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THE STRUCTURE OF QUALITY INFORMATION SYSTEM IN A COMPUTER INTEGRATED MANUFACTURING ENVIRONMENT

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COMPUTER INTEGRATED MANUFACTURING (CIM) ENVIRONMENT

By now it becomes a well accepted fact that computer technology can significantly improve the productivities of manufacturing systems. More and more manufacturing functions are computerized, and the results are usually encouraging. Among them, CAD (computer-aided design), for instance, is a successful example. For over twenty years, CAD applications were dominated by the aerospace industries and appeared only the rich industrial giants could afford such luxury. Now the development of microcomputer based CAD packages has popularized the use of such interactive computer graphic designs, and therefore even small firms can enjoy the benefits of using CAD in their design processes.

CAM (computer-aided manufacturing), a concept of applying computer technology in manufacturing planning and control, has also been flowing in industries over the last two decades. Like CAD, CAM packages once could only be afforded by a small number of industrial giants, now almost any firm can consider to install some affordable packages to improve its manufacturing processes. In the early days, MRP (material requirements planning) systems had generated numerous unpleasant stories that brought serious doubts about the computerized manufacturing process. After years of improvement, MRP II (manufacturing resource planning) was eventually widely accepted by the industries. The development of MRP II also represents the recognition of isolation of production module from the other functions, such as capacity and resource planning, is not realistic. The production planning and control function have to consider the capacity requirements and available resources in generating feasible plans, schedules and recommendations.

Extended from the concept of integration, some system vendors believe business functions like marketing, finance and administration are all relevant to the production and planning processes. An example is MAPICS II (manufacturing accounting and production information control system version 2). It integrates information across functional areas and manages the resources of manpower, facilities and materials effectively. Its production function uses business data to expedite planning, forecasting, scheduling and control. The ultimate goal of applying computer technology in manufacturing environment is to shade all the engineering and business activities under one single umbrella called CIM (computer integrated manufacturing). Although up to now there is no commercially available CIM system that can build up a totally automated system, the trend is clearly toward that direction.

THE ROLE OF QUALITY FUNCTION IN A CIM SYSTEM

In order to support the development of a totally automated system, one has to first examine the state of computer-based manufacturing systems in the United States. One observation is that the quality assurance module is usually missing in the systems (Garvin, 1983, and Takeuchi and Quelch, 1983). Even for those companies that include quality assurance modules in their control systems, many of them are limited to after-fact quality inspections and statistical process control only. It is clear that in order to design the right products for customers and improve the ability to predict and detect quality problems at an early stage, there is a strong need for an information system to support the quality function. Such function should be extended from the production stage to cover the pre-production and post-production stages as well. This broader view of the quality function is a tough lesson learned from the recent competition with foreign industries, especially the Japanese. U.S. industries find out that producing defect free products is not enough. One has to know the customers first and then provide the right products to satisfy their needs in order to stay competitive.

To achieve such objective, a company has to launch a research on customer needs that which will be the inputs to the manufacturing plans, so that desired products can be produced and delivered to the target customers. After sales, the quality function will collect feedbacks to see if the

products are actually what the customers desire. In a broader sense, activities, from marketing research to field service and audit, are parts of quality function. This kind of quality assurance information system can be used to monitor the production performance, to prevent defects, and to find out the customers' perception of product quality. That will lead to better performance, better products, better service, and eventually, better sales. The importance of such quality information system to a company's competitive edges is easy to recognize, but unfortunately none of the existing computerized manufacturing systems comprehensively fulfills that need (Suresh and Meredith, 1985). For a basic design, this paper is now going to study the architecture of the quality information system and its interfaces with CAD/CAM and other functions in a computer integrated manufacturing environment.

THE STRUCTURE OF A CIM SYSTEM

CIM (computer integrated manufacturing) is an evolved concept. There is a close relationship among CAD, CAM and CIM. Many practitioners believe the term 'CIM' can be used interchangeably with CAD/CAM. It represents an integration of the computerized design and manufacturing functions into a sequence of activities. The interface to connect CAD and CAM is CAPP (computer-aided process planning), where the design is converted into manufacturing process plans in the making of the product.

However, a broader view of CIM will involve all the relevant engineering and business functions. For example, management information systems and decision support systems that support the management and operations in a manufacturing system are considered as parts of a CIM system. That is the same for a quality information system. It plays an unique and important role in the manufacturing system, and it can also be considered as an individual part in a CIM environment. Figure 1 contains the major components of a CIM system.

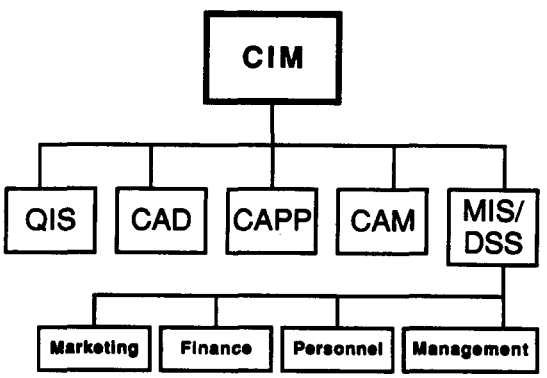

Fig. 1 Components of a CIM System

One may view a CIM system through the information flow in the system. The earliest phase perhaps is marketing where customer needs and competitors' strategies are studied. Collected information will help to set up company strategies. The marketing research supplies the input to the design and development phase. So during the CAD process, one can design a product that meets customer requirements and is fully functional in the way customers expect. The completed design will be converted to manufacturing process plans by the CAPP function. The CAM process accepts inputs from CAPP, forecast demands and information of available capacities and resources. It generates top-down manufacturing planning schemes. From a medium-range planning point of view, the master production schedules plan the material requirement orders for each level of a product's structure (bill-of-material). The shop floor dispatching, based on the short term available capacities and resources, will adjust the shedule to fit the current situation. There are devices at the shop floor level to collect various data for monitoring the process and performance. Inspection and testing procedures are used to enforce quality through the statistical process control. Even after the products are packed and shipped out, the system continues to collect field data. Service, warranty and follow-up are important to the customers. The post-sales feedback indicates the customers' opinions about the product, and such information will contribute to the future development and product designs. Figure 2 illustrates the product cycle information flow in a CIM system.

THE STRUCTURE OF A QUALITY INFORMATION SYSTEM

The life cycle of a QIS (quality information system) starts early from the marketing phase, where customer needs and competitors' strategies are studied, to the post-sales service and follow-up phase where customer feedbacks are collected to determine the level of their satisfaction. It is truly a function crossing the whole CIM process. We may roughly divide a quality information system into three stages: pre-production stage, production stage and post-production stage.

Functions of QIS During Pre-production Stage

The pre-production quality function has lately drawn a lot of attention from the quality control industries. It is mainly because of companies starting to recognize the importance of customer satisfaction in their sales. During this stage, the quality function does marketing researches on the customers and competitors. In order to develop optimized company strategies to be competitive, a company has to know its

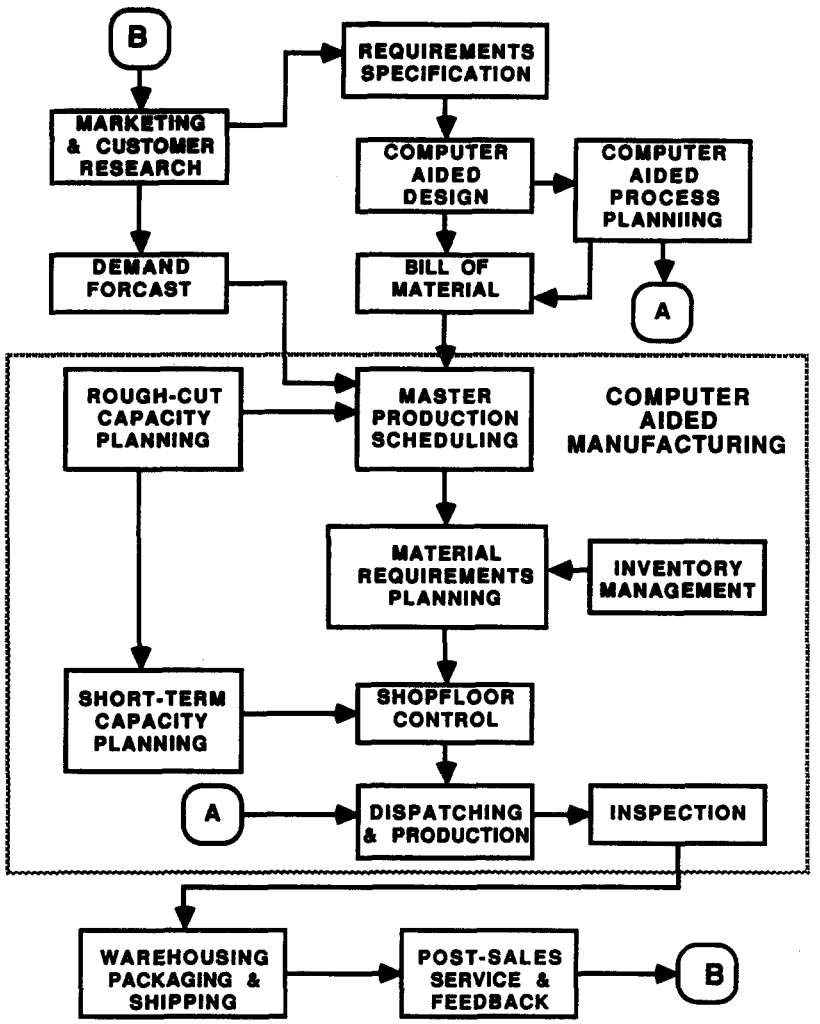

Fig. 2 Information Flow in a CIM System

main competitors. Their status and strategies will affect the company on setting its own offensive and/or defensive strategies. Collected data, analyzed information and company strategies will all be stored in the database as part of the company's decision support systems.

Pre-production quality function also collects and studies the information about the company's customers: their background, status, and needs. A customer-driven company believes that satisfying its customers should be the company's goal. Through marketing research, a company tries to find out the requirements to satisfy its customers. The quality function deployment process will convert the requirements in terms of product functions, styles and other engineering descriptions. Based on those engineering descriptions, the design process will develop a quality design of the product that customers want. The geometrical shape of the parts making the product will be established and the bill-of-material will also be initiated. At the time to release the design, the specifications of all parts will be detailed sufficiently to develop the process plans. Those specifications and designs will be stored in the storage medium to be retrieved by further processes.

The process planning analyzes the existing processes and/or new processes required to produce a designed product. The needs of numerical control programs in the shop floor level will also be considered during the process planning. Quality goals and standards are developed along with the process planning, so the establishment and specification of quality standards can help to assure that the planned processes will produce the product with quality of conformance. The database stored with quality standards becomes a linkage to CAD, CAPP and CAM processes.

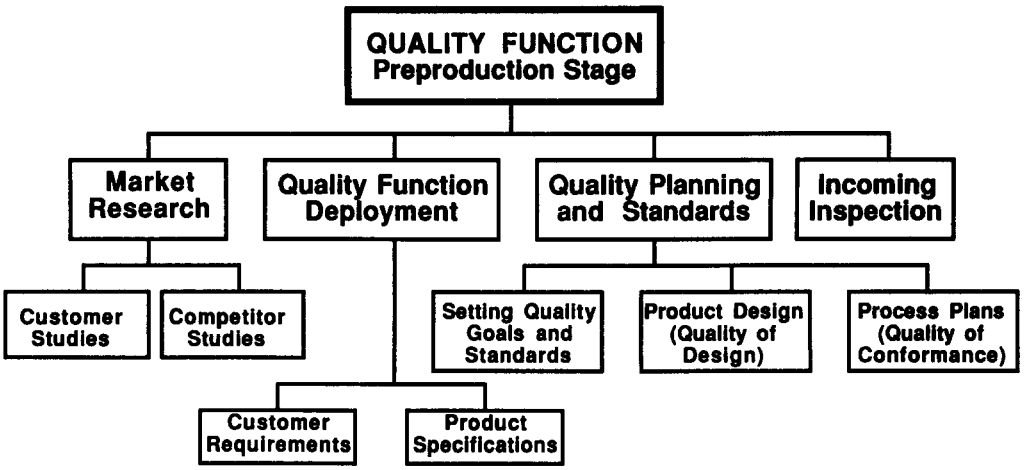

Fig. 3 Functions of QIS During Pre-Production Stage

To protect the quality of the product from using defective parts, the pre-production quality function also enforces incoming inspection. It tests the incoming parts and makes sure that only quality parts will be sent to the production lines and/or warehouse. Vendor performance will be studied along with the incoming inspection process. Any acceptance or rejection will be recorded in the vendor-history database. The feedback from the production lines may also form the input to update the information about the vendor's performance. Figure 3 represents the hierarchical view of the functions of QIS during the pre-production stage.

Functions of QIS During Production Stage

In the past, quality control during the production stage was considered the mainstream of quality function. One can find a rich number of publications discussing the function and techniques implemented in that stage. The basic operations include inspections of parts and assembled products, and statistical process control. The quality information system collects data during the process to support the statistical process control. That includes the rapid detection of out-of-control conditions and generates the process alarm. The quality information system helps to locate the causes of defects, and recommends the corrective actions. Like any other function, the statistical process control function also allows information retrieval through report generation and real time inquiry.

While the pre-production stage focuses on the quality design of a product that satisfies customer needs, the objective of production stage is to produce products with low defect and nonconformance rate. Figure 4 represents the hierarchical view of the functions of QIS during the production stage.

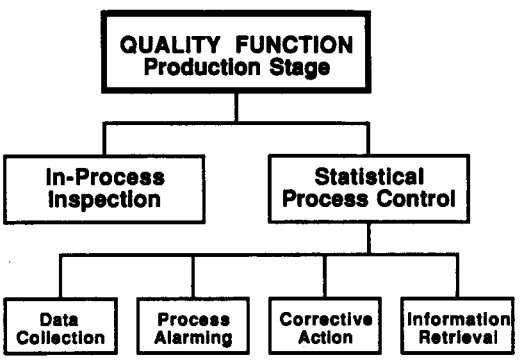

Fig. 4 Functions of QIS During Production Stage

Functions of QIS During Post-production Stage

During the post-production stage, quality function will cover warehousing, packaging and shipping processes to ensure error-free product delivery to the customers. After selling the products, customer satisfaction will significantly depend on vendor supports and after sales service/warranty. Sales returns will be recorded and investigated. Reliability laboratories can examine and locate the causes of defective products. Other causes of customer dissatisfaction should also be investigated. Those study results and other customer feedbacks will be stored in the quality information system, which acts like a communication channel between the customers and the company. With the help of the quality information system, the company can find the customers'

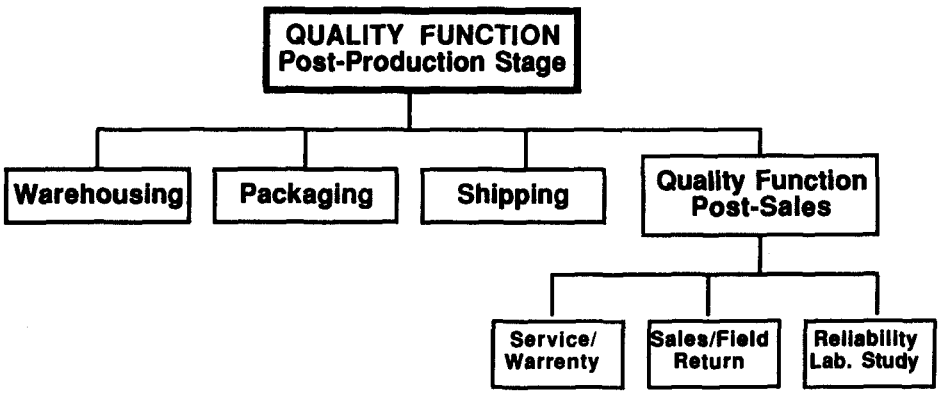

Fig. 5 Functions of QIS During Post-Production Stage

requirements, reduce defective rates, implement corrective actions and produce quality products. Figure 5 represents the hierarchical view of the functions of QIS during the post-production stage.

Basic Operations of Information Systems

The structure of computer-based information systems to support all the above mentioned quality functions involves similar basic operations. Each function collects the relevant data to be stored in some sort of storage medium. The data will be analyzed. The generated information will be used to support the decision making and operation. Databases will be maintained and updated constantly. Scheduled and ad hoc reports will be generated from those databases to support the management's operations. The recent advancements of nonprocedural query languages allow more non-technical management personnel accessing databases using real time inquiries. Basically every function should have these operations: data collection, data analysis, database updating and information retrieval for both report generating and real time inquiry. Upon the needs, each individual function may also require additional operations.

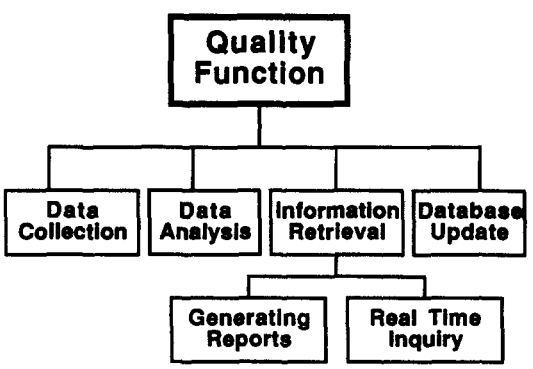

Fig. 6 Basic Information Systems Operations

INTERFACES WITH OTHER FUNCTIONS IN A CIM SYSTEM

Quality information system is not an isolated function in a CIM system. Along with the product life cycle, it constantly exchanges information flow with other functions. When other functions need information such as customer requirements, competitor status, quality standards, quality histories, updated quality information, defective rates, sales return rates, the distribution of defective causes and etc., they expect to be able to retrieve those information from the quality information system. Quality information system collects data from marketing, design process, manufacturing and production process, up to the post-sales field service phase, and those data are stored in the databases to be used for analysis and to support various functions in the CIM system.

During the pre-production stage, most of the time the quality system interfaces with the external environment, and a lot of human factors are involved. The system studies the customers, competitors and vendors. External environments are usually not under company control, and human behavior is dynamic rather than static. That makes the stage a complex and difficult one to deal with. In the past, the importance of pre-production quality function was underestimated. The recent trend in the quality industries is to put more weight on customer studies and new design quality control. It is believed that a better quality planning and prevention can save significant costs in the subsequent processes.

During the production and manufacturing phase, the quality function is less complicated. It is usually affected only by the internal environmental factors, and most of them can be under company control. There are human factors involved during the production

stage. These factors are usually associated with the operational personnel such as foremen and operators. At the operational level, most jobs are structured, and the need for personal decision is relatively low. Most of the time, the quality control function deals with machines, materials, processes and other technological subjects.

After the production, the quality function deals with various internal functions such as warehousing, packaging and shipping, and also external environment after the products are being sold to the customers. Marketing again plays an important role during this stage. Information collected from customers' feedback and reliability test results will contribute to a further design improvement. Figure 7 represents the interfaces of quality information system with other functions during a product life cycle in a CIM system.

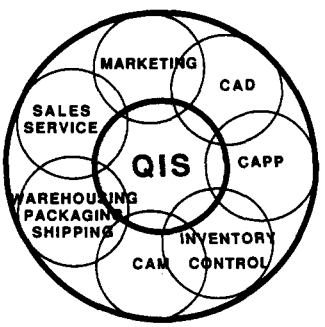

Fig. 7 Interfaces of QIS in a CIM System

CONCLUSION

This paper has studied the role of quality function in a computer integrated manufacturing system from the view of information flow during a product's life cycle. The study provides a hierarchical structure of quality information system and its functions during the pre-production, production and post-production stages. The interfaces of quality information system with other functions in the CIM system are also discussed.

The hierarchical structure thus developed represents a top-down view of the general design of quality information system. A further study on the data flow in the system can serve as the complementary part to this modeling process.

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BIOGRAPHICAL SKETCH

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