# BOOK REVIEWS

# Concurrent Engineering: Automation, Tools and Techniques

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**Claudia Ionescu** is the head of CAE Systems Laboratory in the Research Institute for Informatics. She had the responsibility for and participated in several projects related to the design and implementation of CAD/CAE systems, with contributions to computer graphics, graphical simulation, structural engineering and architectures for engineering problem-solving. Claudia Ionescu is also co-author of a book on computer graphics. Her current professional interest is in intelligent CAD/CAE systems, concurrent engineering, virtual reality systems.

Nowadays the computer application areas in production and engineering have no boundary as to penetrating all human activities from management, research and development, design, specification,to calculation, planning, manufacturing, production control, quality assurance, monitoring and maintenance.

The book gets significant as bringing forth an understanding of, helping it be ,shared, how information needs be modelled, communicated, stored, and accessed all over the enterprise, starting with the customer's requirements definition and proceeding on to product planning, conceptual product, process, materials, manufacturing system design, prototype validation, detailed pre-production planning, and all life cycle aspects from delivery to disposal/recycle. Indeed, the book filled in the application designers' waiting horizon over engineering and manufacturing.

The book is a collection of contributions, either original or published elsewhere (but revised) by authors working in well-known academic institutions or companies throughout the world. The book consists of a short introduction and 21 chapters which cover a broad spectrum of contemporary research topics in concurrent engineering. A subject Index is included at the end of the book. It seems appropriate, in order to better highlight the contents of the book, to list the chapters by their title and length, while also giving an indication of the ideas of each chapter. The chapter titles are:

1) **Life-Cycle Design of Products: A New Opportunity for Manufacturing Enterprises (17 p.)**

This chapter introduces the life-cycle design concept and some of its associated principles. Life-cycle design, which is seen as a new opportunity for companies to meet the demands of customers and society, covers the following phases:need recognition, design/development, production, distribution, usage, and disposal/recycling. Different solutions of such a design are to be explored based on a criterial function having such elements as environmental protection, working conditions (occupational health), resource optimization, ease of manufacture, properties of the products, life-cycle costs, and company policies.

2) **Modelling of Concurrent Engineering Design (21 p.)**

Here, one starts by admitting concurrent engineering as a practice of incorporating various life-cycle values into the early stages of design. In this respect, a key position in computer application to concurrent engineering is held by the computer programs helping designers evaluate a candidate design with respect to the various life-cycle values. Thus, this

chapter focuses on an assessment method of the total life-cycle value of candidate designs. The Design Compatibility Analysis (DCA) method is described, which captures the design guidelines and cost models in a compatibility format; in fact, DCA uses the object-oriented compatibility data to (a) compute an overall "goodness" of a design, (b) give reasons, and (c) provide suggestions for improvement.

**3) Automated Analysis Idealization Control (33 p.)**

Here, analysis idealizations during concurrent engineering are checked and the design of an engineering modelling system supporting analysis idealizations in a concurrent engineering environment is explained. Both analytical and knowledge-based methodologies are considered in order to evaluate and control analysis idealizations. Also, it is shown that expert system technology coupled with numerical analysis techniques aids in the automation of this task.

**4) Concurrent Engineering in Optimal Structural Design (35 p.)**

This chapter is dealing with one of the oldest engineering disciplines, which still commands attention: structural engineering. The Integrated Structural Optimization System (ISOS) presented has the ability to generate topologies on a rigorous analytical foundation, albeit in the form of imprecise images. Obviously, this opens up the way to integrating tools of different domains such as mechanics, manufacturing, computer vision, expert systems and mathematical optimization. Another particular attribute of ISOS is its capability to allow concurrent examination of design constraints in so many different domains.

**5) Real-Time Constraint Checking in the Design Process (30 p.)**

Complex design problems are reflected with their long check and review cycle and, therefore, time-consuming and costly in completing the design. How the constraint-based design process is checked and reviewed is actually very important in the implementation of an efficient CAD system. How to develop an intelligent interactive CAD system, aiming at providing an innovative design environment in which the designer can concurrently generate and check a design solution in real-time, is shown.

**6) Conceptual Design of Mechanisms: A Qualitative Physics Approach (22 p.)**

The goal of the conceptual design of mechanisms is to find the most appropriate combination of mechanical elements and physical phenomena associated with them for meeting the requirements. Since the quality of any design largely depends on decisions in the conceptual design, this chapter focuses on the intelligent support of the conceptual design. In this respect, a qualitative physics approach is made to an integrated design object modelling environment based on knowledge about physical laws. The key idea is the use of a central qualitative model called metamodel.

**7) An Intelligent Design for Manufacture System (24 p.)**

This chapter points to the effects of a lack of communications between engineering and manufacturing personnel (a major problem of industry today). As a result, many parts enter a re-design process, which not only results in longer lead times but also increases product costs. The approach to overcoming the limitations and producing a manufacturable design is proposed to be the "intelligent design system", IDS. In its simplest terms, the IDS merges a CAD system, an expert system and a DBMS.

**8) Modelling and Reasoning for Computer-Based Assembly Planning (29 p.)**

In this chapter, the assembly (an integrative activity in the design-manufacturing process and therefore especially important for concurrent engineering) is examined and a new computerized environment is proposed which enables the automatic generation of assembly sequences (assembly plans). A knowledge-based approach to analysing products and deriving their exploded view layouts first, and their assembly sequences second is also presented, together with some advantages over conventional methods. A prototype uniaxial system implemented in Turbo Pascal is also presented.

**9) Design for Automated Manufacturing (27 p.)**

This chapter reviews the traditional and present approaches to mechanical product development. Then, an engineering feature- oriented modelling approach to representing mechanical features, their tolerance relations, and feature-tolerance

associations is made. Methods for representing and using manufacturing knowledge are also discussed under an integrated design and manufacturing system. The automated optimal tolerance design is used to illustrate the methodology of optimal design incorporating manufacturing knowledge.

**10) Quality by Design (52 p.)**

This chapter shows how a quality planning and improvement method can be used systematically for product design, beginning with the conceptual design and going to through establishing tolerance limits for component parts.

According to Taguchi, the off-line quality planning and improvement activities are carried out in three stages: system design, parameter design, and tolerance design. First, the system design using QFD (Quality Function Development) is presented. During this stage - quality by design -, a statement of product requirements is gathered from customer inputs and then converted into engineering and manufacturing requirements. Next, some methods and examples of the parameter design stage are presented. which ensure that the design is robust against production or manufacturing variabilities and environmental stress. Finally, an approach to tolerance design enabling an assessment of the important subsystem and components of the design, is made.

**11) Quality Engineering and Tolerance Design (20 p.)**

This chapter includes a mathematical formalization of the quality characteristics and some results concerning the QFD methodology introduced in the previous chapter.

**12) Design for Reliability (41 p.)**

Reliability is a measure of an item's ability to remain functional during a specified time, expressed by the probability that the item will perform its required function under stated conditions for a stated interval of time T. For complex technical systems quality assurance activities, as this chapter assumes, are co-ordinated by two programs: a quality assurance program and a reliability assurance program. In this respect, the main subjects of the chapter are (a) reliability analysis during the design phase, (b) design guidelines, (c) reliability tests, and (d) quality and reliability assurance during the production phase.

**13) Reliability Design for Manufacturing ULSI Circuits (13 p.)**

An optimal testing algorithm for ULSI circuits; it is formulated as a non-linear integer programming problem.

**14) Life-cycle Serviceability Design (22 p.)**

Serviceability measures the ease with which a system can be serviced; how often the system needs servicing, how easy it is to service, how long the service takes, and how much the service costs. Service includes diagnosis, maintenance, repair, and anything else that affects the activity needed to keep the system function properly. This concept is closely related to reliability.

This chapter describes a methodology capable of identifying a design and of analysing it from a serviceability point of view. The underlying idea is that of phenomena based service modes representing the malfunctions of a product and their relationship to the repair. The new method of deploying out serviceability into its key elements (a revised service mode analysis) allows the use of currently known data from industry.

**15) Design for Maintainability (15 p.)**

This chapter is dealing with one of the most important aspects of a design, namely maintainability. In the new concurrent engineering environment, the role of the maintainability engineer will change from that of a design auditor to a new one. The responsibility for a design meeting maintainability requirements will now reside with the design engineer, who will be helped by the design rules entered into the design database. These design rules will be the responsibility of the maintainability engineer (who becomes an expert advisor whose knowledge is captured into the design environment). A short description of The Air Force/Army RAMCAD Program (RAMCAD is an acronym that stands for "reliability, availability, and maintainability in computer-aided design") is also included (and of a special interest in our opinion).

**16) Design for Economics (35 p.)**

This chapter discusses the scope of manufacturing system design as it relates to system design and economic issues and sets up a framework within

which the economical design of manufacturing systems could be considered.

The need for and the difficulty associated with an economical design of manufacturing systems are examined from an integrated perspective; a framework, termed design justification is presented that supports designing for economics. Design justification uses a knowledge-guided design approach that requires economic justification on each design decision to ensure a functionally and economically viable manufacturing system.

It is worth noting the extensive review of the literature dedicated to manufacturing system design and justification.

**17) Intelligent Evaluation of Designs for Manufacturing Cost (25 p.)**

This chapter describes a methodology integrating concurrent engineering into artificial intelligence - based tools for design and manufacturing, focusing on procedures for design evaluation of multiple attributes under uncertainty.

**18) Use of Agent - Based System for Concurrent Mechanical Design (17 p.)**

The purpose of this chapter is to examine how expert systems may be designed and configured to emulate and extend the existing processes of concurrent design. As a means of automating concurrent engineering, a prototype system called AGENTS is also described. It must be noted that the construction of appropriate interfaces to existing automated systems (for example, geometric design and analytical modelling systems) is an open problem, far from being trivial.

**19) Decomposition in Concurrent Design (27 p.)**

In this chapter a methodology for the decomposition of the design process is outlined. The objective is to minimize the "interaction density" among groups of design tasks and enhance concurrency of the design process. Two types of decomposition including task space and constraint space are considered.

**20) An Approach to Parametric Machine Design and Negotiation in Concurrent Engineering (25 p.)**

Parametric design is an important task in the process of designing mechanical product. In the parametric design, the system configuration and product behaviour are characterized by parameters that determine geometry, tolerances, material, load, stress, fluid flow, and so on. The "design diagram" is used as a graphical representation for parameter relationships to model the parametric design process. This is further used to model design agents and their interaction in a concurrent engineering process, where different design agents represent different engineering disciplines or different concerns during the product life-cycle. A concurrent design schema is proposed where design agents can, when conflicts arise, negotiate on shared parameters using utility functions.

**21) Concurrent Design: A Case Study (47 p.)**

This chapter describes the design of a light commercial utility helicopter for Mc Donnel Douglas Helicopter Company according to the methodology of CERWAT Georgia Institute of Technology.

The book is largely a set of case studies on the applications of various concurrent engineering techniques and methodologies. It is also an account of some of the successful applications of AI techniques to concurrent engineering.

In summary, this book treats what is known as "concurrent engineering" in a coherent manner (despite the large dispersion of contributors) starting with basic paradigms and ending with using them in a number of pilot projects or applications. It fulfils its purpose of being written as a "comprehensive handbook" primarily for engineering and computer science oriented personnel. Because it has a large number of case studies and elaborate examples, as well as references, it is also suitable for self - study and as a reference for entry into digesting the technical journal literature, especially that literature which is engineering design and manufacturing oriented.

**Claudia Ionescu**