main server to support the former by performing basic accounting, inventory control, and purchasing. Moreover, IT provides the support and information required for Production Control to properly schedule and control production and provides hardware support for all computers.

IT assures system security through controlled user access and through regular database "back-ups" and provides advice in purchase of hardware and software.

In Sohat each department is responsible for control of its data, with IT responsible for coordination. Where report generation can occur according to authorized access rights.

Research Results

This section analyzes the results described previously, and is divided into two parts. The first part addresses the research question of how AMT is being integrated with production, and what problems are occurring. The second part addresses the question of how involved the companies are in TQM.

AMT integration

The following is an evaluation of AMT equipment integration for the study participant. This analysis considers both functional and physical components.

Physical Integration: The physical component consists of system connectivity issues such as: the number and variety of AMT in use; the number and variety of computer platforms in use; networks in operation; whether incompatibilities exist, and how they are being tackled.

Functional Integration: The functional component comprises all efforts to maximize productive efficiency, achieve system goals, and assure process synchronization. Productive efficiency efforts are characterized by success in activities such as reductions in WIP and inventories, and material handling. Corporate system goals can be defined as adequate product quality and timely delivery.

Research results: Although there is subjectivity inherent in the evaluation of AMT integration based upon the preceding criteria, the factors identified are reflected in much of the literature. An analysis of the results is presented in Table 1.

The MPC system is designed to assure process synchronization by providing accurate production planning and developing realistic production schedules. Both manual and automated means can be used, with scheduling accuracy dependent upon production "feedback" monitoring and control mechanisms. The feedback control mechanisms may include production tracking, order status reporting, and interdepartmental communication. Safety stocks and safety lead times offer a means of adjusting shop floor scheduling tension.

AMT Integration

AMT Equipment Used	CNC, PLC, Barcode Scanning, Shop Floor Terminals.
Physical Integration	
Multiple Platforms	Yes
Multiple Networks	Yes
Networks Linked	Yes
Intra-Network File Transfers	Yes
Platforms Compatible	No
CNC Linked	No
Functional Integration	
Interdepartmental Communication	High
Scrap and Rework Levels	Low
Raw Material Safety Stock	High
Production Expedited	Most
Use of JIT	Some

Table 1. AMT Integration

TQM Policy Deployment

The level of TQM policy deployment can be determined through the use of TQM tools and methods, the presence of "corporate transformation" characteristics, and the absence of transformation obstacles exhibited by the participant.

Use of TQM tools and methods: the use of TQM tools and methods discussed in Chapter III is an indication of how involved the company is in TQM in general. Since the overall effectiveness of the tools is dependent upon the extent of TQM policy deployment, tool use can not be applied as a measure of involvement. They can be used, however, as a subjective measure of TQM interest and intent.

Research results: An analysis of the participant's TQM policy deployment is presented in Table 2. The three criteria are TQM tools used, presence of key corporate "transformation" characteristics, and avoidance of certain TQM "obstacles".

TQM Policy Deployment:

Use of TQM Tools	**Sohat**
JIT	Some
Control Charts	Some
Check Sheets	Some
Transformation	
Use long-term goals	Yes
Manage the process	Yes
Use Teamwork	Some
"Market-in" basics	Some
Use PDCA	Yes
Cooperative Business	Some
Use Prevention	Yes
TQM Obstacles Avoided	
Executive Participation	Yes
Encouragement	Yes
Team Empowerment	Some
Reward System	Some
Implementation Plan	Yes
Vendor Participation	No
No worker fear for job	Some

Table 2. TQM Policy Deployment

Summary

This chapter discusses the results of the case study. The selected participant is introduced. Organizational, productive, and managerial information is reported as obtained from corporate documents, interviews, questionnaires, and observations. The reporting emphasizes MPC systems and AMT equipment, and management practices and TQM, evaluating system connectivity issues and assures process synchronization, and achieves system goals. The last section is an analysis of the participant's levels of AMT integration and TQM policy deployment.

Chapter VI

Conclusion

This chapter summarizes the reasoning behind the literature research and the case studies, and why such research is important. The limitations of case study methods and rationale are then discussed, with both the advantages and disadvantages pointed out. The case study results, discussed in the previous chapter, are then interpreted, with conclusions related back to the original research questions. The chapter ends with a discussion of the implications of the current study for future research.

Summary of Research Purpose

The research questions asked how AMT equipment have been integrated with production, what difficulties have been encountered with production, what difficulties have been encountered and why, how intensive is involvement in TQM, and whether AMT integration has any bearing on TQM problem resolution.

TQM is a system philosophy, designed to assure superior quality through management-supervised, employee-lead, coordination and integration of the production process through simplification, optimization, and communication. TQM appeared to combine physical and functional integration efforts. It is designed to first determine the process, and determine its current capabilities; second, strive to maintain stability in production through statistical process control and close departmental interaction and communication; third, once stabilized, the production process can be evaluated for its efficiency.

Successful AMT integration stabilizes the production process. Thus production process' that successfully introduces and integrates AMT further develop and enhance TQM orientation.

This particular approach of the research, that of combining AMT evaluation with TQM analysis, may provide useful information in the field of production and operations management.

Summary of Case Study Methodology

The use of the case study seemed most appropriate for a number of reasons. The study was an empirical study inquiring a real-world situation, in which data is derived from multiple sources of evidence.

The case study methodology proved to be a useful format within which to conduct this research. It provided the flexibility needed to evaluate a wide variety of data sources. However, there were certain downfalls in the execution of the methodology.

Limitations of the methodology

A significant obstacle to the effective execution of the study was the scope of topic. The literature indicated that AMT integration has technical, organizational and managerial implications. As a consequence, the research examined a variety of disciplines, and in a variety of formats such as: shop floor diagrams, and other technical literature; corporate goals; control charts, quality assessments, and other SPC documentation; personnel practices and policies; and operations manuals. The researcher's limited expertise in the fields may have adversely affected the necessary objectivity and consistency.

Advantages of the Methodology

The major advantage of the methodology was that it provided the flexibility with which to use a variety of information-sourcing forms. If one source failed to point out, the researcher could resort to another. Interviews and observation often clears up inconsistencies or inadequacies in the responses to questionnaires.

Summary and Discussion of Results

Chapter II is a review of literature highlighting the difficulties industry has experienced implementing AMT. It concludes with discourse on a basic need for an integrated systems management approach to the integration of AMT. The concern areas this approach must address include; the need for system goals, the need for management support, recognition of employee factors, the need for a complete data collection and distribution system, the need for plant wide involvement, the need for strategic investment, the need to manage technology, the need for quality and productivity improvement, and the overall need for physical and functional integration.

Chapter III ends with a discussion of how TQM may adequately address needs by specifically working to assure the physical and functional integration of production. Theoretically, TQM can address the physical integration concerns by assuring the necessary information collection and dissemination; supporting development of talent in-house; minimizing the effect of ambiguous standards, reducing overall system complexity; and improving network uniformity through consistency in managerial objectives and goals, long-term planning, and cooperation with vendors and customers. TQM address functional integration concerns by concentrating on process description and analysis; spreading communication and departmental cooperation;

demanding uniform corporate goals; pushing employee involvement, training, and teamwork; and creating the proper work and management orientation.

The Case Study

The research hypothesized that having a successful physical and functional integration of AMT will enhance TQM policy deployment. From reviewing the tables, it may be assumed that there is some relationship between functional integration and TQM policy. Sohat has a considerable functional integration and a noted degree of TQM policy deployment.

Although results suggest that Sohat enjoys a moderate physical and functional integration, they may imply that AMT can aid TQM through extensive process description and analysis, and "production rationalization." The use of SPC provided Sohat with the detailed information necessary to determine process capabilities, and begin to address the linkage between process steps.

The extensive use of teams in TQM may provide the means to bring together the elements of different functions and the forum within which to discuss the necessary measures to assure proper integration. Sohat use of teams has enhanced functional AMT integration through the introduction of JIT techniques.

Another important element of TQM is the emphasis it places upon the long-term decision making. Investments, marketing efforts, and business survival all become long-term objectives: The company cannot base decisions upon short-term profits and short-term return on investments, but rather on their contribution to the ultimate survival of the venture. Sohat's investment decisions appear to support long-term planning essential to securing uniformity in AMT equipment.

Sohat uses several systems with little physical integration but with more functional integration. Sohat is able to achieve consistency in delivery performance and has a very good product quality.

Sohat seems to have two training programs in operation: a comprehensive one for management to be fully trained on SPC and fault diagnosis, while supervisors possess basic knowledge of SPC fundamentals in statistics and process capability. But on the level of operations Sohat overcame the resistance to change by providing all workers with the training that will enhance TQM orientation.

Communication is an important part of functional integration and without which no synchronization can occur. Hiring practices have an effect upon how well departments communicate. HR uses experience and applicant's ability to do the job. If HR resorts to foreign workers as a means of reducing labor expense, one consequence may be workforce without a sufficient understanding of the Arabic language. In Sohat all workers speak Arabic, thus Sohat has no problems with language barriers. Moreover bilingual supervisors and managers assure adequate communication with foreign vendors and Nestle. With good communication a cornerstone to TQM, language acts as an advantage to comprehensive policy deployment and AMT integration. Good communication result in fast and accurate information exchange demanded by MPC systems.

To sum up, the case study and literature review brought forward a variety of obstacles facing batch manufacturers. They must push quality in production to assure sales. They also stress the importance of meeting delivery schedules. They have emphasized their active participation in TQM programs to continuously improve product quality. They stress the importance of using technology to meet the need for efficient production.

They also face obstacles resolving both physical and functional integration problems. Budgets, previous management practice, resistance to change, and mother company interests; all serve to interfere with system objectives of process simplification, process synchronization, and long-term planning.

If a common theme can be extracted from the studies, it is the need for setting and adhering to long-term goals. There must be a plant-wide support for the goal of corporate survival. Sohat's goals stress the importance of long-term improvements in process, as well as continuous improvements in product.

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Appendix A

Questionnaires

Production Manager

- What are your responsibilities?
- How familiar are you with the processes used in other areas of manufacturing? (1. Don't know 2. Know some people 3. Meet regularly 4. Worked area 4. Managed area)
  Industrial Engineering/ R&D---- Quality Control---- Purchasing----
  Accounting/ Finance---- Information Systems---- Human Resources---
- Have you been trained in error control and fault diagnosis? If so, please describe.
- How do you use statistics in production? Have you had any experience with control charting and Statistical Process Control (SPC)? If so, please describe.
- Do you have programming experience? If so, which languages?
- Are you involved in tracking parts or jobs, and/or developing the tracking system? If so, how?
- Does the company have merit review, bonus, or "Employee of the Month" programs? If so, describe.
- Would you describe the computerized systems currently used as being overly complex? How easy has it been to maintain these systems?
- Has there been any change in programming needs or in the quality of input materials used once new machining systems were on-line?
- Describe employee acceptance of the new equipment. Were there many production delays?
- What percentage of total production time is spent on production activities?
- How are non-value adding activities such as machine setup and material handling measured and controlled?
- Please provide a shop floor diagram showing where raw material, WIP, and finished goods are stored.
- How many days of raw material stock is available for major products?
- How are the setup procedures of preparation, tool mounting, and trial runs measured and evaluated for improvement?
- How is the material handling function supervised and controlled? How is transfer delay unnecessary motion evaluated and corrected?

- How is data collected for part characteristics, available space, plant floor design, and physical/ engineering/ budgeting constraints? What departments are involved?

- How are design changes coordinated?

- Are more than one Computer Aided Design (CAD) systems in use? If so, can files be transferred between them? Are peripheral devices shared?

- How are design changes implemented (initiated, database updated, departments notified, etc.)?

- Do production personnel operate under particular job and assignment specifications, or do they have flexibility in deployment, or both?

- Are production workers trained in error control and fault diagnosis?

- Are work standards specified for most jobs? How strictly enforced are work regulations? Is difficulty encountered getting upper management support for AMT projects?

- Can all shop floor Computer Numeric Control (CNC) machines accept data from one another?

- Please add any comments you feel are important.

Quality Control

- What are your main responsibilities?

- How familiar are you with the processes used in other areas of manufacturing?
(1. Don't know 2. Know some people 3. Meet regularly 4. Worked area 4. Managed area)
Industrial Engineering/ R&D---- Quality Control---- Purchasing----
Accounting/ Finance---- Information Systems---- Human Resources---

- Describe the basic approach used to measure product quality (e.g.: acceptance/ rejection, inspection, control charting, SPC (Statistical Process Control)).

- What particular product quality (costs, materials, performance, specification, etc.) does the customer most demand?

- How would you compare you product quality to your competition?

- Where do you use the most room for improvement in product quality?

- Who do you feel are the key company players in the quality improvement program?

- What are the basic objectives of the TQC effort?

- Which employees are trained in statistical quality control? Which employees do you feel should be trained?

- Is upper management actively in TQC (e.g., in policy formulation, in steering committees, seminars, and in problem diagnosis and feedback)?

- Have Quality Control Circles been formed? How are they organized, what particular problem do they tackle, and how are they empowered? How are problems prioritized?

- Please add any comments you feel are important.

Information Technology

- What are your main responsibilities?
- How would you describe the role of Information Technology (IT) in production control?
- How familiar are you with the processes used in other areas of manufacturing? (1. Don't know 2. Know some people 3. Meet regularly 4. Worked area 4. Managed area)

  Industrial Engineering/ R&D---- Quality Control---- Purchasing----
  Accounting/ Finance---- Information Systems---- Human Resources---
- Who should maintain control of data for the company?
- Has IT been affected by data-entry and report generation outside the department? If so, describe.
- Is network security and access a problem? Is data encryption used in the system?
- How would you describe overall budgeting and company support for IT?
- How often is the system down?
- Describe IT involvement in engineering change?
- How often are master schedules revised?
- How often are master schedules audited?
- Would IT performance improve substantially if not constrained by the budget? Please describe briefly the changes you would make.
- Are you aware of any system or network incompatibilities within the company? Please describe.
- How are parts tracked (in the system, on the floor, and how reconciled)?
- What protocol conversion interface is used?
- Do personnel from different departments assist the IT staff in tracking system development? If so, please describe.
- How is workflow coordination, data entry, and database sharing supervised?
- Is a LAN/ WAN currently in operation? If so, is access policy and encryption uniform company-wide? Are network requirements defined for delay, reliability, and availability?

- Does IT suffer from overworked people, excessive backlogs and maintenance activity, insufficient budgeting, and inadequate equipment?
- Please add any comments you feel are important.

Human Resources

- In your own words, what is quality control?
- How familiar are you with the processes used in other areas of manufacturing? (1. Don't know 2. Know some people 3. Meet regularly 4. Worked area 4. Managed area)

  Industrial Engineering/ R&D---- Quality Control---- Purchasing----
  Accounting/ Finance---- Information Systems---- Human Resources---
- In what areas is Quality Control (QC) most important? Do you feel that QC can be applied to others?
- Are personnel currently involved in the TQC effort? If so, please describe how.
- How should HR support QC activities?
- Are most positions considered unskilled, semi-skilled, or skilled?
- What criteria are most important in hiring decisions?
- If job description manuals are used, how frequently are they updated?
- How difficult would it be to reduce the number of job categories?
- Are most jobs and workers rigidly assigned, flexible, or vary?
- How difficult would it be to get flexibility in worker deployment?
- How important is previous training as a selection criteria?
- How often are training seminars conducted for line workers, staff, and management?
- Does the company have merit review, bonus, or "Employee of the Month" programs? If so, describe.
- Does the company have a newsletter? If so, please attach a sample copy.
- Have machine installations ever resulted in special pushes to get programmers?
- Would you say that this company instills in the employee a sense of pride of workmanship? If so, please describe briefly how.
- Who is the first to go when the "axe falls"? Is this well known within the company?

- Has training been recently instituted to address TQC and AMT (Advanced Manufacturing Technology) needs? If so, please describe.

- With the addition of any computer-controlled equipment, was there a reduction in the number of skilled machinists? Were software engineers hired to program?

- Has employee training and orientation time increased?

- Has AMT reduced the number of supervisory levels?

- Has AMT reduced the Size of work crews or teams?

- Has Performance Appraisal methods and techniques changed after introducing automation?

- Does automation reduce the size of the work force?

- Please add any comments you feel are important.

Appendix B

Glossary

AMT	Advanced Manufacturing Technology
APICS	American Production and Inventory Control Society
AS/RS	Automated Storage and Retrieval Systems
BOM	Bill Of Material
CAD/CAM	Computer Aided Design/ Computer Aided Manufacturing
CAPM	Computer Aided Production Management
CIM	Computer Integrated Manufacturing
CMM	Coordinate Measuring Machine
CNC	Computer Numeric Control
DFA/DFM	Designing For Assembly/ Design For Manufacture
DOD	Department Of Defense
DNC	Distributed Numeric Control
FMS	Flexible Manufacturing System
HR	Human Resources
IS	Information Systems
IT	Information Technology
JIT	Just In Time
LAN	Local Area Network
MPC	Manufacturing Production Control
MRP	Material Requirements Planning
NC	Numeric Control
OSI	Open System Interconnect
PDCA	Plan Do Check Act
PLC	Programmable Logic Control
QC	Quality Control
SPC	Statistical Process Control
TQM	Total Quality Management
WIP	Work In Process