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Optimization of Technological's Processes Industry 4.0 Parameters for Details Manufacturing via Stamping: Rules of Queuing Systems

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Abstract

The main purpose of this study is to optimize the parameters of the technological process of manufacturing parts by embossing in Industry 4.0. A multifunctional queuing system in relation to production was used for the research. We took the example of a production line at the plant, which demonstrates the functionality of the technological process of production and processing of parts by embossing. We achieved the strategic goals of the research due to a complex combination of detailed studies of the parameters of the technological process by modeling. The method is implemented in the FlexSim simulation system with a real set of data. In the process of production of details, it is possible to use the equipment of various quality. Its analysis shows that the effectiveness of even the most modern technological line depends to a greater extent on the performance of its weakest element, unit or part. In particular, in the production of stamping parts the weakest element is a stamp. Research, modeling and calculation of its surfaces, in particular by the method of finite elements make it possible to identify problem areas of the stamp and strengthen them by calculating with using this method. A simulation model of a part of the production process is created and the stages of production are analyzed. We take into account that the implementation of such processes is accompanied by the formation of queues of parts or products that come from the manufacturer for further processing on the conveyor.

Keywords: industry 4.0; simulation model; factory; queuing systems; stamping process.

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1. Introduction

Modern enterprises use information technology to organize the production process, automation of production with involvement robotic production complexes, which are based on the Industry 4.0 platform.

The following processes in general are automated: management of production processes, packing, sorting, etc. is carried out in real mode time using changing data every second. In production, there is often a failure of the process, which depends on failures in the queue due to incorrect calculation of flow parameters of the number of planned and manufactured products. For a successful technological process it is important to study its features. This requires the use methods of mathematical, geometric and simulation modeling. [1, 2, 3]. Modeling of processes of interaction between various parameters of system describes the general scheme of manufacture work. Algorithms for modeling the dynamics of technological systems play an important role for researches. In the article, we have implemented an algorithm that shows the interaction of elements of production, at the center of which is the technological process, built in accordance with the quality criteria of parts. Based on the theory of queuing and taking into account the main stages of technological processes, we have the following points:

- the operations for the manufacture of parts (drilling, milling, grinding, embossing etc.);
- an elements of modern production technologies (3D models, 3D printing etc.);
- the methods of management in production (Product Lifecycle Management) [1], namely the consideration of product life cycle from manufacture to disposal.

For the technological process was created a single virtual space (information control). To analyze, we involved the manufacture of products that make up the production process in which errors occur. The analysis of the problem of increasing the efficiency of the technological process is aimed at studying ways to solve it, as well as to identify current trends in improving the quality of the process. Therefore, the main research approach is the system approach. It consists of classical methods involving computer technology. We choose the approaches and the methods used in the complex. It creates the research methodology (discrete modeling, production-planning systems, geometric modeling tools, taking into account the multiparametric nature of the research, creative search experiment etc). We used these points to analyze and to model the technological process to eliminate abnormal situations in the workplace.

2. Related works

When modeling technological processes, the use of simulation modeling is effective, which has proven itself well for solving various technical problems [1, 3, 4]. The main point is the analysis and adaptation of the features of the object of study to the capabilities of the environment of such modeling [2]. Because of modeling such objects, phenomena or processes, the results are obtained in the form of time dependences of statistical data [5].

Based on the basic provisions of the theory of mass production, it is possible to determine the main parameters for the effective operation of the model for the technological process of manufacturing products by stamping [6].

We used the means of the FlexSim simulation program [6, 7] allow to build simulation models of such technological processes and to select data for their final research and analysis [8].

The main prerequisite for creating a simulation model is the analysis of the features of the technological process of stamping [9]. We take into account the fact that the technological process does not depend on the modernity of the equipment, but is dependent on finding a problem area in the technological line, which leads to blocking the whole process and economic and time losses throughout the enterprise [8, 9]. We consider the technological process of stamping, where the problem area is the stamp. We emphasize that in our case the stamp is a tool designed to provide a part of a given configuration by plastic deformation of the workpiece or its division into parts [9]. To select the type of stamp, take into account their technological and design features [10,11]. Technological include performed operation - felling, bending, extraction, the degree of complexity of operations (combination of operations). The design features include methods of connecting working parts, fixing workpieces, methods of removal and removal of products in the stamping process.

The name of the stamp is determined by the operation performed: cutting is performed on cutting dies, extraction is performed on exhaust stamps, bending is performed on bending, and so on. The working part of the punch of the cutting stamp corresponds to the shape of the contour of the part to be cut. We take into account the important point that the stamp may have internal surfaces in the form of a hole on the thickness of the material of the part.

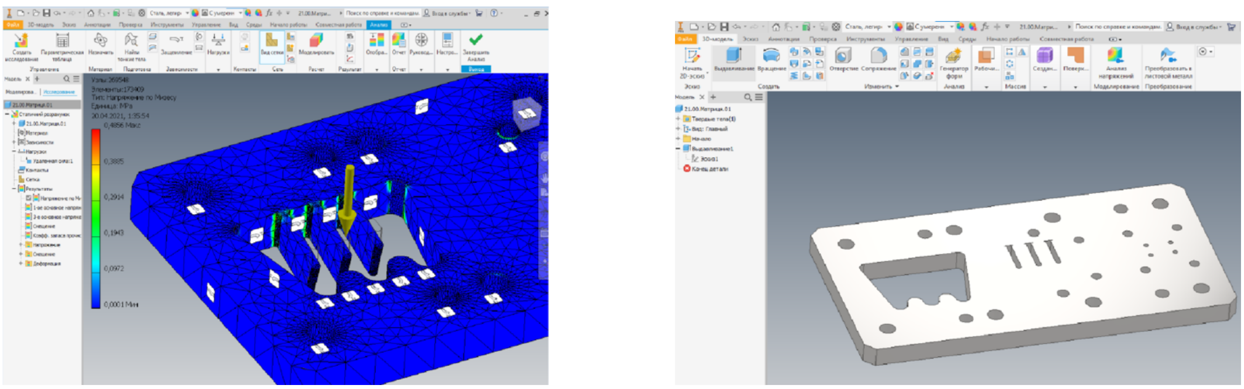
For effective modeling, the main stages of the choice of dies are analyzed, as this is a key element for the implementation of the technological process: 1) construction of matrix's 3-D model in a CAD system; 2) calculations in the CAE system taking into account the following parameters: material of the part, area and shape of the cross section, its fixing and loading on the matrix; 3) the calculation of the part model for strength by the finite element method is performed.

3. Finding a problem area for serial production of details created with stamping

The design of the part, namely the matrix, and its functional purpose and place in the assembly unit affect the adoption of many engineering decisions in the construction of the technological process of its machining. Before submitting the part for production, it is necessary, after analyzing the assembly drawing in general and the design of the part, to identify problem areas, to eliminate bottlenecks in dangerous sections. Therefore, the design should represent the design of the part, its purpose in the assembly unit, the principle of operation and its interaction with adjacent parts of the assembly unit. Important stages are the construction of the drawing of the part, the development of 3-D model, its calculation for strength and rigidity by the finite element method. One of the first tasks to improve the configuration of the matrix and prevent puncture of the contour in the early stages of stamping is to eliminate bottlenecks in dangerous sections.

3.1. Optimization of problem elements in the process of stamping.

The matrix is one of the main part, in the process of use the production of any materials is created. The geometry of the parts determines the configuration of the matrices by the manufacturers of the outer contour. By calculating the traditional matrix by the finite element method, we support problem areas exactly where there are dangerous sections that lead to the control of parts. This requires additional material costs in production. Our proposed method of analysis of the calculation allows us to move to an improved version of the design of the matrix, which demonstrates, the unloading of the cross section of the investigated part and prevents damage to the product. For the technological process, we chose a matrix model and investigated it for strength by the finite element method, which allowed us to identify its problem areas (Fig. 2).



a) b)

Fig. 1. The design of the matrix investigated for strength by the finite element method to identify its problem areas (a); the improved design of matrix (b).

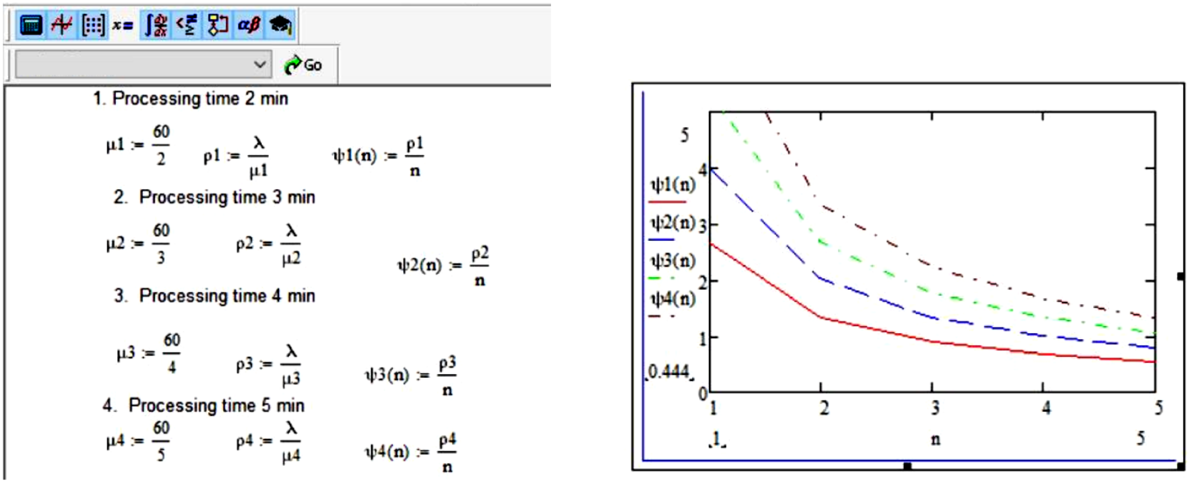
3.2. Proposed method

We consider the queuing system in relation to the production process of manufacturing products involving stamping. According to the technological process, the products are processed by stamping after previous operations and go to the next stage. Processing of products in the production process is carried out based on the provisions of regulatory documents. Like queuing systems in production, processes adhere to the main requirement of sequential passage of the product in accordance with the instructions of the technological process. In the production process with the involvement of stamping, the process is solved on one of the parallel lines, and one of them can be a backup. Then the automation of the entire production of stamping parts requires the study of features at each stage of their manufacture. This requirement is universal and common to each previous and all subsequent operations. In the process of manufacturing products of technological operations, the production of its internal and external surfaces of equivalent and detailed data takes place on the operation that precedes stamping. With a significant number of workpieces at the entrance may not be able to supply the product for processing, the product is either mostly waiting in line, or it may be possible to remove it from the processing. Obviously, there are contradictions between the actual process of manufacturing products. Limited or no opportunities for the real process of manipulating the product positively compensate for the endless possibilities of modeling, which allow you to set the queue for receipt of the product for processing is also infinite. Possibilities of process of processing of a product with involvement of stamping can be limited by several various requirements, which should be met, ie hierarchy of directions of movement, statement of products on processing with observance of conditions of coordination of requirements, etc. Different requirements involve in the presence of values of discrete time of process of stamping. or directions of movement (in particular, the possibility of movement between machining operations involving stamping). The change of processing directions is closely related to a certain probability, the set of which at the point of intersection of the directions of the sequence is always equal to one. The set of such different requirements, often opposite is analyzed if necessary, to assign primacy in the processing process, considering the type of requirement or the total processing time of the product, etc. We analyze the process of manufacturing mechanical engineering products as a multi-directional system, which provides the movement of products in the production complexes of stamping and finishing. $S_{1}; ..., S_{G}$ - arrays of input material for cutting parts; $C_1, ..., C_G$ - the number of processing lines; $L_{1}, ..., L_{s}$ - array of queues for workpieces. The stamping division on manufacture can act as the analyzed system. From several such subdivisions ($S_{1}; ..., S_{G}$) products for stamping arrive. Before the start of the processing process at the control points, technical documentation is prepared for them. The stamping unit in production can act as the analyzed system. From several such subdivisions ($G_{1}, ..., C_{G}$) products for stamping arrive. Before the start of the processing process at the control points, technical documentation is prepared for them. Then they arrive at the processing line. Note the following elements of the process: Dispatching - the first stage of processing. Stamping of products - the second, and technical control and regulation - the third stage. We have in the end the transfer of the finished product to the customer or further manufacture - the fourth stage. The technological process also involves the possibility of packaging manufacturers, which is required before a certain stage. If the transfer of producers to a further consumer is envisaged, they are preparing for transportation, then we can make the sixth stage. These stages are serviced and performed by specialists of a special profile. The next step in this study is to analyze the workload of the production line and determine the optimal time for submission of materials for data processing and placement [11, 12]. The material arrives p - channel download intensity at μ the processing point with intensity λ, the average duration of processing. We performed the calculation (Fig. 2), determining the optimal processing time for the same material. The algorithm for finding the optimal time for feeding parts to the line is determined by the following explanations: the intensity of loading lines is determined [10]:

$$p = \frac{\lambda}{\mu}. \tag{1}$$

Intensity of supply of materials for n channel ψ(n):

$$\psi(n) = \frac{p}{n}; \tag{2}$$



a) b)

Fig. 2 . Determination of the optimal number of channels for the production line(a), graphical dependences intensity of supply of materials and number of channels (b).

Analysis of graphical dependences shows that $\psi_2(n)$ and $\psi_3(n)$ are considered optimal. They are optimal because the processing time of 2 minutes and 3 minutes provide high-quality stamping of parts. Less time (less than 2 minutes) leads to failure, more time (more than 5 minutes) is the cause of line downtime.

3. Modeling and results

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 stamping:

- Four sources from each of them details are moving on Queue.
- The details are sorted and everyone gets on the conveyor.
- On the Processors there are operations of stamping.
- Then details move to the formation of transport packaging units Combainer and Conveurs.

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 stamping Processor1, Processor2, Processor 3, Processor 4; 3) At each workplace a technological operation of stamping is carried out.

4. Comparison and discussion

Analysis of Fig.3 shows the following result. To study the process of material supply to the processing point took 3 channels, the stamping time of one part is three minutes, because less than two minutes leads to failure, and more than five minutes leads to downtime on the line. We have chosen the exponential law of distribution [6] of material on the line of stumping. Fig. 3 shows the uniform distribution of material on the stamping station. Graphical dependences of the number of products on the processing time shows the relative uniformity of the distribution of parts, four input parts, for the time range 08: 10… 08: 15.

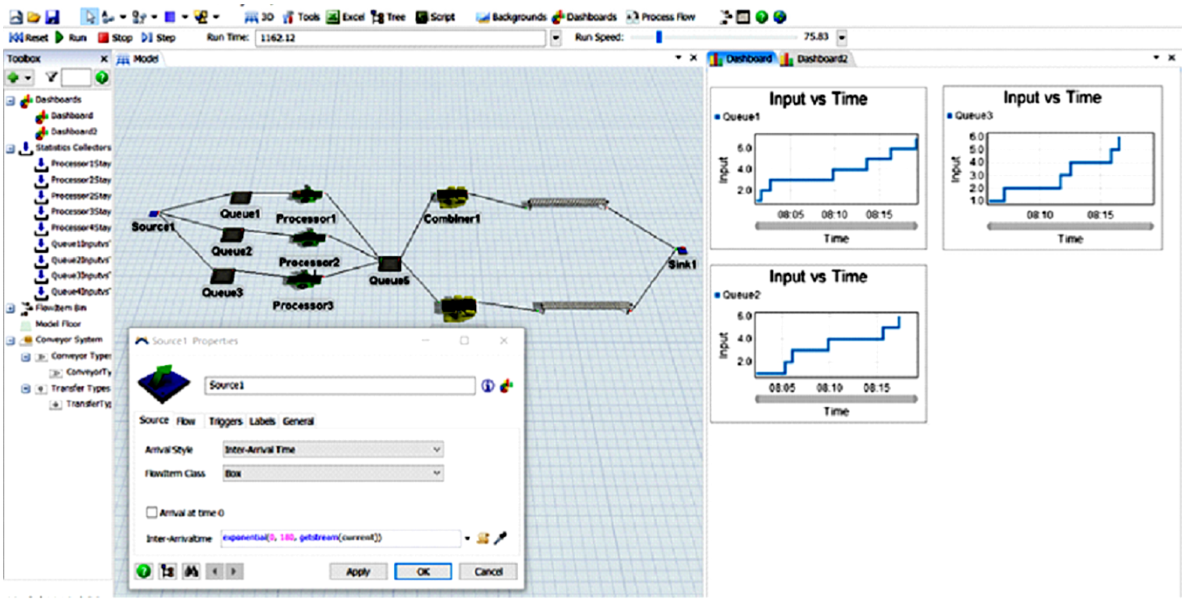


Fig. 3. Determination of the optimal number of channels for the production line.

5. Conclusions

The technological problem of manufacturing parts with the involvement of the stamping operation was investigated, which made it possible to optimize the process and identify problem areas, the stamp matrix, in the studied technological line. The problem area on its surface is calculated by the finite element method and a variant of its solution is proposed. The result of the analysis and research of the technological process involving stamping as a queuing system is a model of such a system that allows to determine the main characteristics of the stamping process.

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