Андријана БОЦЕВСКА[1]

МЕТОДИ НА ВИРТУЕЛНО ПРОТОТИПИРАЊЕ ПРИМЕНЕТИ ВО ПРОЦЕСОТ НА РАЗВОЈ НА ПРОИЗВОДОТ

Апстракт

Успешно внесување на производ на пазарот може најдобро да се случи ако циклусот (планирање на производот, концептуален дизајн, подробен дизајн, процесот на планирање и производство) за развој на производот и реализација заврши во најкус можен рок и по најниска цена, со истовремено одржување на многу висок квалитет на производот и сигурност. Во овој поглед, физичкиот прототип може да се покаже како многу долготраен и скап, особено ако измените што произлегуваат од дизајнот вклучуваат редизајн на алатот. Можноста и достапноста на напредната компјутерска технологија создаде услови за зголемена примена на прототиповите, кои се дигитални и креирани во компјутерски-базирани средини, односно тие се виртуелни наместо физичките. Прототипот може да биде дефиниран како "прв или оригинален примерок на нешто што ќе биде или ќе биде копирано или развиено, тоа е модел или прелиминарна верзија." Виртуелното прототипирање станува многу напредно и конечно може да доминира на процесот на развој на производот. Тоа ја олеснува комуникацијата меѓу различните инженерски дисциплини во почетокот на процесот на

[1] М-р Андријана Боцевска, Технички факултет Битола, Иво Лола Рибар б.б., Партизанска 54/54 Битола, abocevska@yahoo.com

дизајн, и исто така обезбедува квалитетни илустрации кои ја помагаат "продажбата" на дизајнот.

Во овој труд врз основа на целите на моделирање и тенденциите, опишани се пет обемни класи на методи на VP како: визуелизација, монтажа и интерференција на механичките склопови, испитување и верификација на функциите и перформансата, евалуација на производство и работата на склопот и анализи на човечкиот фактор.

Клучни зборови: виртуелно прототипирање, развој на производ, моделирање.

VIRTUAL PROTOTYPING METHODS USED IN PRODUCT DEVELOPMENT PROCESS

Abstract

Successful entry of a product into the market can best occur if it can complete the cycle (product planning, conceptual design, detail design, process planning and production) for product development and realization in the shortest possible time and at the lowest cost, while maintaining very high product quality and reliability. In this respect, physical prototyping can prove to be very lengthy and expensive especially if modifications resulting from design reviews involve tool redesign. The availability and affordability of advanced computer technology has paved the way for increasing utilization of prototypes that are digital and created in computer-based environments, i.e. they are virtual as opposed to being physical. A prototype can be defined as “the first or original example of something that has been or will be copied

or developed; it is a model or preliminary version.” Virtual Prototyping is becoming very advanced and may eventually dominate the product development process. It facilitates communication between different engineering disciplines during the early design process, and also provides quality illustrations that help "sell" the design.

In this paper based on the modeling objectives and purposes, five broad classes of VP methods such as Visualization, Fit and interference of mechanical assemblies, Testing and verification of functions and performance, Evaluation of manufacturing and assembly operation, Human factor analysis are described.

Keywords: virtual prototyping, product development, modeling.

1. Introduction

The purpose of this paper is to provide a general survey of available techniques in virtual prototyping (VP) in order to provide a broad picture of the field and to identify issues and information relevant to the deployment and implementation of VP technology. A typical scenario for product development and realization consists of:

- Product planning to define the product purpose and targeted market sector,
- Conceptual design specifying intended functions and properties,
- Detailed design to carry out and document the actual design,
- Process planning,
- Commissioning of the product into production.

Successful entry of a product into the market can best occur if it can complete the above cycle in the shortest possible time and at the lowest cost while maintaining very high product quality and reliability. The availability and affordability of advanced computer technology has paved the way for increasing utilization of digital (hence the term 'virtual'), as opposed to physical, prototypes. A virtual prototype may be represented as a series of graphical images or computer aided design (CAD) models, in animated or still format, created in the form of mathematical models and stored digitally in computer usable memory.

2. Virtual prototyping

Virtual prototyping is an aspect of information technology that permits analysts to examine, manipulate, and test the form, fit, motion, logistics, and human factors of conceptual designs on a computer monitor. Based on the modeling objectives and purposes, five broad classes of VP methods are identified. These classes consist of prototypes for:

- Visualization,
- Fit and interference of mechanical assemblies,
- Testing and verification of functions and performance,
- Evaluation of manufacturing and assembly operation,
- Human factor analysis.

2.1 Visualization models

Visualization models are used for examination of form as well as appearance. These models play a crucial role in communication of product information between a variety of users including marketing people, customers, managers, product development teams and engineering and even repair and maintenance personnel.

2.2 Fit and interference of mechanical assemblies

Fit and interference assessment is generally an iterative, time consuming and error prone process that would benefit from being replaced with VP using three dimensional models. Using VP, the product can be evaluated automatically with great accuracy and speed, resulting in a listing of all the interference's. It is also possible visually to inspect the virtual prototypes, where clearances and interfering areas of the CAD model can be highlighted with different colors.

2.3 Testing and verification of functions and performance

Prototypes are used frequently to verify the functionality and performance of various features of a new product during its development phase. Virtual prototyping relies on three-dimensional solid models to create accurate models that are complete and comprehensive in terms of both detailed geometrical and non-geometrical data.

2.3.1 Structural and physical phenomena analysis:

Finite element analysis. Finite element analysis is the most accepted and widely used VP tool. It calculates the relations between material properties and structural performance to predict the behavior of a structure with respect to virtually all physical phenomena. Hughes[2] (2000). Using sophisticated FEA software packages, engineers can design complex structural systems and perform detailed analysis of complexities with either none or only very few physical prototypes prior to production.

Computational fluid dynamics (CFD). CFD is a VP tool that is used to simulate flow and/or heat transfer for fluids and solids increasingly

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[2] Hughes, T. (2000). The Finite Element Method: Linear Static and Dynamic Finite Element Analysis, (Dover Publications, USA).

more reliable prediction of movement and velocity, shear, temperature and pressure contours and distribution patterns inside the systems under study. This is achieved by solving the Navier Stokes transport equations using the conservation of mass, energy and momentum.

2.3.2 Motion analysis

The motion of any mechanical assembly may be modelled, evaluated and optimized in two or three dimensions. The results can be recorded using powerful animation tools and can be replayed at any time later. The two main types of motion simulation are:

Kinematics performance. Velocity, acceleration, position, displacement and rotation are determined without considering the mass or force properties. The main objective is to verify proper geometry of motion.

Dynamic motion. The main difference from kinematics simulation is that dynamic analysis considers additionally both the mass and the forces associated with the constituent elements of an assembly. The method for calculation of the dynamics of forces and motion is used to approximate the motion of mechanical systems by solving differential equations. Golub, Ortega[3] (1992).

2.4 Evaluation of manufacturing and assembly operation

Prototype evaluation should include prediction and simulation of manufacturing processes and production planning both during the conceptual design when design data are incomplete and during the later stages when the design has matured after several design iterations. The risks of transition to

[3] Golub, G. H. and Ortega, J. M. (1992). Scientific Computing and Differential Equations: An Introduction to Numerical Methods, (Academic Press, USA).

full production can be reduced by integrating virtual design and testing with manufacturing simulation.

2.4.1 Manufacturability

It is a condition that must be satisfied before a design can be considered valid. Lack of any prototyping of the manufacturing stage heightens the risks of having to carry out design changes shortly after commissioning expensive dies, tools and other production equipment.

2.4.2 Assembly analysis

The main capabilities of existing VP tools for assembly analysis include. Tseng, Jiao,Su[4] (1998):

Assembly plans generation. Rules of the assembly method for feeding, grasping, orientation and insertion of all the elements are applied to evaluate assemblability and the reliability of an intended assembly system.

Assembly system design. Ease of maintenance, quality control checks, reconfiguring, workplace layout and station design for all the various stages of assembly are evaluated following the generation of an assembly plan. This will include the creation and configuring of assembly stations, and operations and resources such as tooling, and fixture can be assigned to each process on the basis of a bill-of-material structure.

2.4.3 Manufacturing management

Financial (e.g. the costs of implementing various manufacturing and assembly plans) and logistics and production control requirements are the direct result of design decisions. Manufacturing management needs to

[4] Tseng, M. M., Jiao, J. and Su, C.-J. (1998). Virtual prototyping for customised product development. Integrated Mfg Syst., 334343.

evaluate the implications of these requirements prior to commissioning new products into actual manufacture.

2.5 Human factor analysis

The manufacture of a product may involve handling, assembling, packaging and maintenance by human operators. Traditionally, expensive full-size mock-ups of the product, together with either life-size human models or real users, are used to evaluate safety, ergonomics, visibility, maneuverability, etc.

Summary

Virtual prototyping can provide a clear, competitive edge to companies who embrace and successfully implement its features. Reduced cycle times provide the opportunity to make new products available in less time and thus permit a company to become a market leader.

Virtual prototypes can be a valuable tool for program managers to use in identifying and managing program risks. Program managers are required to develop new product development strategies and program plans that are event-driven and that explicitly link major contractual commitments and milestone decisions to demonstrated accomplishments in development, testing and initial production.

Virtual prototypes can assist both the contractor and the program manager in understanding new product concepts and operational impact of new products and systems. More importantly, it provides a means for the engineers to visualize, maybe for the first time, the interactive results of what previously has been represented by two-dimensional tables of data and thousands of complicated equations.

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