Chapter 3.7
Intelligent Design Advisor:
A Knowledge–Based Information System Approach for Product Development and Design

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ABSTRACT

The rapid development of computing technology has facilitated its use in engineering design and manufacturing at an increasing rate. To deliver high quality, low cost products with reduced lead times, companies are focusing their efforts on leveraging this technology through the development of knowledge-based systems such as an IDA. An IDA, which can also be referred to as a design information system, is a part of the overall enterprise information system framework, and plays an important role in improving competitiveness in product development oriented companies. Not only must such a system utilize human expertise and address CE issues in decision making, it must also lead to the preservation and transfer of technical knowledge to minimize the knowledge loss from organizational moves such as personnel retirements and company relocation. The emphasis in CE is to consider downstream aspects of different phases in the product life cycle as early as possible in the design stage. These aspects include production process planning and realization, manufacturing and assembly resources, maintainability, costing and other factors. Both human expertise and downstream aspects predominantly consist of information that is descriptive. This paper discusses the structure and development of a knowledge-based design information system that can convert this descriptive information into forms that are suitable for embedding within decision-making algorithms. Information in such a system is sorted in terms of its nature into three groups: input data infor-

mation, constraint information, and objective information, all having different representations. Information is also mapped to the relevant design objectives and ranked in importance to facilitate the trade-off analysis.

INTRODUCTION

Concurrent Engineering (CE) has become a very attractive and enthusiastically discussed product development approach in recent times. To realize the concurrent design process, a key demand is to find an appropriate way to present life cycle information to the design stage. On the other hand, designs are normally required to achieve a set of objectives. Generally, these objectives are correlated to each other with either positive or negative dependencies. Therefore, solving a design problem always involves numerous trade-off decisions. It is a big challenge even for an expert to find an optimal compromising point and almost an impossible task for a less experienced designer. Thus, designers need a computer system to support the design course by providing them with the right advice at the right time (Reidsema, 2001). The rapid development in computer science and information technology has given birth to many new software tools for product development. Computer-Aided Design (CAD), Computer-Aided Manufacturing (CAM), Computer-Aided Engineering (CAE), Computer-Aided Process Planning (CAPP), Design for Manufacturing (DFM), and Design for Assembly (DFA) are quite commonly-used tools in today's product development practice. To a large or less extent, these tools adopt some aspects of the concurrent approach through the inclusion of product data management and collaborative work tool functionalities. Quality Function Deployment (QFD) is another successful product development technique which is also compatible with the idea of CE as it provides a systematic methodology for ensuring that constraints and objectives identified

in the client specification phase are maintained through the entire development phase. Although these systems may provide the designer with very good support at specific points, they lack the ability to observe the design problem from an overall point of view.

Knowledge Based Engineering (KBE) represents potentially the most significant product development technique to date. It provides a new strategic approach for realizing the concurrent product development process to improve effectiveness in design and manufacturing. It also facilitates the preservation and transfer of knowledge in companies that operate in a physically-distributed environment. Not only does it utilize traditional elements in the design process such as geometric models, it also captures other underlying attributes of design such as experience and expertise. In our research, an Intelligent Design Advisor (IDA) is proposed based on this approach in an integrated, concurrent engineering environment. On the one hand, it addresses the "life cycle" design challenges by incorporating multi-disciplinary knowledge resources into the system to achieve design and manufacturing intent, and other subsequent requirements generated through the product's distribution, use, and disposal. On the other hand, it utilizes an expert's knowledge in the course of product development to guide less experienced designers. The system can also suggest design alternatives in terms of cost, time, equipment availability, or other critical requirements to enable the creation of a fully-engineered design by acquiring, representing, planning, reasoning and then communicating the intent of the design process. Thus, it can provide the necessary degree of intelligent interaction that enhances the designers own inherent skills and creativity (Cooper, Fan, & Li, 2001).

To implement the IDA, all related product information, including raw numerical input data, physical design and manufacturing constraints, design objectives and various other life cycle

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