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USING COMPUTER-AIDED DESIGN AND TECHNOLOGY TO AUTOMATE THE CREATION OF DRAWINGS FROM 3D MODELS

В. Тігарєв, О. Лопаков, В. Космачевський, В. Доценко. **Використання комп'ютерного проектування виробів та технологій при автоматизованому формуванні креслеників з 3d моделей.** Впровадження використання комп'ютерного проектування виробів та технологій для автоматизації створення креслеників полягає в тому, щоб заощадити час і надати інженерам і дизайнерам можливість зосередитися на завданнях високої цінності. Автоматизуючи створення креслень, Fusion звільняє команди дизайнерів, щоб вони могли витрачати більше часу на інновації та вирішення проблем, а не на повторювані завдання. Автоматизація комп'ютерного проектування виробів та технологій на основі штучного інтелекту дозволяє їм задовольняти ці вимоги без шкоди для якості. Можливість швидко створювати 2D-креслення також допомагає забезпечити точне донесення задуму про проект до виробничих команд. Це зменшує потенційні затримки та непорозуміння під час виробництва. Ключовою перевагою можливостей штучного інтелекту Autodesk Fusion є її безперешкодна інтеграція з хмарним середовищем платформи. Fusion служить центральним центром для даних, дозволяючи командам дизайнерів і виробничих компаній працювати з найактуальнішою інформацією. Це надзвичайно важливо в той час, коли дані є одним з найцінніших ресурсів у галузі. Для більш досконалого розуміння процесу та технології автоматизованого формування креслеників нами запропоновано блок схему автоматизованого формування креслеників у Fusion. Блок схема автоматизованого формування креслеників у Fusion складається із трьох основних частин: формування креслеників окремих деталей, формування креслеників складань, створення шаблонів. Кожна частина блок схеми складається з окремих елементів, які пояснюють сутність кожного з блоків. Наведені приклади використання блок схеми для автоматизованого формування як окремих креслеників різного типу так і креслеників складального вузлу повністю.
Ключові слова: комп'ютерне проектування виробів та технологій, автоматизація формування креслеників, штучний інтелект, Autodesk Inventor, Fusion

V. Tigariev, O. Lopakov, V. Kosmachevskiy, V. Dotsenko. **Using computer-aided design and technology to automate the creation of drawings from 3D models.** The adoption of computer-aided design and technology to automate the creation of drawings is to save time and allow engineers and designers to focus on high-value tasks. By automating the creation of drawings, Fusion frees design teams to spend more time innovating and solving problems, rather than on repetitive tasks. AI-based computer-aided design and technology automation allows them to meet these demands without compromising quality. The ability to quickly create 2D drawings also helps ensure that the design vision is accurately communicated to production teams. This reduces potential delays and misunderstandings during production. A key advantage of Autodesk Fusion's AI capabilities is its seamless integration with the platform's cloud environment. Fusion serves as a central hub for data, allowing design teams and manufacturing companies to work with the most up-to-date information. This is extremely important at a time when data is one of the most valuable resources in the industry. For a better understanding of the process and technology of automated drawing generation, we have proposed a block diagram of automated drawing generation in Fusion. The block diagram of automated drawing generation in Fusion consists of three main parts: drawing generation of individual parts, drawing generation of assemblies, and template creation. Each part of the block diagram consists of separate elements that explain the essence of each of the blocks. Examples of using the block diagram for automated generation of both individual drawings of various types and drawings of the assembly unit as a whole are given.
Keywords: computer-aided design of products and technologies, automation of drawing generation, artificial intelligence, Autodesk Inventor, Fusion

Introduction

In today's fast-paced world of engineering and design, efficiency is everything. Computer-aided design (CAD) tools have evolved rapidly, and with them comes a powerful revolutionary tool: CAD automation. Whether you are an architect, mechanical engineer, or product designer, CAD automation can significantly reduce manual tasks, increase accuracy, and optimize your entire workflow. Currently, the industry is undergoing a process of active integration of automated solutions for creating technical documentation, in particular drawings, based on three-dimensional models. Such tasks are driven by the ever-increasing demands for speed of project execution, high accuracy of technical information, and the need to minimize human error. CAD automation involves the use of scripts, macros, or software tools that automatically generate or modify CAD drawings and models. Instead of manually

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drawing each line, curve, or component, CAD automation allows repetitive or complex tasks to be performed with minimal human intervention. The development of computer-aided design tools and technologies has greatly simplified and accelerated the design process. Automation can include anything from automatically updating part numbers on a drawing to creating complete assemblies based on predefined parameters. This not only saves time but also increases accuracy. However, there are serious challenges associated with adapting software to work with complex geometric shapes and ensuring flexible configuration of drawings in accordance with various standards and requirements of a specific project.

The problem lies in the need to develop a clear understanding among specialists of the functionality of automated drawing generation tools for optimal and well-informed selection and use in work on projects of various types.

Analysis of recent studies and publications

The topic of automating the creation of drawings from three-dimensional models is relevant both in industry and in scientific research. Recent publications in this field focus on improving algorithms for processing geometric shapes, optimizing design processes, and integrating artificial intelligence to solve complex technical problems.

The study [1,2] examines the features of solid modeling and the creation of technical drawings in the Autodesk AutoCAD and Autodesk Inventor software environments. A comparative analysis of the processes of modeling and drawing design is provided, emphasizing the advantages of Inventor in creating volumetric models with threaded connections, automating the construction of drawings, and applying dimensions in accordance with standards. Autodesk Inventor provides a higher level of automation and convenience when working with complex models. Work [3] investigates the effectiveness of modern software for automating the creation of drawings from three-dimensional models, which is a relevant task for the engineering and architectural industries. The main focus is on analyzing the capabilities of AutoCAD, SolidWorks, and Fusion. The work [4, 5] considers the issues of expanding the capabilities of computer modeling and adapting the tools of the corresponding software packages for the development of design documentation in accordance with standards, in particular, in the Autodesk Inventor package environment. In the work [6, 7, 8], one of the most important results is the creation of 2D drawings. It can be sent and distributed using various output options, such as printed and digital formats (DWG, PDF, DWF, etc.). Creating a 2D drawing in the Autodesk Inventor environment can be done manually by the user, programmatically using codes, or using a combination of manual data entry and automation. The latter option is very common, where codes perform some repetitive tasks and the user completes what is missing in the drawing. Source [9] is dedicated to the Autodesk Inventor ADC software application. ADC (Automatic Drafting Constructor) introduces innovative concepts to the drafting process, extending the capabilities of Inventor and enabling creators to reach new heights. When ADC is used with an assembly node, it is possible to choose to create drawings for all assembly levels. This means that it is possible to include every document in the assembly, only the first level of the assembly, or only the current assembly document. ADC understands the specification, guiding the creation of the necessary drawings and providing the freedom to adjust settings according to the task. Work [10] discusses the creation of technical drawings. Autodesk Fusion revolutionizes the creation of drawings with automated dimensioning, view generation, and artificial intelligence features that optimize the process, reduce errors, and improve collaboration between teams.

Source [11] is a Fusion system reference element. Drawing automation is a powerful automated process that quickly generates 2D drawings from your designs in the Fusion Drawing workspace. To get the most out of drawing automation, you need to configure templates. Sources [12 – 15] are dedicated to three AI-based features that have appeared in Autodesk Fusion: Sketch AutoConstrain, Automated Drawings, and Autodesk Assistant. Autodesk Assistant is currently a product support chatbot. Fusion Automated Drawings takes a 3D model and generates 2D drawings of the entire assembly and each of its parts. This core functionality is based on user templates and heuristics, but Autodesk has now included some AI-based features. The tool now includes an artificial intelligence model that scans geometry to classify standard fasteners and exclude them from drawings. Work [16-18] is dedicated to customization features in the Autodesk Fusion automatic drawing template file. The system creates drawings with corresponding views and dimensions based on the 3D model of the project. By default, they will include a drawing sheet with an ISO view and a parts list (if it is an assembly), as well as a sheet with orthographic views and dimensions. It is also possible to create drawing sheets for each component of the assembly.

Based on the analysis, we conclude that the use of computer-aided design technologies and technologies for automating the process of creating 2D drawings from 3D models is highly relevant and strategically important for the further development of engineering design and related industries.

The purpose of the study

The purpose of this study is to conduct a comparative analysis of the capabilities of AutoCAD, Autodesk Inventor, Fusion software, and algorithms used in the automation of flat drawing creation based on three-dimensional models. The study aims to determine their level of efficiency based on key parameters such as processing speed, adaptation to complex shapes, and flexibility in drawing configuration. The results obtained will allow us to form a block diagram of automated drawing generation in Fusion for performing various types of tasks depending on the requirements for geometric complexity, accuracy, and ease of adaptation of technical documentation.

Materials and methods of the research

Modern computer-aided design of products and technologies in industry is increasingly focused on automating the process of creating drawings of various objects. These objects can be both engineering structures and architectural units. The need for faster project execution, minimization of the human factor, and increased efficiency in working with large volumes of technical information are among the priority requirements of industry. Nowadays, engineers, designers, and architects first develop a three-dimensional model of an object and then use it as a basis for developing technical documentation, including the corresponding drawings. This has become possible with the development of computer modeling tools.

The process of converting three-dimensional models into flat drawings depends not only on the features of the software itself, but also on the algorithms implemented in these systems. Our study evaluates the capabilities of AutoCAD, Autodesk Inventor, Fusion, and algorithms for performing such tasks.

AutoCAD uses basic algorithms for converting three-dimensional objects into two-dimensional projections based on the principles of projection geometry. These algorithms enable the rapid creation of drawings with clear lines and simple geometric shapes. This tool is best used for creating drawings of a single part, but AutoCAD’s functionality is not sufficiently developed for converting assembly units. Limitations in working with curved surfaces or complex polygonal objects significantly narrow the scope of AutoCAD’s application in tasks where detailed complex shapes are required.

Autodesk Inventor uses more advanced algorithms for generating projections, including spline interpolation algorithms, which allow for accurate representation of curved elements and roundings. In addition, the system integrates methods for automatically creating cross-sections and displaying the internal geometry of the model, which significantly increases the accuracy and detail of flat drawings. Thanks to its support for parametric models, Autodesk Inventor adapts to changes in a three-dimensional object, automatically updating the corresponding drawings.

Fusion combines the advantages of projection geometry algorithms and cloud computing. Using computer graphics methods to create two-dimensional views, Fusion can quickly process even complex models. The system’s algorithms are optimized for working with curved and organic shapes, making Fusion a versatile tool for a variety of tasks. Autodesk Fusion’s AI-powered automated drafting feature automates what used to be a tedious and time-consuming part of the design process. After analyzing a 3D model, the AI system automatically generates the necessary 2D views, dimensions, and other details required to manufacture the part. This speeds up the workflow and reduces the likelihood of errors that often occur due to manual input. AI doesn’t just generate drawings; it intelligently decides which details are necessary and which can be omitted. It can identify fasteners or other components that do not need to be included in the final set of drawings. The result is an optimized set of drawings ready for production, without the need for excessive manual editing. The software’s ability to work with complex shapes in the context of converting three-dimensional models into flat drawings is determined by its ability to accurately and efficiently process models with complex geometry. Such shapes include objects with complex curved surfaces, multi-layered structures, detailed textures, internal structural elements, and irregular organic contours. Effective software for such tasks uses modern algorithms, such as curve interpolation, surface approximation, or volumetric sectioning. In particular, Autodesk Inventor uses spline algorithms to create accurate projections of curved surfaces, while Fu-

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sion provides high-quality processing of organic shapes through the use of powerful computational methods. AutoCAD, on the other hand, has limited capabilities when working with complex shapes, as its functionality is primarily focused on processing basic geometric elements.

Flexibility in drawing customization is defined as the ability of software to provide users with advanced capabilities for adapting two-dimensional graphics to specific project requirements. This includes customizing the appearance, style, and format of drawings in created templates, as well as modifying parameters created automatically based on a three-dimensional model. One important aspect is the ability to change drawing standards, which allows the software to support a variety of technical standards and adapt to the requirements of a specific project. Flexibility also includes control over the level of detail, in particular the adjustment of the visibility of drawing elements such as hidden or axis lines, as well as cross-sections. Another important factor is the support for exporting drawings to various formats, such as DWG, DXF, or PDF, which ensures convenient data transfer for further work. Software solutions such as Autodesk Inventor and Fusion demonstrate high flexibility thanks to the ability to automatically create standard drawings with subsequent manual editing, such as changing the scale, projection location, or adding text notes or specification tables.

However, less flexible systems, such as AutoCAD in its basic configuration, limit the user's capabilities, which often leads to the need to perform a significant amount of manual work to adapt drawings to the requirements of a specific task. As part of research into the use of computer-aided design of products and technologies in automated drawing generation, a block diagram for automated drawing generation in Fusion using AI was developed. The block diagram allows you to analyze the processes of generating drawings of varying complexity and creating templates to accelerate and expand the capabilities of automated drawing generation. The proposed block diagram is shown in Fig. 1.

The block diagram of automated drawing generation in Fusion consists of three main parts:

1. Generation of drawings for individual parts;
2. Creation of templates;
3. Generation of assembly drawings.

Each part of the block diagram consists of separate elements that explain the essence of each block.

Let's look at each part of the block diagram separately.

The creation of drawings for individual parts is discussed in the first part of the block diagram:

a) automatic placement and scaling of views;
b) automatic rotation of components to the best orientation;
c) automatic breaking of long components;
d) application of center lines and marks;
e) automatic scaling of views and placing them on a sheet;
f) moving overlapping dimensions and changing their order;
g) placement of flat sheet metal templates, bend tables, and identifiers.

These features allow you to create drawings of individual parts of various types and levels of complexity.

The creation of assembly drawings is explained in the third part of the block diagram:

a) automatic placement of drawing sheets for each component in the model and scaling of views;

b) shows dimension strategies in a "generative" style. These dimensions are categorized into broad categories: Base Line, Chain, Symmetrical, and Ordinate;

c) generation of parts lists and positions for assemblies;

d) automatic ignoring of components from the skip list;

e) use artificial intelligence to identify fasteners: nuts, bolts, and washers in assemblies and exclude them from the drawing package;

f) components modeled "in place" require named views for easy detailing using traditional workflows;

g) drawing automation allows you to ignore standard fasteners from the Autodesk fastener library and also ignores components in the "Skip" list (based on the component name);

h) uses advanced artificial intelligence to identify nuts, bolts, and washers in assemblies and excludes them from the drawing package;

i) the use of computer-aided product design and technologies in automating the creation of a set of individual drawings and an assembly drawing performs 60…80% of the work on documenting.

The steps required to create and configure a template file are explained in the second part of the flowchart.

A template file with preconfigured drawing standards, basic inscriptions, and basic views saves time on reconfiguration:

a) create multiple templates for different models or production processes.

b) forming placeholder views, browser nodes, and additional sheets.

c) deleting placeholder views, browser nodes, and additional sheets to convert a “Smart Template” to a “Drawing Template.”

d) create multiple templates with different omission lists.

e) use the omission list to ignore components that do not need to be detailed.

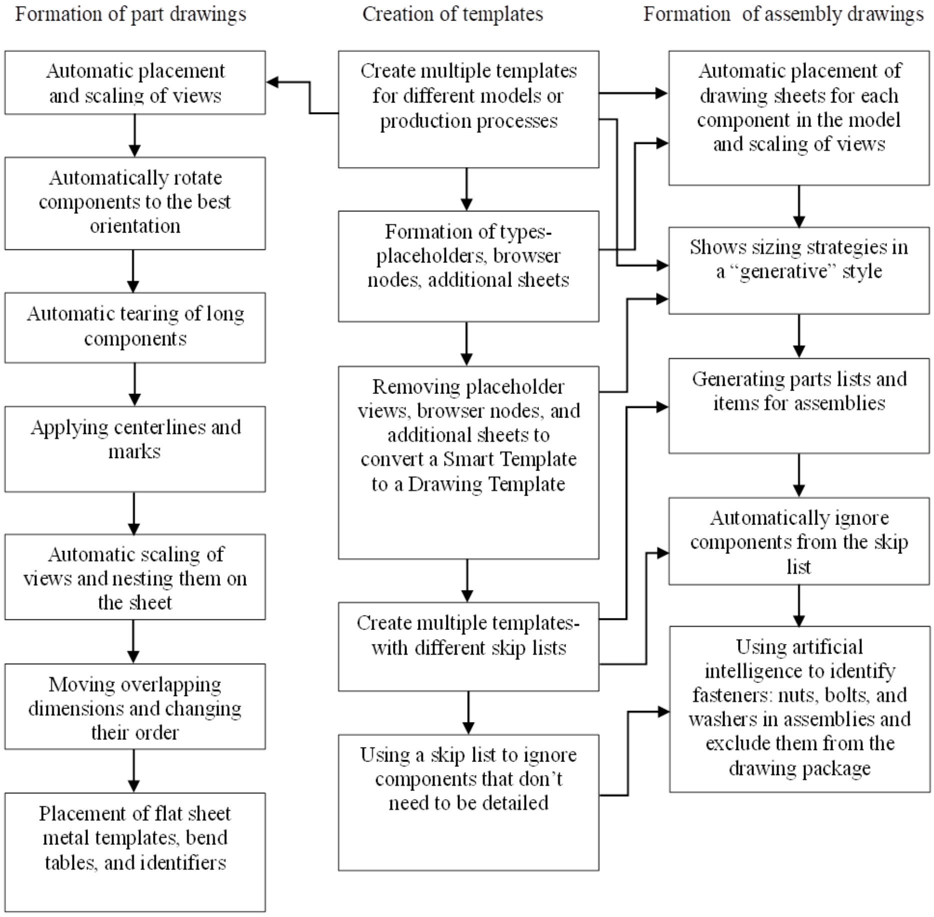

Fig. 1. Block diagram of automated chair formation in Fusion

There are three types of templates: From scratch (Out of the box), Drawing template (user-modified template), Templates based on work processes.

Let’s take a look at each type of template.From scratch. Uses Autodesk default settings. Designed to allow you to “try out” the automation of drawing creation. Drawing templates or Smart templates (outdated – not very suitable for automation). Any template with placeholder views, browser node entries (links or part lists), or additional sheets is considered a smart template. Templates that take into account work processes. They take into account the desired work processes when creating templates, drawing templates, and take into account the template document settings.

Practical implementation

Within the scope of the study, we use the proposed block diagram when testing the specified tools for creating a drawing of a separate part and an assembly node in Fusion. In both examples, the capabilities of automation for creating and designing drawings were used.

Let’s look at the use of computer-aided design and technologies in the automated creation of a drawing from a 3D model of a plate part. To do this, we use the first part of the block diagram. The drawing will be created in accordance with the ISO standard. We use the standard Fusion configuration template. The three-dimensional model of the Plate part is shown in Fig. 2. It was created in a three-dimensional solid modeling environment. We select to create a drawing in the Settings window and set it to Automatic (Fig. 3).

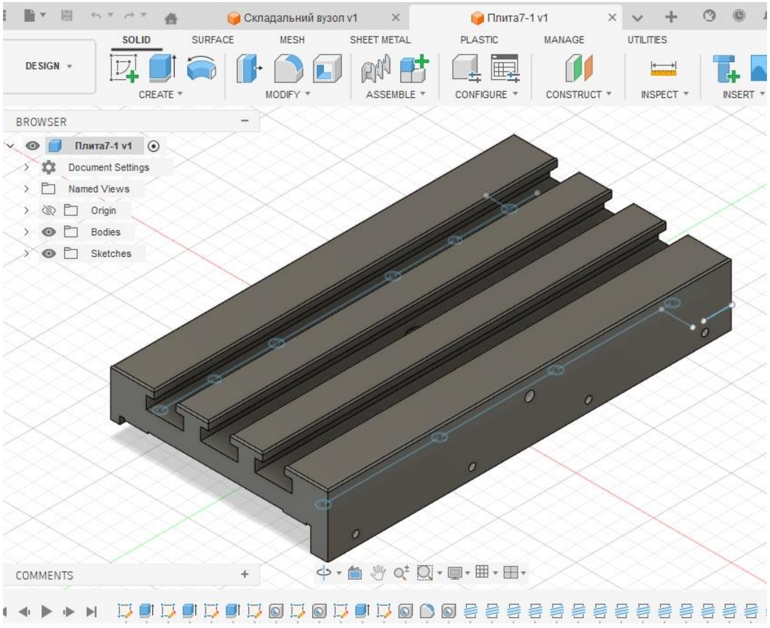

Fig. 2. Three-dimensional model of a part Plate

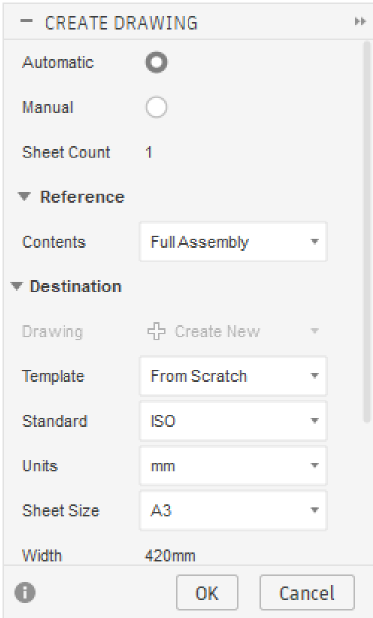

Fig. 3. Setting the parameters

Fusion generates a drawing and offers to select the required type of dimensioning from the table of options. Fig. 4 shows an example of selecting the type of dimensioning on a drawing.

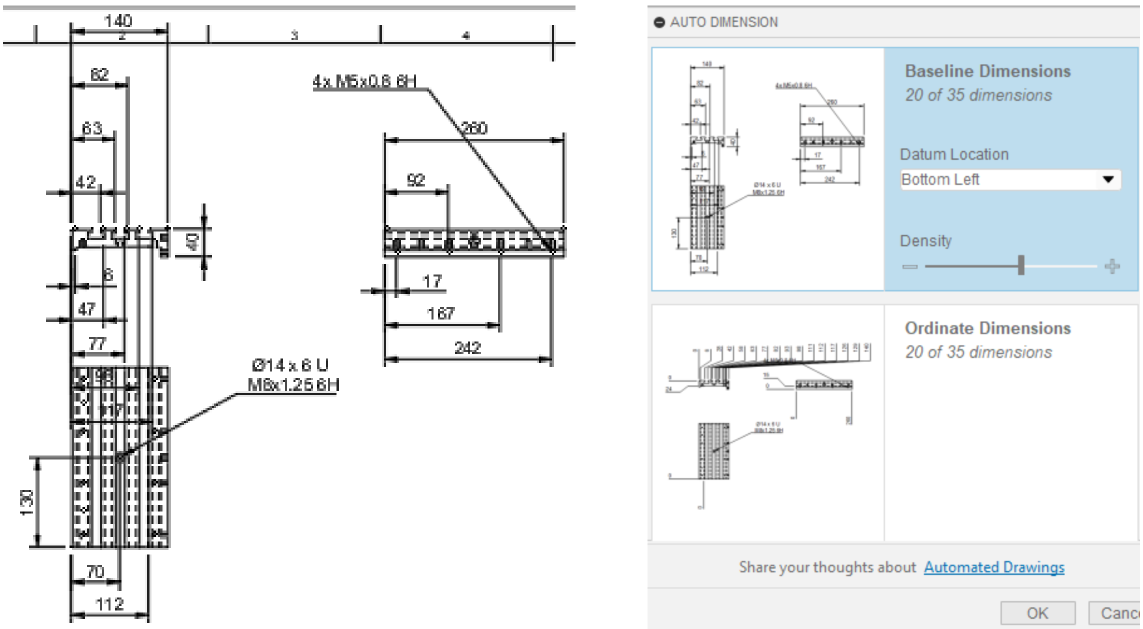

Fig. 4. Selecting the type of dimension formation on the drawing

After selecting the type of dimensions, the final version of the drawing is formed (Fig. 5).

If necessary, you can edit the drawing by adding new types or sections. The automated option for creating drawings significantly speeds up the process and increases the accuracy of document creation.

This procedure can be repeated for other settings and using various templates. If you choose to create the drawing manually, you will need to perform all the actions that the AI performs yourself. Let's consider the option of automated drawing generation from an assembly node based on the third part of the block diagram. When solving this task, it is possible to perform three options for forming drawings: a drawing of a separate part of your choice, an assembly drawing with specifications, or a complete set of drawings for all assembly parts, except for standard and typical parts specified in separate settings. As an example, let's consider the assembly model of a valve pneumatic device. The assembly model of the valve pneumatic device was created from separate part models in a solid modeling environment. After that, all parts were assembled into a separate assembly node. The solid assembly model of the pneumatic valve device is shown in Fig. 6.

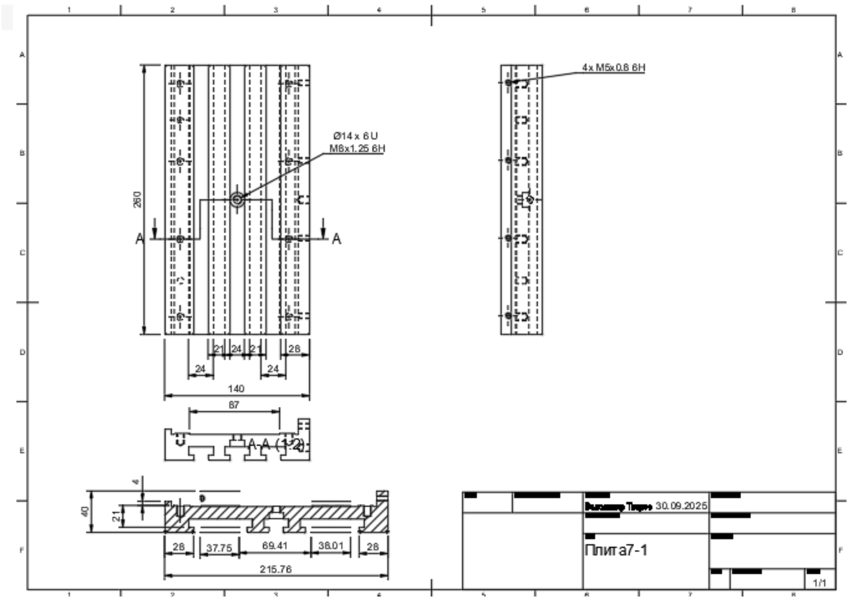

Fig. 5. Drawing of the part Plate

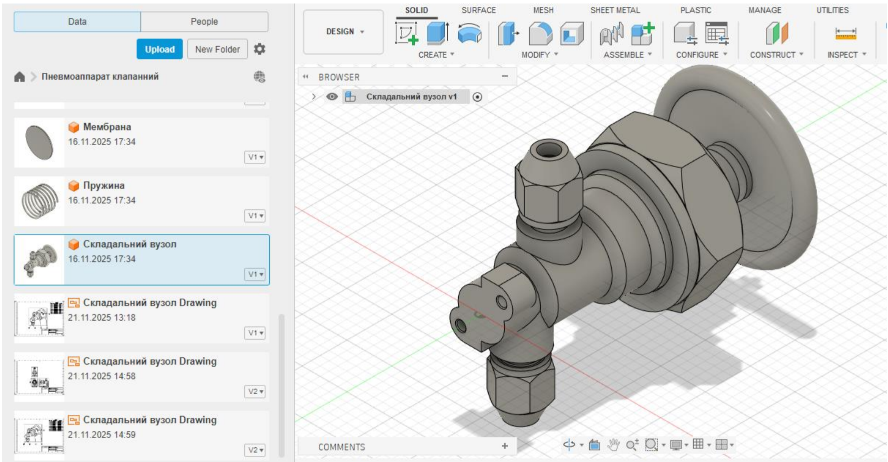

Fig. 6. Solid assembly model of a pneumatic valve device

Fig. 6 shows images of individual parts of the assembly unit in the browser (left side). To select an individual part, select the required part in the graphic area of the assembly tree. It will then be highlighted in a different color, as shown in Fig. 7.

Then repeat the steps as when creating a drawing of a separate part. The drawing of the body part is shown in Fig. 8.

The next task is to create a drawing of the assembly unit from the model. To do this, select the All Assembly and First Level settings, i.e., the entire assembly is shown in Fig. 9. The program generates two drawings: the first is an isometric image with specifications, and the second is a complete drawing of the assembly unit (Fig. 10, Fig. 11). When generating specifications, you need to configure the design template according to the required standard.

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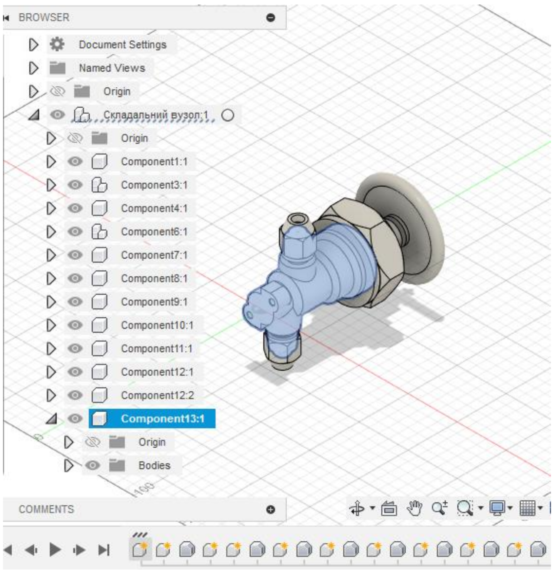

Fig. 7. Highlighting a separate detail in an assembly

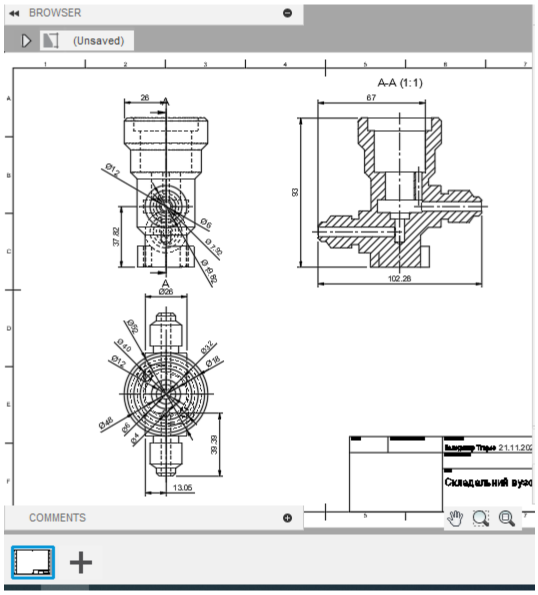

Fig. 8. Detail drawing of the housing

The last option for generating design documentation from an assembly model creates assembly drawings and drawings of all non-standard parts. When configuring the template, you must specify which parts do not need to be drawn; these can be standard parts or typical parts for which drawings already exist. After creating a set of drawings, a row of icons for the created drawings appears at the bottom of the assembly model screen. This allows you to select the desired drawing (Fig. 12) and, if necessary, correct and print it.

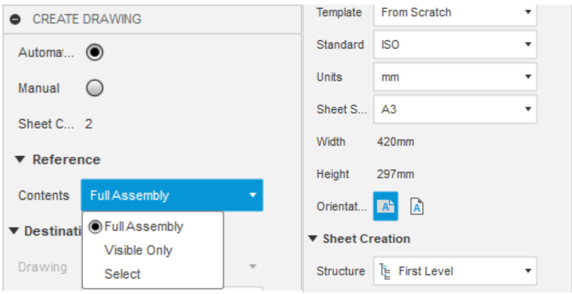

Fig. 9. Settings

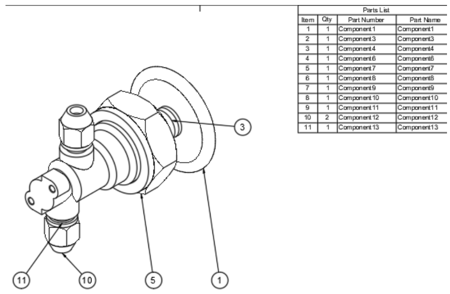

Fig. 10. Isometric image of the assembly with specifications assembly parameters

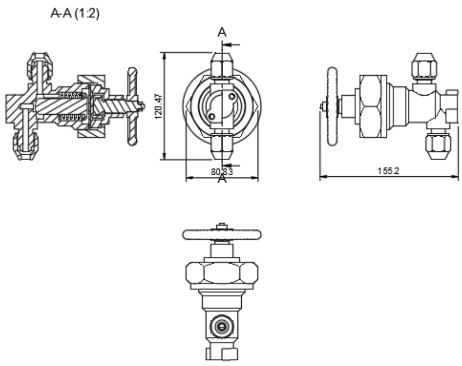

Fig. 11. Drafting of the assembly unit

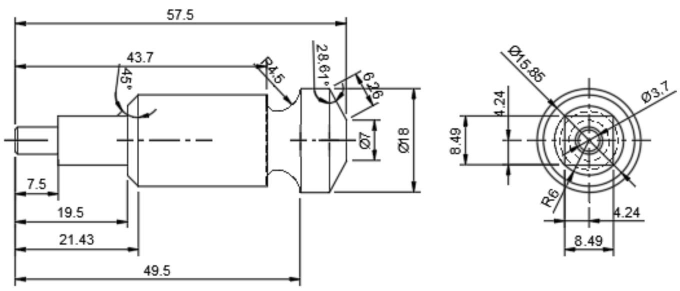

Fig. 12. Detail drawing with a row of pictograms of created drawings

Research results

When analyzing the effectiveness of using the proposed block diagram to accelerate the creation of drawings using automation and AI, the time required to generate documents in automated and manual modes was recorded. The following results were obtained. The drawing of a separate part, the plate, was generated in 32.5 seconds. It took 4 minutes and 25 seconds to create the drawing in manual mode. An assembly drawing consisting of two drawings and specifications was created in 15.6 seconds. In manual mode, it took 3 minutes and 12 seconds. The drawing of a separate simple part from the assembly was obtained in 22.2 seconds, and in manual mode in 1 minute and 35 seconds. A complete set of documentation consisting of 12 drawings of parts and an assembly drawing was generated in 2 minutes and 4 seconds. It took 29 minutes and 34 seconds in manual mode to obtain this set of drawings. The results of the study confirmed the effectiveness of using block diagrams and automating the drawing generation mode.

Conclusions

The paper analyzes the possibility of automated drawing generation from a three-dimensional model in modern CAD systems. The features of drawing generation in AutoCAD, Inventor, and Fusion are considered. Fusion has the greatest capabilities for automated drawing generation. It uses artificial intelligence and a cloud environment to process results for this class of tasks. For a more complete explanation of the technology of automated drawing generation, a block diagram of automated drawing generation in Fusion is proposed. It consists of three parts, which are designed to explain the generation of drawings of individual parts, the generation of assembly drawings, and the creation of templates. The interconnection between the individual elements of the block diagram is shown. An important part is the configuration of templates for high-quality drawing generation, especially for working with assembly units. Using the proposed block diagram, examples of automated drawing generation for a single part and options for working with an assembly node are given. A study was conducted to calculate the time required to generate drawings in automated and manual modes. As a result, a reduction in the time required to generate drawings in automated mode was confirmed. The block diagram can be used to train engineers who use Fusion to speed up the generation of design documentation. Gradually, with the development of new opportunities for using AI to automate work with Fusion, the block diagram will be improved.

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