Development of Technological Process of Production with using the Law of Distribution Products on Conveyors

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Abstract
Modern information technologies have a powerful impact on the evolution of production and industry. Processing large amounts of information, working with real-time data, using large data flows in production allows you to effectively use the resources of the enterprise to produce more goods at lower cost, effectively planning resources. This makes it possible to increase production income. Planning and organization of processes for creating products from drawings, 3D models to the process of its design, which is applied to products, mass-produced goods, are stages that require first of all real and clear planning. Involvement of information graphic technologies of mathematical and geometric modeling makes it possible to take into account the input and output parameters of the process, the relationship between production facilities, and the influence of functional factors on each design and production, from design to product creation and product quality. Other stages of production are important: quality control and goods manufactured for sale. Planning is the first stage for the creation and release of products, its research and development is effective provided that the means of modeling these processes. The purpose of the study is to analyze the main stages of development of a simulation model of process creating equipment for the mechanisms using the environment FlexSim. The law of distribution products on conveyors. It's solution can help to explore the load on functional objects of the process and the influence of technological factors on a particular object. The automated technological complex is considered by means of a multiparametric technical system where input and output parameters are interconnected. It should be emphasized that the model created in the FlexSim environment demonstrates the influence of the input data of one object on the course of the entire production process.

Keywords 1
Information technologies, simulation modeling, production processes, automated technological complexes, data, planning

1. Introduction

The use of traditional methods and management tools for processing equipment design technologies has limited the ability to compare, optimize and select performance parameters as individual products and parts, and equipment as a whole. In addition, the issues of taking into account the requirements of industrial design and quality of raw materials and food semi-finished products were ignored.

These problems in the design of equipment for the mechanical build industry can be taken into account with the involvement of project-oriented management methods based on the use of modern information technology.

2. Related works

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Information technology, mathematical and geometric modeling are an effective means of changing the quality of the enterprise. Simulation modeling, mathematical description of the process using 3D geometric models in space have shown that an effective technological process consists of many factors that interact with each other [1, 2]. Study of the use of each parameter, provided that the operation of the system is effective in mathematical and geometric modeling, where there is a general picture of the operation of technological systems in production [3, 4]. This requires the use of tools to form a common model of working systems. The simulation results allow the use of optimal solutions to unify problems, increase resource efficiency, etc. [5, 6].

It is necessary to use information technology and modeling to obtain a management decision that is effective to minimize time costs [7]. The results of the study of the effectiveness of management decisions in the food industry, machine-building industry in relation to the design of mechanical equipment and its components for processing and food production indicate the need to develop and attract appropriate information technology [8, 9].

The importance of taking into account the requirements for the designed equipment to ensure consumer quality and safety of the product by the appropriate choice of software for information and technological support [10] of the design process, taking into account its life cycle [10,11,12]. A model scheme for managing the design processes of processing and food production equipment using the FlexSim environment includes the process of designing and manufacturing products [13,14], both individual parts and equipment as a whole on the basis of choosing appropriate information technology in terms of processed and control programs[15]. The specialized software also takes into account the requirements for the safety of input products and equipment design[16].

3. Problem statement

We have proposed a model scheme for the effective use of the process control program for the design production equipment based on the use of FlexSim Simulation environment. An important problem in providing.

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3.1. Stages of research of production problem and creation of its model

The highest efficiency and of management quality of architecture software processes of designing the equipment industry is reached by using the life cycle process creating details, modern methods of management.

The process of designing and manufacturing examples of equipment depends on the life cycle of projects, software, mathematical researching and analyzing components that influence projects. (Fig. 1).

In the process of equipment development, new connecting elements are used, which significantly affect the dynamics of equipment operation. Therefore, the priority is to create and use methods for managing modeling research with available schemes and the inclusion of new elements, protected, separate, patents. At this stage, it is possible to select and use scientific mathematical processors, in particular, MatLab MatCad, Maple, etc. In the first steps for the design of products are accepted weather with the customer ranges of model parameters of production and set restrictions, the need to control the quality of raw materials or semi-finished products, reliability and functionality of production. An important problem in designing a product is its technical design, because a perfect functional object is always aesthetic.

The technical data agreed with the customer are processed using computer means of CAD in two directions. On the basis of involving different types of software, information, mathematical, methodical, etc. perform the selection of rational parameters of equipment as a basis for creating design documentation involving engineering and computer graphics, in particular, AutoCAD, 3Dmax, Inventor etc. A significant advantage of modern graphic computer platforms is the ability to create with their help as working drawings of individual parts, assemblies, equipment and 3D-models, which is an effective visual means of regular coordination of current documentation on equipment with the customer as an important component of sequential implementation of each subroutine in managing the manufacturing process of equipment. An important and crucial subprogram in this chain is the preparation and transfer of technical documentation for the manufacture of a model of equipment, the implementation of which is aimed at the results of previous programs. In the process of its testing with the involvement of the customer and in his presence, the technical characteristics of the equipment are determined.

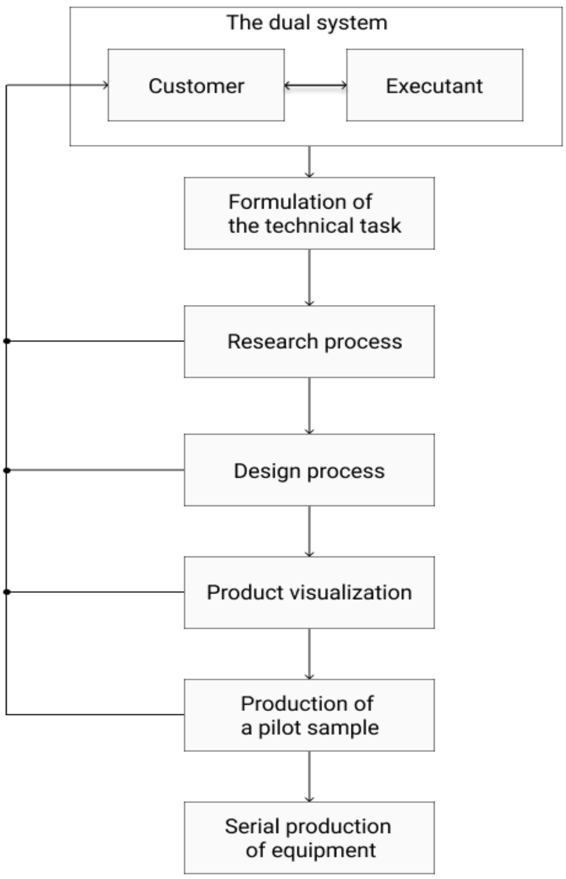


Figure 1: The life cycle of manufacturing.

When executing the next subprogram, the creation of equipment for processing raw materials, part of the technical data comes taking into account the tests of the pilot sample of equipment of the previous stage, in particular, the stage of creating equipment for preparation of raw materials. Analysis of the life cycle of one of the subprograms, subprogram of raw material preparation equipment, indicates the possibility of using different options for the implementation of the project of manufacturing equipment, namely sequential, parallel, sequential-parallel combination of individual subprograms. The life cycle of each subprogram, in particular, the creation of equipment for the preparation of raw materials is determined by its contribution to the implementation of the overall program of equipment production. Given the different life cycle of subroutines in the manufacturing process, we have established an appropriate sequential-parallel approach to the implementation of the principle of object-oriented management. The implementation of each subroutine of the process involves the use of the principle of feedback, which improves the quality of the final product and the safety of its products.

3.2. Optimization of parameters for technological processes using the FlexSim Simulation Program

For effective research of processes in production we used the principle of simulation modeling, which is an effective method of research of technological systems and processes. In special environments, we create simulations of production processes, using logic for each object in particular. The created model allows to investigate work of production in time and to receive statistics of processes. The created model allows to investigate work of production in time and to receive statistics of processes.

The objects of FlexSim modeling can be the technological system in general and its elements, in particular, individual technological processes, production lines, functions and relationships between them. The used software tools allow us to create models of production and technological systems, to calculate indicators of the process functioning of a system in real time.

We built a simulation model involving developments from FlexSim Software including the following basic elements: sources (Source), processes (Process) and queues (Queue). In our case, sources are the elements from which information or objects enter the product model. The speed of data or objects from the source is usually set by a statistical function. The concept of flow production in our case is understood as a form of production organization in which repeated time-coordinated main and auxiliary operations performed at specialized workplaces located in the sequence of operations of the technological process. Stream production achieves high productivity due to the continuity of the manufacturing process, ensures high quality while saving labor costs, material and energy resources compared.

The main link of flow production is a production line, which is a group of jobs, which is assigned to the manufacture of one or a limited number of items of labor.

Therefore, modeling and control of the production line (conveyors) is one of the common tasks of mass production. The conveyor is a production line along which the parts move, over which certain operations are performed sequentially. The model of movement of details on the conveyor describes the indicator law of distribution for definition of intervals of time of receipt of details on the conveyor. The exponential law is modeled using the inverse function.

Let’s take uniformly distributed random variables by α in the interval [0; 1] (basic random variables). Distribution function for the exponential law:

$$F(x) = 1 - e^{-\lambda x}, \tag{1}$$

where x≥0

$$F(x) = y \tag{2}$$

relative to the variable *x*:

$$x = F^{-1}y,$$

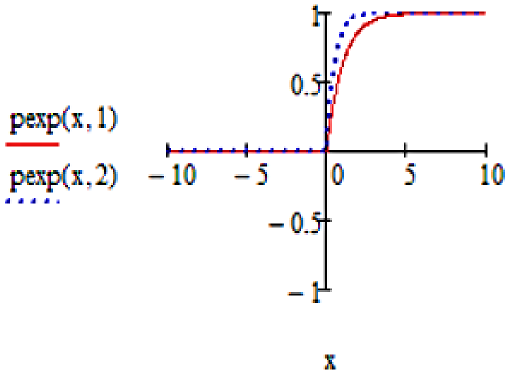
Random numbers ζ, distributed according to the exponential law, are generated by the formula.

$$\xi = F^{-1}(\alpha), \tag{3}$$

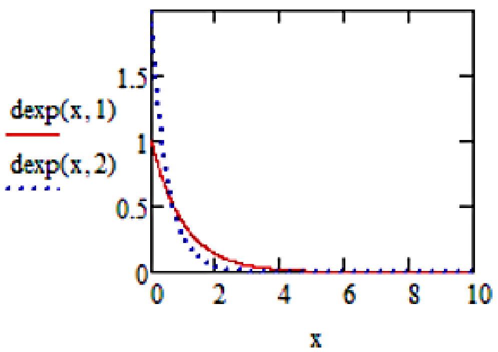
When modeling a production line, values distributed according to the normal law are also required. To do this, consider a standard Gaussian random variable $\xi^*$with a mathematical expectation of 0 and a standard deviation of 1. We can see that in this case for any values of a, σ normally distributed value will be obtained by formula (4):

$$\xi = \alpha + \sigma\xi^*. \tag{4}$$

The distribution law depends on the parameters λ, waiting time for a unit of product to be distributed. On fig.1 the function of indicator distribution is given, where λ = 1 (solid line). The dashed line corresponds to the time wait λ = 0.5, the waiting time of the product is 0.5 units of time. Figure 2 shows the distribution density with the parameter λ = 1 (solid line), the distribution density of products for which the waiting time is 1 unit of time. The dashed line corresponds to the distribution density for products whose waiting time is 0.5 units of time. Thus, we have the effectiveness of using a unit of time for different product receipts to help increase the efficiency of the production process (Fig.3).



a)



b)

Figure 2: Graphs of dependences of time waiting elements for 1 unit of time and 0.5 unit of time (a) and density of distribution for 1 unit of time and 0.5 unit of time (b)

The exponential distribution law has objects arriving randomly 10 seconds. Using the results of calculations (fig.3), we created a model where the logic for each object is introduced (fig.3 a). We considered the law of distribution at a stage of sorting products (fig.3 b). Setting the logic for the Source1 object, select the following parameters. In the Source section, select the distribution law - exponential law. The exponential distribution law has objects arriving randomly 10 seconds. We have to edit this number to 60 seconds, so it is one time period. We can see the graphics on fig. 3 that demonstrates production line load on Conveyors. We also have results to demonstrate for 30 seconds (0.5 unit of time).

FlexSim Software's capabilities were used as a means of research and creation of a simulation model for the production process. Figure 3 presents a 3-D model of the technological process of packaging, namely the process of packaging design:

1. Five types of move from the source to the main conveyor. The details are sorted and everyone gets on the conveyor depending on type of detail.
2. On the conveyor, there is an operation of labeling and gluing of a color strip.
3. Then details move to the formation of transport packaging units.

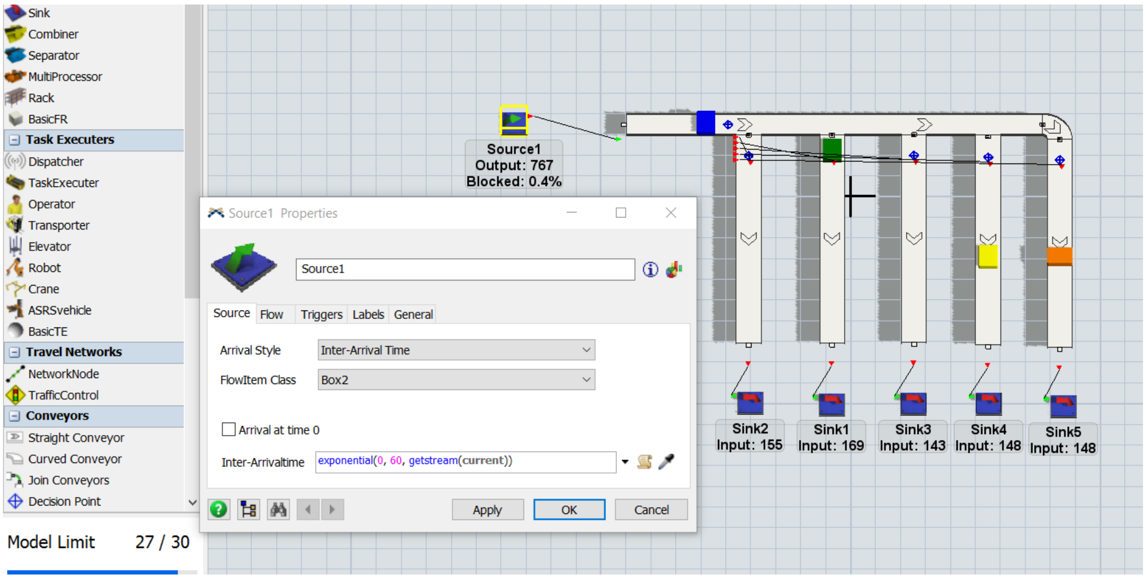


Figure 3: Type of distribution process on conveyors of the production line

The following elements of the FlexSim program were used to model this task:

Source, Queue, Separator, Conveyor.

At the input, the first element is Source, where we specify the following logic:

Source1 – Source – FlowItemClass – Box.

In this case, we usually observe the review of product packaging, if it is a box. In the Flow section, specify the number of ports, , this is one available port:

Source1 – Flow – Send To Port – First Available.

The next stage is the generation of products of different types (five types):

Triggers – On Creation – Set Item Type and Color.

We have to divide each type of product into a different port. We have four ports to each conveyor.

Separator – Flow – Send to Port – Port by Case.

The Figure 5 demonstrates the result of the program work sorting products on Conveyors.

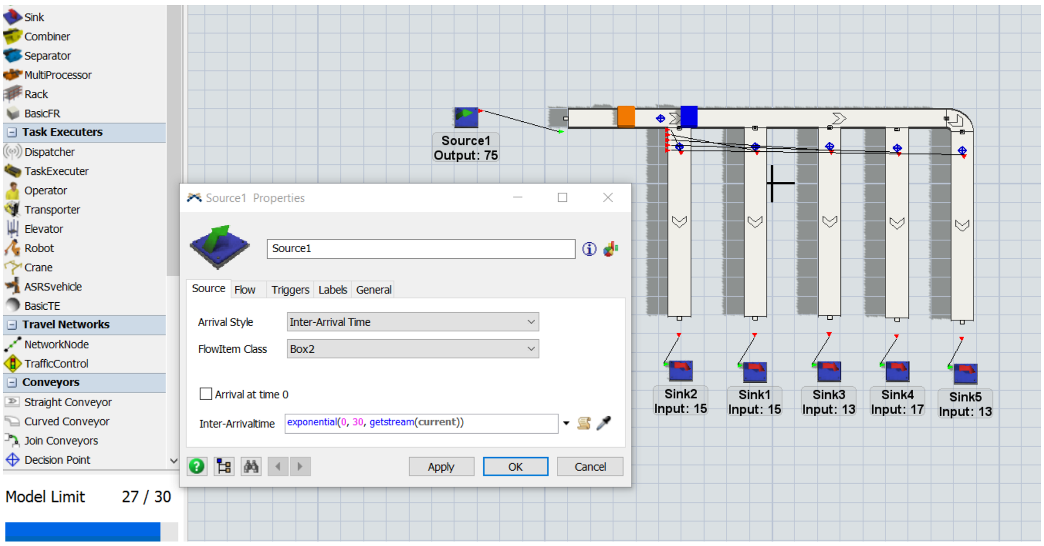


Figure 4: The result of the program work sorting products on Conveyors

Analysis of Fig. 3 and Fig. 4 shows the following result. Using the value of the parameter λ = 1, is 60 s., there is an overload of Conveyor 2, this can be seen in Fig. 3, for Sink1 (169 elements). When entering the value of the parameter λ = 0.5 we obtain a more uniform distribution: in Fig.4 there is a small overload Conveyor 4.

Using statistical analysis, it is possible to observe the frequency of details at the Conveyor1, Conveyor2, Conveyor3, Conveyor4, Conveyor for an each moment of time (Fig. 5).

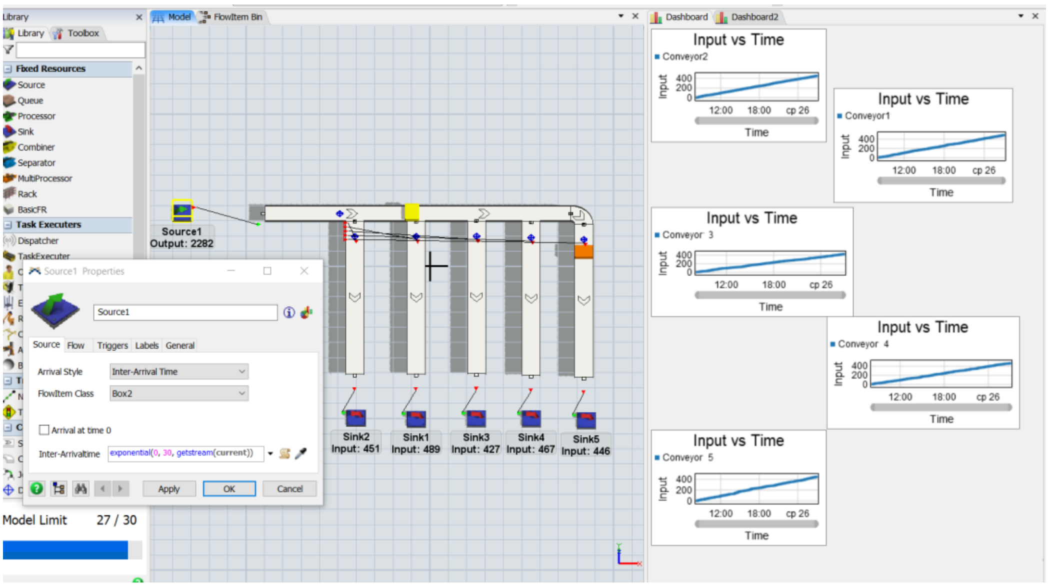


Figure 5: Statistical analysis of sorting products on Conveyors

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The statistics we have can help us to analyze the load on each conveyor.

The results of the analysis can be used for other kinds of industry. For example, we can analyze technological processes of processing.

Fig. 6 demonstrates the model of the processing details in the technological process.

Description of the technological process of processing:

1. Queue1 receives the details.
2. Then they move alternately to the working positions of the technological process of processing Processor1, Processor 2, Processor 3, Processor 4, Processor 5.
3. At each workplace a certain technological operation is carried out

Processor 1- drilling holes
Processor 2 - milling of keyways
Processor 3 - rough turning
Processor 4 - pure turning
Processor 5 - polishing

4. After the machining process, the parts go to the galvanizing process

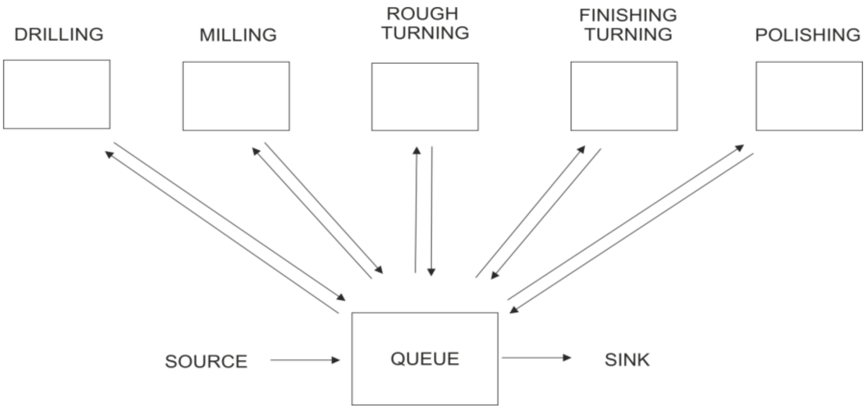

Figure 6: The model of a part of technological process of processing of details

The Fig.7 demonstrates the result of the program work in FlexSim.

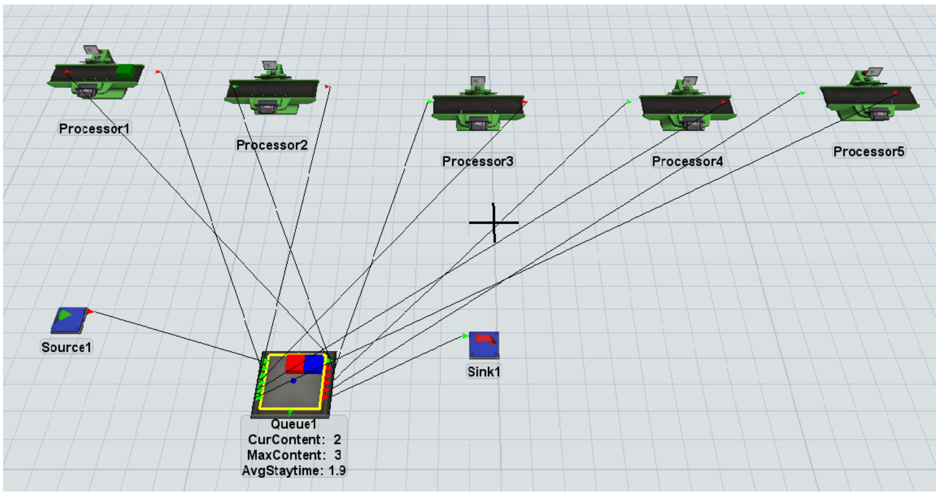

Figure 7: The model of a part of technological process of processing of details in FlexSim

Flow production is characterized by a chain arrangement of jobs in accordance with the course of the technological process, which eliminates the reverse movement of manufactured objects, the continuity of their transfer from one operation to another or the simultaneous execution of several operations using multifunction machines.

4. Conclusion

In conditions of market competition it is necessary to identify optimal ways of designing technological processes for the conditions of a large number of fields, inaccuracies of input information, changes in various production processes, time and resource economy, which requires the solution of modern information technologies. The key figure is a qualified engineer, project manager, who operates all the necessary information about the process under study, data about each object. Listening to the relationships between the various parameters of the three levels of model design, you can provide quality information about sorting, data, changes in the process, which provides a significant economy through resources.

5. References

[1] Wang, Xin, Tapani Ahonen, and Jari Nurmi. "Applying CDMA technique to network-on-chip." IEEE transactions on very large scale integration (VLSI) systems 15.10 (2007): 1091-1100.

[2] S. Cohen, W. Nutt, Y. Sagic.” Deciding equivalances among conjunctive aggregate queries”, J. ACM 54 (2007). doi:10.1145/1219092.1219093.
[3] Tkachenko R., Izonin I. “Model and Principles for the Implementation of Neural-Like Structures Based on Geometric Data Transformations”, Advances in Intelligent Systems and Computing, vol 754, 2019, Springer, Cham, pp. 578-587.
[4] Sornettea D., Maillart T., Kröger W. “Exploring the limits of safety analysis in complex technological systems”, International Journal of Disaster Risk Reduction, vol. 6, 2013, pp. 59-66.
[5] Mustafa Fatih Yegul, Fatih Safa Erenay, Soeren Striepea, Mustafa Yavuza. “Improving configuration of complex production lines via simulation-based optimization”. Computers & Industrial Engineering (109), 2017, pp.295-312.
[6] Forcael E., Gonzalez M., Soto J., Ramis F., Rodriguez C. “Simplified Scheduling of a Building Construction Process Using Discrete Event Simulation”, 16th LACCEI International Multi-Conference for Engineering, Education and Technology: " Innovation in Education and Inclusion”, 19-21 July 2018, Lima, pp. 1-11,
[7] Jon Holt, Simon A. Perry, Mike Brownsword. “Model - Based Requirements Engineering”, Institution of Engineering and Technology, 2012, London, United Kington. - 333 p.
[8] Manavalan E., Jayakrishna K.” A review of Internet of Things (IoT) embedded sustainable supply chain for industry 4.0 requirements”, 2019, vol.12, pp. 925-953.
[9] Ljaskovska S., Martyn Y., Malets I., Prydatko O. “Information Technology of Process Modeling in the Multiparameter Systems”. 2018 IEEE Second International Conference on Data Stream Mining & Processing (DSMP), 2018, pp.177-182.
[10] Hao Peng, Qiushi Zhu. “Approximate evaluation of average downtime under an integrated approach of opportunistic maintenance for multi-component systems”. Computers & Industrial Engineering, vol.109, 2017, pp. 335-346.
[11] Kampas Frank J. General “Ellipse Packing in Optimized Regular Polygons, Submitted for Publication February 2016” Frank J. Kampas, Ignacio Castillo, Janos D. Pinter // Global Optimization Submissions. 2016. http://www.optimization-online.org/DB_FILE/2016/03/5348.pdf.
[12] Xu W. An overlapping detection algorithm for random sequential packing of elliptical particles Physica. 2011. Vol. 390. P.2425-2467. doi:10.1016/j.physa.2011.02.048.
[13] Kramer S., Gritzki R., Perschk A., Roesler M. & Felsmann C.: Numerical simulation of radiative heat transfer in indoor environments on programmable graphics hardware. *International Journal of Thermal Sciences*, 2015, Vol. 96, pp. 345-354.
[14] Paolo Giudici, Silvia Figini. Applied Data Mining for Business and Industry. Wiley, 2009. 260 p.
[15] Nong Ye. Data Mining. Theories, Algorithms, and Examples. - CRC Press, 2014. - 347 p.
[16] Shu Ing Tay, Lee Te Chuan, AH Nor Aziati, Ahmad Nur Aizat Ahmad. An Overview of Industry 4.0: Definition, Components and Government Initiatives. - Journal of Advanced Research in Dynamic and Control Systems 10 (14): 14, 1379 - 1387.
[17] Zhao, Yj., 2013. Dynamic optimum dasign of a three translational degres of freedom parallel robot white considering anisotropic property. Robotics and Computer-Integrated Manufacturing. Vol. 29(4), pp. 100-102.
[18] Kalrath. J., S. Rebennack Cutting ellipses from area-minimizing rectangles. Journal of Global Optimization. – 2014. – Vol. 59 (2-3). – P.405-437.
[19] Fedushko S., Ortynska N., Syerov Yu., Kravets R. E-law and E-justice: Analysis of the Switzerland Experience. CEUR Workshop Proceedings. Vol-2654: CybHyg-2019. Kyiv, 2019. pp. 215-226. http://ceur-ws.org/Vol-2654/paper17.pdf
[20] J.C.Cheng, Y.Tan, Y.Song, Z.Mei, V.J. Gan and X.Wang, “Developing an evacuation evalution model for offshorwe oil and gas platforms using BIM and agent-based model”, Autom.Const.,89,2018, pp. 214-224.