

## ANALYSIS OF PARAMETRICAL MODELING SYSTEMS DEVELOPMENT

**Nomeda PUODZIUNIENE, Vidmantas NENORTA,**

Department of Engineering Graphics  
Kaunas University of Technology  
27 Kestucio st., LT-44312 Kaunas, Lithuania  
email: nomeda.puodziuniene@ktu.lt  
email: vidmantas.nenorta@ktu.lt

**Abstract.** In traditional manufacturing, companies must address a variety of complex challenges to improve product development: frequent design changes, disparate systems with incompatible data, regulatory compliance, and more. Today the market-led necessitates from producer to produce the product of good quality, to reduce the time of product designing, manufacturing and for realization that is assured of all Product Lifecycle Management (PLM). Many software solutions have been developed to organize and integrate the different phases of PLM. This phase of product's lifecycle is CAD/ CAM/CAE (automated design, manufacturing and engineering). The paper deals with analysis of CAD/CAM/CAE systems development, its prospect, analysis of its popularity all over the world and new challenges related with today's requirements. The survey of today's problems in this field of industry is done. New long-term solutions are analyzed compared with idea to choose the 'best' system assigned for machine design works and learning process in the universities today.

**Key Words:** automated design systems, CAD/CAM/CAE/PLM.

### 1. Introduction

Today's automated design of product includes a variety of phases from the idea itself – to the real object and its realization in a market. The first stage of product creation involves creating the model of a product, analysis evaluating diverse impact on the model. Due to this analysis constructional decisions are made, general technical documentation prepared, treatment technology composed. Further, on enterprise orders production materials, income and expenditure are planned and recorded, production process is designed and innumerable tasks are distributed. This is already the second stage of product creation.

Various systems guarantee projecting data essential for the first stage of production, for instance *Autodesk Inventor*, *SolidWorks*, *Pro/Engineer* and *CATIA*. Due to these programmes, volumetric models CAD (Computer Aided Design) are created, constructional analysis CAE (Computer Aided Engineering) is performed and technical documentation is compiled. With the help of CAM (Computer Aided Manufacturing), based on the geometry of a created element, numerical control programmes are created for equipment. This data becomes the point data for business management – the second stage. Nevertheless, this data is abundant and has interconnected relations. For example, an element belongs to a certain compound, calculation might belong to an element, technology is written for the element or the compound, equipment programme belongs to a certain element. This data is ruled by PDM – system of product data management. Finally, an enterprise has to realise the product in a market, i.e. present it to the customer and guarantee its appropriate functioning and utilization. The entire cycle of a product from its design to market presentation is guaranteed by PLM – product life cycle management.

Only high-end designing systems such as *Pro/ENGINEER*, *Unigraphics*, *CATIA*, employed in automobile, ship or aviation industries are able to secure the entire cycle of product existence [1].

### 2. The Peculiarity of Parametrical Modeling System

The four main PLM corporations: *Autodesk*, *Dassault Systemes*, *PTC (Parametric Technology)* and *UGS (Unigraphics Solutions)* cover over half of the area of development of CAD software [2].

*Autodesk* focuses on improving the design-to-manufacturing process, delivering the benefits of an end-to-end solution without the cost or complexity. The *Autodesk* solution for manufacturing is unlike any other offered on the market. It includes the 2D and 3D design software integrated with process automation tools to help manufacturers create, manage, and share data—simplifying the design-to-manufacturing process. As the creators of *AutoCAD* software, *Autodesk* created *Inventor* to make the process of adding 3D as easy as possible. *Inventor* gives designers freedom to integrate existing 2D designs into their 3D design environment, making it easy to reuse and share both *AutoCAD* DWG files and 3D design data with other *Autodesk* manufacturing applications and their users. *Inventor* 2008 includes standardized sketching functions with *Inventor* part modeling that look the same (in terms and icons) and operate the same as within *AutoCAD*. Driven by the concept of functional design, only *Autodesk Inventor* software enables customers to create designs based on the functional requirements of a product before they commit to complex model geometry, allowing designers to put function before form. This innovative technology found only in *Autodesk Inventor* helps *AutoCAD* software users become more productive in faster designing in 3D [2, 3].

The *Autodesk Inventor* product line provides a comprehensive and integrated set of design applications and 2D transition tools to help manufacturing companies move to 3D. It includes *Autodesk Inventor Series* software for 3D design and documentation, *Autodesk Inventor Professional* products for creating routed systems and validating designs, *AutoCAD Mechanical* for 2D drawing and detailing, and *Autodesk Vault* software for data management. It is possible to save time and reduce prototyping costs with specialized tools that allow engineers to create and validate routed systems, including tube, pipe, or wire harness designs. *Autodesk Inventor Professional* provides the tools to create complete products, including complex routed system designs, while automatically creating accurate bills of materials (BOMs) and complete manufacturing documentation. It validates designs before they are built. With *Autodesk Inventor Professional*, engineers can simulate the dynamic behavior of a design throughout its full operating cycle and accurately predict operating loads and accelerations. In addition, the integrated Finite Element Analysis (FEA) tool allows engineers to analyze designs and avoid stress-related field failures [2, 3].

For quite a number of years *SolidWorks* product of *Dassault Systemes*, has always placed great emphasis on making 3D modeling operations as self-evident and straight-forward as possible. The major areas of enhancement in *SolidWorks* 2007 are in the tools for surface modeling and manipulation, design analysis and validation, and design assistance. The analysis tools have been more tightly integrated into the modeling environment, so that designers can very quickly check on the feasibility of ideas as they proceed, instead of having to go into a separate module and then go back into modeling to fix any problems that the analysis revealed. This integration also enables ‘what-if’ ideas to be checked out without having to fully develop a possibility at that stage [3].

The other major part of the 2007 release is a technology that called SWIFT, which stands for ‘*SolidWorks* Intelligent Feature Technology’. This system is designed to provide expert design assistance while designing and to automate some aspects of the design process. SWIFT Feature Xpert helps the designer to build complex features more easily, modeled in a particular order to achieve the intended result. It can re-order the steps automatically, or guide the build-up process. This feature also helps in the stage of drawing profile sketches to define solids, by monitoring and resolving dimensional and constraint conflicts and over or under definition of dimensions or constraints. SWIFT Mate Xpert similarly deals with mating conflicts when mating parts are modified. *SolidWorks* initially focused solely on designing parts and small assemblies but has expanded that scope to much larger assemblies and a greater range of types of parts. *SolidWorks* market is mainly general manufacturing and makers of custom engineering equipment such as in mining and agriculture [3, 4].

New data management features in *Solid Edge V20* is also the product of *Dassault Systemes* which offers increased performance, robustness, and allows easy access to your da-

ta, regardless where it is stored. The user can easily initiate a design changes, clone, and revise assemblies directly in *Solid Edge* or in company PDM system. Massive assemblies mean massive drawings. *Solid Edges'* new Instant Drawing Review mode allows just that—opening drawings instantly, regardless of size. Instant Drawing Review is fast and smart, this new mode allows instant drawing access for adding dimensions and annotations. *Solid Edge* now includes Goal Seeking that lets engineers solve complicated systems with an easy to understand 2D graphical approach. Users simply set a target value and Goal Seeking efficiently solves the system to achieve the desired result. Results can be used to drive 3D geometry in a true hybrid 2D/3D design environment. Improvements to Feature Libraries allow users to establish complete libraries and define instructions to simplify their reuse. New tabulated drawings make detailing family of part drawings much easier. Adding tables that list family of part parameters can be created in just minutes [2, 5].

The range of *CATIA V5's* 'high-end' system of *Dassault Systemes* capabilities allow for its application in a wide variety of industries, from aerospace, automotive, industrial machinery, electrical, electronics, shipbuilding, plant design, and consumer goods, to jewelry and clothing. *CATIA V5* is the only solution that covers the complete product development process, from product concept specifications through to product-in-service, in a fully integrated manner. Based on an open, scalable architecture, it facilitates true collaborative engineering across the multidisciplinary extended enterprise, including style and form design, mechanical design, equipment and systems engineering, digital mock-up management, machining, analysis, and simulation. In conjunction with *ENOVIA* for collaborative product lifecycle management, *SIMULIA* for engineering quality and *DELMIA* for production performance, *CATIA V5* have all components of V5 PLM [2].

*CATIA V5R17* strengthens the integration between 3D electrical harness design and documentation, reducing the design-to-manufacturing cycle time for the automotive and aerospace industries. The release increases *CATIA* Machining NC programming and simulation efficiency to significantly reduce overall manufacturing process time. It facilitates design innovation with core styling capabilities that enable designers to explore product ideas more rapidly, while permitting last minute styling modifications. This version extends the 3D master approach by enabling fast and convenient display of product information, such as tolerances and annotations, in a familiar drawing layout within the 3D environment. *CATIA V5R17* delivers auto-filleting capability that enables automotive powertrain and chassis designers to reduce the time required to fillet complex parts from hours or days to just minutes. This release accelerates the adoption of *CATIA V5's* breakthrough functional modeling. *The V5R17 VPM* navigator boosts the use of relational design by making it easier for designers to work concurrently on different part versions. 3D XML format now includes finite element analysis output to widen the scope for the use of this lightweight format and makes it easier to reuse and share 3D outside the design office. Additional partner V5 applications launched since V5R16 extend the process coverage of V5 solutions with highly specialized applications that cover many disciplines, such as sheet metal design-to-manufacturing [2, 6].

The fact which is worth mentioning is that *SolidWorks* can read native *AutoCAD*, *Inventor*, *Solid Edge*, *UGS*, *Pro/ENGINEER* file, but it cannot read natives *CATIA* files, because they are built on different kernels. *CATIA* uses the ACIS kernel by Spatial, and *SolidWorks* uses the UGS Parasolid kernel. Even though *CATIA* and *SolidWorks* are owned by the same parent, the modeling kernels are exclusive to different companies [2, 4, 6].

The product of *PTC* company high-end system *Pro/ENGINEER* is a mechanical engineering and design CAD tool capable of creating complex 3D models, assemblies, and 2D measured drawings however; it does not support architectural or civil engineering practices. It originally caused a major change in the CAD industry when first released by introducing the concept of Parametric Modeling. Rather than models being constructed like a mound of clay with pieces being added or removed to make changes, the user constructs the

model as a list of features, which are stored by the program and can be used to change the model by modifying, reordering, or removing them. *Pro/ENGINEER* is considered a part of the high end 3D CAD modeling packages. *Pro/ENGINEER* outputs consist of solid model data for tooling and rapid prototyping (the automatic construction of physical objects using solid freeform fabrication), CNC manufacturing and finite elements analysis. A product and its entire bill of materials can be modeled accurately with fully associative engineering drawings and revision control information. It is compatible with Unix-variants, Windows and Linux operating systems. All data is interchangeable between these platforms without conversion [2, 7].

*Pro/ENGINEER Wildfire* is the new, breakthrough, award-winning version of *Pro/ENGINEER*, PTC's market leading product design software. This product won the title of the best product of 2006 years in the world [7].

The fourth of the main PLM operators *UGS (Unigraphics Solutions)* corporation specialized in 3D and PLM software. The main products of *UGS PLM Software* company are CAD/CAM/CAE commercial software with integrated set of PDM and collaboration (CPD) tools [2, 8].

### 3. Conclusions

1. Automated design systems process a vast amount of data which are necessary to be grouped, alterations to be checked, documents assist in performing various procedures in current industries. Therefore, data management system PDM is widely applied in designed systems and high-end designed systems such as *Pro/ENGINEER*, *NX (Unigraphics)*, *CATIA* which use PLM have a possibility to transfer the necessary information in the most appropriate way to the stages of business management.
2. It is purposeful to use high-end CAD/CAM/CAE systems in institutions of higher education, they can be applied in all stages of education, i.e. teaching students fundamentals of engineering graphics, projecting new products, performing scientific surveys, etc.

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## ANALIZA PARAMETRYCZNEGO MODELOWANIA SYSTEMÓW ROZWOJU

W tradycyjnej produkcji, przedsiębiorstwa muszą podejmować różnorodność złożonych wyzwań, by ulepszyć rozwój produktu: częste zmiany projektowania, całkowicie różne systemy z niekompatybilnymi danymi, odniesienie norm i in. Wprowadzany system rynkowy wymaga od producenta, by wyprodukować produkt dobrej jakości, zmniejszyć czas projektowania produktu, wytwarzania i realizacji, wszystko co zapewnia Management Lifecycle Product (PLM). Wiele rozwiązań oprogramowania rozwinięto, by zorganizować i łączyć różne fazy PLM. Tą fazą cyklu życia produktu jest CAD/CAM/CAE (automatyczne projektowanie, produkcja i inżynieria). Artykuł dotyczy analizy systemu CAD/CAM/CAE, jego rozwoju, jego perspektywy i analizy jego popularności na całym świecie; nowych wyzwań związanych z obecnymi wymaganiami. Dokonano przeglądu problemów z tej dziedziny. Analizowano nowe perspektywiczne rozwiązania w kierunku poszukiwania "najlepszego" systemu związanego z obecnym procesem projektowania i nauczania w uniwersytetach.