Logistics Integrated Product Design under Concurrent Engineering Environment - A Case Study

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Abstract — **Logistics, transportation and distribution engineering can be divided into internal or in-plant logistics and external manufacturing or distribution logistics. The Internal or in-plant logistics includes the material handling systems and storage systems and the external manufacturing or distribution logistics includes the transportation modes such as trains and trucks. Both must be integrated into the overall operations using a systems approach that minimizes costs at a competitive level of service. For example, plant layout and production planning must consider internal logistics. The design decisions are made in the early phases of product design and development will have a significant effect over future manufacturing and logistical activities. In this paper, a methodology is developed and presented for decomposition of the logistics design process to analyze the effectiveness of the system and minimize design cycle time of any manufacturing firms including their suppliers.**

Index Terms — **Concurrent Engineering, Design and Manufacturing Interface, Logistics Design, Product and system design.**

I. INTRODUCTION

The general opinion about many people thought that logistics means only warehouses and lorries. However, the real logistics is concerned with all those activities of an enterprise, which ensure that customers are given total satisfaction at minimum cost. This means that almost every function of an organization is involved in the logistics process. In complex manufacturing processes with many different product lines, it is not possible to respond fast enough to match the customer's demand exactly day by day.

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Hence, the firms need for finished goods stocks. However, it is possible to improve the responsiveness, and hence reduce the size of the stocks, by careful control of the shop floor processes. This might mean working to reduce batch sizes and speed up changeovers, or it might mean improving forecasting methods so that output can be adjusted in advance of a rise or fall in demand [3][4]. Most of the manufacturing organization has some usual practices in manufacturing their products without considering the logistic parameters. The logistic features are available with them either directly or indirectly in doing their manufacturing activities. Larger manufacturing firms are interested and considered the logistic parameters and they have a separate department for logistics and smaller manufacturing firms are giving least importance over logistic parameters. The paper supports the trade-off between smaller and larger firms for easy implementation of logistic design.

II. OBJECTIVES AND ORGANIZATION OF THE PAPER

The objective of this paper is threefold.

- To demonstrate the importance of early logistics involvement in the product design and development process.
- To present a conceptual as well as an analytical basis for integrating logistics concerns, constraints, and contributions in the design process.
- To provide a product design conceptual framework, where managerial implications of design for logistics can be explored.
- The efficiency and effectiveness of the methodology, results, and their managerial implications are analyzed.

Section 3 gives brief theoretical issues of interest when discussing product design under concurrent engineering environment and presents a logistic design framework model for integrated product design. Section 4 comprises the methodology adopted with a case study and its results. Finally the Section 5 implies the concluding section discusses theoretical/managerial implications of the framework and the process model and gives recommendations for further research.

III. PRODUCT DESIGN IN A CONCURRENT ENGINEERING ENVIRONMENT

It focuses on an interdisciplinary approach that utilizes methods, procedures and rules to plan, analyze, select, and optimize the design of products. In the early stages of the design process, concurrent engineering considers and includes various product design attributes such as aesthetics, durability, ergonomics, interchangeability, logistics, maintainability, marketability, manufacturability, procurability, reliability, remanufacturability, Safety, schedulability, serviceability, simplicity, testability and transportability [5][6][9]. The greatest impact and benefits of concurrent engineering are realized at the design stage of product development. This paper supports the logistics involvement in the early phases of product design and development in a concurrent engineering environment. A concurrent engineering environment and the benefits of such involvement are considered in detail [11][13][14]. The research facilitates the design interface between the designer and the logistician. A quantitative and conceptual interface of design for logistics is considered in the four areas of interfaces i.e. Logistics Engineering, Manufacturing logistics, Design for packaging, and Design for transportability. Modularity, as a basic rule of good design, is more easily changed, expanded, or contracted than large and complex system designs.

Most managers find modular system designs easier to understand and apply. These module families can be designed and implemented simultaneously. This can potentially reduce the total design cycle time and bring about the merits of concurrent engineering to the design of integrated logistics. This paper has specifically explored a large number of areas where collaboration and interface of logistics and design activities can result in significant achievements for a manufacturing enterprise.

A. *Logistic Design Framework Model For Integrated Product Design.*

There are two issues of the core of successful implementation of concurrent engineering: -

- All activities related to the development of a product should be focused in the early stages of product design, so that the greatest benefits of such integration are achieved. The information requirements and exchanges at the conceptual design are not well defined and usually fuzzy. This poses a challenge for implementing concurrent engineering.
- The impact and constraints associated with various functional requirements should be communicated to the designer on a timely, accurate, and relevant basis.

Figure1 represents an integrated logistics system as it relates to product design. An effective design for logistics cuts across a number of functional areas as illustrated. These activities converge to product design as the embodiment of all future activities. As the design for logistics affects other functional areas, other areas in turn affect logistics considerations. This process is inherently a dynamic one requiring negotiation and trade-off among the functional areas in a concurrent engineering environment. Different functional areas and their interrelationships can be explored and culminated into several other research articles. The focus of this paper, however, is on exploring and analyzing the link between logistics and product design.

B. *Group Technology in CE*

Batch manufacturing is a dominant activity in the world, generating much industrial output. The major characteristics of batch manufacturing are a level of product variety and small manufacturing lot sizes. The product variations present design engineers with the problem of a design stage that significantly affects manufacturing cost, quality and delivery times. The impacts of these product variations in manufacturing are high investment in equipment, high tooling costs, complex scheduling and loading, lengthy set-up times and costs, excessive scrap and high quality control costs. However, to compete in a global market, it is essential to improve the productivity in small batch manufacturing industries [1][2].

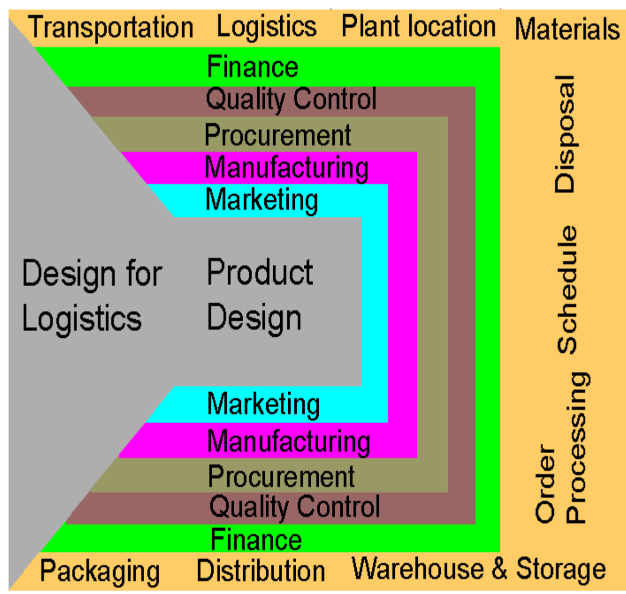

Figure 1: Integrated Logistics System For Product Design

IV. METHODOLOGY

The paper is based on both desk research and field research project into providing a logistics support perspective to the product design process. This desk research has been further developed in cooperation with the field studies through day-to-day work in a manufacturing firm and their suppliers. The objective is to maximize the system effectiveness and minimize the design cycle time. The existing Bond Energy Algorithm (BEA)was analyzed [12] and tested for enhancing the cluster efficiency and proposed an enhanced and improved algorithmic approach was developed and used for computational purpose to get clusters to the appropriate family of logistic design [7][8][10]. The methodology used in this paper generates modules that are cohesive, bounded, or contains a self-contained group of activities. For effective implementation of integrated logistics design, each module solves one clearly defined segment of the total system. These clustering algorithms are used for the decomposition of complex design problems into simple and manageable sub design problems. A Case Study is presented for this problem to test and validate the algorithm.

A. *Case Study*

The study was mainly focused on logistics concerns and supplier activities relationship between a main industry and a chain connecting with these suppliers. They are followed the regular manufacturing practices including Product design and development, tool design, die design, raw material planning, scheduling, inventory, manufacturing, storage and warehousing etc. The problem is found in this juncture is to make an interlink between the main industry and segregate the various logistic and logistic design activities involved in manufacturing activities from product design and development and to the disposal of products to the customer. These suppliers also have some sub suppliers of various secondary operations of the same components. The study took all necessary steps to link all the activities held between the manufacturers and suppliers. The above study produced high bond energy clusters by the incremental rise in the system effectiveness when comparing the existing design and proposed module based logistics design. The resulting clusters are as shown in Figure2.

B. *Results*

The Initial Measurement of System Effectiveness (MSE) Value for this study was obtained is 35 and the Measurement of System Effectiveness (MSE) obtained was 122. The system effectiveness is maximized and hence the clustering process releases highest bond energy and the solution consist optimal bond energy. The above results shown in Figure2 indicate that the overall design of logistics can be accomplished in five self-contained clusters or modules. The DPF3 (Design Parameter Family 3) formed as a checkerboard cluster and other families forms body diagonal. The objective of BEA in a logistic design has been attained through clustering. The design for logistics model results with five module families with related design parameters. By the application of Gantt chart and the application of concurrent engineering principles by overlapping the module family resulted in reducing design cycle time. All the necessary data were analyzed from the existing system and proposed a model to the above optimization process. The total cycle time for the existing system was 13.5 weeks. The proposed system was validated and it results the reduction of the design cycle time was 1.5 weeks.

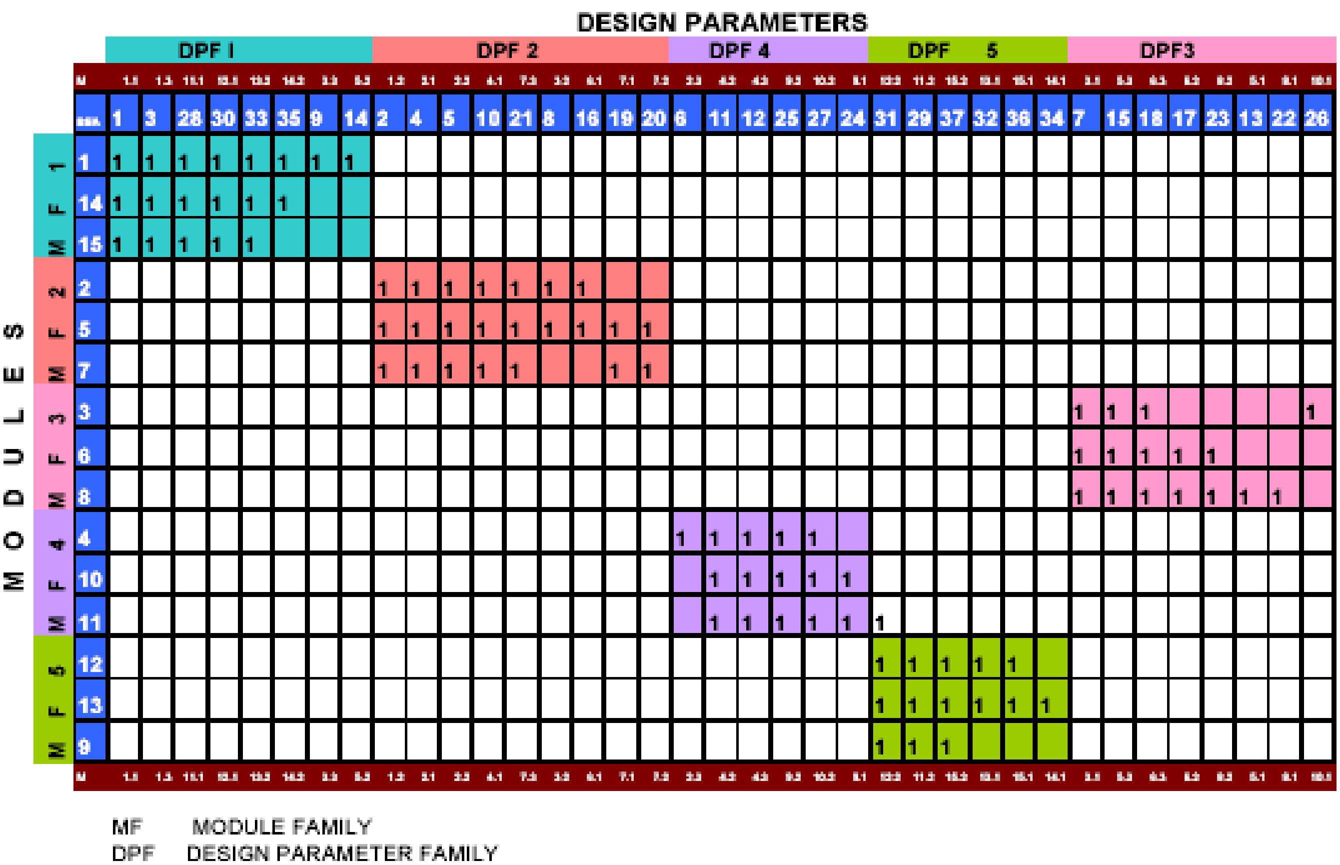

Figure 2. Clusters for logistics integrated product design

V.CONCLUSION

This research has specifically explored for a large number of areas where the collaboration and interface of logistics and design activities. The study conducted was resulted in significant achievements for a manufacturing enterprise through manufacturing logistics. The collaboration and interface between product design and logistics must be done on a long-term basis. Hence the design engineer and Logisticians should be given an essential role as the key player in the design process. The concurrent engineering and design for manufacturing provides a continuous development to consider the logistics problems. The contributions of logistics and its constraints are enriched in the early phases of product design cycle. The merits of concurrent engineering were realized under the logistics requirements as a part of the overall product design. A logistic engineering model called the Design for Logistics Model for Product Design Framework is developed for this research. This model worked as a tool for logistician to include the necessary and relevant subsystems, modules, and design parameters. This approach allows the designer to become a full participant in the logistics systems design. This methodology is applicable to matrices of any size or shape. The only requirement is that the elements of a matrix be non-negative. The BEA solutions are finite. This makes the BEA algorithm applicable to new designs as well as currently existing designs. The final solution obtained by using this algorithm is independent of the order in which the rows and columns are presented. This methodology generates modules that are cohesive, bounded, or contains a self-contained group of activities. For effective implementation of integrated logistics design, each module solves one clearly defined segment of the total system.

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