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FEATURES OF THE USE OF MODERN AUTOMATED PROJECTING SYSTEMS OF MACHINE-BUILDING INDUSTRIES

The purpose of the study covered in this publication is to analyze the features of the use of modern automated projecting systems, in particular CAD/CAM/CAE technologies from the point of view of the feasibility of introducing into the technological process of manufacturing products of a machine-building enterprise. The most popular specialized integrated CAD/CAM/CAE systems of the highest category for solving design and technological problems of varying complexity are listed, the features of their use are revealed, the main advantages and disadvantages and the most significant functionality are outlined. The research used a set of general scientific approaches: visual-analytical, systematization of information, modern methods of research of mechanical systems, analysis of scientific literature and method of classification. The most important factors that directly affect the technological process of creating quality products of a modern enterprise of the machine-building industry are highlighted. The choice of the integrated cloud software platform CAD/CAM/CAE Autodesk Fusion 360 for three-dimensional modeling of machine-building industries is substantiated. Certain recommendations have been formulated for the effective use of the CAD/CAM/CAE Autodesk Fusion 360 automated projecting system in the technological processes of the engineering industry. The main specialized modules of the CAD/CAM/CAE Autodesk Fusion 360 computer-aided system are considered to solve complex problems of varying complexity. It is established that the use of modern CAD/CAM/CAE technologies can significantly reduce the complexity of technological processes of manufacturing products of machine-building industries. The scientific novelty of the performed researches is the development of engineering methods of designing a modern high-tech machine-building complex with the use of integrated CAD/CAM/CAE systems.

Keywords: CAD/CAM/CAE technologies, technological process, machine-building complex, engineering methods of projecting, three-dimensional modeling, Autodesk Fusion 360.

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ОСОБЛИВОСТІ ВИКОРИСТАННЯ СУЧАСНИХ СИСТЕМ АВТОМАТИЗОВАНОГО ПРОЄКТУВАННЯ МАШИНОБУДІВНИХ ВИРОБНИЦТВ

Метою дослідження, висвітленого у цій публікації, є аналіз особливостей використання сучасних систем автоматизованого проєктування, зокрема CAD/CAM/CAE технологій з позиції доцільності впровадження в технологічний процес виготовлення продукції машинобудівного підприємства. Перелічено найбільш популярні спеціалізовані інтегровані CAD/CAM/CAE системи вищої категорії для вирішення конструкторсько-технологічних завдань різної складності, розкрито особливості їх використання, зазначено основні переваги та недоліки та найбільш значущі функціональні можливості. При проведенні досліджень використано комплекс загальнонаукових підходів: візуально-аналітичний, системно-інформаційний, сучасні методи досліджень механічних систем, аналізу наукової літератури та метод класифікацій. Виокремлено найбільш важливі фактори, що безпосередньо впливають на технологічний процес створення якісної продукції сучасного підприємства машинобудівної галузі. Обґрунтовано вибір комплексної інтегрованої хмарної програмної платформи CAD/CAM/CAE Autodesk Fusion 360 для тривимірного моделювання машинобудівних виробництв. Сформульовано певні рекомендації щодо ефективного застосування системи автоматизованого проєктування CAD/CAM/CAE Autodesk Fusion 360 в технологічних процесах машинобудівної галузі. Розглянуто основні спеціалізовані модулі системи автоматизованого проєктування CAD/CAM/CAE Autodesk Fusion 360 для вирішення комплексних завдань різного рівня складності. Встановлено, що використання сучасних CAD/CAM/CAE технологій дозволяє суттєво зменшити трудомісткість технологічних процесів виготовлення продукції машинобудівних виробництв.

Наукова новизна виконаних досліджень полягає в розвитку інженерних методів проєктування сучасного високотехнологічного машинобудівного комплексу із застосуванням інтегрованих CAD/CAM/CAE систем.

Ключові слова: CAD/CAM/CAE технології, технологічний процес, машинобудівний комплекс, інженерні методи проєктування, тривимірне моделювання, Autodesk Fusion 360.

Introduction

In our days, the rapid development of the Fourth Industry 4.0 Industrial Revolution, which implements a new, innovative approach to the production process. Emphasis is placed on the comprehensive integration of modern information and communication technologies into industry, complete automation and robotization of technological processes of production. The fourth industrial revolution is fair to be considered as another logical stage of development caused by world technological improvement. In order to continue to be competitive, enterprises of the machine-building industry must produce quality products in accordance with established requirements and look for ways to minimize the cost of production [1-4].

The prerequisite for the stable functioning and development of a typical machine-building enterprise of the industry in today's conditions is a rational management, which involves:
- systematic updating and modernization of the existing equipment fleet;
- improving the energy efficiency of technological processes;
- implementation of modern automated projecting systems, in particular CAD/CAM/CAE technologies in the technological process of manufacturing products;
- minimization, recycling and rational use of production wastes.

It is worth mentioning, that the world manufacturers of automated projecting systems, that can be taken into the technological process of manufacturing products of a modern machine-building enterprise, coexist in conditions of rather fierce competition. There are a sufficient number of fairly powerful high-level automated projecting systems in the software market, in which CAD/CAM/CAE technologies are implemented and do serve they purposes. However, it is often the question of what software product is appropriate to use to solve a particular problem [5, 6].

Problem statement

Given the relevance of the use of modern automated projecting systems, in particular CAD/CAM/CAE technologies at the machine-building enterprises of the industry, the task of research is to further develop engineering methods of three-dimensional modeling; selection of the most adapted software product for introduction into the technological process of manufacturing products of a competitive machine-building enterprise for it to solve the tasks of varying complexity.

Presentation of the main material

CAD (Computer-Aided Design) is a technology that is used to create, analyze and optimize various designs and parts using computer programs. CAD technologies allow you to create accurate and detailed models of objects before their physical creation is given start [7-9].

CAM (Computer-Aided Manufacturing) is a technology that is used to automate the production and processing of materials. CAM technologies allow you to create numerical programs and instructions for machinery and equipment that produce parts, products, tools, etc. [10-12].

CAE (Computer-Aided Engineering) is a collection of technologies and software that use computer models to solve engineering problems. CAE includes a variety of tools for analyzing, modeling the situation of possible tension and optimizing projects for it being worth manufacturing [13-15].

The most common specialized software products for three-dimensional modeling (Fig. 1), which are complex systems of automated design of middle and upper levels, as good as largely adapted to the needs of the modern typical machine-building complex include next:
- Autodesk Inventor – 3D mechanical projection system for creating and studying the behavior of digital prototypes products and parts [16, 17];
- SolidWorks – system of automated 3D design, engineering analysis and preparation of production of any complexity and purpose [18, 19];
- PTC Creo Parametric is a fully integrated two-dimensional and three-dimensional modeling software that allows you to design, analyze and check products [20, 21];
- TopSolid – comprehensive software for solving design and technological problems: creation of CAD-models, kinematic analysis, work with sheet metal, design of molds, tuning control programs for machines with numerical software control [22, 23];
- Computer Aided Three-Dimensional Interactive Application (CATIA) is a system of automated projecting, the concept of which is based on three-dimensional modeling, imitation and teamwork in real time [24, 25];
- Autodesk Fusion 360 – integrated cloud software platform for automated projecting, production, engineering calculations, analysis and simulation of physical processes [26, 27].

In order to make a reasonable choice of the most rational program for three-dimensional modeling that can be implemented in the technological process of manufacturing the products of a competitive machine-building enterprise, it is advisable to consider in detail the characteristics of the software products that were mentioned above.

Autodesk Inventor is a comprehensive specialized software (CAD/CAM/CAE system) for three-dimensional modeling and product design, including deeply developed field of analysis needed for engineering. First

of all, this automated projecting system is aimed at creating digital prototypes of industrial products. The built-in toolkit allows you to provide a complete cycle of product design and creation of the necessary design documentation in accordance with the standards [16, 28].
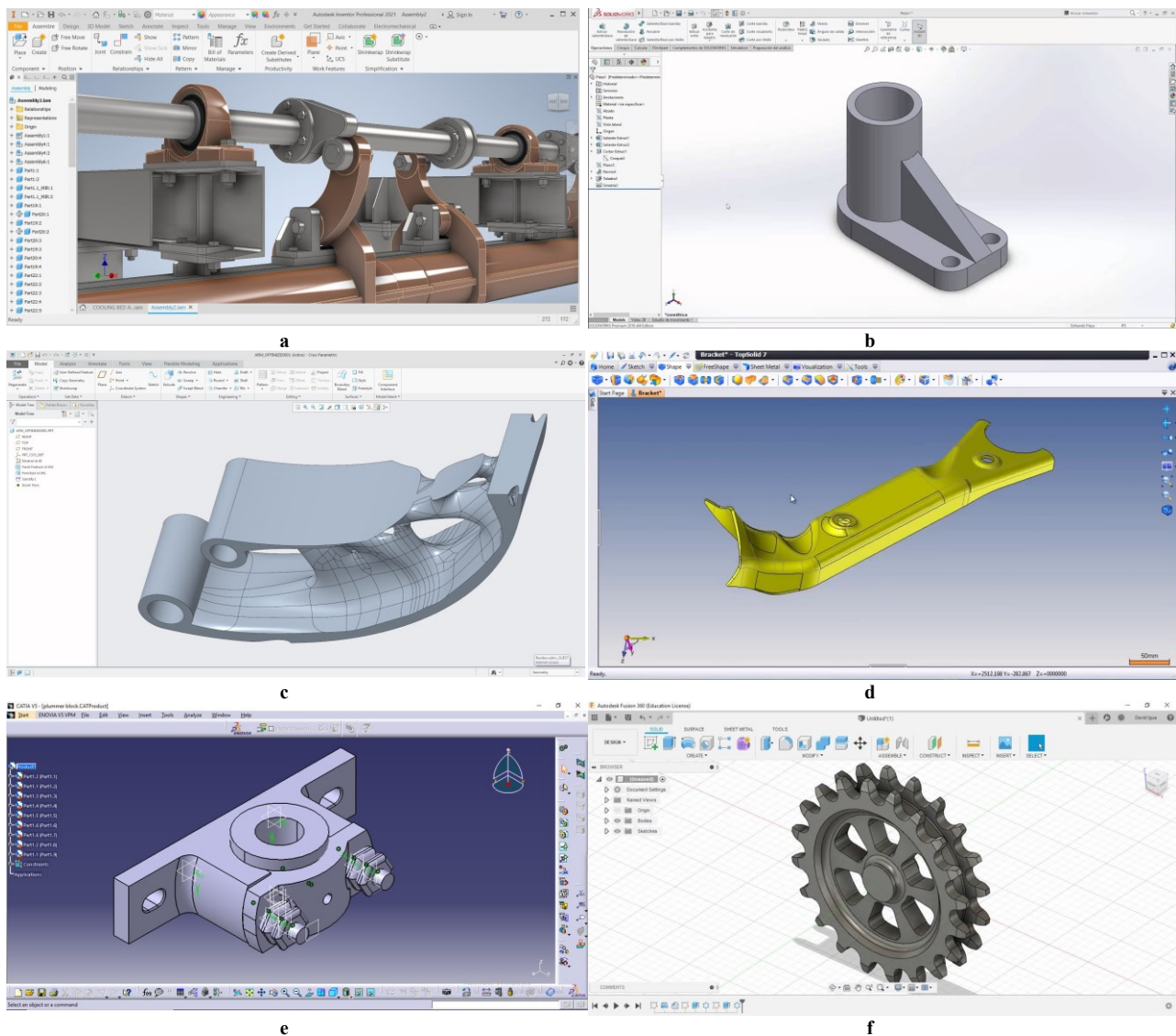

Fig. 1. The working windows of the programs for three-dimensional modeling: a – Autodesk Inventor; b – SolidWorks; c – PTC Creo Parametric; d – TopSolid; e – CATIA; f – Autodesk Fusion 360

SolidWorks is one of the most popular, currently, software product with all of CAD/CAM/CAE are included, mainly for 3D modeling and design of mechanical structures, engineering analysis and preparation of production of any complexity and purpose. SolidWorks in its asset has powerful tools for automated design, creation of complex digital models of products and carrying out virtual technical researches over them [18, 29, 30].

PTC Creo Parametric is a one more powerful software (CAD/CAM/CAE system) that allows you to create accurate digital models of products that have full associativity. All real-time changes to the product lead to a comprehensive update of the working documentation. This software product makes it easy to create three-dimensional product models, 2D and 3D drawings, work with assembly units, model sheet steel components, simulate welded joints and their designs, perform a number of necessary engineering test calculations [21, 31].

TopSolid is a comprehensive CAD/CAM/PDM solution from the French company TopSolid SAS, which includes a number of integrated software products that form a single powerful package for the design, machining and life cycle management [23, 32]. Capacities are more than enough to work with huge assembly units. TopSolid specialized software is a modern, powerful self-sufficient CAD/CAM/PDM system that fully meets the most stringent production requirements [33].

Computer Aided Three-Dimensional Interactive Application (CATIA) is a complex CAD/CAM/CAE system for three-dimensional modeling and product design of any complexity in the context of their behavior in real conditions. The French company Dassault Systèmes is positioning its software product as a leading solution for projecting and optimizing manufacturing processes. It should be noted that the CATIA's work platform for product creation can be integrated with existing processes and tools [25, 34].

Autodesk Fusion 360 is a comprehensive software for automated design, manufacturing, engineering calculations, analysis and simulation of physical processes. It is worth noting the successful combination of the whole process of product development in one cloud software environment with integrated 3D CAD, CAM and CAE systems. Autodesk Fusion 360 has a fairly powerful functionality that allows you to create a variety of design, animation, perform test calculations, develop the technological process of manufacturing parts on CNC machines, etc. [27, 35].

In addition to functionality, an important role in the selection and further introduction into the technological process of manufacturing the products of a machine-building enterprise of a modern automated projecting system can serve as the cost and conditions of the license agreement for the use of this software product, requirements for computer equipment and more. Therefore, choosing a rational CAD/CAM/CAE system for introducing high quality products into a specific technological process is quite a challenge.

Responsible employees of the machine-building enterprise should be clearly aware of what specific purposes the CAD/CAM/CAE system has been selected in their technological production process, and what its functionality will be used. It is also necessary to calculate the economic impact of implementation, to take into account the specifics of use, adaptability and power to solve potential design and technological problems. Only such a rational economic approach will allow to make the correct choice of the necessary system of automated tending for a particular enterprise with fully predictable and promising results [5].

In our days, attracts special attention to the Autodesk Fusion 360 computer-aided design system. The functionality of the CAD, CAM and CAE modules program and capacities would be rather sufficient to satisfy the typical average machine-building enterprise of the industry. It is worth noting a fairly democratic price in comparison with the closest competitors for those functionalities that the client company will receive under the relevant license agreement. Another undeniable advantage of Autodesk Fusion 360 is the use of cloud technology. Employees of the company can work remotely (create, edit models, perform test calculations, generate control programs on CNC machines, etc.) from any personal computer. All you need is a stable internet connection and a registered Autodesk account.

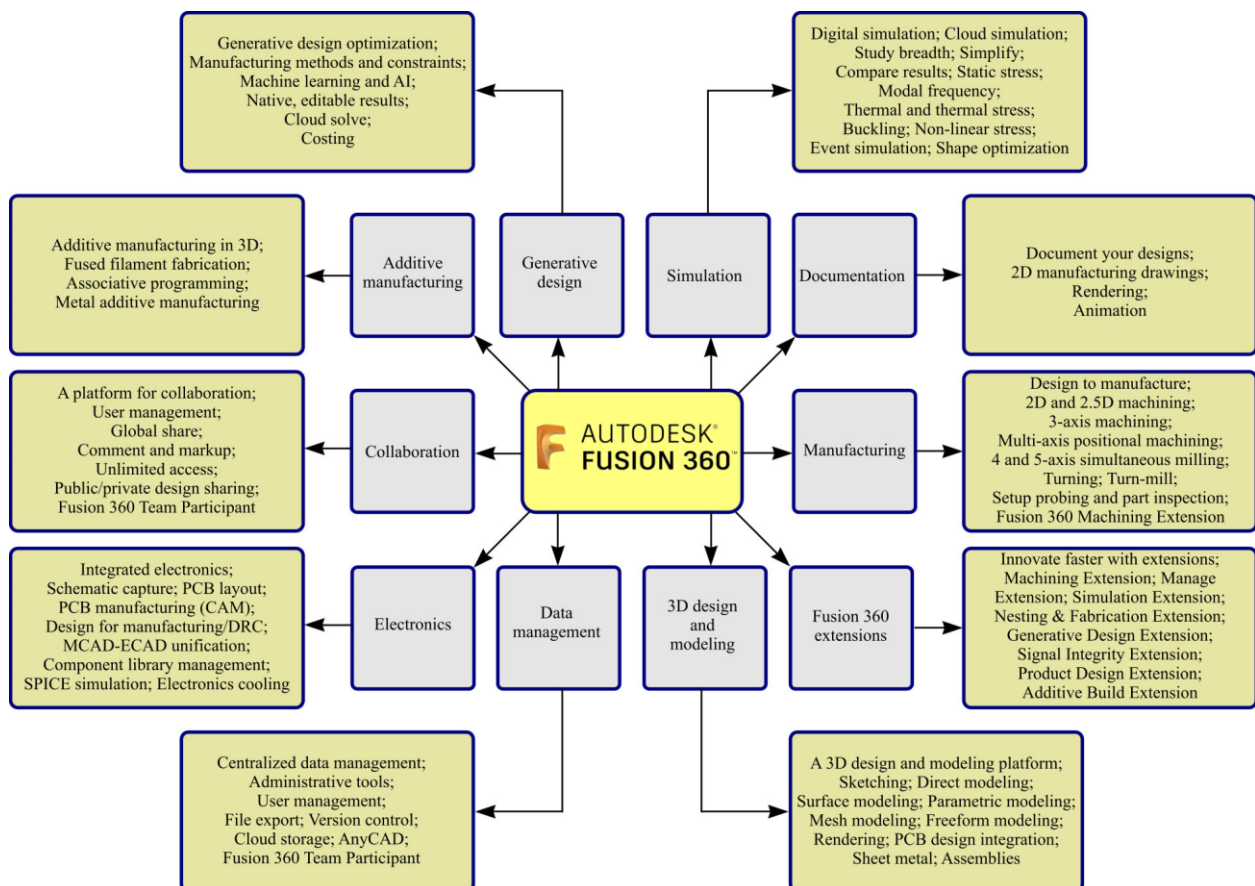The functionality of the Autodesk Fusion 360 automated projecting system is shown in Fig. 2 [36].

Fig. 2. The functionality of the Autodesk Fusion 360 automated projecting system

Conclusions

The performed researches show the following:

- development of the modern enterprise of the machine-building industry is impossible without the introduction of innovative technologies of automation and robotization of production;

- the comprehensive Autodesk Fusion 360 automated design system, thanks to its powerful functionality, fairly democratic value in comparison with the closest competitors and the use of cloud technologies, fully meets the

modern requirements of small and large machine-building enterprises of the world wide level and can be implemented in the technological process of typical production of machine-building industry.

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