Productivity Improvement through Computer Integrated Manufacturing in Post WTO Scenario

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Abstract: *This paper emphasizes the significant role of Computer Integrated Manufacturing (CIM) to the national economy. Ranges of topics have been covered in this paper: CIM definition, history, requirements in post WTO scenario, organization, and application. Today's industry competes in a truly international marketplace. Efficient transportation networks have created a "world market" in which we participate on a daily basis. For any industrial country to compete in this market, it must have companies that provide economic high-quality products to their customers in a timely manner. The importance of integrating product design and process design to achieve a design for production system cannot be overemphasized. However, even once a design is finalized, manufacturing industries must be willing to accommodate their customers by allowing last-minute engineering-design changes without affecting shipping schedules or altering product quality. Therefore, Most U.S.-based manufacturing companies look toward CAD/CAM and CIM to provide this flexibility in their manufacturing system. The Pakistani industry would have to change from a conventional manufacturing style to computer integrated manufacturing style in order to cope with the post WTO requirements. The paper discusses productivity improvement by using computer integrated manufacturing in Pakistan.*

Keywords: *Productivity Improvement, Computer Integrated Manufacturing [CIM], WTO*

1. INTRODUCTION

"Computer Integrated Manufacturing (CIM) is a management philosophy in which the functions of design and manufacturing are rationalized and coordinated using computer, communication, and information technologies" according to Bedworth et al. (1991). CIM has the capability to largely or entirely automate flexible manufacturing by coordinating work cells, robots, automatic storage and retrieval facilities and material handling systems.

"CIM is a new kind of philosophic theory used in organizing, managing, and running the enterprise's production; it takes advantage of computer software and hardware, synthetically uses modern managing technology, manufacturing technology, information technology, automatic technology, system engineering technology, and it integrates organically the three relative factors of Person, Technology, Running Management in the whole process of enterprise's production, as well as information flow and material flow, and runs them optimally, to make service excellent, bring products to market timely, and realize product's high quality, low cost, so that enterprises will win the market competition".

It is axiomatic that computers, computer applications and integrated (such as enterprise and value chain wide) computer systems will be applied in next generation manufacturing companies. The key problem that remains to be resolved is to define where we will apply these systems, how we will apply these systems, and how these systems will be created and how the division of tasks between the "people system" and the CIM system is decided. The paper discusses such matters.

Simply, CIM is the use of computer systems to integrate a manufacturing enterprise. CIM provides the tools to enable the use of organizational programs such as Total Quality Management, Continuous Improvement, Concurrent Engineering, and Design for Manufacturability, Design for Assembly, and back-to basics concept of "Do it right the first time". Integrating information and organizations will decrease the logistical size of a company, making it appear to be small again-at least from the management, administration, and information-sharing viewpoints. The goal of CIM is to provide the computer applications and communications needed to bring about the integration (with matching organizational changes) that will allow a company to take advantage of these new capabilities. The CIM technologies may include:

- Computer-aided design
- . Computer-aided manufacture
- Computer numerically controlled machines
- Flexible manufacturing systems
- . Robotics
- Automated material handling systems
- . Group technology
- Manufacturing resource planning

2. PRODUCTIVITY IMPROVEMENT THROUGH COMPUTER INTEGRATED MANUFACTURING

2.1. Historical developments in advanced manufacturing technologies

Historical developments in advanced manufacturing technologies can be outlined as Exhibit 1:

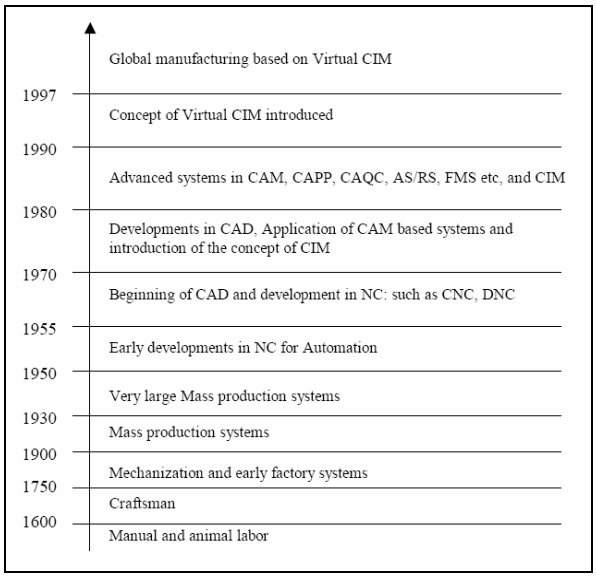

Exhibit 1: Developments in Manufacturing Technology

2.2. The causes of the slowdown in US manufacturing industries

The need for integration has evolved in response to the problems faced by the traditional manufacturing process of industrial automation. Individual automation in each functional unit created islands of automation. These islands of automation did not facilitate communication between the functional units. Errors in data sharing and other mismatches with these islands of automation continually plagued the Manufacturing industry. The complexity of new manufacturing technologies, economics, increasing human limitations, computer developments, and competition from abroad has forced the initiation of integrated computer aided manufacturing (ICAM) program by the United States of America Air force. The ICAM program conducted in 1983 found the following critical problems in industrial automation:

1) Information could not be controlled by users,
2) Changes were too costly and time consuming,
3) Systems were not integrated, and
4) Data quality was not suitable for integration.

Manufacturing managers consider and adopt innovative and advance technologies due to the global competition, which exists today, not only from Japan and Europe, but also form low labor cost countries such as China. The manufacturing engineer today must understand and be able to plan for these new technologies to survive in the present world condition. They should have a clear concept of automating the manual and semiautomatic machinery to reap the benefits of these emerging technologies. Implementation of CIM could help companies achieve their competitive goals to survive in the global market environment as long as the technologies chosen are appropriate to meet their objectives.

2.3. Benefit from CIM

The integration of the technologies brings the following benefits:

1. Creation of a truly interactive system that enables manufacturing functions to communicate easily with other relevant functional units.
2. Accurate data transferability among the manufacturing plant or subcontracting facilities at in-plant or diverse locations.
3. Faster responses to data-changes for manufacturing flexibility.
4. Increased flexibility towards introduction of new products.
5. Improved accuracy and quality in the manufacturing process.
6. Improved quality of the products.
7. Control of data-flow among various units and maintenance of user-library for system-wide data.
8. Reduction of lead times which generates a competitive advantage.
9. Streamlined manufacturing flow from order to delivery.
10. Easier training and re-training facilities.

2.4. Why is CIM very important to National Economy

In today's competitive international business environment, companies are calling for new approaches to manufacturing. Also, the growth in computer-based technology during the 1980s, coupled with the emergence of flexible manufacturing systems (FMS) and just-in-time (JIT) inventory control forced movement away from the traditional product focused manufacturing paradigms of the mass-production era to that of a process-focused paradigm. Through the use of various computer-aided technologies, computer integrated manufacturing (CIM) attempts to pull all of the functional areas of a business into a cohesive, interconnected, interactive, self-aware whole. CIM includes such activities as product/process design, manufacturing technology, material acquisition, information resource management and total quality management. CIM utilizes enterprise-wide computer-aided technologies to maintain quality, speed new product development, minimize costs and maximize flexibility to respond to ever-changing customer desires. Thus, the competitive advantage of CIM in industry comes from its ability to:

- Develop a large quantity of new products quickly;
- Produce small production runs of custom-made items efficiently; and
- Maximize the flexibility of the manufacturer in responding quickly to changes in the environment.

Historical manufacturing paradigms cannot deliver all these goals simultaneously, but CIM holds the potential to do so. The current state of expectations is that Computer Integrated Manufacturing (CIM) will ultimately determine

the industrial growth of world nations within the next few decades. Computer Aided Design (CAD), Computer Aided Manufacturing (CAM), Flexible Manufacturing Systems (FMS), Robotics together with knowledge and Information Based Systems and Communication Networks are expected to develop to a mature state to respond effectively to the managerial requirements of the factories of the future that are becoming highly integrated and complex. CIM represents a new production approach that will allow the factories to deliver a high variety of products at a low cost and with short production cycles. The new technologies for CIM are needed to develop manufacturing environments that are smarter, faster, close-coupled, integrated, optimized, and flexible. Sophistication and a high degree of specialization in materials science, artificial intelligence, and communications technology and knowledge-information science techniques are needed among others for the development of realizable and workable CIM systems that are capable of adjusting to volatile markets. CIM factories are to allow the production of a wide variety of similar products in small batches through standard but multi-mission oriented designs that accommodate flexibility with specialized software. CIM factories are to operate in accordance with such characteristics as decentralization, desegregation, flexibility, and rapid conversion of product lines, response to innovation, production tied to demand, and multiple functions. Other requirements for CIM are minimal downtime and maintenance, maximum product family range, ability to adapt to variability in materials and process conditions, the ability to handle increasingly complex product designs and technologies within the existing systems with minimum disruption and minimum cost.

2.5. Barriers to CIM adoption

Despite all the money, energy, and time spent by companies trying to automate their factory, CIM is still an unfulfilled promise for many. Managers have continually struggled with the problem of successfully putting the pieces together to get the most out of CIM technology. In the past few years, several surveys have attempted to investigate the problem and identify the primary obstacles to more rapid adoption of CIM technology. Some of the findings are identified below.

2.5.1. Management perception and attitude

In late 1970s and early 1980s, as CIM advanced quite rapidly in the USA, disillusionment with automation has surfaced. Frequently, top executives viewed CIM as just technology – a master computer controlling many robots and automated machines. They are wrong; if CIM were just technology, there would not have been as many companies having difficulty implementing it. CIM is the management of technology rather than a technology itself. It is the integration of people and functions utilizing the computer and communication networks to transform automation into interconnected manufacturing systems. CIM requires a new perspective on the part of management – maybe even a new philosophy. Top management, manufacturing and industrial engineers must change their way of thinking and develop new skills.

2.5.2. Top management commitment

In many companies where CIM does not fail to realize its potential "top management's commitment and ongoing support" is cited as a major reason. The magnitude of undertaking can be a great problem if there is not major and absolute commitment by management of the necessary time and resources. CIM installation must start from the top with a commitment to provide the necessary time; money; and other resources needed to make the changes that CIM requires.

2.5.3. Lack of planning

CIM success requires deliberate and careful planning of the technical element in conjunction with training from day one. Lack of understanding of the technology and suitable infrastructures to support the new technology, inappropriate matching of technology to organizational strengths and weaknesses will all contribute to top management's failure to appreciate the promise of CIM. Organizational design is an integral part of CIM, promoting or inhibiting the implementation.

2.5.4. Integration challenge

Experts agree that the important issue to be addressed before CIM can become a reality is integration. The ultimate objective of CIM is the integration of all parts of the organization across the major functional boundaries. If the company environment is right, CIM can even assist in pulling together teams of people to work on project. To take full advantage of CIM's benefits, the entire manufacturing process from product design to procurement, production scheduling, management, production and delivery must be integrated.

2.5.5. Organizational structure

CIM requires flexible organizational structure. There is a growing consensus that old fashioned approaches to manufacturing and rigid corporate rules are a significant barrier to CIM. The majority of manufacturing organizations in this country were designed to support specialization as opposed to integration.

In summary, the following are the major problems faced by manufacturers that may lead to failure in CIM (or FMS) implementation.

- Inadequate measurement system.
- Partially obsolete facilities.
- Inadequate database.
- User hostility.
- Shortage of technical skill.

- Incompatibility between systems.
- Management generation gap.
- Changes in management philosophy.
- Facilities with mixed processing.
- Dynamic volume and mix.
- Outdated organization.
- Varieties of process options.
- Loss of superior/subordinate support.

2.6. Design of the CIM System

The following business and manufacturing objectives should be considered in the design of the CIM system:

1. To maintain the consistency of the quality of products.
2. To deliver products on time.
3. To offer more products to customers.
4. To design products that will improve performance.
5. To design electronic devices that can be made on the shop floor.

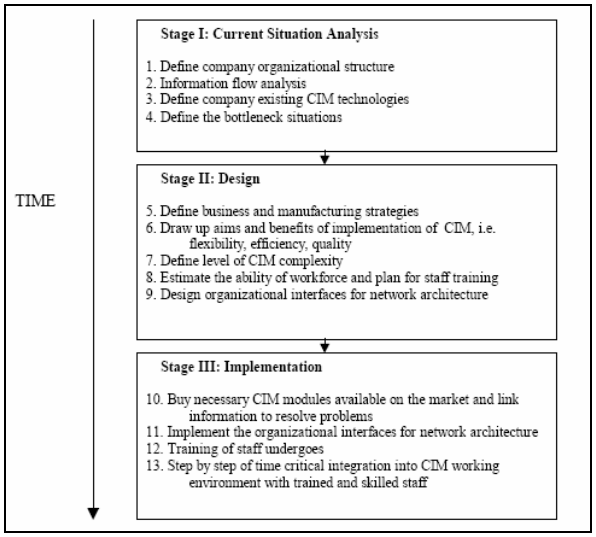

Exhibit 2: A framework of the design and implementation of CIM

2.7. Rising Needs

CIM is the concept of a totally automated factory in which all Manufacturing processes are integrated and controlled by a CAD/CAM system. It enables production planners and schedulers, shop-floor foremen, and accountants to use the same database as product designers and engineers. It is one of the most advanced tools for improving the economic performances. It is also becoming a fundamental base for designing and building the next even more advanced generation of manufacturing systems presently called as Intelligent Manufacturing Systems (IMS). It offers a number of useful and potential opportunities for improving the competitiveness of manufacturing. The motivation for CIM has been based on the perceived need for manufacturing industry to respond to changes more rapidly than in the past. CIM has potential applications in the manufacturing strategies such as agile, lean and virtual enterprises. Therefore, there is a need to investigate the areas of further development, applications and implications of CIM in the next generation manufacturing organizations. Rather than CIM, today's concepts seem to center more on ERP (Enterprise Resources Planning, but not really restricted to planning) and MES (Manufacturing Execution Systems).

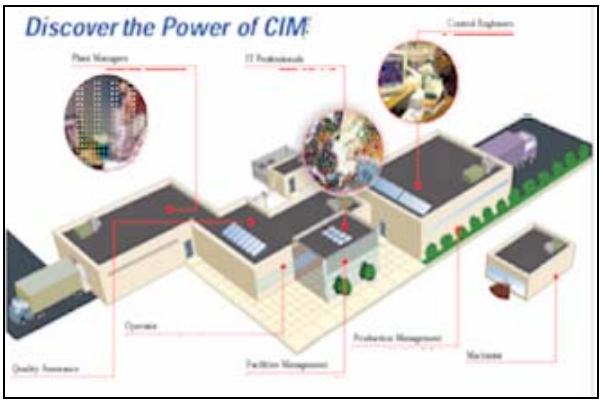

Exhibit 3: A Proposed CIM Industry

2.8. Working principles

The following working principles may lead towards implementing CIM for productivity improvement:

- Guiding by application, driving by technology, adopting finite targets, stressing the main points, combining with the situation in Pakistan, paying attention to practical results and forming business.
- Adopting expert leading mechanism under the leadership of Ministry of Science and Technology.
- Emphasizing on Team Work, which cooperates multi-disciplines to work and system integration.
- Paying attention towards building CIM groups, especially training of youth in this subject.
- Strengthening international cooperation.

3. IMPLEMTING COMPUTER INTEGRATED MANUFACTURING

3.1. Proposed Research Environment

To better explore the avenues of CIM technology in Pakistan, setting-up of the subscript research laboratories is the need of the hour. The subscript proposal was first presented by Mr. Tariq Masood during ISCON-2002 at Lahore [5].

Table 1: Proposed CIM Research Labs.

Proposed Laboratory	Main Tasks	Proposed Location	Proposed Commencement	Tentative Completion
Product Design Automation	R & D of technology and products for CAD/CAM/CAE in CIMS	NWFP Univ. of Engg. & Tech., Peshawar	2002	2005
Process Planning Design Automation	R & D of technology and products for CAPP in CIMS	NUST, Rawalpindi	2002	2005
Integrated Management Decision Information	R & D of technology and products for Computer Aided Management and Decision in CIMS	LUMS, Lahore	2002	2005
Flexible Manufacturing Engineering	R & D of technology and products for FMC/FMS/FME in CIMS	Univ. of Engg. & Tech., Lahore	2002	2005
Quality Control Technology	R & D of technology and products for CAQ in CIMS	NED Univ. of Engg. & Tech., Karachi	2002	2005
Database and Network	R & D of technology and products for Network and Database in CIMS	GIK Institute of Engg. Sciences & Tech., Topi	2002	2005
System Theory and Technology	R & D of technology and products for theory, simulation, and AI in CIMS	Univ. of Engg. & Tech., Taxila	2002	2005

3.2. Application Basic Research

The research task on application basic technology is a kind of technology-driven research under certain application background. This task develops necessary explorations, verifications, and new ideas in the concepts, principles, and methodology suitable for the forward development of worldwide CIM science and technology. This task can be divided into following sub-topics:

- Management Information System (MIS)
- Design Automation and CAD/CAM Integration
- Shop floor Automation
- Quality, and others

3.2.1. Proposed Application Basic Research Topics

The subscript is a short list of potential topics for further research in the field of Computer Integrated Manufacturing in Pakistan:

- Experiences with the implementation of integration in Computer-Integrated Manufacturing Systems (CIMS) in different countries.
- Design methodologies of integration systems including architectures and evaluation of adaptability.
- Object-oriented modeling methods for the design of CIMS.
- Knowledge-based decision support system for CIM.
- Human role in Computer-Integrated Manufacturing.
- Quality management in CIMS
- Strategic and organizational adaptation of Computer-Integrated Manufacturing Systems (CIMS) for 21st century manufacturing competitiveness.
- Implications of lean and agility on CIMS.
- Design methodologies for CIM systems including architectures and evaluation of adaptability for the lean and agile manufacturing, and value chain integration.
- CIM in a Physically Distributed Manufacturing Environment.
- Enterprise integration and environmental issues as the main objectives in the design and implementation of CIMS.
- Rapid prototyping, virtual design, manufacturing, enterprise and CIM.
- Investment Justification in the future CIMS.
- Operations Control (productivity, quality, flexibility, cost and dependability) in the future CIMS.
- CIM in Small and Medium Enterprises as the Qualifying Criterion to become a Partner of Virtual Enterprises.
- Human factors and CIM in 21st Century Manufacturing Environments.

3.3. Pre-Research and Development

This is the kind of product pre-research with major study and development for the market requirement after 3 to 5 years, on the base of product and achievement technology combining with new ideas, concepts, and principles of product developed in the world. Presently, when Pakistan

has to start from a scratch, this pre-research is also needed extensively while setting up CIM research labs.

3.4. Applied Engineering

Applied Engineering should be one of the important considerations while implementing laboratories concept. The reasons for setting up applied engineering are listed in the following text:

- CIMS is an integration or optimization system of people, organization, technology, management, and administration; therefore it is necessary to master CIM technology completely by typical enterprise practicing.
- The works of typical enterprises practicing can guide the carrying out of CIMS in other enterprises of Pakistan.
- The practice of applied enterprises and research labs. will counter check each other for better results.
- There should be more than seven enterprises to be declared as role models.

4. INTERNATIONAL ASPECTS OF CIM IN POST WTO SCENARIO

4.1. The International Role Models

Today, Japan is one of the more advanced countries in implementing CIM in the world. Nevertheless, the implementation of CIM in Japan has some differences to that of Western countries. Among these companies we have Hitachi Ltd, Mitsubishi Electric Corporation, Toyota Motor Corporation, Toshiba, Toyo Engineering Corporation, Omron Corporation, Tokyo Electric Corporation, Fanuc Ltd., Shimizu Corporation and Nippondenso Corporation. The CIM study concerning Intelligent Manufacturing Systems (IMS), and the basis for preparation of the so-called Future Generation of Manufacturing Systems (FGMS) permits a better understanding of Japanese competitiveness using advanced technology. This is an important point when the economies enter in the global world market, and when Japan is passing to the so-called "Open-CIM", a new CIM generation that combines the classical CIM and the more advanced technological advantages offered by the advances in information technology and telecommunications.

General Motors replaced the dissimilar hardware and software that existed throughout the corporation and created an integrated system known as C4 (computer-aided design, computer-aided manufacturing, computer-integrated manufacturing and computer-aided engineering). As part of its C4 program, GM linked the design, manufacturing and assembly teams that were previously unable to communicate with each other. GM made the decision that although its legacy systems represented a sizable capital investment, it was important that the entire manufacturing process be overhauled to ensure interoperability and interconnectivity among all the players on the new network, including suppliers.

4.2. International Cooperation Required

The national and international conferences in Pakistan should include CIM as the topic of the day for research papers and discussions. Scholars should be invited to deliver lectures in Pakistan from USA, Europe, Australia, Japan, China, Taiwan, and other capable countries in this subject. We should strive to achieve great successes in the main cooperative topics and to open up actively the new prospect in order that the international academic exchanges become one of the important means for promoting the development of our CIM technology. Development of regular links with related international societies is an ample need of the hour. The list includes Society of Mechanical Engineering-USA, Society of Manufacturing Engineering-USA, and Society for Computer Simulation International-Belgium, International Fuzzy System Association-Canada, and many more.

5. FUTURE DIRECTIONS OF CIM

In today's competitive global market survival of any industry depends on its ability to communicate and transfer the right information at the right time to the right people. Manufacturing cannot escape from this present requirement. Having an ability to communicate for elective management and manufacturing activities across the geographical boundaries among the globally distributed resources will significantly benefit manufacturing industries. Today a number of global conglomerates are formed in many facets of industry. A virtual enterprise is defined as a network of interconnected global conglomerates in this paper. Predicting the future research direction of CIM and related areas is a difficult task in ever expanding and growing technological development era. However, an attempt is made to foresee the future direction, which will dominate the researchers' mind for the next decade, based on the current developments in CIM research. Today’s competitive and agility requirements of the global market can be only met by virtual enterprises. To provide a better future in the present market requirements research in virtual CIM and the application of it in worldwide manufacturing industries are beginning to emerge. Application of virtual CIM has been proposed as a necessary step towards the future in manufacturing to face competitive challenges. However, many development works need to be carried out to face challenges faced by virtual enterprises. Hence, the research should be further strengthened towards developing a virtual CIM to satisfy the globalized and distributed manufacturing enterprises of today in order to meet the competitive and agility requirements of present market conditions. In a virtual enterprise the integration of information is extolled, as only through information can a virtual organization become meaningful, and only by electing a new generation of information technology can this vision be realized.

6. CONCLUSIONS

In summary, CIM is a means of using computer systems to integrate a manufacturing enterprise. The scope of CIM ranges from product design, process design, product scheduling and control, to advanced integrated functions within a production facility. It is important that all functions of a company be part of a CIM plan. Functions from business planning, strategic planning, and processing to customer should be included. There is no single definition of CIM because CIM is designed to fit the needs and applications of a specific situation. Thus, each company will implement CIM in a slightly different fashion. The paper tries to enlighten the rising needs of setting up industries working on CIM in Pakistan of 21st century. These systems are inevitable to improve productivity in post WTO scenario.

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