Concurrent Engineering in Total Quality Management

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Abstract

The philosophy of concurrent engineering is to change the pattern of "redo it until it right" into “do it right the first time.” In this paper, a model has been developed that combines the concept of concurrent engineering and total quality management for an improved product design and manufacturing. The model emphasizes five integrated components of total quality program, namely: employee involvement, customer relations, product design and development, material flow, and process control and evaluation. The model also incorporates employee involvement and human resources development, method of team formation, and the strategic importance of communication into developing a total quality management program. The paper concludes that the driving force behind total quality management in design and manufacturing enterprise is the combination of teamwork, education, training, and good communication at all levels in every organization.

Introduction

Concurrent engineering can be defined as a systematic approach to integrated product development that emphasizes response to customer expectations and embodies team values of cooperation, trust, and sharing of information and knowledge. Therefore, generally, concurrent engineering can be viewed as the earliest possible integration of the overall company's knowledge, resources, and experience in design, development, marketing, manufacturing, and sales into creating successful new products, with high quality and low cost.

Recently, there has been a dramatic change in product design and manufacturing methods for product quality. In this computer age, a change has come about, the old production method of "over the wall" is being phased out and making way for a more optimal and efficient method through teamwork and total quality management. Total quality seeks to implement quality management system that simultaneously improves quality, increases productivity, and reduces costs in design and manufacturing enterprise, using teamwork.

Integrated Model for Proactive Corporate Management in Total Quality Program

The proactive approach to total quality management requires that the concept of design and manufacturing be integrated throughout the company's management structure. Integrating proactive corporate management structure into the company's operations involves a two-step process. The first step is to create a supportive management structure within the company for proactive total quality management. The second step is to use that supportive environment to establish and communicate business plan for quality.

The use of "cross-functional resources" is necessary to be effective in implementing quality program for design and manufacturing. The use of cross-functional resources assumes that no individual has all the knowledge and resources available to implement changes that cut across all levels of a company.

Total Quality and Objectives

By total quality, we are looking for implementing quality-management system that simultaneously improves quality, increase productivity, and through continuous improvement reduce costs. Most companies choose to develop their own objectives rather than use a generic set of objectives from a quality handbook. The objectives are established after much consideration and discussion. Despite the personal flair, company objectives for achieving a world-class quality of excellence still share the common fundamental concepts and philosophies espoused by world quality leaders as Deming, Duran, Shewhart, and Taguchi. The summary of these objectives for total quality management in concurrent engineering environment is as follows:

1. Provide products and services of a quality that meet or exceed the requirements and expectations of the customer.
2. Develop quality systems to foster continuous quality improvement.
3. Define and implement quality programs based upon employee involvement.
4. Provide all employees with the training and support needed to produce quality products.
5. Develop and communicate objectives with all employees and assign responsibilities and accountability.
6. Use statistical methods to monitor quality and isolate major problems for immediate solution in teams.
7. Acquire knowledge of production processes, focusing on defect prevention instead of defect detection.
8. Provide an atmosphere that encourages employees to achieve their full potential and pride on workmanship.
9. Develop and maintain a team approach that emphasizes enhancing the competitiveness of the company through increased quality and productivity.
10. Form partnerships with vendors and customers that improve quality in all aspects of purchased parts and product usage.

Figure 1 illustrates the concept of concurrent engineering (teamwork) and the relationships and interaction and/or communication between quality-management (QM) committee with other organizational levels in the company. As shown, the senior management provides direction and leadership for defining the strategic goals and objectives associated with total quality. QM committee is responsible for the program development based on total quality program objectives; and reports to senior management on status and effectiveness of the program. At the department level, supervisors and team leaders are responsible for planning, implementing, and controlling the specific activities required for assuring and obtaining quality. The employees are trained to participate in planning program activities and for the execution of requisite programs.

Components of Total Quality (TQ) Program

TQ consists of five integrated components[1] (see Figure 2), which provide a clear mission and set of objectives that everyone in the company can understand and to which they can subscribe. The following are the key elements and activities for the integrated components: employee involvement, customer relations, product design and development, material control, and process control and evaluation.

Employee Involvement and Development

One of the basic tools needed to survive in a competitive environment is the development of the value of the people: teamwork; everybody in the organization must be involved in that teamwork. But, such employee involvement (EI), if not done correctly, can be expensive and ineffective, lowering productivity, and increasing levels of frustration. Employee involvement is the participation of the entire firm's workforce in improvement efforts for the working environment, product quality, equipment productivity, and increase in company competitiveness. Involvement takes place after educating the work force. Figure 3 shows how (EI) is used as a tool to become a world- class competitor (WCC) in an environment for total quality management[2].

A Plan to Achieve Employee Involvement (EI)

Employee involvement is a foundation; it is a fertile ground that must be cultivated to allow changes to be firmly rooted and competitive manufacturing techniques to develop. The actions to be completed for achieving (EI) can be grouped into four successive phases:

Phase 1: By creating the conditions for (EI); establishing goals then communicate goals to employee, involve the work force, implement changes, then come the EI committee to find different proposal that been accepted by management.
Phase 2: Starting EI pilot program that enables employees to analyze problems and communicate suggestions to management.
Phase 3: Evaluating the results of the EI pilot program.
Phase 4: Extending EI program to the rest of the organization.

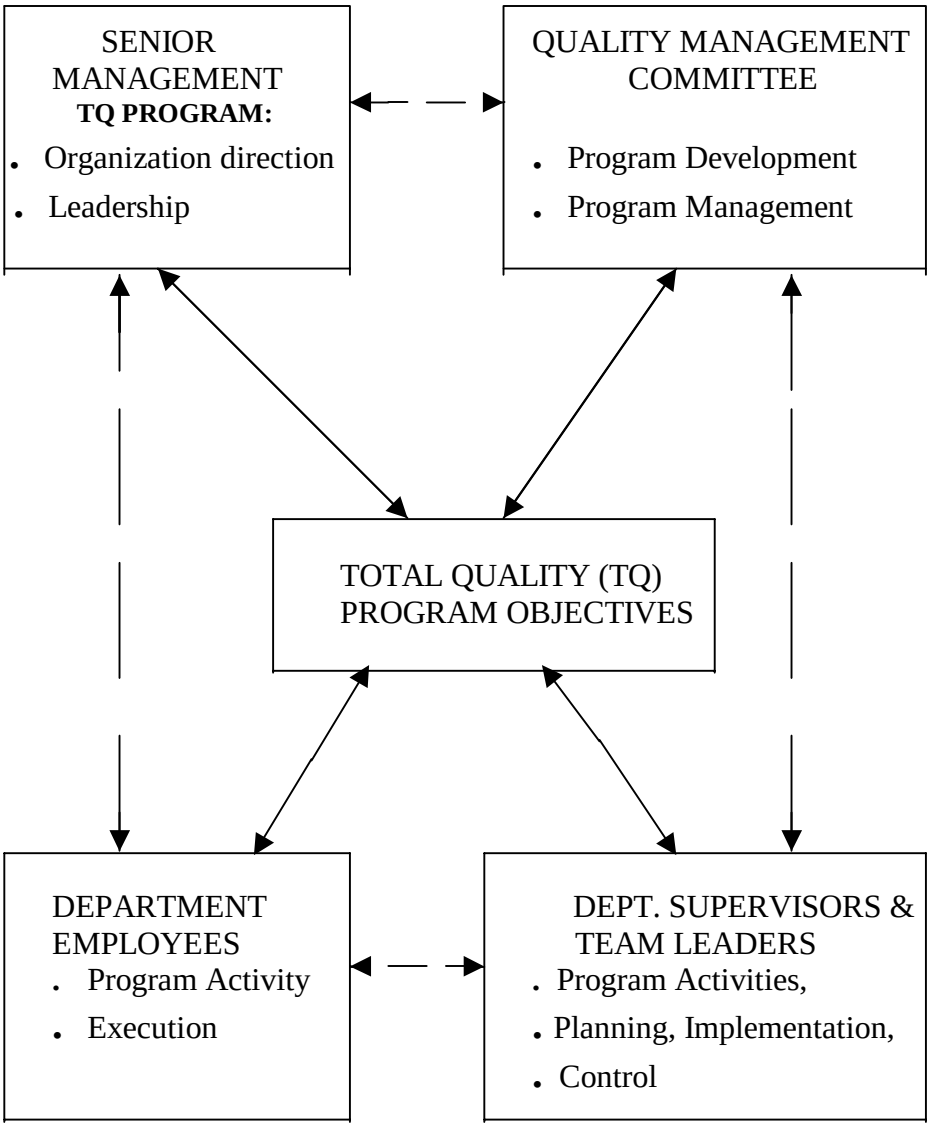

Figure 1: Teamwork in Quality Management by Committee and Employee Involvement.

Team Approach

Working in teams is beneficial because within the team, more ideas and proposals are supplied, and more solutions are derived. Besides, a team can solve larger and more difficult problems by dividing that problem among its members. It is very important to educate and train the teams (workforce) regularly. It enables the company to acquire the ability to compete in a continuously changing global market.

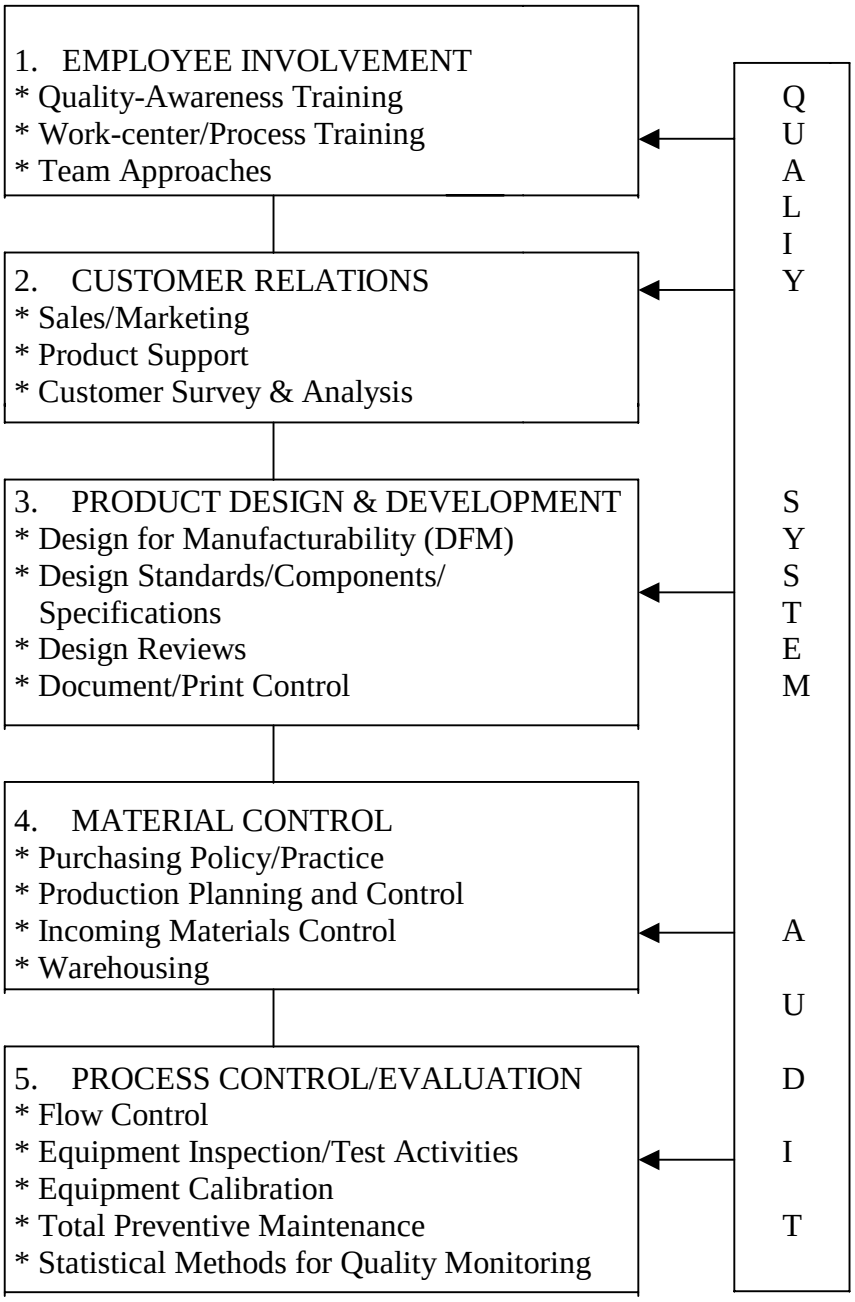

Figure 2: The Five Integrated Components of a Total Quality Program in Concurrent Engineering Environment[1].

Education is a long-term investment in the company's resources, so it must be a long term objective. Training is the most efficient investing in human resources. Such a training could be on-job-training or out-of- job training and there are several steps to take in order to achieve a successful training like these listed in Figure 3 (as discussed by Owusu)[2].

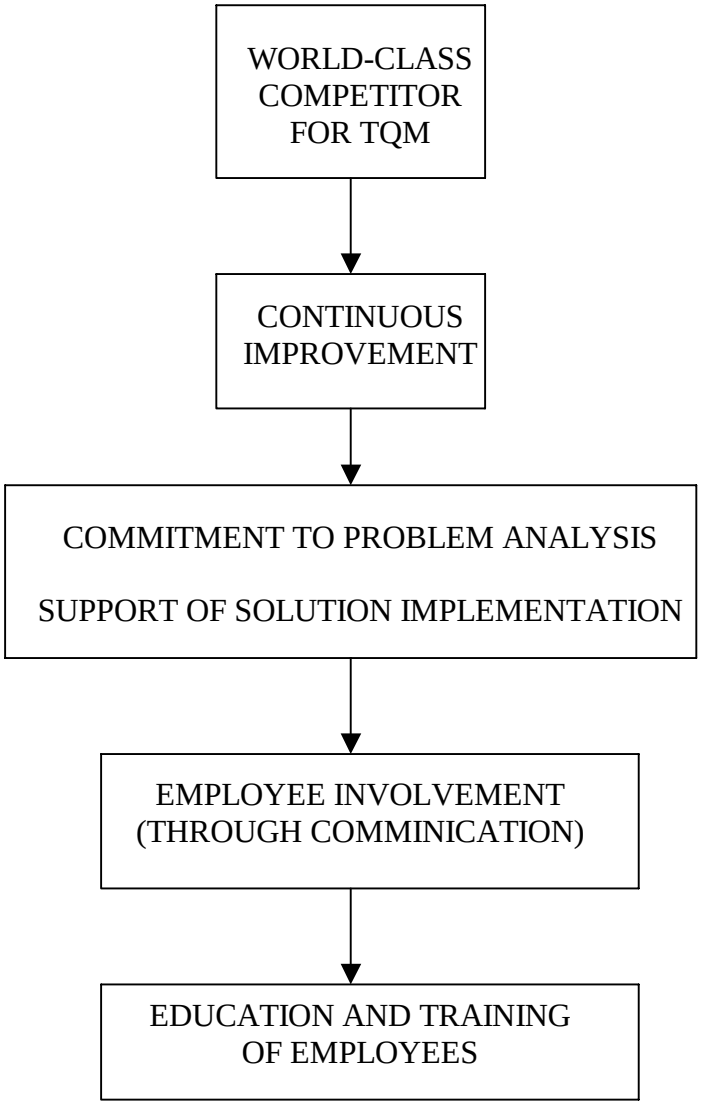

Figure 3: Role of Employee Involvement (EI) in Strategic Plan for a World-Class Company for Total Quality Management System[2].

Management First

Team participation can only take place after the management is wholeheartedly participating in the improvement process. Just because a decision is made by a group does not necessarily mean it is the best one, for these reasons:

1. Group decisions are often gained by compromise.
2. A flashy member who expresses himself/herself well may mislead the group.

While the one with the best solution may need help in organizing and expressing his/her thoughts, people tend to lose accountability for group decisions. Managers should be aware of these potential problems so that they can be involved in the process and have final approval of decisions made by the team.

What are Teams in Concurrent Engineering Environment for Total Quality?

A team exists when two or more similar entities cooperate to accomplish a specific task. Usually departmental improvement teams comprise of all the members of a department. The purpose of a team is to provide a focus and a means for all the employees to contribute to an ongoing activity aimed at improving the quality and productivity of the department. The manager is usually the chairperson of the team, but the chairperson may train a capable non-management employee to lead the team. The team identifies problems that cause errors and/or items that decrease the department's productivity; then develops and implements corrective actions to eliminate the errors and increase productivity.

Rules for Improving Team Meetings

The entire department should meet close to the work area so that the department members can study specific problems or discuss sample items without any delay. Short meetings should be held regularly. Under no circumstance should a meeting ever be cancelled because of production schedules. For this reason, it may be best to schedule meetings early in the week. Here are some ground rules for improvement in departmental team meetings:

1. An agenda should be prepared and distributed beforehand.
2. The meeting should start at the scheduled time by reviewing the agenda and modifying it appropriately. Once the agenda has been accepted, it should be followed.
3. The manager/team leader should conduct the meeting in a manner that encourages participation from all the members of the department or the team.
4. The responsibility for taking minutes should be rotated among the members in order to provide a learning opportunity for employees who are not effective at technical/business writing. The minutes should track corrective action status, employee suggestions, and the managers should have a copy of the minutes for that meeting.
5. The meetings should define the inputs that department is dependent upon, what is the department value-added content, who the department customers are, and how the quality of the department output should be measured.
6. The manager should make it clear that all the employees are required to attend the meetings and those reasons for absence should be reviewed in advance.

The employees should be trained to accept increased responsibilities. To accomplish this the department improvement team must evolve through the following three phases:

1. Awareness and education.
2. Understanding.
3. Problem solving and decision making.

Customer Relations (Using Customer Contacts)

It is hard to sell a new product to an existing customer unless they have been satisfied in the past. It is even harder the sell a new product to a new customer, but they will buy if they see old customers are satisfied. Judgments of customers are made almost entirely by the cost of owning and using a product. Moreover, they know what they want. Therefore, you need your customers' input when you are developing a product. That does not mean just having the marketing and sales people be in contact with your customers, but making sure that the product design team members are in close contact with the customers so they understand exactly what it is they should be designing. In this process, your design personnel will gain valuable insights into what your customers may need in the future and what they think of both your company and your competition in terms of both products and service. Customer-directed research and development pay big dividends in the future.

Product Design and Development in Concurrent Engineering for Total Quality Management

The maturation of an organization from a sequential design culture to a culture that embraces concurrent engineering is comparable to the evolution if a company aimed in the direction of total quality management (TQM). An analysis of this evolution has been done and identified in five specific phases, and they are as follows:

1. Short-term focus phase
2. Product focus phase
3. Product and service focus phase
4. System focus phase
5. Continuous improvement focus phase

Most companies are already in the third phase, but their objective is to move into the fifth phase. The next few sections are dedicated to elaborating on each of the above phases.

Short-term Focus Phase

Too many companies unfortunately are in this phase; they have no mission statement and no vision beyond this month's bills or end of the month profits. Research and Development (R&D) is cut backed to increase quarterly profits, mortgaging the company's future. Traditional design practices are used; meaning every product design appears different and has its own manufacturing, test, performance, and service characteristics.

There is minimal cooperation between disciplines and the funds for training personnel are nonexistent. Basically, the managers are too busy putting out forest fires on the factory floor instead of developing new and innovative ideas.

Product Focus Phase

The companies that have developed to this phase from the limited short-term mentality have realized the pitfalls they were headed for and are trying to become competitive again. Nevertheless, they still experience major problems. Their design methods are inconsistent and the quality merely meets the customer's standards, instead of exceeding expectations. Design for manufacturing, testability, performance, and service are not in the mission for design and is ignored by the development engineers, but latter becomes a focal point for conversation among the people in plant operations. Senior managers are too busy (or as they say "fighting forest fires"), but see the importance of customer input. The engineers developing products are getting all of their information from the sales or marketing people and may be scolded by upper management because of a customer complaint.

Product and Service Focus Phase

After being trounced by foreign competitors, many companies have now grown to this phase. Their mission has a focused priority, aimed at utilizing concurrent engineering, which also includes Design for Manufacturing (DFM), Design for Testability (DFT), Design for Serviceability (DFS), and Design for Performance (DFP). The company has an efficient way of developing products, because of the consistent use of design methods. This consistency helps put data collection and analysis activities in place and functioning. Customers are periodically surveyed to determine their expectations to help the company stay on top of competition.

As a result of re-engineering the organization is that the savings from streamlining is being used to train all employees affected by a design decision. This training shows up in accounting books because there is a reduction in scrap and rework costs. Additionally, the employees take pride in their work and assume responsibility for the product.

Process or System Focus Phase

At this stage, organizations have recognized the value of cross-functional teams. Concurrent engineering design methods are being used for all products. Data on product design and quality requirements exists in extensive form internally and somewhat externally. Overall costs are lower by the reduction of the time to market for new products. Many companies used in earlier examples are in this phase. It took significant effort, time and investment in training to arrive at this stage.

Continuous Improvement Focus Phase

This final phase is described as being in the "world class phase" of concurrent engineering. Design methods are benchmarked against the best existing products. All affected employees are a part of concurrent engineering teams and are empowered to fulfill the organization's mission. The factory produces products that are defective less than 5% of the time. Employees are motivated and proud of their work and, the overall benefits are in place.

Driving Forces behind Concurrent Engineering for Total Quality Management

Discussed below are the major driving forces supporting concurrent engineering, especially relating to total quality management. Each concept has been briefly articulated with references and examples.

The Cultural Change

The changes needed to develop to the highest phase presented above are not easy, moreover; it scares a lot of people but, realize it has to be done. The primary guidelines for changing and implementing the changes in culture are[3]:

1. Understand your existing culture.
2. Do not attack the existing culture head on.
3. Encourage people that want change in the existing culture.
4. Let information be permeated through the company.
5. Compile data that tracks costs and time
6. Give things time to change.
7. Thing always start with you, live the culture you want.

Look around and get a mental picture on how things should be, then find others that share your vision and encourage them to make a change in what they do. Be a "pocket" of forward thinkers in your organization.

Open the gates of information to your employees. Demystify the direction and strategy of your company. Let them know the product is profitable, the division revenues, and the company's performance; this way, they feel respected. Empower them to do their jobs without needing numerous justifications for decisions from the upper management. Then track the time and costs before and after the change to justify this modification in engineering practices. The bottom line of a business is to make money and these changes help in the long run.

Sharing Goals with Management as Cultural Change

A new culture or attitude necessary for a modern world-class organization is to foster and encourage all workers of the company: production workers and workers' representatives,

middle managers, top managers, and a company's professionals (such as engineers, scientists, accountants, etc.) to share common goals and efforts. The set of new attitudes is shown in Table 1; and the company personnel must acquire these in order to become a world-class company for a total quality management system.

Table 1: New Attitude for Concurrent Engineering in Total Quality Management System

TOP MANAGEMENT	. DEFINE ORGANIZATION EVOLUTION . INFORM AND LISTEN TO THE WORK FORCE . NEGOTIATE WITH WORKER REPRESENTATIVE . MOTIVATE WORK FORCE TO ACCEPT THE CHANGES
MIDDLE MANAGEMENT AND PROFESSIONAL	. ACQUIRE KNOWLEDGE OUTSIDE OF INITIAL DOMAIN
STAFF	. BE ABLE TO EVOLVE . LEARN TO INFORM, TEACH, AND LISTEN
SUPERVISORS	. MOTIVATE WORKERS . ADOPT A COACHING ATTITUDE
WORKERS	. BE READY TO CHANGE TO BECOME MORE AUTONOMOUS AND MORE FLEXIBLE
WORKER REPRESENTATIVES	. NEGOTIATE WITH TOP MANAGEMENT TO PRESERVE JOBS AS WELL AS COMPANY COMPETITIVENESS.

Material Flow and Material Quality (Using Supplier Contacts)

Suppliers also constitute a valuable part of a product developmental team. It's usually less expensive to buy an existing technology than to develop it yourself. Partnering with suppliers adds their expertise to the process with virtually no cost. They often suggest better and less expensive ways to do things. Tying them into your technology and production needs also speeds design and manufacturing practices, and reduces the overhead costs of running a business.

However, keep in mind, cost is not the most important facet of concurrent engineering and total quality management. Using higher quality parts, though they may be more expensive, can result in lower costs further down the line. Therefore, the emphasis should be on quality and on-time delivery and not cost alone.

Process Control and Evaluation: Managing, Organizing, and Measuring in Concurrent Engineering for Total Quality

At Hewlett-Packard, teams and their total quality control program were applied to order processing. Customers now pay more promptly. The average days outstanding dropped from 62 to 54 days, and this improvement represented more than $150 million savings per year[4]. Customer satisfaction must become the focus of corporate thinking. Providing customers with high quality goods and services that meet or exceed or their expectations at a reasonable price is critical to being competitive. Continuously improving quality in every aspect of a corporation's process is the best way to accomplish this. The philosophy of producing larger quantities of low-quality products and services in order to increase profits must be replaced by a commitment to lower defects and continuously improve the overall process to produce the good or service. Lowering the defects will simultaneously reduce profit lost to waste and increase productivity.

Building an Effective Product Development Team for Total Quality

The essence of concurrent engineering is summarized in one word: teamwork. According to Shina[5], there are some characteristics that are essential for the success of a product development team; and they are:

1. Meetings are conducted in a relaxed, informal and supportive manner.
2. The goals and objectives of the team are well defined and each team member is aware and agrees with them.
3. The set of skill that members bring is divergent, but each team member is credible in his or her knowledge and experience in their area of expertise.
4. Every team member is respected for their knowledge in their own area, and team members listen and respect each other's ideas.
5. The team quickly arrives at a set of informal procedures to conduct team business
6. During team meetings, discussions are animated, disagreements are common, and conflicts are dealt with directly, openly, and quickly.
7. Decisions are mostly arrived at by consensus, with team members working together toward collective agreement.

Resolving Conflict in Teamwork

Anybody that has worked in a group knows how hard is to make it work. Difficulties arise when trying to get everybody to agree on where the project is going, and what it will

take to succeed. Therefore, a strategy is needed for the team to succeed. The following is proposed strategy that can be used as an integrated process planning approach to resolving team conflicts in a concurrent engineering setting:

1. Fighting the elements: The traditional view of individual effort rather than cooperation must be eliminated. Specialists must learn how to work in a group and help each other.
2. Bringing the team together: The team leader must have the support of top management. He or she also should include task and functional management into the group. The number of people recommended is about 12 or 13 members. However, is better to have more people than needed than to lack them.
3. Establishing a common mission: One of the most important steps is to establish the mission and end result of the group.
4. A sense of interdependency: The schedule of the tasks to be performed, how, who and when are going to be completed shows the relationships between the different parts of the project. This creates a sense of interdependency and process control.

The heart of the matter for process control and evaluation teamwork for total quality management is directed at the following goals:

1. Creating a better understanding of team goals and missions.
2. Creating a better understanding of team member roles and their interdependent efforts.
3. Increasing communication and creating greater support among team specialist.
4. Creating greater collaboration among specialists, and reducing costly competition.
5. Developing the ability to use conflict in a productive, constructive manner.
6. Creating a true sense of team spirit and fostering great interdependency among team players.

Provide Education and Training for Workforce for Total Quality Management System

Proper communication is a learned art; and therefore, people must have proper education and training in the art of communication and working in teams. Educating the workforce involves investing in the company's manpower resources and must be envisioned with long-term objectives in addition to short-term results. Training programs must be carefully integrated with the company's strategic plan so that the company can experience desired results and will meet the initial objectives while avoiding common pitfalls of poorly instituted programs. The benefits of educated and trained for workforce to the company have been depicted pictorially in Figure 4, have been discussed by Owusu[2].

People working in a company are not merely an available supply for manpower for executing limited-scope, predefined tasks, but represent a resource that must be counted on to improve working environment and thereby also improve the company's competitiveness in the global market. The skill requirements for program managers in an

agile management system or total quality management system are often complex and multifaceted. Managing such a system represents a challenge requiring skills in team

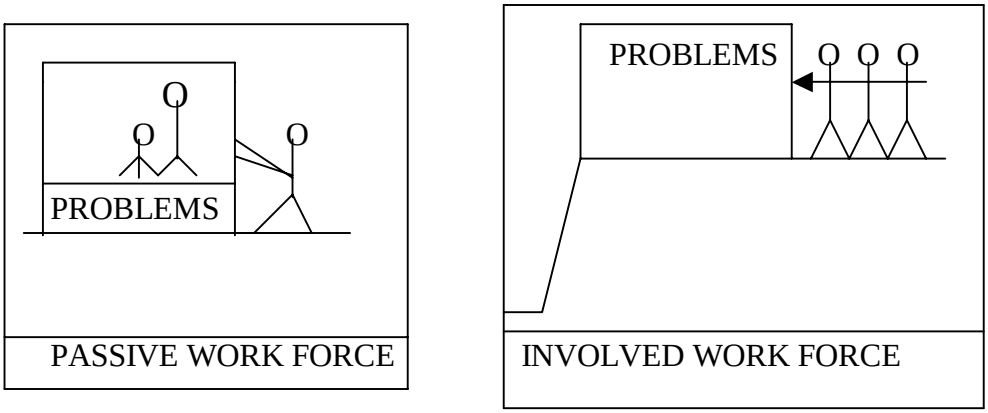

Figure 4 (a): Involving the Workforce facilitates Problem Elimination[2].

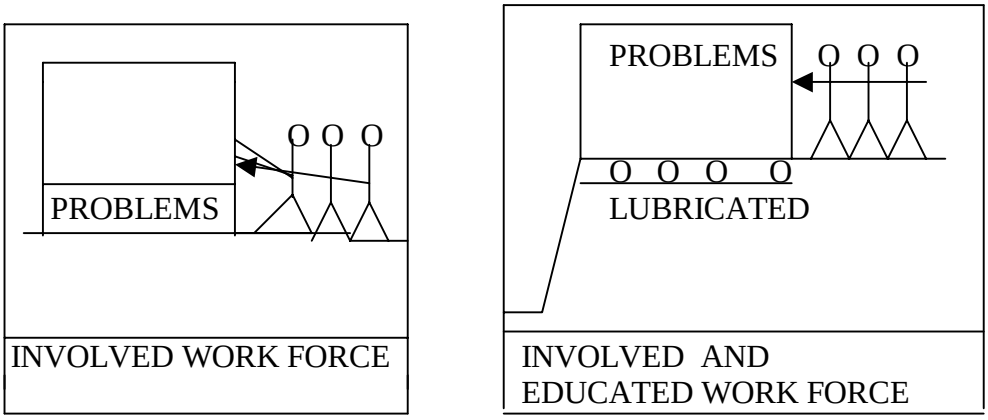

Figure 4 (b): Educated Employees Eliminate Problems[2].

building, leadership, conflict resolution, technical expertise, planning, organizational skills, entrepreneurship, administration, management support, and ability to allocate resources. Kerzner (1995) has discussed these skills relative to program management effectiveness in details in the book entitled 'Project Management: Systems Approach to Planning, Scheduling, and Controlling'[6].

Concluding Remarks

Concurrent engineering is an open-ended, continuous improvement process, but not a quick fix solution. To successfully change to a concurrent engineering, the methodology requires taking the following into account:

1. Specifications come from the top-down.
2. Designs come from the bottom-up.
3. Management must be involved and committed.
4. A language that everyone is educated in and speaks must be developed.

Developing specifications from the top-down is a slow process, but it gets easier when more workers or staff members do it. They will recognize that the benefits outweigh any inconvenience they may cause. They will implement concurrent engineering guidelines more often once they realize that it does not take a lot of time or money to do so and it simplifies their own design efforts and reduces time to market.

Management must spread the message to the people in the organization, but it must start at the top. Management must teach by example, then introduce it to the personnel in a nice formal manner. Educate them, either in-house or hire someone to develop a concurrent engineering program that is tailored to your needs. Remember that implementing concurrent engineering takes commitment from the company and its management. There will be no tangible results otherwise.

Summary of Communication Guidelines for Total Quality Management in Concurrent Engineering Environment

Proper communication of ideas and/or information to people is an art, which must be learned, developed and/or nurtured through practice, dedication, and commitment. The next step after having defined strategic goals is for top management is to communicate these goals to the entire workforce through company-wide teamwork. Communication channels need to be established or reinforced that:

1. Enable management to communicate to the workforce.
2. Enable the workforce to provide feedback and input to Management, regarding the means to reach these objectives and goals.

Company managers should first assess the company's present culture and then, by comparing current culture to desired goals, identify the prerequisites for implementing change. A new attitude often has to be acquired by both managers and employees. Managers then plan a list of actions that will enable the sharing of common goals and efforts. This can occur only if the ultimate objective for the company (i.e. customer satisfaction and resulting profit) and intermediate goals (i.e. improved product quality, reduced cost, and increased company flexibility) are clearly stated and understood (i.e.

properly communicated) by everyone. Employee involvement and proper communication can be articulated efficiently through team-base approach.

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