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Development of concurrent engineering system for design of composite structures

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Abstract

This paper explains the development of a concurrent engineering system for the design of composite structures. The concurrent engineering system is developed to meet the demand for the better quality products with lower production cost and time. In this study, to compose the architecture of concurrent engineering system, the commercial and non-commercial programs related to design and analysis of composite structures are surveyed and classified. The concurrent engineering system includes various design modules such as design/analysis of composite structures using CLPT and finite-element method (FEM), buckling and postbuckling analysis, thermo-elastic analysis of carbon–carbon composite and optimum design using expert system. For the integration and management of softwares, a graphic-based design environment that provides multi-tasking and graphic user interface capability is built. © 2000 Published by Elsevier Science Ltd.

Keywords: Concurrent engineering system; Composite design; Graphic user interface; Multi-tasking

1. Introduction

With the development of the global economic market, it has become a major challenge for most manufacturing enterprises all around the world to optimize their production strategies because of the demand for the better quality products with shorter lead-time and lower life-cycle cost. In order to meet these requirements, many enterprises face a critical need for advanced system engineering tools and methods. One solution to improve competitiveness is to change from a traditional design and development process to a concurrent engineering process.

A literature survey reveals that there has been a number of studies associated with the concurrent engineering system. Jiang et al. [1] developed a graphics-based design environment of chemical processes for concurrent engineering and insisted that graphics and visualization enable engineers to meet the challenges of reducing physical capacities while enhancing decision making capacities. Cheng et al. [2] developed the interactive information database for concurrent engineering design of plasma spray processing. Fruchter et al. [3] developed an interdisciplinary communication medium to support concurrent engineering by improving communication among members of interdisciplinary teams. Reddy et al. [4] developed a user-friendly software package for the linear analysis of composite material structural elements. This package is intended to calculate the most commonly required information (deflections, stresses, buckling load, etc.) for basic structural elements in a few seconds with very high accuracy and low computational cost. Hahn et al. [5] proposed the architecture of concurrent engineering system in the composite manufacturing area.

From the paper survey, we do know that the studies on the concurrent engineering system in the composite design field have stayed in a primary stage.

The objective of the present study is to develop a concurrent engineering system for composite design (CESCD). In this system, each program related to the design and analysis of composite structures is effectively integrated to reduce the design time and cost. For the effective management and interaction among each program, a graphic-based design environment is constructed. The graphic-based design environment provides multi-tasking and graphical user interface capabilities.

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2. Concurrent engineering

In the traditional design and development process such as a serial engineering environment as shown in Fig. 1, it has been known that different stages such as product design, review, manufacturing, and testing are conducted separately and sequentially [6]. Therefore, if some problems rise during design reviews, these may cause the need for the product to be redesigned and this redesign activity adds to overall time to market for the product. These factors will weaken the competitiveness of products. The concurrent engineering as shown in Fig. 2 is a systematic approach to the integrated, simultaneous design of both products and their related processes, including manufacturing, test and support. The concurrent engineering environment integrates design for manufacturability, testability, quality and serviceability equally and in parallel with product design [6]. The concurrent engineering environment integrates the expertise from the various engineering disciplines during the actual design stage. With proper forethought, many of the problems that can be occurred under the serial engineering process can be completely prevented. The whole focus of concurrent engineering is on a "right-the-first-time" process, rather than on the typical "redo-until-right" process that is so common in the serial engineering. The elimination of design iterations reduces product development costs and shortens time to market for new products [6].

2.1. Modeling of concurrent engineering system

In this study, the CE system is represented by a system modeling technique as shown in Fig. 3. The design process of composite structures is composed of material selection, product modeling/design, and analysis/simulation [5]. It can be noticed from Fig. 3 that the composite design process starts from the material selection. In the material selection module, some adequate materials are selected by appointing fiber and matrix types along the design objectives. It can be found from Fig. 3 that there exist multiple interrelationships between

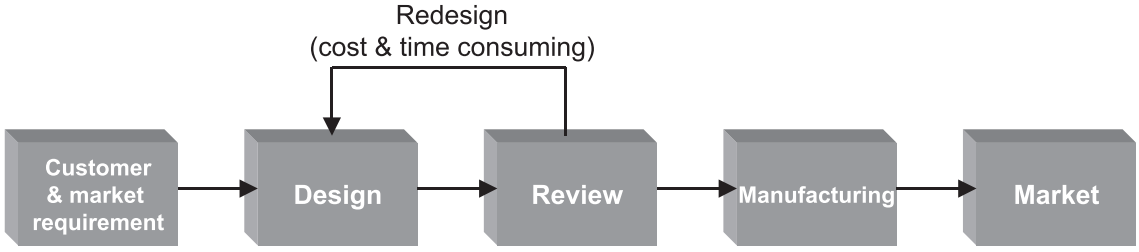

Fig. 1. Product development process with serial engineering.

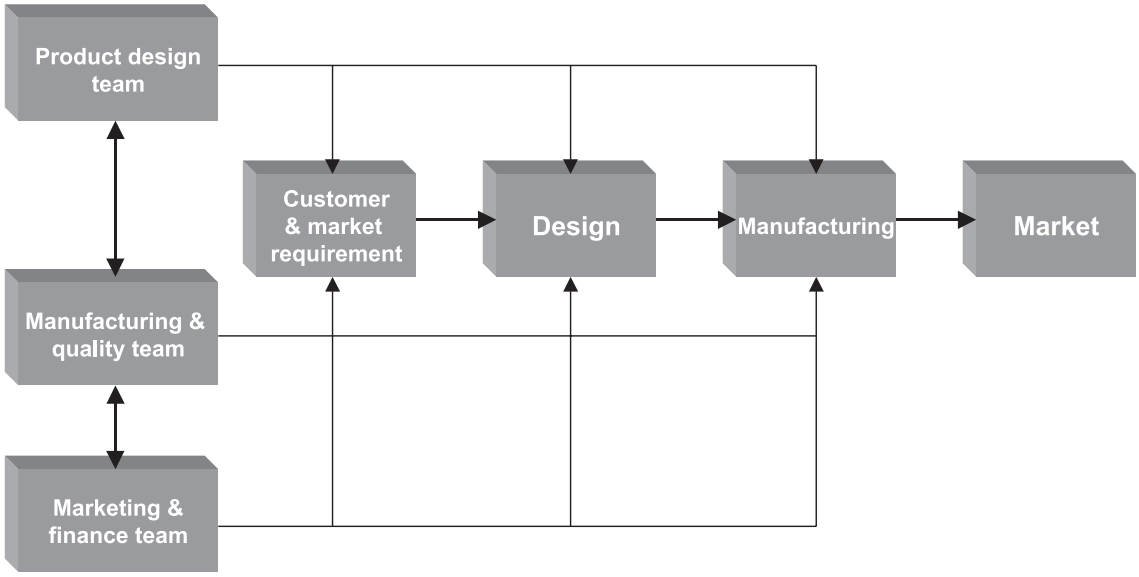

Fig. 2. Product development process with concurrent engineering.