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AN APPROACH TO CREATING A FLEXIBLE MANUFACTURING MODELING SYSTEM INTRODUCTION

Abstract: In manufacturing, the technologist is faced with tasks that need to be solved as quickly as possible, otherwise severe delays may occur due to the queues or the process to stop altogether. Therefore, fast troubleshooting is the main task of maintaining efficient production. Flexibility allows us to replace quickly defective machines with other machines that are working, to translate the operation of failed vehicles into other vehicles. To detect the error and correct it quickly, a technologist must use a dedicated software environment. In the following we will look at several environments that work with 3D space and have different functions.

Keywords: flexible production modeling systems, PlanReal system, expansion of the functional

1. Formulation of the problem

In the process of flexible production, there are certain problems: unexpected failure of vehicles, sensors, elements in the shops or the need to change urgently the plan of processing parts, which will affect all elements of production. These problems need to be addressed immediately, as any delays can result in disruption of the plan and unforeseen consequences: queues, downtime, trucks, autonomous vehicles and failure to comply with the plan. In order to anticipate some problems or solve problems quickly, you must have software in place to model quickly and adapt your production system, taking into account malfunctions or other types of problems that may arise. Modeling and visualizing the system in virtual space will allow you to see immediately what problems may occur in real production, whether it is possible to solve the problem in some other way, and how to do it in the best way to minimize losses. Therefore, the software should provide full functionality to independently build flexible production in the software environment, namely to solve the following problems:

– location planning of warehouses;

– planning the total number of parts and operations that they need to undergo during the processing;

– modeling of the system of workshops and their location;

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– adding a number of machine tools and autonomous vehicles to each shop;

– the ability to run a simulated system in virtual space;

– displaying the process of processing all the details in the environment and displaying information on them in a separate window table;

– calculating the approximate processing time for each part with a unique set of operations;

– calculating the processing time of a given batch of parts;

– visualization of intermediate and final statistics in various forms.

2. Description of the prototype T-Flex Cad

The first prototype to be considered is the T-Flex Cad program. T-Flex Cad is a professional design system that combines powerful parametric 2D and 3D modeling capabilities with drawing and design tools and documentation. Built on the Parasolid geometric kernel, which is considered to be the best kernel for 3D modeling and is used by more than a million jobs worldwide. The kernel used also integrates with the best overseas design and calculation programs.

Technical innovations, a user-friendly interface and high performance make the program a versatile and effective 2D and 3D design tool. T-Flex Cad has extensive design automation tools, special tools for large builds, a unified documentation structure and the ability to collaborate on a team.

The application allows the user to choose his own style of work: to create fully parametric drawings, to develop non-parametric 3D models, to build parametric models and assemblies in 3D, and then based on them to form 2D-projections or combine these methods in their own opinion. In Fig. 1, the work with the T-Flex application, namely the work with the helicopter model and the program interface.

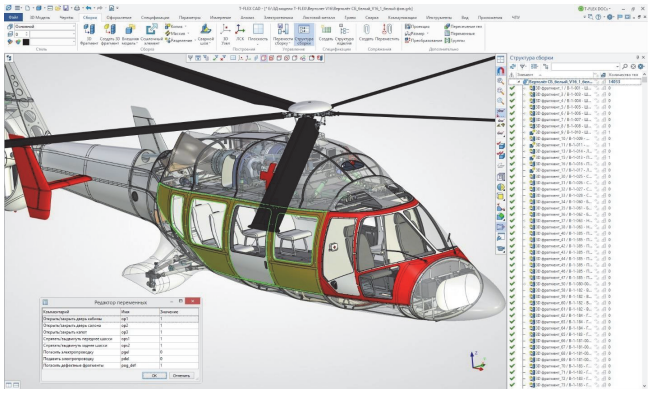

Figure 1. *Working with helicopter model*

The T-Flex Cad graphics subsystem provides powerful 3D rendering speed. With maximum use of video card capabilities, the work of creating large-scale 3D assemblies, even those with hundreds of thousands of details, is not available to owners of both professional and simpler graphics accelerators.

The software environment supports standard design techniques adopted for "heavy" class systems and provides direct work with files such as: Siemens NX, CATIA V4 and V5, Creo (Pro / E), Autodesk Inventor, Solid Edge, SolidWorks, Rhino, Revit and others. This functionality makes it possible to significantly accelerate the process of working with several systems. In addition to its own design systems, T-Flex Cad also supports universal exchange formats: Parasolid, ACIS, JT, STEP AP 242, IGES, 3D XML, IFC and others. Thanks to such functionality, the system works well with any existing information and software structure of modern production.

T-Flex's integrated virtual reality application enables users to not only perform visual analysis of products, evaluate designs, test their ergonomics, but also conduct real-world design in virtual space. While in the VR scene, the user also continues to work with the parametric T-Flex Cad model (Fig. 2).

***Figure 2**. Working with a drone model in T-Flex VR space*

The parametric application technologies allow the high-efficiency user to automate both the design and the process of making changes to the project, resulting in a significant increase in the productivity of engineers and designers.

The industrial system of calendar-network planning and management of production resources is focused on the formation and tracking of different plans-schedules, the solution of tasks of project management, as well as the organization of the project approach to the management of production work at all levels of planning. In terms of network management, the system provides:

– To use in the project any data stored in T-Flex docs stored at different stages of the product life cycle: requirements, product structure, distribution scheme, regulations, technological data and more;

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– To organize related planning vertically (multi-level planning) and horizontally (different presentation of plans, for example, product structure and development stages);

– To build a transparent outline for working with project portfolios, programs, individual projects, and business unit schedules. That is, to cover all the tasks of increasing the timing of programs, orders or projects, taking into account the planned and actual load of resources (Fig. 3).

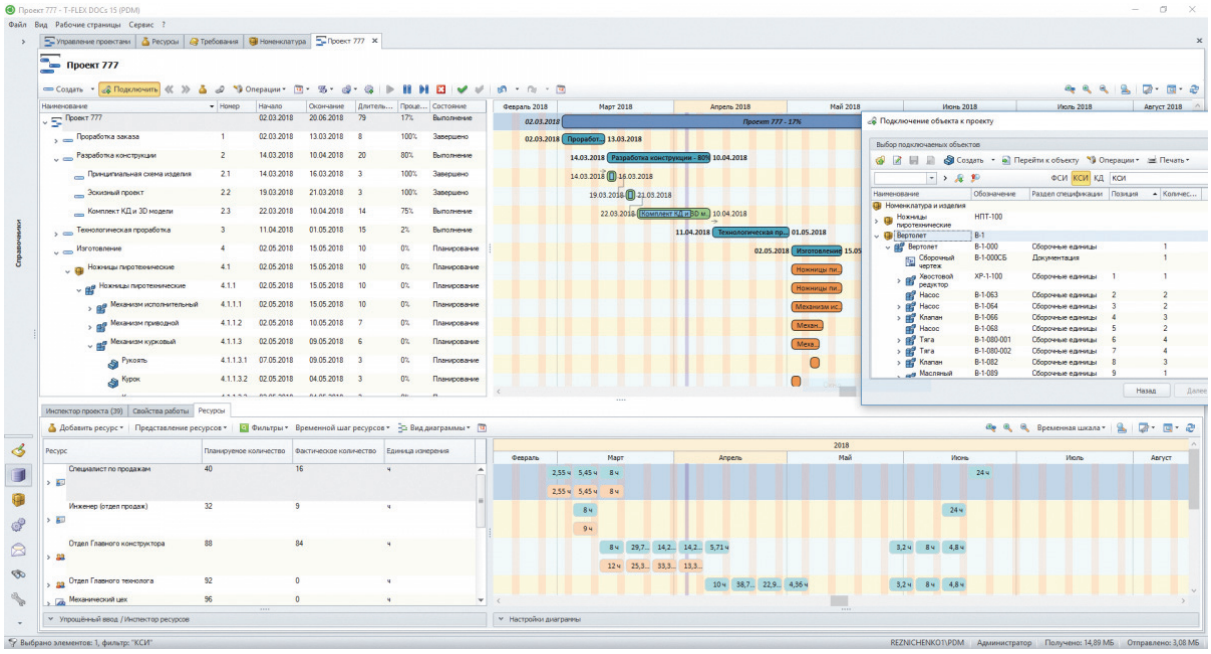

Figure 3. *Project Management, Resource and Cost Planning*

One of the opportunities in project management mode is the organization of teamwork and interaction of project participants and the planning of complexes of related work. The system has settings for role access in projects. For working with product data and any other system data, there is a handy toolkit related to project work. It is possible to configure and schedule unit and contract downloads, to keep track of units and contractors' scheduling. A very important role is played by material planning, work progress tracking, actual timing and resources.

The above system has a very wide range of functionality and capabilities that can help you to solve most of the tasks involved in organizing and managing flexible production systems. T-Flex Cad combines the powerful parametric capabilities of 2D and 3D modeling and solves the tasks of automation of design, robots with large assemblies, modeling of parts, to lead the process of designing electrical and mechanical components of electrical products, calendar-network planning and enterprise resource management.

3. The disadvantages of the prototype T-Flex Cad

However, the T-Flex Cad lacks the tools to model a flexible production system. Namely: there are no tools to create your own flexible production system model. The management function does not allow you to drive autonomous vehicles, it is not possible to set them specific rules and prescribe the algorithm of their movement. When creating a large production model, it is impossible to install workshops, run flexible production modules, and review the production process. There is no toolkit to create a simulation of the transportation of parts between workshops by trucks, to optimally manage these trucks, to create a list of some rules for them. Functionality of T-Flex Cad does not allow to create and run simulation of own GVM both in shops and outside them, does not allow to set algorithm of their work, rules of behavior, to view graphs or tables of their idle time, to collect statistics. There is no functionality available for specifying the interaction between objects, organizing the processing and transportation system of each part, optimizing the movement of trucks and autonomous vehicles, partitioning in shops, transportation and partitioning in warehouses.

4. Description of the prototype PlanReal

PlanReal is a system developed in the Unreal Engine 4 engine that details the work of manufacturing parts processing. The system provides a demonstration of production in 3D, that allows us to see clearly the deficiencies in the location of the objects of the enterprise or the deficiencies in the operation of some automatic features (Fig. 4).

Figure 4. *The process of machining parts in the workshop*

The system creates a simulation of production work in virtual space. The parts are generated, they are given sequential numbers and a set of operations is randomly selected to complete the processing process. Since the parts are generated during the

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program, the number of copies can be from 20 (capacity of the first truck that starts the cycle) to 1000. Scheme of the initial location of the actors of the system (Fig. 5).

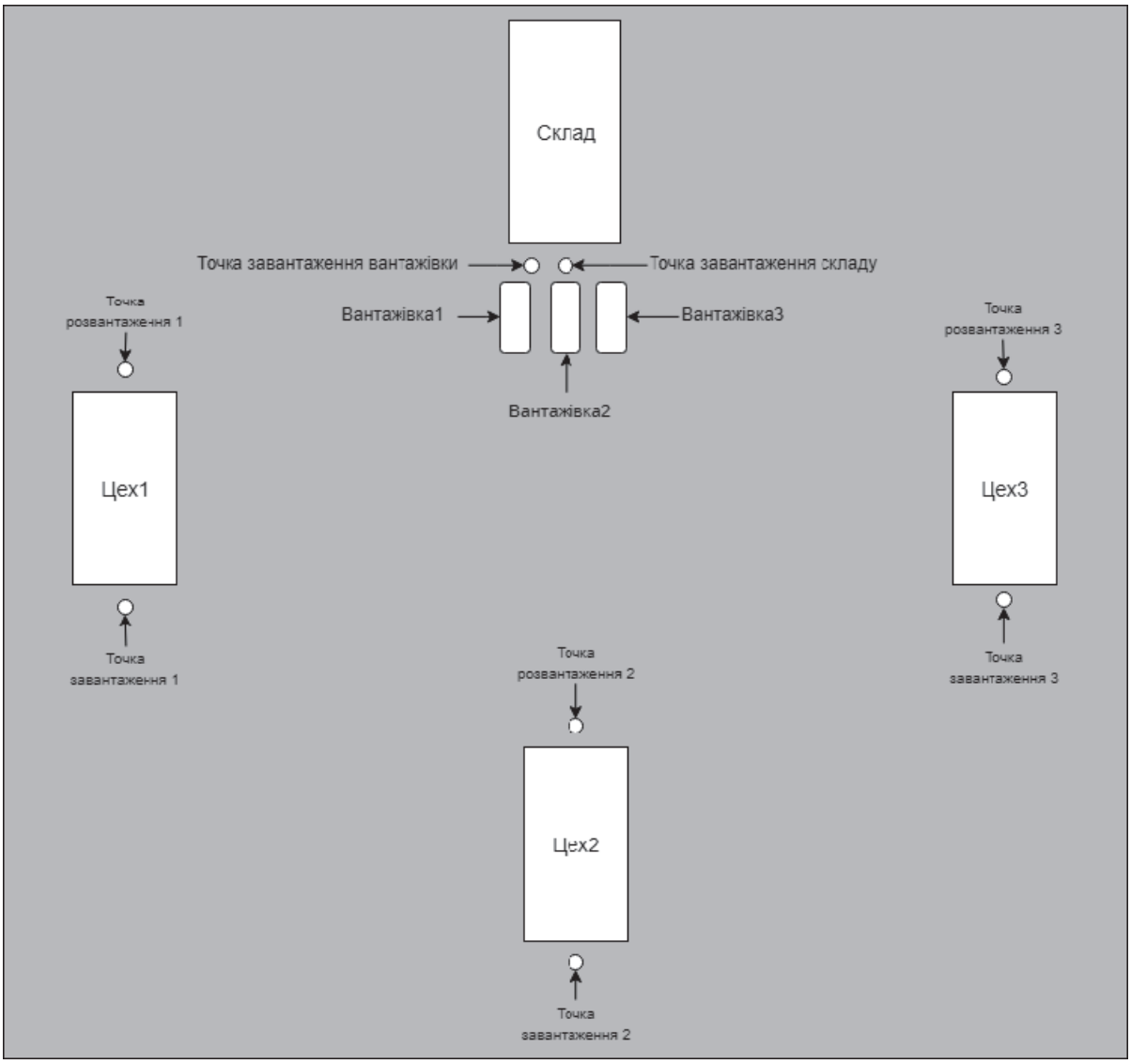

Figure 5. *Scheme of the initial location of the actors*

Three trucks are moving from one point to another. Each is responsible for transporting a specific group of parts: unprocessed parts, semi-finished parts and finished parts.

Scheme of the initial location of the actors in each of the workshops (Fig. 6). "Partial locations" are places where space is reserved for each part by means of an array of cells.

After starting the program, the algorithm of each scene object begins to be executed. Yes, all trucks, ATMs that move inside the workshops are endowed with a personal algorithm (Fig. 7), and machine tools. Pressing the TAB key displays statistics

on all the details in the environment. Lists of all the parts, individually in each shop, in the warehouse and in the trucks, are obtained. Each detail in the list is a location and what operation it will take next. The separate algorithm of the program is connected to all objects and is configured to analyze the workload of the shops and pass this information to the trucks, thus avoiding the formation of large queues or idle time.

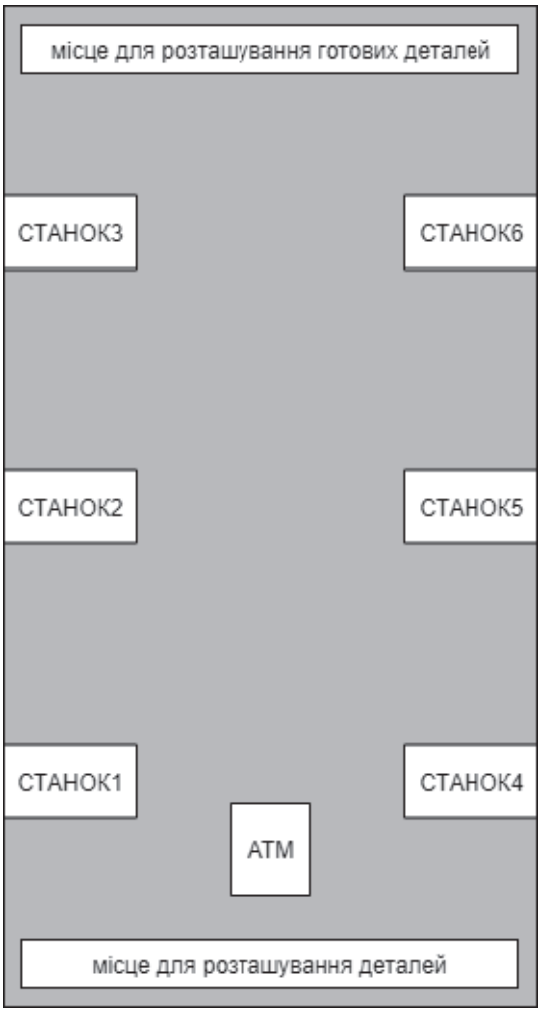

Figure 6. *Scheme of the initial location of objects in the workshops*

Thus, the environment creates 3D-visualization of production, independently locates the actors of the scene (trucks, workshops, ATMs, warehouses) and allows a sufficiently detailed review of the system, follow the process of processing and transportation of each detail. Each moving object of the system is endowed with a personal algorithm of operation and has an information connection with other objects, which allows the system to work completely independently and gives the opportunity to change some parameters. Also, PlanReal is protected against large part queues or idle time during simulation because its algorithms provide for such problems..

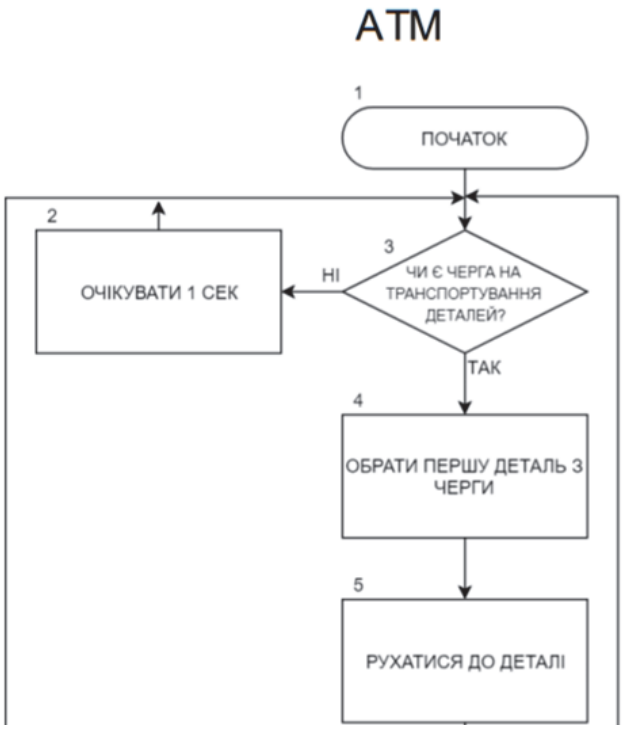

Figure 7. *Part of the flowchart of the ATM algorithm in the workshops*

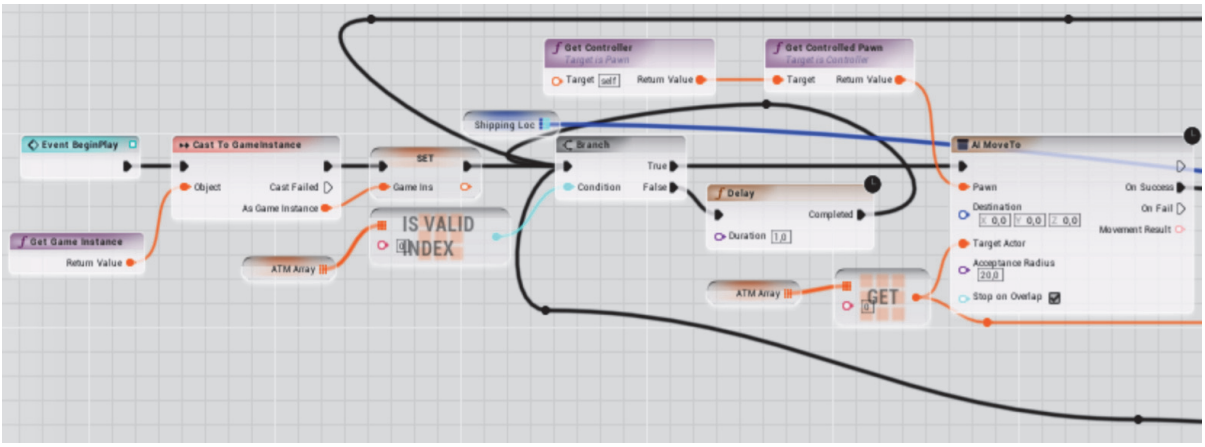

Figure 8. *Part of the visual algorithm of ATM operation in the Unreal environment corresponding to the flowchart in Fig. 7*

5. The disadvantages of the prototype PlanReal

PlanReal is a convenient system and demonstrates production in 3D environment, but does not provide full standalone functionality for modeling and forecasting production schedule, does not calculate the processing time of parts with a different set of operations, does not allow independently, without the help of third-party software, to edit distances between workshops, the number of vehicles transporting the parts, the locations of the machines inside the warehouses, their number, the time of the operation

and the list of operations that they perform. Also, it is not possible to change the number of autonomous vehicles inside each shop, the number of parts and operations that they will need to complete before completion. That is, this software environment does not provide stand-alone flexible functionality for its user.

6. Problem solving

The best solution to prototype issues is to extend the system to take into account the drawbacks of the above applications and allow us to create a full production simulation in 3D and have full functionality and flexibility to solve quickly most of the problems a production manager may encounter. The PlanReal prototype has the most similar functionality, so the new application will be based on its existing functionality, expanded and complemented with full functionality that will allow for flexibility of the software and its ability to adapt to different user situations. The program already solves the following problems: generation of parts with a certain set of required operations in a warehouse, transportation of parts in the fastest way by truck that generates and loads workshops, unloading into each workshop only those parts that need processing in this workshop, optimal transportation of parts to the machines they need inside the workshops, the organization of a queue of parts for each autonomous vehicle inside the workshops, the processing of parts by the required operation on each flexible production module, each workshop is waiting for loading and unloading of parts, signaling in case of overloading, transportation of parts that have already been partially processed between workshops by means of a truck transporting parts, transportation of parts that have passed all operations and ready for loading into a warehouse, output of detailed statistics by details, workshops, trucks and malt.

After a thorough analysis, the main shortcomings were identified and the functionalities of the application supplemented were determined. Namely: to provide full independent functionality for modeling and forecasting of production schedule, to supplement with software tools that allow to calculate the processing time of parts with different set of operations, to edit distances between workshops, the number of vehicles engaged in transportation of parts, to specify the location of machines inside the workshops , the total number of machines inside each workshop and the total number of workshops themselves, the functions that allow you to set the time of the machine operation and the list of operations neither do they. Supplement with software tools that allow you to change the number of autonomous vehicles inside each workshop, the number of parts, and the operations that the parts will need to complete before completing the machining cycle.

As follows, by carrying out the above functional additions and providing the necessary software to the given environment, that is, expanding the capabilities provided to the user and organizing full flexibility, the system will have the functionality that will allow simulating the flexible production system and solving problems at the stage of production creation.

Conclusion

The problems of creating a flexible production simulation system are discussed in detail. The problems that a technologist may encounter while managing and the possible ways of solving them with the help of software are described, the functional requirements are clearly stated. Two prototypes were selected - T-Flex Cad and PlanReal, which are as close as possible to solving the problems. Each of the prototypes is described in detail, their functionality is investigated and the shortcomings are considered. It is concluded that the considered software environments do not fully meet the requirements and are not fully equipped with the required functionality. In order to optimally address the shortcomings found, you need to expand the system that most clearly meets the requirements. The PlanReal system is selected, the solutions to the problems identified and the directions of system expansion are described. After expanding the functionality of the plan, PlanReal will meet the requirements and fully challenge the tasks.

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