Concurrent Engineering: Concepts and its Implementation

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Abstract— **In the wake of globalization, concurrent engineering (CE) is a promising for design, modification and development of new products for the challenging Indian organizations. Success of CE demands that key areas of new product design and development of an organization need to be under constant focus. Most of the companies adopt CE procedures to reduce the time for introducing new product in to the market. This study analyzes the impact of concurrent engineering practices followed by some selected Indian organizations in the area of new product design and development as they seek to improve their competitive position in global markets. The research survey presents its evaluation based on analysis by application of statistical tools on the primary data which was collected through a well-structured and pre-tested questionnaire. The results disclose that the selected manufacturing organizations in India are realizing maximum advantages with the implementation of the concurrent engineering in design and development of their new products.**

Keywords—Concurrent Engineering, Product Development

I. INTRODUCTION

The simultaneous performance of product design and process design. Typically concurrent engineering involves the formation of cross functional teams. This allows engineers and managers of different disciplines to work together simultaneously in developing product and process design.

Concurrent engineering is a business strategy which replaces the traditional product development process with one in which tasks are done in parallel and there is an early consideration for every aspect of a product development process. This strategy focuses on the optimization and distribution of firm resources in the design and development process to ensure effective efficient product development process.

II. LITERATURE REVIEW

King N. and Majchrzak A. (1996) in his paper "The effect of project and process characteristics on product development cycle time" discussed about design integration as a "management process that integrates all activities from product concept through to production using multidisciplinary teams, to simultaneously optimize the product and its manufacturing processes to meet cost and performance objectives". Griffin A. (2000) feels that design integration uses design tools such as modelling and simulation, teams and processes to develop products and their related processes concurrently. Design integration evolved in organizations as an extension of work, such as Concurrent Engineering to improve customer satisfaction and competitiveness in a global economy. Verganti R. (1999) illustrates the importance of anticipating the capabilities of design integration during early development of the product. Early anticipation also referred to as forward planning means that information is anticipated as early as possible in the product development process so that solutions generated in the early phases already account for manufacturing constraints and opportunities. The challenge for global new product design and development with design integration is to achieve the prescribed activity whilst operating under the problems faced by teams are differences in communication and time, barriers between design, intermediate departments and customer lack of supplier involvement, management and teams working towards different goals and targets.

III. OBJECTIVE OF THE STUDY

The objective of the research study is to explore and establish the benefits gained by using concurrent engineering in product design and development on selected Indian organizations.

The specific goal of the thesis is implementing Concurrent Engineering to improve the interactive work of different disciplines affecting a product. The following are some of the benefits:

- Minimize the product life cycle - Shorten the redesign procedure and manufacturing planning.
- Minimize production cost - results from the minimization of the product life cycle.
- Meeting delivery schedule and time to market - The Organization can increase the prospect of delivering a quality product to the customer

IV. CONCURRENT ENGINEERING BACKGROUND

The traditional approach to product development is sequential in nature where upstream functional experts perform their

tasks and deliver final product related information to downstream activities. This is done with no or minimal interaction and cooperation between the different functional groups. Minimal interaction increases the probability of design conflicts between the functional groups. Resolving such conflicts requires designers and engineers to iterate through trial designs until an agreement is reached. This iteration process results in an elongated product development time, increased development cost, and consequently loss of market share.

Numerous design improvement strategies and techniques have evolved to solve the problems inherent in a sequential design environment. Design for Manufacturing (DFM), Design for Assembly (DFA), Quality Function Deployment (QFD), Continuous Process Improvement (CPI), and Total Quality Management (TQM), to name a few. All of the above mentioned techniques offered a partial improvement to the development process; however, the industry felt the need for a more comprehensive approach that can tie all their concerns together. Finally, the extensive research in product development resulted in the creation of a conceptual framework that acts as an umbrella to all design improvement tools and techniques and was called Concurrent Engineering.

Another important CE dimension that is discussed extensively is the concept of overlapping. In overlapping, we determine what fraction of the predecessor task must be completed before the follower task can begin. For overlapping to be effective, upstream (predecessor) information availability and downstream (successor) information needs must be understood. In many design situations, the official release time of design information does not coincide with the time this information is really available. Finding this information is really available and whether it can be released right away to subsequent tasks is critical for overlapping. The critical step in overlapping is identifying a point within the predecessor task duration where preliminary (i.e. partial) design information is sufficiently evolved to be utilized by the successor task.

V. DEFINITIONS OF CONCURRENT ENGINEERING

Several approaches concerning the reduction of time-to-market have been developed in the last years. Approaches related to the product development and its interdependencies with different departments of the entire organization can be summarized under the expression ''Concurrent Engineering (CE) ''

An overview of variants of Concurrent Engineering is given in:-

- Simultaneous engineering
- Integrated Product Development
- Synchronous Product-Process Development
- Generalized Systems Engineering
- Transition to Production
- Enterprise Integration

To get a notion of how widespread the approach of Concurrent Engineering is, it is important to see the definitions.

''Concurrent Engineering is a systematic approach to the integrated, concurrent design of products and their related processes, including manufacture and support. This approach is intended to cause the developers, from the outset, to consider all elements of the product life cycle from conception through disposal, including quality, cost, schedule, and user requirements.''

''Concurrent Engineering is the process of forming and supporting multifunctional teams that set product and process parameters early in the design phase"

''Simultaneous Engineering is the integrated and time related parallel carrying out of the development of products and processes with the goal to reduce time-to-market and costs, while the quality of a product - in its most comprehensive sense - is improved."

VI. THE ROLE OF CONCURRENT ENGINEERING

The Role of Concurrent Engineering approach is to the integrated, concurrent design of products and their related processes, including manufacture and support. This approach is intended to cause the developers, from the outset, to consider all elements of the product life cycle from conception through disposal, including quality, cost, schedule, and user requirements.

Concurrent Engineering is not a quick fix for a organization's problems and it's not just a way to improve engineering performance. It's a business strategy that addresses important organization resources.

VII. CONCURRENT ENGINEERING APPROACH

In the Concurrent Engineering approach to development, input is obtained from as many functional areas as possible before the specifications are finalized. This results in the product development team clearly understanding what the product requires in terms of mission performance, environmental conditions during operation, budget, and scheduling. Multidisciplinary groups acting together early in the workflow can take informed and agreed decisions relating to product, process, cost and quality issues. They can make trade-offs between design features, part manufacturability, assembly requirements, material needs, reliability issues, serviceability requirements, and cost and time constraints.

Getting the design correct at the start of the development process will reduce downstream difficulties in the workflow.

The need for expensive engineering changes later in the cycle will be reduced.

VIII. CONCURRENT ENGINEERING VS TRADITIONAL SERIAL DEVELOPMENT

The problems with product development performance that Concurrent Engineering aims to overcome are those of the traditional serial product development process in which people from different departments work one after the other on successive phases of development.

In traditional serial development, the product is first completely defined by the design engineering department, after which the manufacturing process is defined by the manufacturing engineering department, etc. Usually this is a slow, costly and low quality approach, leading to a lot of engineering changes, production problems, product introduction delays, and a product that is less competitive than desired. Concurrent Engineering invariably reduces total product cost.

Concurrent Engineering brings together multidisciplinary teams, in which product developers from different functions work together and in parallel from the start of a project with the intention of getting things right as quickly as possible, and as early as possible. A cross-functional team might contain representatives of different functions such as systems engineering, mechanical engineering, electrical engineering, systems production, fabrication, quality, reliability and maintainability, testability, manufacturing, drafting and layout, and program management. Sometimes, only design engineers and manufacturing engineers are involved in Concurrent Engineering. In other cases, the cross-functional teams include representatives from purchasing, marketing, production, quality assurance, the field and other functional groups. Sometimes customers and suppliers are also included in the team (Lenfle 2010).

IX. CONCURRENT ENGINEERING BENEFITS

Concurrent Engineering provides benefits such as reduced product development time, reduced design rework, reduced product development cost and improved communications. Examples from companies using Concurrent Engineering techniques show significant increases in overall quality, 30-40% reduction in project times and costs, and 60-80% reductions in design changes after release (Maylor 1997).

X. BASIC PRINCIPLES OF CONCURRENT ENGINEERING

Timing is an important consideration in CE. A lot rides on timing of decision making and problem discovery. Concurrent Engineering is founded on eight fundamental principles:

- Early Problem-discovery**:** Problems discovered early in the design process (particularly during the first 20% of the cycle-time) are easier to solve than those discovered later.

- Early Decision-making: The "window of opportunity" to affect a design is much wider during an early design stage than at a later stage-when some of the decisions are frozen and when the design is matured. Teams often have the natural tendency of making quick and novel decisions, which is good, except those decisions should be lasting as well.

- Work Structuring**:** Human minds practically cannot work on multiple tasks simultaneously, parallel computers do. What a human mind is good at is systematically structuring the work, or more importantly structuring the work environment so that each task can be performed independently of each other either by a human being, a machine or by a computer.

- Teamwork Affinity**:** Teams of people working in separate groups are likely to create designs, which may be optimal in their individual domains but will seldom remain optimal in a domain, which is a union-sum of those individual domains. Also, teams will have a better affinity if they trust each other. Trusting members, if they agree to accept responsibility for a task, do prefer to work together rather than working in isolation.

- Knowledge Leveraging**:** The domain of product design is often very large. It may be impossible to create a general purpose "automated" or knowledge-based system, which will use appropriate tools and knowledge-driven rules (mostly computerized) to guide decision making. Inter-linking decision support tools with spurts of "human knowledge-base" will continue to be the most valuable tool for solving complex problems.

- Common-understanding**:** Teams will work better if they know what other members are doing. This includes operational understanding of all relevant interplay; e.g., what constraints a team-member would encounter when certain parameters will be changed.

- Ownership**:** Teams will work enthusiastically to make a good product if they are empowered to make decisions in shaping the design and are given "ownership" of what they produce.

- Constancy-of-purpose**:** Most departments have a natural tendency to make their departments look good to others-create false profits, even though it

may be detrimental to the overall corporate goals. The whole corporation will do even better if everyone works towards a common set of consistent goals irrespective of departments, they have allegiance to. This requires a change in thinking beyond the goals of one individual department or teams to the organization's goals. The obligation of any supporting unit is not to sub-optimize its own goals (such as unit's profit potential or sales) without a clear and direct relationship to the organization's overall goals. It must contribute its best towards the system goals.

XI. IMPLEMENTATION OF CONCURRENT ENGINEERING

The implementation of Concurrent Engineering addresses three main areas: people, process, and technology. It involves major organizational changes because it requires the integration of people, business methods, and technology and is dependent on cross functional working and teamwork rather than the traditional hierarchical organization. One of the primary people issues is the formation of teams. Collaboration rather than individual effort is standard, and shared information is the key to success. Team members must commit to working cross-functionally, be collaborative, and constantly think and learn. The role of the leader is to supply the basic foundation and support for change, rather than to tell the other team members what to do. Training addressed at getting people to work together in teams' plays an important role in the successful implementation of concurrent engineering.

XII. METHODOLOGY

Concurrent engineering methodologies permit the separate tasks of the product development process to be carried out simultaneously rather than sequentially. Product design, testing, manufacturing and process planning through logistics are done side by side and interactively. Potential problems in fabrication, assembly, support and quality are identified and resolved early in the design process (Reddy et al 2013).

The research methodology is based on empirical data collected through a questionnaire survey. Before designing the questionnaire, a literature review on CE has been carried out. This step is very important to enable to understand the concept of CE thoroughly. Before the questionnaire was prepared, it was necessary to identify the important elements of the CE. Therefore a precise analysis could then be carried out according to the received questionnaires. The questionnaire had to be clear and brief to ensure that the respondent would not be confused with the questionnaires. Clear instructions were added in the questionnaire and all the possible answers had to be answered by the respondent while answering the questionnaire.

The survey includes organizations from sectors namely Manufacturing (incl. agro based), Manufacturing Related Services, Services (incl. ICT), Construction, Primary Agriculture, Others. In order to obtain more representative results on a broader scale, the samples were not limited to one type of organizations only. However, there were two restrictions applied for the samples. Firstly, the samples were restricted to engineering based industries. Secondly, the samples were restricted to the companies with more than thirty employees

Before sending the questionnaire to the organizations, a pilot study was carried out, to add questions, if any, missing from the questionnaire, to delete any irrelevant questions, and to refine the language of the existing questions to bring more clarity to the questionnaire.

XIII. FINDINGS

A survey package was sent to the 92 organizations in India. Out of 92, only 68 had replied the questionnaire. This yielded a total of 68 responses for a response rate of 73.91 percent.

Table 1 various industrial sectors involved in the surveyed companies

Sector	**%**
Manufacturing (incl. agro based)	27.27
Manufacturing Related Services	18.18
Construction	18.19
Services (incl. ICT)	9.09
Primary Agriculture	4.55
Others	22.72

In the research personnel characteristics of respondents have a very significant role to play in expressing and giving the responses about the problem, keeping this in mind, in this study a set of personal characteristic position, education, experience and age group of the respondents have been examined. The data appropriate to the outcomes of concurrent engineering in different organizations are presented in the next sections.

USE OF CONCURRENT ENGINEERING TECHNIQUES

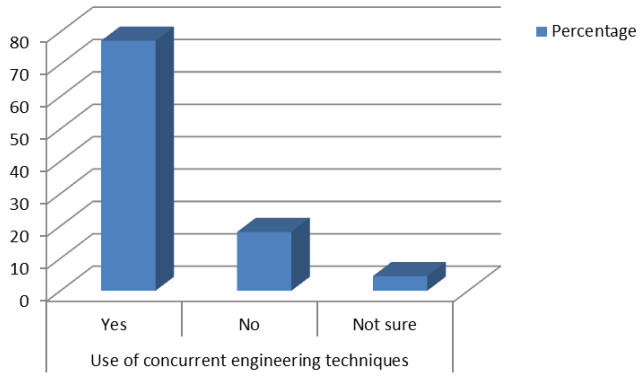

Fig.1: Use of concurrent engineering techniques

Most of the general feedback that was obtained from the survey showed that use of concurrent engineering techniques was being practiced. The practice of concurrent engineering techniques is very important because every team members can contribute their specialized knowledge or skills necessary for the organization project. Figure 1, shows that 77.27% of the companies have practiced the concurrent engineering techniques, and only 18.18% of companies did not practice. However, 4.55% of the companies did not answer this question.

ENCOURAGING EXTERNAL PARTICIPATION (SUPPLIERS AND CUSTOMERS) IN DEVELOPING AND DESIGNING THE NEW PRODUCTS

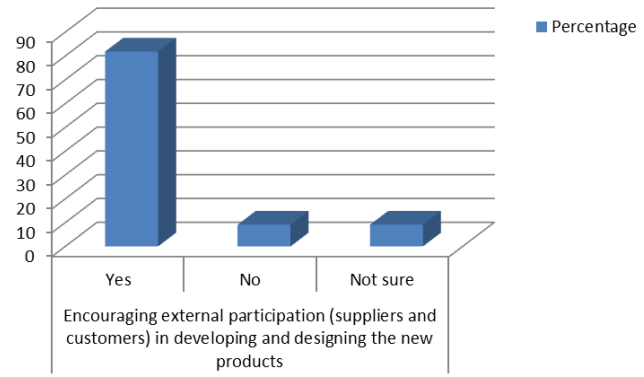

Fig.2: Encouraging external participation (suppliers and customers) in developing and designing the new products

According to Figure 2, it can be seen that 81.82% of the companies had a communication path between all aspects of the concurrent engineering; 9.09% of the companies did not practice the concurrent engineering techniques, and 9.09% of the companies were not sure about this question.

COORDINATION OF INTERNAL GROUPS – DESIGN, MANUFACTURING

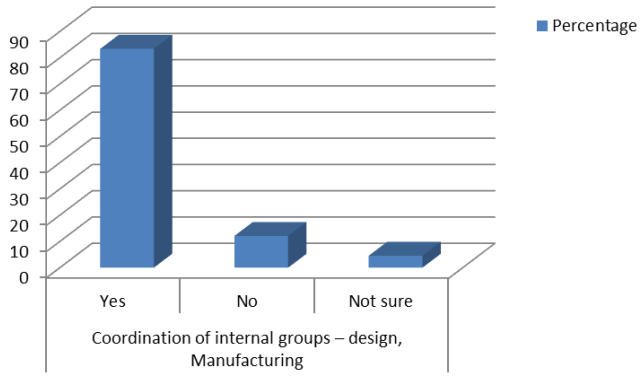

Fig.3: Coordination of internal groups – design, Manufacturing

In this survey 83.36% of the respondents thought that their team members have internal coordination with each other while. 12.09% of respondents did not agree, and 4.55% were not sure.

IMPLEMENTATION OF COLLABORATION /PARTNERSHIP OF MANAGEMENTS

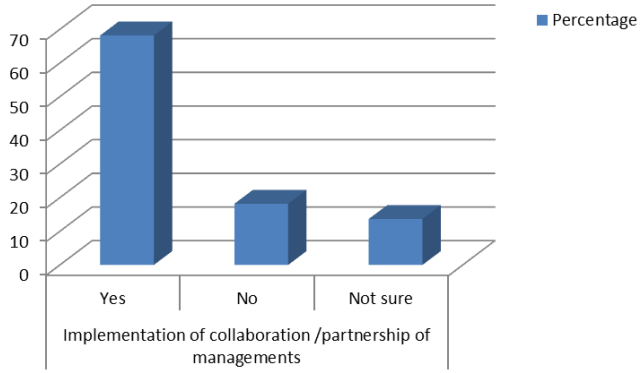

Fig.4: Implementation of collaboration /partnership of managements

This survey revealed that 83.36% of the organizations involved in Implementation of collaboration /partnership of managements while 8.18% organizations did not agree. However, 8.46% of the organizations were not sure of this question.

XIV. OUTCOMES AND DISCUSSION

Concurrent engineering has shown a very positive impact on design, development and introduction of new product in Indian organizations. Though organizations are implementing concurrent engineering and realizing maximum benefits, they need to focus their attention in identifying the appropriate revolutionary technologies for proto-typing and thus increase cost savings and reduce time to market ultimately satisfying the customer needs.

XV. SCOPE FOR FUTURE WORK

The survey made involved number of people related to the concurrent engineering, but ignored the expertise of the skilled people who are working in the concerned area but not qualified and the demographic factors such as gender and age were not taken into consideration which might influence the process to a greater extent. Further studies can be made by considering the above factors will reveal much more interesting facts.

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