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CONCEPTUAL FRAMEWORK FOR IMPLEMENTATION OF CONCURRENT ENGINEERING IN PRODUCT DEVELOPMENT

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Abstract: Concurrent Engineering (CE) has been successfully implemented in many organisations during the last two decades. However, inspite of the well-known practices and benefits that make CE a standard for product development, many organisations still experience difficulties in putting it into practice. This work is an exploration of the concept of 'Concurrent Engineering (CE)' and 'Concurrent Engineering Implementation' through extensive review of articles published in various journals, Proceedings etc., on the topic and intends to enumerate the varied dimensions of the concept of Concurrent engineering CE) and its role in new product development. It also focuses light on its inter-relationship with different constituents that affect Product Development process. Based on the literature review, a conceptual framework has been developed which emphasises on the key elements required for successful implementation of concurrent engineering for product development., which in turn justifies the rationale of the role of Concurrent Engineering in Product Development.

Keywords: CE Philosophy, CE Principles, CE Implementation, Factors for Implementing CE, Product Life Cycle, Product and Process Development.

1. Introduction

Globally, it has been experienced that during the last two decades, the industries in almost all business sectors, have been experiencing major challenges in the field of product development. Researchers have tried to identify the reasons behind emergence of such challenges in product development. As a result of such studies, many reasons have been found responsible for emergence of such challenges. The primary reasons that emerged were: increasing product variety and technical complexity that prolong product development process and it becomes more difficult to predict the impact of design decisions on the functionality and performance of the final product; increasing pressure of global competitiveness that results from the emerging concept of re-engineering; the need for rapid response to fast-changing consumer demand; the need for shorter product life cycle; globalization of market; rapid technological challenges; environmental issues; customer demanding products with advanced features at higher quality and lower costs; demand for more customized products; large organisations with several departments working on developing numerous products at the same time; new and innovative technologies emerging at very high rate, thus causing the technological obsolescence of new product within a short span of time, thereby reducing product life cycle.. (Addo-Tenkorang, Richard, 2011). In order to overcome these significant challenges and to remain competitive globally, most of the business-driven organisations have adopted Concurrent Engineering (CE) philosophy, for designing and developing new products/ developing innovative products. CE is an integrative approach to develop product which is conducted concurrently by cross functional team including external organization representative and by taking into consideration the whole stage of product life cycle. (Wognum, et.al, 2006)

Concurrent Engineering is a highly systematic approach implemented to achieve design of products in an integrated and simultaneous manner. The objective of this approach is focussed on the developing partners, to consider from the very beginning, all elements of life cycle from conception to disposal. (Pennell, Winner et.al. 1988). Technology and market changes introduce different problems in the product development arena, and firms are considering various structural relationships to help them cope with these changes. Concurrent engineering (CE) is a mechanism that can reduce these change effects and improve an organization's competitive capabilities.

The philosophy of CE has shown great success in private industry, especially in the automotive and technology industries, and researches on the application has been performed in high production and/or manufacturing environments. Research into the applicability and benefits of CE into a low/no production, service, research and development, and/or government environment is limited.

The objective of the present paper is to study the papers related to CE and its implementation from key journals and other key forums between 2000 and 2020. This study shall attempt to enumerate on the different dimensions of concurrent engineering and thereafter develop a conceptual framework highlighting the integration mechanism of different factors for implementation of concurrent engineering in product development.

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2. The History of Concurrent Engineering

Concurrent Engineering has been framed mainly by the US Department of Defense (DoD) to enable its suppliers to produce better products at lower costs within shorter time. In 1982, the Defense Advanced Research Projects Agency (DARPA), called ARPA now, began a study into ways to improve product development processes. Based on the study, DARPA started a five- year program: the DARPA Initiative in Concurrent Engineering (DICE). The purpose of this program has been to encourage and enable the practice of Concurrent Engineering in the US military industry (Ashley, 1990).

DICE should lead to the creation of a defense industry environment where time to market would be reduced, total quality would be improved, and costs for products and systems would be lowered. This environment should enable all disciplines and functions involved in the product lifecycle to collaborate interactively in defining, planning, designing, manufacturing, maintaining, refining, and retiring new defense products. To provide tools for the pursuit of these goals, the concurrent Engineering Research Center (CERC) was founded at West Virginia University in Morgantown in the US. Before, these industries have been far more focused on Computer Integrated Manufacturing (CIM) approaches to solve control related problems in product development (Brooks 1990).

Better process control alone has proven not to be sufficient for solving the problems (Raia, 1993). Managers in industries have become aware of the fact that many of the downstream problems in e.g., production, logistics, or service, can be prevented in development (Hollingum, 1989)

3. Concurrent Engineering: Implementation Issues

According to Karningsih (2015), CE implementation achievement level in a company is assessed by using Simultaneous Engineering Gap Analysis (SEGAPAN) and Analytical Hierarchical Process (AHP). This study shows that management's role, cultural change, and the cross functional team are three factors that have the least level of CE implementation compliance. According to this study, these three factors are the most difficult barrier to implement CE successfully in company. The next important stage is the identification of root cause of these impeding factors and for doing so, a managerial technique termed as 'Five Whys Method' is utilised to investigate these issues. Based on the outcome, necessary steps are taken to eliminate these impediments. In an Indonesian manufacturing industry, which has implemented CE for almost 17 years, though the compliance rate of CE implementation of company X has achieved excellent level (more than 60%), there are three CE implementation impediments that need to be improved.

An intensive research study was carried out by Sirivella Vijaya Bhaskar (2015) to evaluate and establish the effect of concurrent engineering on product design and development of Indian two-wheeler automobile industries. Evaluation of this research study was based on the data analysis of the primary data using Cumulative Weighted Average (CWA) statistical analysis technique. The data on analysis, practically as well as theoretically established that the benefits of implementation of concurrent engineering in new product development of two-wheeler companies was immense and the outcome was very beneficial.

The research study concluded that, Concurrent engineering has great impact on new product design and development in Indian two-wheeler automobile companies. The design and development of products have to strive for sustainability, because of growing competition in the market. Every attempt should be made by the company to adhere to the ever-changing customer demands in the field of product development.

4. Review of Literature

An extensive literature review on 'Concurrent Engineering and its effect on Product Development' and other related articles during the period 2000 to 2019 has been carried out. The said literature has been categorized for comprehensive understanding of the subject.

Review of the literature on the subject enumerates varied dimensions of the concept of Concurrent engineering CE) and its role in new product development. It also shed light on its inter-relationship with different constituents that affect Product Development. The review of literature includes a seminal work done by R. Addo-Tenkorang (2011) who studied the subject published in eighty articles from 28 journals, eight Conference Proceedings and two books on the topics between 2000 and 28th July, 2010. This study is very useful to researchers interested in understanding and following the recent trends in the area of CE. The study is also significant for businesses or industries; because it seeks to highlight the current engineering unanswered but justified research and development (R&D) questions raised in research papers for research and/or development needs. The research is summarized to identify key references in the form of a literature review; thus, identifying key journals and other key forums such as conferences and

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societies as well as some books in the field of CE. The summary also identifies most cited authors by using a sample statistical report from Harzing's Publish or Perish software. This report also addresses the issues and trends, including future perspectives of CE and the CE Product Life Cycle (PLC).

As per the literature review, the subject is explained under the following broad heads:

- The concept
- Competitive Advantage
- Meeting Customer Needs and Wants
- Concurrent Engineering
- Meeting Customer Needs/ Wants
- The Behavioural Dimensions
- CE Approach to NPD

4.1Understanding the Concept

The precept of Concurrent Engineering and its increasing significance in today's competitive scenario is well explained in the literature. Various areas for current and future research and application have been presented, and reference made to the future relevance of concurrent engineering as a discipline.

Putnik, Goran & Putnik, Zlata (2019) state that at its core, there have been differences in understanding the very concept for long. As per the authors, there have been issues in correctly defining Concurrent Engineering (CE) in the literature that have often generated misinterpretations about the underlying contents of the said precept. Authors have sought to clarify the meaning of CE and termed it as 'Simultaneous Engineering'(SE), 'Concurrent Engineering', and 'Collaborative Engineering' and provided a framework which would enable simultaneous activities for design and development of a product in a concerted manner. Authors however have also said that though these concepts resemble each other, there are definite differences amongst them which decide their scope and effects on new product development. These differences are with respect to their 'Common goal, Development effort focused on the initial phase of the product development life-cycle, Relationship graph or network type, Group type, Conversation type and Principal engineering/design process Management objective'.

As Putu Dana Karningsih Dewanti Anggrahini, Muhammad Imam Syafi' (2015) have also mentioned, that Simultaneous Engineering (SE) is not a new concept and has been in adoption since more than thirty years. It is an approach to design a new product in an integrative manner. The application of concurrent engineering in product development involves close coordination between different functions thereby creating opportunities for development of competitive products within a short span of time. However, traditional product development process had a very limited focus on inter departmental collaboration and integration. This paper uncovers difficulties during CE implementation. Defines management's role, cultural change, and the cross functional team are three factors that have the least level of CE implementation compliance. These are the most difficult barrier to implement CE successfully. It investigates root cause of these impediments and proposes recommendations to reduce or to eliminate these CE implementation impediments.

4.2 Competitive Advantage

Literature provides definite viewpoints that elaborate the manner in which organizations should respond to the pressures of the competitive markets and suggested actions organizations should initiate to sustain and grow in a competitive scenario. Different authors unequivocally emphasize that in order to survive and grow; organizations must have competitive advantage and new technology development provide a definite source of gaining competitive edge. C. Pienaar, E. van der Lingen & E. Preis, (2019) feel that competitive advantage depends upon a company's ability to define its core competency and sharpen it continuously. Organization must be capable of developing a competitive technology efficiently and effectively and use it in new product development process. Authors say that this process depends upon numerous success and failure factors. These are divided into three categories: input requirements, stage kick-off guidelines, and continuous prompts. As such there is a need for improvements to the existing new product development framework to remain competitive in the current economic and environmental climate.

The contention is reinforced by Tonya G. McCall and Sara C. Fuller (2018) who mentions that the challenge in the workplace is with delivering high quality products is to offer it to the market in a timely manner. The importance of incorporating standardized manufacturing input in the design cycle exists to minimize risk to performance, cost, quality, and schedule, is thus of critical importance. The prime challenge in this context is how to evaluate the different designs being considered for development and

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commercialization. Charles Chikwendu and Jude E. (2017) opine that new product quality, decrease in production cost and lead time is a must. It is possible if CE is defined in the Project Definition Document (PDD) so that all production stages run simultaneously instead of sequentially.

Literature on the subject indicates that business strategies are fast changing with demands of highly competitive globalized market. The lifecycle of a project needs to be shortened to fulfil customer needs and sustain in the market competition. Obviously, the technical solutions are to be business driven. CE is one of the technical solutions to overcome these challenges (Basu S, Biswas N, Biswas S N and Sarkar S, 2013).

Rosnani Ginting & Thamer Ramadhan (2016) contend that competition requires organizations to develop products based on customers' needs and considering the timeliness of delivering the product to the customer.

There are thoughts on implementation of concurrent engineering technologies in the field of design and product development also. Here the technology approach and the trend of applications and beneficial effects have been studied wherein scholars have recognized CE as the way of achieving long-term sustainability in this highly competitive business climate.

4.3 Meeting Customer Needs/ Wants

Hambali1, S.M. Sapuan1, N. Ismail, Y. et al (2009) state that reduced time in product development process, higher product quality, lower cost in manufacturing process and fulfilment of customers' requirements are the key factors to determine the success of a company. The authors strongly feel that to produce excellent products, the concept of Concurrent Engineering must be implemented. The authors feel that CE is a systematic approach which can be achieved when all design activities are integrated and executed in a parallel manner. They mention that the CE approach has radically changed the method used in product development process in many companies and have reviewed the basic principles and tools of Concurrent Engineering and discusses how to employ them. The authors feel that to ensure a product development process in the CE environment to run smoothly and efficiently, some modifications of the existing product development processes are proposed; these should start from market investigation to detail design.

Timely delivery of projects has been restated by several scholars as a critical parameter of new product development. It is found important to deliver projects within the schedule. To do that it is necessary to find new methods, processes and techniques to challenge the delivery time of the construction projects becomes more than a simple requirement. Overlapping the sequential activities is one way to reduce the delivery time of the project (Youcef J-T. Zidanea, KjerstiBjørkengStordalc, AgnarJohansenb, 2015).

Tshiki Pr, Masibonge (2015) opine that critical success factors for projects include time, cost and quality. It also discusses leadership qualities of a project manager and his competency in risk identification and risk management. Tan Owee Kowang, Choi Sang Long, Amran Rasli (2014) believes that for an organisation to remain noticeably competitive in the dynamic market environment, it should continuously put in cohesive efforts to launch new products at a faster pace. Describing CE in the context of South East Asia, Authors state that organizations have often relocated their R&D, design and manufacturing activities to South East Asia region in order to gain geographical and economic advantages to improve competitiveness. Hence, NPD in new MNCs in SE Asia often involves coordination of activities across multi-locations teams. Based on Theory of Integrated-Product Development, the authors also proposed a new conceptual NPD integrated framework for multinational and multi-locations-based organizations in South East Asia.

4.4 Concurrent Engineering

Literature describes Concurrent Engineering (CE) as a trans-disciplinary approach that is used to accelerate the product development process in an industry (TomažSavšek, Igor Makovec, MitjaCerovšek, 2015). As Aniket U. Dongre, Jha Bipin Kumar, Pratik S. Aachat, Patil Vipul R. (2017) believe, the current scenario of market demand is the product has less costs, best quality and that should be available within less time. Also, getting a right product within an estimated term and controlled and reduced cost is considered essential for creating and sustaining competitive. Hence, Concurrent Engineering is considered to be important for any engineering company to survive in market with their product.

Ecehan Sofuoglu (2011) reinforce the views on CE and explain that as technology and market changes could face different problems in the product development arena, firms are considering various structural relationships to help them cope with these changes. CE is a mechanism that reduces these change effects and improves organization's competitiveness. The author defines CE, explains new product development methods by applying it, gives the tools for it, and compares the CE with Sequential Engineering (SE) and also defines the organization structures in Big vs. Small Companies in the application period of CE.

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Rosnani Ginting & Thamer Ramadhan (2016 say that Concurrent Engineering Tools would be necessary to by implement the two-phased of product development. The implementation of Concurrent Engineering approach results in applying the stage of project planning, conceptual design, and product modules. The product modules consisting of four modules that use Product Architecture - Design Structure Matrix, would be necessary to ease the designing process of NPD.

Studies underline that there is a definite need to develop a model of an effective product development. An industry based on the trans-disciplinary approach wherein important factors like higher productivity, lower operating costs, change in personnel structure, higher added value, lower sales costs, lower administration costs, reduction in growth of expenses, and lower costs of work equipment should be looked at (TomažSavšek, Igor Makovec, MitjaCerovšek, 2015). The authors opine that the ultimate aim should be to ensure higher customer's satisfaction, increased flexibility of operations, better quality of information, improved control of sources, less waste materials and less pollution. This is possible only through improved planning process, more favourable consideration of employees and improved portfolio management.

Venkata Ramana V. (2012) apprises that in the present globalized scenario, CE has great importance in design and development of new products and is posing a big challenge to Indian firms. There is a major impact of CE on major areas of product design and development in any organization. He also states that most companies adopt CE procedures to reduce the new product introduction time into the market and that companies are realizing maximum benefits with the implementation of the CE procedures in new product design and development process.

Bhattacharya A (2011) also has a similar notion about CE. He presented a brief overview of the various aspects of concurrent engineering including the basic elements of the Concurrent Engineering practice in today's competitive world with special emphasis on its main advantages and constraints.

PM Wognum, R Curran et al (2006) proposed Concurrent Engineering as a concept that includes integration of technology, and other functional areas within and between organizations with a strong focus on enterprise-wide processes. He further stated that in addition, new forms of business have emerged, due to new technological developments that need to be merged to create a synergistic effect for New Product development.

In the literature, much emphasis has been given to such new technological development, but the importance of applied research is increasingly being recognized. The concept and principles of concurrent engineering has strengthened during the last two decades and is known by different names such as parallel engineering, simultaneous engineering etc.

4.5 Challenges in NPD

Development of successful new products is today of challenge to most manufacturing organizations. They have to shorten their response time, pushing their development processes to move faster while keeping on competitive prices and quality. Thus, companies are forced to find effective and innovative approaches as work methods to overcome to pressures (Alireza Aslani, Petri Helo, Marja Naaranoja, 2012). CE is an approach to address these managerial and manufacturing dilemmas in new product projects. The foundational basis of CE has been working in team concept. However, most managers face with problems when they want to promote teamwork culture, especially in conditions that the project faces with complicated problems.

Sanjay Raheja, Sunil Verma, Prof. Mohd. Parvez (2011) believe that nowadays the competition among companies is so compelling that they should not only be on the top of technology in the area, but also run their business according to life-long models. They emphasize on product post-sale life as common for these models for it embodies team values ofcooperation, trust, and sharing in such a manner that decision making proceeds with large intervals of parallel working by all life-cycle perspectives early in the process, synchronized by comparatively brief exchanges to produce consensus.

It is also felt that the various elements of product life cycle like manufacturability, assimilability, testability, serviceability, reliability, quality, cost, disposability, user requirements etc. are considered during the design and development stages of product. CE encompasses designing and validating a product in totality, while considering its manufacturing and maintenance processes simultaneously. As per David C. Wynn, Claudia M. Eckert (2017), Design and development involves iteration. Iteration has positive effects, such as enabling progressive generation of knowledge, enabling concurrency, and integrating necessary changes, but it also increases the duration and cost of a project. Iteration is inherently a part of design and development process of product development. Inspite of the enumerated benefits of iteration, it prolongs the time for introduction of product in market along-with added cost and reduced quality. Thus, iteration in a process has to be optimally minimised for achieving significant benefits. The authors clarify the

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different perspectives on iteration and state that it brings together insights into iteration gained from different research communities (mainly design and product development), alongside selected work in construction management and software project management) and different research approaches, including conceptual frameworks, mathematical and simulation models, case studies and surveys, and protocol studies.

4.6 Behavioural Factors

S. Pretorius, H. Steyn, T.J. Bond-Barnard (2017) say that Leader's behaviour is a crucial factor in managing projects to meet unique leadership demands in different situations. Leadership styles to be moderated as per project types, stage in PLC, organizational project management maturity, and level of trust and collaboration between project team members. H. Shidpour, A. Bernard, M. Shahrokhi (2013) state that a group decision-making process is proposed by using multi-objective programming to address three-dimensional concurrent engineering (3D-CE) problems involving product, process and supply chain design.

Qingshan Zhang, Zhihui Wang (2010) provide important research inferences in this regard and state that in the fierce market competition, formation of crisis management teams working on concurrent product development for "Precise knowledge of self and precise knowledge of the threat leads to victory".

4.7 CE Approach to NPD

Dag Raudberget (2010) states that Set-Based Concurrent Engineering is a means to dramatic improvements in product design processes. As per the author, the number of reported applications has so far been limited. Implementations of Set-Based Concurrent Engineering are possible in different product developing companies. There is a need to investigate if the principles of Set-Based Concurrent Engineering can improve the efficiency and the effectiveness of the development process. The set-based projects are highly flexible in nature as it keeps requirements and design options open for considerable duration, at the initial stage. But for achieving success in these projects, adequate collaborative support from all concerned stakeholders is essential. The set-based approach has positive effects on development performance, especially on the level of innovation, product cost and performance. Also, improvements were achieved at the expense of slightly higher development costs and longer lead time. As the benefits of set-based CE are manifolds as compared to the traditional approach, companies have an inclination towards application of set-based approach for CE, in design and development stage of products. TorgeirWeloa, AtleLyckea, GeirRinge (2019) also endorse Dag's theory that Set-Based approach to Concurrent Engineering is needed. Authors say that Set-Based Concurrent Engineering represents one of the basic principles of Lean Product Development and mention that research studies documenting the successful use of SBCE in other companies is still scarce. The authors firmly believe that Product Development capabilities associated with the Set-Based Concurrent Engineering concept in a real-world operation is essential. It is necessary to have Set-Based Concurrent Engineering capabilities are needed along with a categorization into maturity levels.

As per literature on the subject it also emerges that analysis of application of Set-Based Concurrent Engineering principles in a two-staged R&D project selection process is based on alternative technology routes for grant allocation (Karyn M. Lopesa, Eduardo Zancula, 2019). Set-Based Concurrent Engineering principles have allowed the assessment of technology routes, supporting the identification of most promising alternatives.

Literature indicates thoughts about the selection of a configuration for processes and suppliers in CE environment are a critical step in the NPD process. Significance of problems related to new product development relate to understanding of cost and time parameters at the early design stage (M. Shahrokh, A. Bernard H. Shidpour, 2011). Authors feel that simultaneously considering many of approximate parameters is necessary to develop an efficient product design. A hybrid method is suggested to address.

CE problem involving selection of processes and suppliers is an uncertain occurrence. Authors also propose a method that integrates multi objective programming and fuzzy AHP to select processes and suppliers, by simultaneous consideration of cost and time of production, quality and safety of the final product. As per the authors, this method can be used to develop decision-making systems to determine the optimal production design, in concurrent engineering platform.

Tan Owee Kowang and Amran Rasli (2011) state that relocating organization functional units geographically to an economically advantage location is one way for multi-national companies to improve competitive advantage. The management of new product development is directly influenced by the co-location or multi-location existence of companies and thus affects its operating environment. They also mention that new product development process in a multi-located research and development organization and examine elements for an efficiency new product development process helps in designing and developing new products to customers effectively.

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Authors identified seven concurrent engineering main constructs and 49 concurrent engineering critical attributes. Using 98 survey data from a multi-location research and development organization, their research suggested there was no significant difference in new product development process of co-location and multi-location research and development organization. The research also revealed that efficiency concurrent new product development engineering process in multi-located research and development organizations were driven by "application of concurrent engineering tools", followed by "top-down concurrent engineering approach" and "continuous improvement". "Team "related attributes of concurrent engineering were found to be not so important as the other drivers in the case of co-locational research and development organisations. Venkata Ramana (2012) and others underline the fact that sustainable product development (SPD) requires that product designs achieve minimal or zero environmental impacts, in addition to satisfying the traditional design criteria, parameters like product quality, feature, costs, and time to market the product. Environmental evaluations must, therefore, be incorporated into the design stage. Authors propose a product design process model that included three design requirements, two design tasks, and three comprehensive assessment streams.

Here the functional requirement is derived from the customers' needs, reflecting the product's functional purpose; the environmental requirement reflects society's need for protecting natural resources and the environment; and, the economic requirement ensures the company's basic business goals. Authors' state that SPD aims to simultaneously carry out the two tasks of designing products' physical and lifecycle structures Three assessment streams, viz. lifecycle quality (LCQ) analysis, lifecycle assessment (LCA) and lifecycle cost (LCC), are required to be done during the assessment phase of product design. These assessments are conducted for functional, environmental, and economic appraisal of the product under design. However, for the environmental evaluations, a simplified LCA is used. For effective design evaluations, detailed assessment techniques are also developed. A relevant case study example is provided to highlight the various methods and models for carrying out these evaluations. For new product development (NPD) initiative in any industry, it has become a challenge to align the product features with the customer needs and wants, compete with other vendors and increase the business benefits. CE thus has considerable significance in product design and development especially new products (Sirivellavijayabhaska, 2015). Author also stresses that CE is indisputably the wave of the future for NPD for all companies regardless of their size, sophistication, or product portfolio. In order to be competitive, firms must alter their product and process development cycle to be able to complete diverse tasks concurrently. The studies tacitly point to the fact that in a competitive scenario, manufacturing fundamental issue of gaining and sustaining competitive advantage.

Rosnani Ginting and Thamer Ramadhan (2016) state that it could be reached by applying strategic planning while developing an integrated approach to product development. The researchers intended to get an integrated product design concept of tire pertaining to the customer's needs.

5. Literature View: A Critical Analysis

The literature on the subject provides definite indicates to the role of concurrent engineering in product development. The viewpoints converge to certain fundamental issues – the competitive scenario and necessity to create and sustain competitive edge; identifying and fulfilling the needs and wants of the target customers; and role of Concurrent Engineering (CE) as a potent instrument for addressing customers' needs. Authors have explained the concept of Concurrent Engineering, its influencing factors and specified how leadership and team working can enhance the effectiveness of CE as a process. The literature also describes vividly the benefits that organizations can accrue from CE that ultimately reflects in market superiority.

As a snapshot, the literature provides a 360-degree view of the subject under study and provides a logical flow of the entire process that can be emulated by product design and development organizations to their best advantage. A diagrammatic representation of the flow of perspectives described in the literature is illustrated below:

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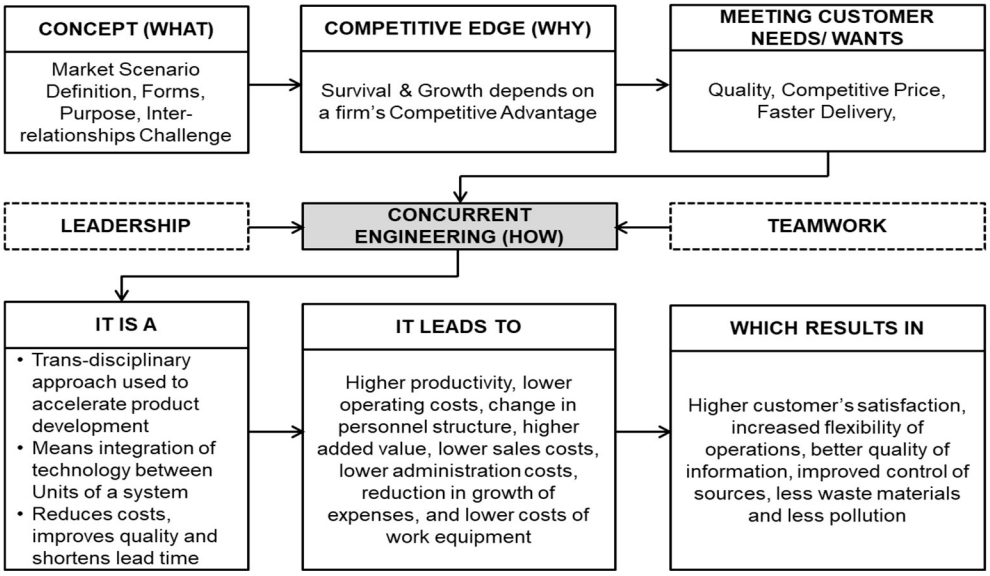

Fig.1. Concurrent Engineering and its Basis

Accordingly, a conceptual framework can be designed that justifies the rationale of the role of Concurrent Engineering and its New Product Development. The premise for the subject can be drawn from the fundamental precept of Theodore Levitt (1983) wherein he stated that 'The purpose of business is to create and keep a customer. To do that, you have to produce goods and services that people want, and value at prices and conditions that are reasonably more attractive to those offered by others.

The literature also points out that in any competitive market scenario, the purpose of any organization is to create and sustain competitive advantage. To do that, companies will have to understand the needs of its customers. Primarily, customer needs centre around quality, least cost to the customers, Speedy delivery, manufacturability, serviceability, reliability and disposability. In today's context it is possible only through 'concurrent engineering' which, through its trans-disciplinary approach that is used to accelerate the product development process in an industry. Steered by a capable leadership and supported by an efficient teamwork, Concurrent Engineering can lead to higher productivity, powering down the, increase value to the offering, and shorten the project life-cycle, which ultimately lead to higher customer satisfaction and enables companies to acquire a competitive advantage.

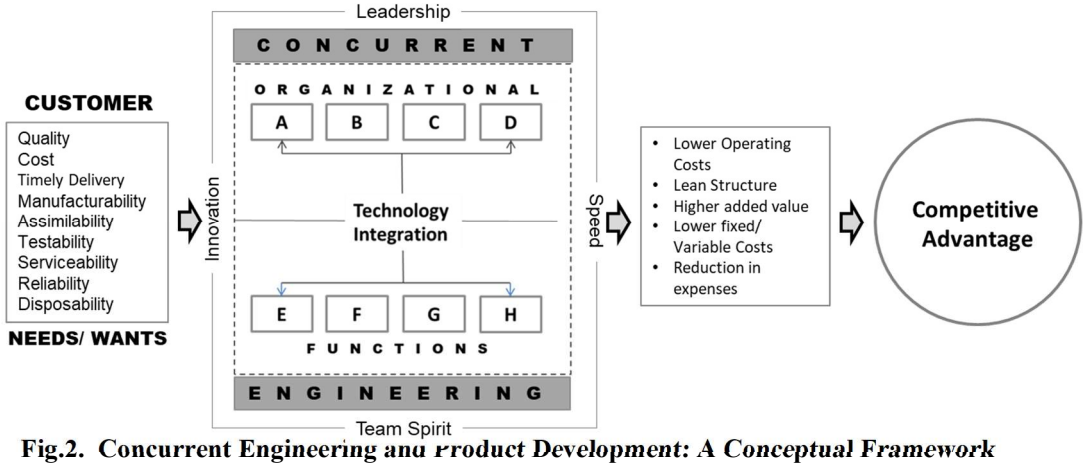

Fig.2. Concurrent Engineering and Product Development: A Conceptual Framework

6. Conclusion & Discussions

Concurrent Engineering has been the focus of many industrial organizations for new product development, due to the ability of the cross functional team to reduce the total time to design and manufacture or time to market. This reduction in the time to market is a major source of competitive advantage in the manufacturing environment we have today. Use of concurrent engineering should

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improve the performance of the organization in general but certain human and organizational characteristics may affect the degree to which improvement is felt in the organization.

The application of the philosophy of Concurrent Engineering or Simultaneous Engineering aims to achieve enhanced rate product development and also elevates the performance of developed product. It is an integrated product development strategy, which is adopted by organizations which are geared up to invest in the up-front end and wait for long-term benefits. The implementation of CE does not happen overnight but it involves major organizational and cultural change, with cross- functional multidisciplinary groups acting together in a cohesive manner, early in the process and product design.

CE implementation requires a very dynamic and well-informed decision-making process, pertaining to product development requirements such as material issues; reliability issues; serviceability and maintainability issues; quality cost and time constraints etc. During the early stages of Concurrent Engineering implementation, it is very essential that the company's entire workforce, the design partners, the production partners, technology partners and all other stakeholders are adequately sensitized on what are the possible benefits of CE implementation, so that a whole hearted and concerted effort is achieved.

Since CE requires the integration of people, business methods, technology and is dependent on cross-functional team work. A highly vibrant organisation culture with strong bonding among different entities is required for successful implementation.

7. Research gaps; Findings and Contributions for Future Research

The extent/degree of integration at every stage of the Product Development process during implementation of concurrent engineering depends on various factors viz. the extent of newness of the product being developed, the ability of the design and production team to manage the constraints of quality, cost and time, the set of competencies possessed by various teams working in each phase, the technological capability for design, development and realization etc. A detailed study may be taken up by the researchers in future to assess the various elements which determine the degree of integration in Concurrent Engineering environment.

REFERENCES

- AHambali, S.M. Sapuan, N. Ismail, et. al (2009)," The Important Role of Concurrent Engineering in Product Development Process" Pertanika J. Sci. & Technology, Vol 17 (1), pp. 9 – 20
- Alireza Aslani, Petri Helo, MarjaNaaranoja (2012)," Development of Creativity in Concurrent Engineering Teams" American Journal of Industrial and Business Management, Vol.2 (03), pp-77-84
- Anandaroop Bhattacharya (2011)," Concurrent engineering: road to the future" Research Gate Publication
- Aniket U. Dongre, Bipin Kumar Jha, Pratik.S. Aachat, Vipul R. Patil (2017)," Concurrent Engineering: A Review", International Research Journal of Engineering and Technology, Vol 4 (5), pp-2766-2770
- Ashley, S. 1990. The battle to build better products. Mechanical Engineering, Vol 112(11), pp-34-38
- B. Lu, J. Zhang, D. Xue and P. Gu (2011)," Systematic Lifecycle Design for Sustainable Product Development" Concurrent Engineering: Research and Applications, Vol 19(4), pp 307-324
- B. Prasad, Integrated Product and Process Organization, in: Concurrent Engineering Fundamentals, vol. I, Prentice Hall PTR, Englewood Cliffs, NJ, 1996, pp. 216–276.
- Brooks, B. (1990), "Design - the starting point for CIM R&D Management", Vol 20 (3), pp. 221-227.
- C. Pienaar, E. van der Lingen & E. Preis (2019), "A Framework for Successful New Product Development", South African Journal of Industrial Engineering, Vol 30 (3), pp-199-209
- C.E. Levandowski, D. Corin-Stig, D.Bergsjo,A. Forslund,U. Hogman, R.Soderberg and H Johannesson (2012)," An Integrated Approach to Technology Platform and Product Platform Development" Concurrent Engineering Research and Applications, Vol 21(1), pp. 65-83
- Charles Chikwendu and Jude E. (2017)," Benefits and Barriers to Successful Concurrent Engineering Implementation" Journal of Multidisciplinary Engineering Science and Technology (JMEST), Vol 4(8), pp-7868-7873
- Dag Raudberget (2010)," Practical Applications of Set-Based Concurrent Engineering in Industry" Journal of Mechanical Engineering, Vol 56(11), pp 685-695
- David C. Wynn1 • Claudia M. Eckert (2017)," Perspectives on Iteration in Design and Development" Research Engineering Design, Vol 28, pp-153-184
- Ecehan Sofuoğlu (2011)," Different Approaches to Concurrent Engineering", Research Gate Publication
- H. Shidpoura, A. Bernardb,*, M. Shahrokhic (2013)," A Group Decision-Making Method Based on Intuitionistic Fuzzy Set in the Three-Dimensional Concurrent Engineering Environment: a multi objective programming approach" Forty Sixth CIRP Conferences on Manufacturing Systems

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- Hollingum, J. 1989. Design and manufacture overlap to Advantage. Assembly Automation, Vol 9(3), pp. 128-131
- Karyn M. Lopesa, Eduardo Zancula (2019)," Application of Set-Based Concurrent Engineering Principles in R&D Project Prioritization", Procedia CIRP, Vol 84, pp 49-54
- 'Masibonge Tshiki (July 2015)," Critical Success Factors for Infrastructure Construction Projects in South Africa", South African Institution of Civil Engineering (SAICE)
- M. Lawson and H.M. Karandikar, "A Survey of Concurrent Engineering," Concurrent Engineering Research and Applications, Vol. 2, No. 1, 1994.
- M. Shahrokhi'A. Bernard, H. Shidpour (2011)," A Hybrid Method to Select Best Process and Suppliers, in the Concurrent Engineering Environment" Proceedings of the 18th World Congress the International Federation of Automatic Control Milano (Italy)
- PM Wognum, R Curran et al. (2006)," Concurrent Engineering - Past, Present and Future." Proceedings of the 2006 conference on Leading the Web in Concurrent Engineering.
- Putnik, Goran & Putnik, Zlata (2019), "Defining Sequential Engineering (SeqE), Simultaneous Engineering (SE) and Collabrative Engineering (CoIE) on Similarties and Differences", Procedia CIRP, Vol 84, pp 68-75
- Putu Dana Karningsih, Dewanti Anggrahini, Muhammad Iman Syafi (2015), "Concurrent Engineering Implementation Assessment: A case study in an Indonesian Manufacturing Company", Procedia Manufacturing, pp.200-207
- R. Addo-Tenkorang (2011)," Concurrent Engineering (CE): A Review Literature Report" Proceedings of the World Congress on Engineering and Computer Science, Vol II
- R. Badham, P.Couchman, M. Zanko (2000)," Implementing Concurrent Engineering", Human Factors & Ergonomics in Manufacturing, Vol 10 (3), pp.237-249
- R.I. Winner, J. P. Pennell, H. E. Betrand, and M. M. G. Slasurezuk (1988), "The Role of Concurrent Engineering in Weapons System Acquisition," Alexandria VA IDA Report R-338
- Raia, E. (1993)," The Design Team: Suppliers Move into the Line of Fire. Purchasing 115(8), pp. 9-13.
- Rosnani Ginting & Thamer Ramadhan (2016)," The Application of Concurrent Engineering Tools and Design Structure Matrix in Designing Tire" IOP Conference Series: Materials Science and Engineering, Vol 114 012088
- S. Pretorius, H. Steyn & T.J. Bond-Barnard (2017)," Exploring Project-related Factors that Influence Leadership Styles and their Effect on Project Performance: A Conceptual Framework" South African Journal of Industrial Engineering, Vol 28 (4), pp 95-108
- SandipBasu, Nabarun Biswas, Supriya Naha Biswas (2013)," A Study on Concurrent Engineering-Based Design and Product Development" International Journal of Recent advances in Mechanical Engineering, Vol.2(1), pp 15-20
- Sanjay Raheja, Sunil Verma, Prof. Mohd. Parvez (2011)," Concurrent engineering for process improvement of product" International Journal of Computer Science & Management Studies, Vol. 11(2), pp 2231 –5268
- Sirivella Vijaya Bhaskar (2015)," Performance Impact of Concurrent Engineering on Product Development in 2-Wheeler Auto-Industry" International Journal of Advanced Scientific Technologies in Engineering and Management Sciences, Vol 1 (4), pp 13-16
- Tan Owee Kowanga,* , Choi Sang Longa , AmranRaslia (2013)," New Product Development Framework for Multinational Multi-locations Based Organizations in South East Asia" International Conference on Innovation, Management and Technology Research, Malaysia, pp 22 – 23
- Tan OweeKowang* and Amran Rasli (2011)," New product development in multi-location R&D organization: A concurrent engineering approach" African Journal of Business Management Vol.5 (6), pp. 2264-2275
- TomažSavšek, Igor Makovec, MitjaCerovšek (2015)," Tran disciplinary product development" Journal of Universal Excellence,Vol 4,pp 171-182
- Tonya G. McCall and Sara C. Fuller (2018)," Manufacturability and the Product Design: Case Study Exploration of Manufacturability Assessments Across a Product Life Cycle" Proceedings of International Annual Conf of American Society of Engineering Mgmt
- Torgeir Weloa, AtleLyckea, GeirRinge(2019)," Investigating the Use of Set-Based Concurrent Engineering in Product Manufacturing Companies",Procedia CIRP Design, Vol 84,pp 43-48
- V. Venkata Ramana (2012)," Concurrent Engineering: Impact on New Product Design and Development in Indian Two-Wheeler Auto Industry, International Journal of Modern Engineering Research, Vol.2(4), pp-2699-2701
- Youcef J-T. Zidanea, KjerstiBjørkengStordalc, AgnarJohansenb (2015)," Barriers and challenges in employing of concurrent engineering within the Norwegian construction projects" Procedia Economics and Finance
- ZHANG Qingshan, WANG Zhihui (2010)," Organization of Concurrent Product Development", IEEE