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Modern CAD/CAM/CAE Systems: Brief Overview

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Abstract*—The article provides an overview of generalized CAD classification. Attention is focused on application of CAD / CAM / CAE in instrumentation. As result, 8 main criteria for choosing CAD / CAM / CAE instrumentation are proposed. The modern leaders in "medium-sized CAD" market are considered: SolidWorks, Autodesk Inventor, KOMPAS-3D and "heavy CAD" CATIA. Their functionality and features are described.*

Keywords—design; tools; modeling; CAD/CAM/CAE; systems.

1. INTRODUCTION

Global trends in growth of novelty and complexity of industrial products determine high requirements for their quality. CAD / CAM / CAE systems play special role in design of technical innovations (in development of their prototypes or prototyping).

The development and production of instrumentation products is associated with solution of circuitry, design and technological problems [1]-[5].

Within framework of product life cycle (PLC) of instrumentation, computer-aided design (CAD) system solves tasks of automating work at design and production preparation stages based on use of information technologies. The result of design will be complex of technical documentation, which contains full amount of information for production of object.

CAD / CAM / CAE systems of instrumentation direction open up additional opportunities in field of automation of repetitive work processes and solving everyday project tasks, as well as in implementation of projects and coordination of teams with any territorial location.

So, for example, with help of systems for 3D modeling, we can complete projects 50-80 % faster than they would do it when working in 2D. Applying CAD / CAM / CAE systems also reduced cost of products by reducing number of rejects.

At modern level of instrumentation development and devices development, use of CAD / CAM / CAE is simply vital.

2. RELATED WORK

The life cycle of any product – design, preparation for production and production, etc.

The use of CAD for design is described in [6]-[9].

In [6], use of CAD programs for design of special tools in adhesive technologies is described. The authors present technique for creating equipment that allows one to study adhesives cured by UV rays.

The use of CAD / CAM for design of metal orthodontic appliances is presented in [7]. Finite element analysis of actual Hyrax instruments was performed by authors to ensure that print media used in combination with selected design will withstand the stress generated during activation.

The use of three industrial CAD models of different levels of complexity is described in [8].

The internal structure of models is analyzed and comparison is made of reliability and flexibility of models when changing geometry.

The design of shaft driving elements in rear axle gearbox is discussed in detail in [9]. Strength modeling has been carried out.

The latest advances in CAD / CAM / CAE technologies are given in [10]. The authors briefly reviewed use of CAD / CAM / CAE for modeling and analysis of various objects.

In [11], set of CAE computer simulations is presented. Deformation is considered, taking into account estimated local properties of material.

Also, use of CAE for numerical simulation of multi stepped ACS, changing speed and air flow under casing, is presented in [12].

Modeling and implementation of CAD-integrated CADLAB system that automatically identifies and generates variety of data from CAD assembly model in usable forms is discussed in [13]. The authors presented computer implementation of CADLAB using several software packages such as Solidworks, Excel and MATLAB.

The features of CAM using are described in [14]. The authors consider implementation of software for design of parts and elements of machines in Solidworks. The introduction of AutoCAD in manufacture of technical equipment parts is considered.

In [15], method for automatic programming of CNC machines using special machining templates built into CAM program is presented.

A complete overview of CAD / CAM features is given in [16].

3. MODERN CAD/CAM/CAE SYSTEMS

Modern CAD / CAM / CAE – systems for various purposes and are part of technically complex design and production complexes. The common thing is that at present it is customary to divide them into engineering graphics systems (CAD), engineering calculation systems (CAE), and preparation automation and production management (CAM) systems (fig. 1).

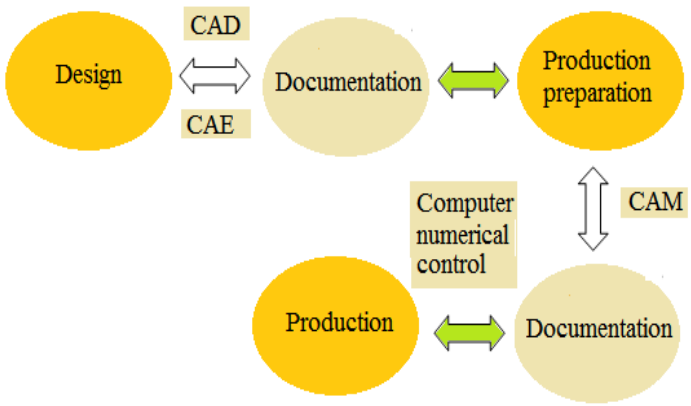

Figure 1: Interaction of CAD / CAM / CAE at design, pre-production and manufacturing stages

There are number of CAD / CAM / CAE classifications:

- by functional purpose;
- by specialization;
- by technical organization;
- by formalization degree of tasks being solved;
- by automation degree;
- by complexity of automation, etc.

This diversity is due to advantages of using systems:

- designing based on 2D and 3D models, that is, reducing design time and minimizing design errors;
- effective interaction of all project participants;
- centralized data storage, project management and consistency of changes;
- reducing cost of manufacturing objects and improving their quality.

At same time, development times are rapidly decreasing, while requirements for product quality remain as high.

In order to choose CAD / CAM / CAE, features of electronic structure formation of complex in instrument engineering are important. In course of analysis of complex instrumentation products structure, it was determined that all industrial products are divided into four types: parts, assembly units, complexes and sets.

The variety of instrumentation products is created as result of their various combinations and quantities, taking into account corresponding hierarchy (level of entry) [17].

In course of analysis, we highlight main criteria for choosing such systems:

- functionality;

- presence of unique functions;

- compatibility of working subsystems at hardware-software and information levels;

- price;

- best possible requirements for necessary machine resources;

- simplicity of interface and ease of training;

- "convenience" when assembling various devices;

- "convenience" when unrolling sheet products.

The working window of SolidWorks during creation of product from sheet metal is shown in fig. 2.

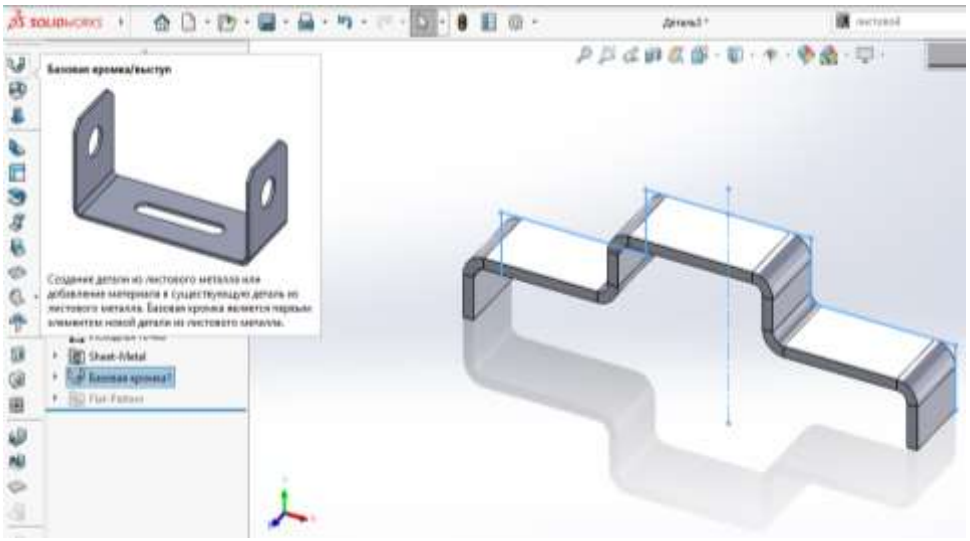

Figure 2: SolidWorks working window

There are two main leaders in today's “mid-size CAD” mechanical engineering market: SolidWorks and Autodesk Inventor.

Both systems are intended for three-dimensional parametric modeling of mechanical engineering products and related industries at stages of design and technological preparation of production.

SolidWorks and Autodesk Inventor have wide range of tools for "convenient" user experience and make it possible to develop projects of any complexity.

Let's start our review with SolidWorks – "mid-level" CAD system. Three-dimensional software package for automation of design work of industrial enterprise. The developer is Dassault Systemes.

SolidWorks has long been successfully used in instrumentation for mechanical design, documentation, project management, technology preparation.

SolidWorks has sufficient functionality and versatility – it expands possibilities for three-dimensional modeling of many electronics developers with relatively high complexity.

The functionality for working with sheet material, wiring cables and harnesses has become quite every day, modules for circuit design and three-dimensional layout are actively developing and being implemented [18].

Features include:

1. Native interface.

2. A large number of add-ons for solving highly specialized tasks.

3. Orientation to both design and technological preparation of production.

4. The ability to customize design of drawings and models in accordance with different standards, including unified design documentation systems (UDDS).

5. Recognition and parameterization of imported geometry.

6. Deep integration with AltiumDesigner.

7. Integration with SolidWorks PDM system.

The latter is important, since product structure is not created using CAD tools and is then transferred to Product Data Management (PDM), but PDM itself is means of forming product structure (electronic product structure) after which it is transferred to CAD. It is also important to preserve associative relationship between documents and mathematical model itself.

When using SolidWorks in field of instrumentation, it was determined that work of professionals in various fields, organized in single environment, radically improves result, makes design process transparent for both performers and management, minimizes blunders and makes it easier to find culprit in non-obvious situations [18].

The second system is Autodesk Inventor.

Autodesk Inventor is 3D CAD system that contains complete set of flexible tools for 3D instrument design, product analysis, tooling and design data exchange.

Inventor is digital prototyping technology based on highly accurate 3D model that allows design, visualization and analysis of products even before first sample is produced [19], [20].

Inventor, like SolidWorks, provides functionality for designing, editing and documenting both finished products after bending and flat patterns associated with sheet metal products.

Instrument layout in Inventor can be organized in different ways: top-down or bottom-up design method.

The working window of Inventor during creation of product from sheet metal is shown in fig. 3.

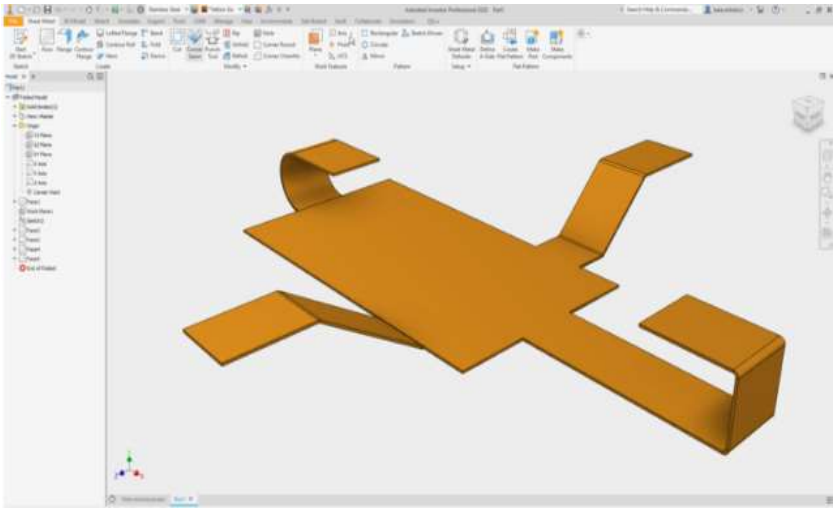

Figure 3: Inventor working window

Features include:

1. Ample opportunities for product design:

- solid models;

- surfaces;

- networks;

- free forms;

- direct and hybrid modeling tools.

2. Support for different assembly design methods:

- ascending;

- descending;

- wireframe modeling.

3. The ability to integrate Autodesk Inventor with InventorCAM "gives" high-quality tool for developing control programs for CNC machines.

4. Engineering calculations:

- dynamic;

- strength;

- calculation of brazed, welded, riveted, bolted joints, etc.

5. The ability to use "cloud" storage and work with public documents in "cloud".

6. Functions for working with large assemblies.

Instrumentation and robotics are among largest branches of mechanical engineering that have gained in importance over years.

The most promising mechanical engineering CAD systems include: SolidWorks, Autodesk Inventor, KOMPAS-3D, CATIA.

KOMPAS-3D is system for parametric modeling of parts and assemblies, which are used in mechanical engineering, instrument making and construction industries. The developer is ASCON company [21].

KOMPAS-3D is standard for thousands of enterprises, combining ease of learning and ease of use with powerful functionality of solid and surface modeling.

KOMPAS-3D is widely used for design of products of main and auxiliary industries in such industries as mechanical engineering (transport, agricultural, energy, oil and gas, chemical, etc.), instrument making, aircraft engineering, shipbuilding, machine tool building, car building, metallurgy, industrial and civil engineering, consumer goods, etc.

KOMPAS-3D in instrumentation will allow:

- automatic creation of cables and harnesses 3D models, taking into account number and diameter of conductors passing along routes;

- automatic creation of harness assembly drawing and specification.

KOMPAS-3D in course of product creation is shown in fig. 4.

At the end of 3D models development, IDF file is exported to KOMPAS-3D.

Features include:

1. Simple and intuitive interface.

2. Using three-dimensional core of our own design (C3D).

3. Full support of state standard (SS) and UDDS in design and execution.

4. A large set of add-ons for design of individual sections of project.

5. Provides support for most common formats of 3D models (STEP, ACIS, IGES, DWG, DXF), which allows you to organize effective data exchange with related organizations and customers using any CAD / CAM / CAE-systems in their work.

There are, perhaps, no obvious advantages of KOMPAS-3D over other systems in terms of provided capabilities.

KOMPAS-3D has specialized modules that allow you to work in field of architecture and instrumentation.

Let us briefly pay attention to KOMPAS Electric module for design of electrical equipment in which wiring is used. If from point of view of instrumentation, then work with connection of device parts inside case or connection between different devices, but difference is that work is carried out with detachable connections.

The features of KOMPAS Electric include:

- ability to basic capabilities of KOMPAS-3D use;

- integration with ASCON products;

- technical support.

There is also KOMPAS-3D set: Instrumentation.

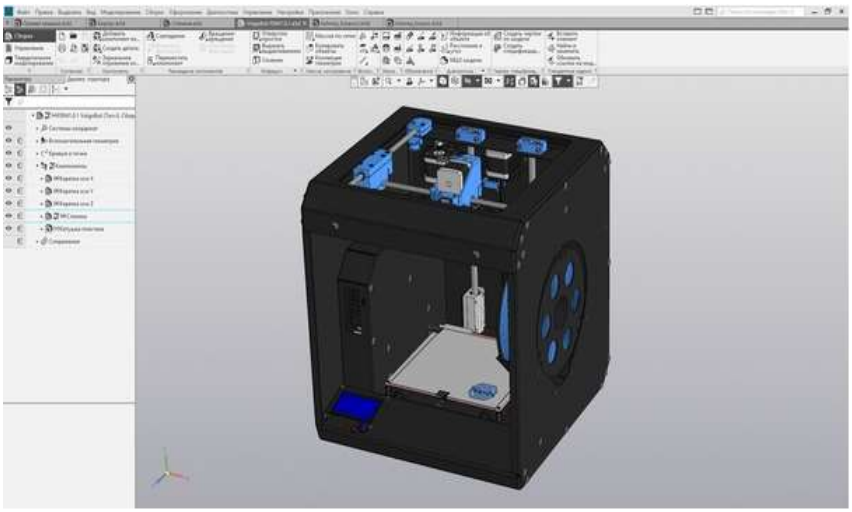

Figure 4: KOMPAS-3D working window

Possibilities:

- set that solves problems of designing all kinds of electrical appliances and devices, such as alarm and control systems, frequency converters, sensors, logic modules and cable systems, etc.;

- development of printed circuit boards;

- design of automation unit;

- construction of intra-instrument and inter-instrument connections;

- paperwork.

The cost of KOMPAS-3D set: Instrumentation is significantly lower than cost of KOMPAS-3D.

CATIA (Computer Aided Three-dimensional Interactive Application) is world leader in software products that support design and innovation.

A computer-aided design system from Dassault Systems, focused on design of difficult complex products, primarily in field of aircraft and shipbuilding.

Around the world, thousands of different companies are using virtual design features created with CATIA products [22], [23].

This is integrated computer-aided design (CAD), technological preparation of production (CAM) and engineering analysis (CAE) system, which includes advanced 3D modeling tools, subsystems for software simulation of complex technological processes, advanced analysis tools and single database of text and graphic information [22], [23].

The system allows you to effectively solve all tasks of technical preparation of production – from external (conceptual) design to release of drawings, specifications, wiring diagrams and control programs for CNC machines.

A system for describing product and its modeling at different stages of life cycle.

Let's briefly present some configurations of CATIA:

- CATIA – Drafting (contains tools for generating drawing and graphic documentation in accordance with most widely used standards. Includes number of interfaces, including interface in CAD / CAM format);

- CATIA – Mechanical (3D modeling of parts and assembly units, as well as for formation of drawing and graphic documentation. Includes ability to obtain realistic images (rendering) in real time, supports most widely used drawing standards. Includes number of interfaces, including an interface in format CAD / CAM systems);

- CATIA – Mechanical Engineering (3D modeling of parts and assembly units, as well as for formation of drawing and graphic documentation. Visual strength testing functions allow testing parts at early stages of design. Supports rendering. Includes number of interfaces, including interface in CAD format / CAM systems).

Working window during product creation is shown in fig. 5 [24].

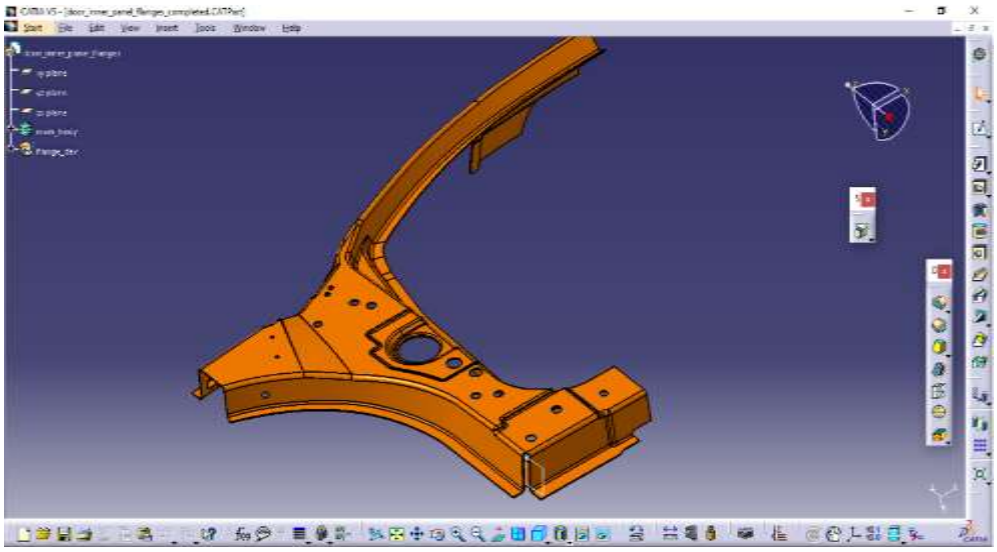

Figure 5: CATIA working window

CATIA products: 3DEXPERIENCE CATIA and CATIA V5.

3DEXPERIENCE CATIA includes over 60 roles in design, engineering and systems engineering.

Let's pay special attention to 5th version of CATIA.

Today CATIA V5 is still only system of this class that was created specifically for Windows platform.

The peculiarity of CATIA V5 is its division into platforms P1 (middle-end class solution), P2 and P3 (high-end class solutions), which is due to division of CAD into high-end (heavy CAD), middle-end (medium CAD) classes, low-end (lightweight CAD).

The features of CATIA include:

- user-friendly interface;

- convenient system for displaying assembly structure;

- excellent design system for bent sheet metal parts;

- convenience of joint design (if more than 1 developer is involved);

- functions of working with surfaces are perfectly implemented.

If we compare SolidWorks and CATIA, although these are systems of different levels, then in SolidWorks there is less functionality for tracing and simpler organization of module.

After analyzing sources [7]-[9], [11], [12], we can conclude that SolidWorks is most optimal solution (fig. 6).

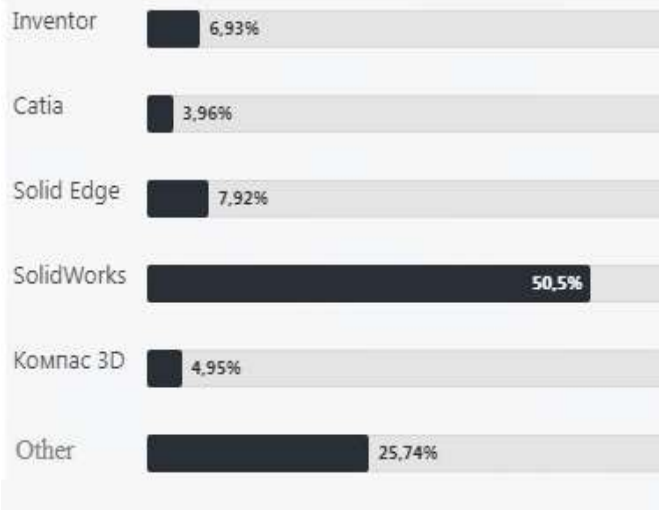

Figure 6: The most optimal solution among modern CAD systems

It was also determined that the "most part" of CAD systems falls on CAD / CAM systems for design preparation of production, third part of CAD / CAE for performing and analyzing calculations, and only one seventh of all systems introduced into domestic production belongs to systems of automated technological preparation of production [25].

4. Conclusion

The article provides an overview of generalized CAD classification. Attention is focused on application of CAD / CAM / CAE in instrumentation.

Modern CAD / CAM / CAE instrumentation providing automation has multi-module structure. Modules differ in their orientation towards certain types of devices and structures.

As result, 8 main criteria for choosing CAD / CAM / CAE instrumentation are proposed.

The modern leaders in "medium-sized CAD" market are considered: SolidWorks, Autodesk Inventor, KOMPAS-3D and "heavy CAD" CATIA. Their functionality and features are described. Such overview not only reveals key capabilities of CAD, but will be prerequisite for choosing rational system. A properly selected system can prevent increase in development time, and possibly eliminate duplication of developer actions.

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