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Abstract. Effective management and possession of smoothly running design processes of production, deliveries, is an integral part of the modern enterprises. One of the main instruments of planning of production is simulation modeling. New tools for digital production support decision-making at design of production systems. Modeling of processes is faster way of finding of the correct solution in view of generation of exact forecasts, allowing to evaluate different alternatives. The research, the showing results received when using techniques of the simulation modeling and careful production created in program providing Tecnomatix Plant Simulation is presented in article. Visualization of all processes presented in article shows advantages and shortcomings of the offered optimization techniques, allowing to draw a conclusion on how many effective or not effective will be a developed system.

1. Introduction

Fast development and growth of the market led to the fact that the modern companies should resolve the issues connected about increase in volumes of deliveries and updating of productions in short terms. The enterprises creating competitive products cannot decide what changes will bring necessary results. Each waiting is a loss, and each loss involves expenses, which the manager should eliminate on production and a warehouse [1].

Key element of careful production is the multilevel matrix of target indicators and resource restrictions (temporary, financial, technological, production, ecological and others) allowing to describe quantitatively subsystems, to define how they influence at each other and interact with each other at different stages of life cycle of a product, that is to make what is usually carried out within natural tests of a prototype [2, 3].

Increase in volumes of virtual tests by world industrial leaders is connected with reduction of temporary and monetary resources by a solution of technological tasks. The copy of a real object or the production line, saving in itself properties of real objects is a digital double. Thanks to digital doubles there is an acceleration of an output of new products on the market, the quantity of design errors and cost of design is reduced, competitive advantages are increased.

The effective enterprise can be considered the enterprise seven types of losses which excluded in the work: losses because of overproduction, dead times because of waiting, losses because of excessive processing, losses because of excess movements at execution of operations, losses when transporting, losses because of release of defective products. The exception of these losses is method simulation modeling. The simulation model of production is useful to a research of all production systems. The model of work consists of the interconnected work models. This model is based on exchanges of

materials and information on connection of operations, which were defined in model of a black box. The simulation model of work can be used for assessment of scenarios in which variables of separate processes interact with each other [3].

Therefore, becomes possible to evaluate objective indicators in terms of bottlenecks, idle times in loading processes and unloading, etc. Besides, at a stage of reflection can be made changes in a production system, as assessment at a stage of observation is complete. Modifications of a production system can vary from adding of operators before change of configuration of machines.

Planning and logistics are inevitable in production. The order of transportation of palettes and preparations affects efficiency of productions, necessary time for execution of orders for products, amount of the energy used for transportation of loads and use of workstations. Therefore, they affect production efficiency and expenses. As build processes have restrictions of an order of operations, and robots should be controlled without people, planning becomes even more important. Many problems of logistics are that that there is no known fast way of calculation of an optimal solution therefore approximation methods are used [4].

When developing such systems factors, both from the computer party and from human should be considered. The computer component of the digital twin is graphics, software, programming language, etc. From the person such factors as communication, design, linguistics, sociology, satisfactions of users and others are considered. The most part from these factors can be considered when modeling processes of production. It is reached due to processing of a large number of data, assessment of rational use of the equipment and personnel, logistics of deliveries and management of lines [3-7].

Except factors of predictable factors, there are also stochastic processes which an element of chance. It is possible to describe these processes with use of probabilistic methods. The description of these methods without use of programmable devices occupies a large number of time that at an output of the enterprise to the market is of great importance.

2. Simulation modeling

Let us review two examples of a simulation model with the identical number of the equipment and time of payback in the Plant Simulate program. Plant Simulate is the software environment intended for optimization of material of flows, loading of resources, logistics and a method of management for all equations of planning. The software allows executing graphic modeling of production, a programming language, modeling of logistic transactions of the set law, etc. The developed production line (figure 1) consists of the pipeline (Conveyor), the robot (FANUC), the CNC machine (MILL), the grinder (Polishing), the 3D scanner (Scanner). The main objective of this line is production of the greatest number of a detail of "M" during the period - 500 days. Movement of a detail comes from one station after completion of work at the previous stage, in all remained time the equipment does not work.

Execution plan of a research:

- Define a problem and the purpose according to set actions for planning of the enterprise.
- Set a set of the purposes.
- Define criteria of decision-making.
- Offer one or several alternative variants solutions.

Research objective is increases in quantity of the made details.

To define problem places of the available production line, we will execute modeling of a system with use of the following components: ChartEnergy (statistics of energy consumption), ResorseStatistic (statistics of resources), CostAnalyzer (calculation of cost of unit of the ave., EnergyAnalyzer (energy consumption), ExperimentManager (experiment manager), HTMLReport (Report).

At execution of modeling of processes such parameters as capital investments, the period of depreciation of the equipment, equipment failure probability, energy consumption, adjustment time the equipment and service were specified.
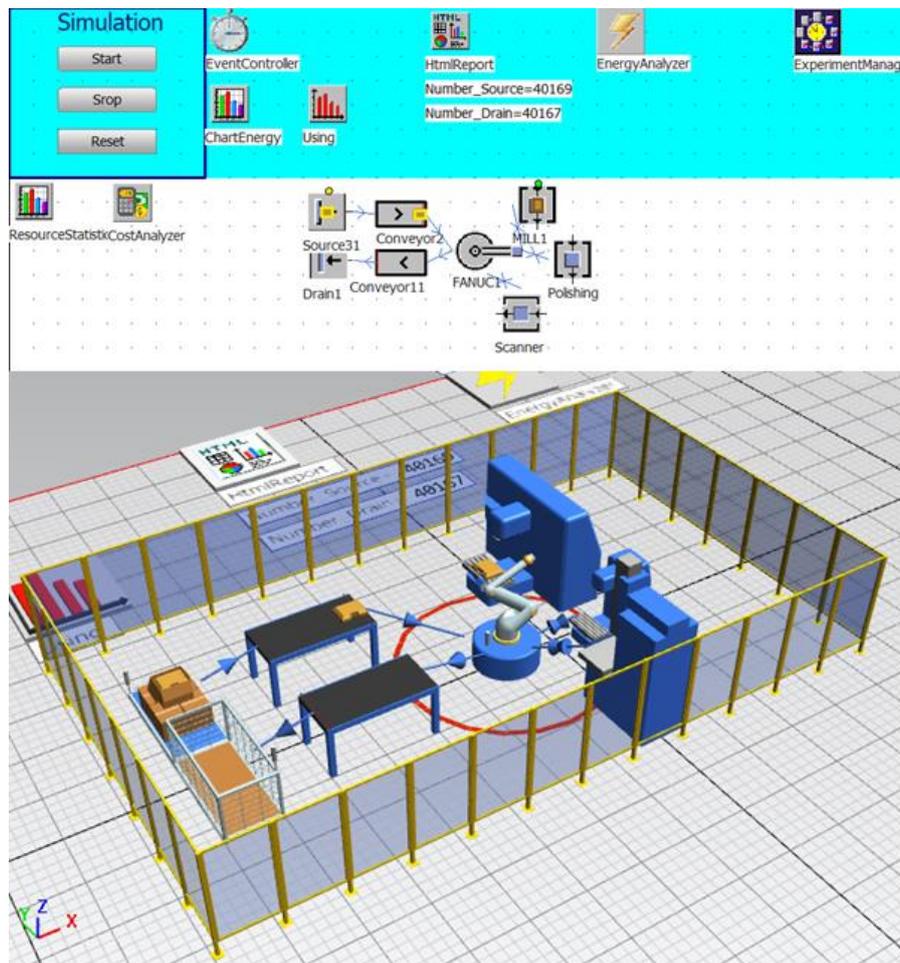
Figure 1. Simulation model for sequential execution of operations.

3. Simulation model for sequential execution of operations

Transportation of preparation on the production line with sequential movement of a detail is characterized by equipment downtimes in bottlenecks.

As a result of the first modeling we receive statistics of resources (figure 2) and energy consumption (figure 3), quantity of the made details for the period (42343 units), cost of production of a detail: $2.55, time of production of one detail: 17 min. From the submitted statistics, it is possible to see that the most not loaded equipment is the robot and the pipeline. The first assumption, which arises for process optimization: increase in speed of delivery of details on the pipeline, but after carrying out several experiments with a speed (1m/with, 2 m/s, 10m/c), became clear that the quantity of details on an output did not change.

4. Simulation model of parallel execution of operations

The second option of model we will consider parallel processing of all details at which the robot we will move a detail from one machine to another after completion of operation and to move behind new after release. Such configuration of actions will demand from the enterprise of the organization of buffers near machines. The model of the presented system is represented in figure 3. The movement of the robot at parallel production of a detail is executed with the help programming of processes. As a result of the offered scheme of production loading of the equipment grew: loading of the grinder grew by 12%, the CNC machine for 24%, the robot for 6%. (figure 4, 5), energy consumption of the equipment also changed.

The applied logistics increased quantity of the made details for the period by 15764 pieces. Because of increase in quantity of the made details the cost of production of a detail was $2.42.

Figure 2. Simulation model for sequential execution of operations.
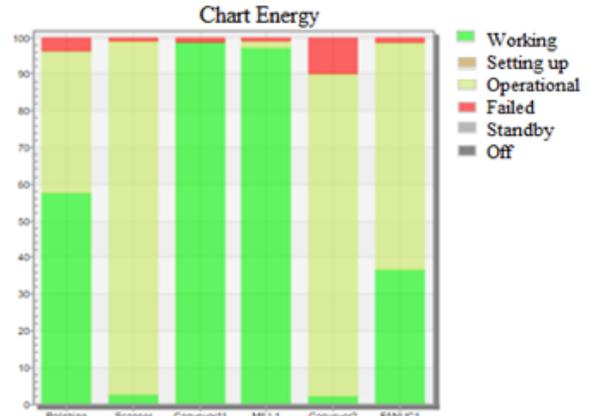

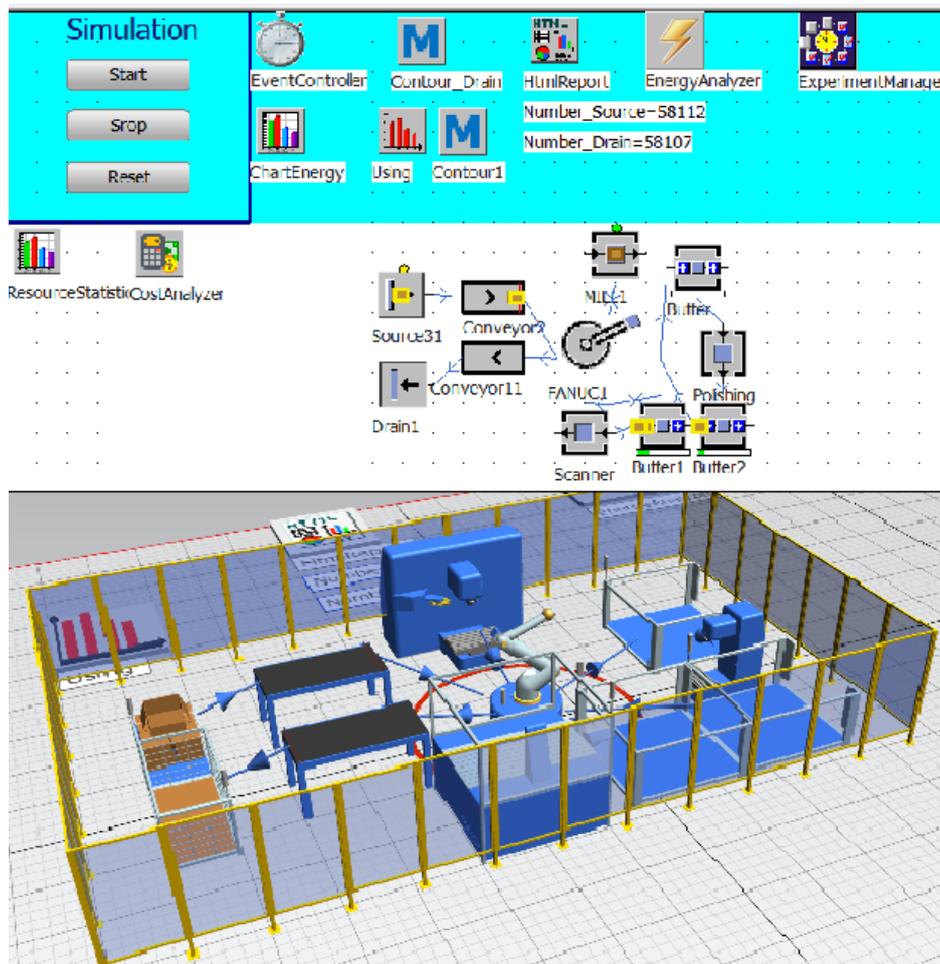**Figure 3.** Statistics of energy consumption at sequential production of a detail.

Figure 4. Simulation model of parallel execution of operations.

Figure 5. Statistics of resources at parallel production of details.
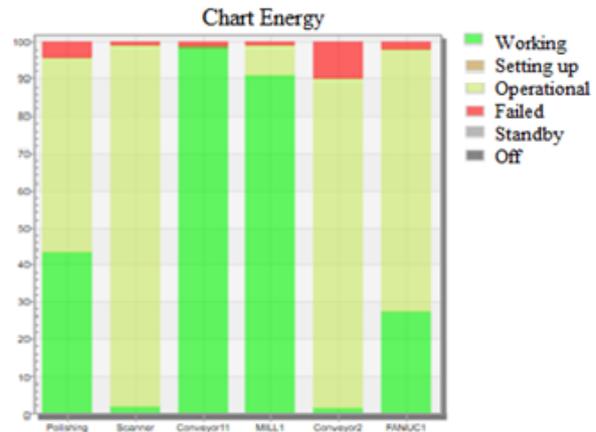

Figure 6. Statistics of resources at parallel production of details.

5. The production line with participation of the worker

In the third model (figure 7), we will consider option of interaction of the person with the processing equipment. In this model of people performs function of the transporter and equipment setup specialist. Thus, before each of machines the workplace should be provided proceeding from what the production line has the appearance presented in figure 8. Movement of the worker will be executed based on advantage of release of the equipment and transfer on it new. Because of the offered scheme of production loading of the equipment in comparison with the first scheme, increased loading of the grinder grew by 2%, the CNC machine for 6%.

This logistics increased quantity of the made details for the period by 2336 pieces. Because of increase in quantity of the made details the cost of production of a detail was $2.5.
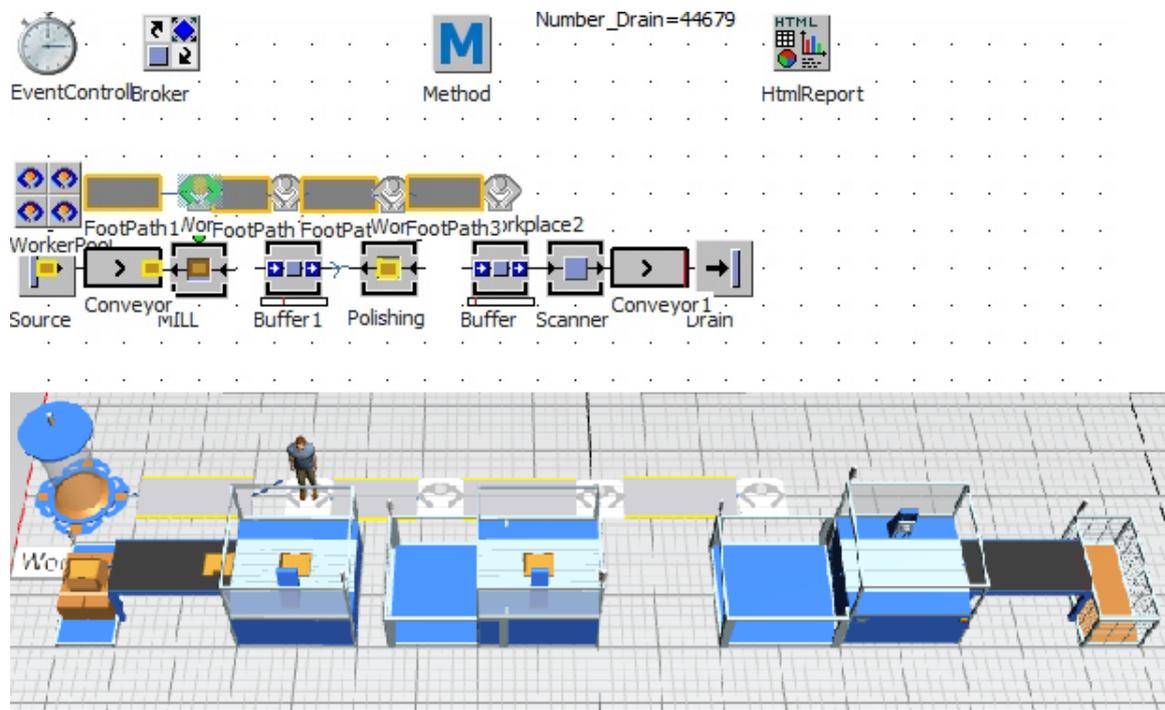

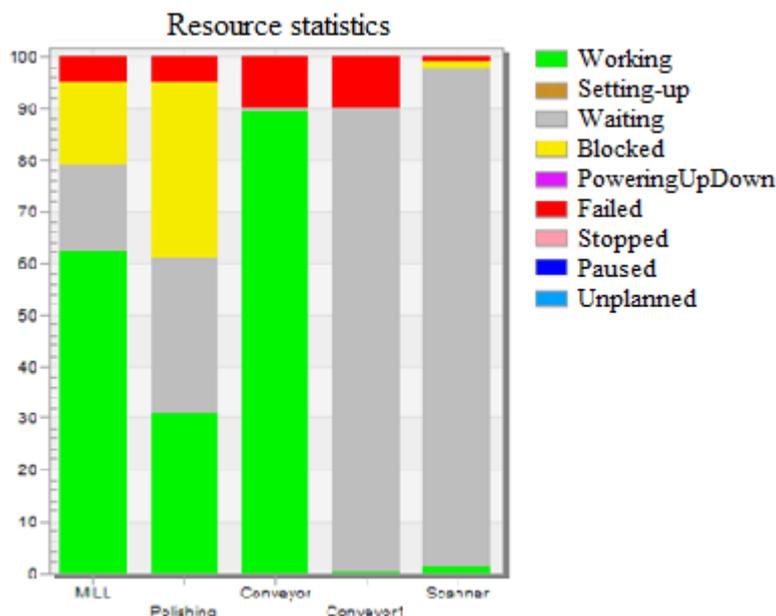**Figure 7.** The production line with participation of the worker.

Figure 8. Statistics of use the equipment with the assistance of the person.

In terms of the statistical factors, influencing work of the person the number of breakdowns and defects of products will increase, but it is necessary to consider that with the assistance of the worker in the 3rd scheme, the quantity of the made products increased.

It is the most effective to use in such production lines industrial robots with the set systems of positioning, and to use work of workers for design and maintenance of these systems.

By consideration of a system of simulation, modeling from quality of the person machine parameters it is possible to select: high-speed performance, reliability, accuracy, safety of work, extent of automation, economic indicators [8]. High-speed performance of a system consists in lack of need to carry out mathematical calculations of efficiency of the equipment manually, lack of need of preliminary equipment checkout. Reliability of a system to be proved by program submission of mathematical laws. Safety of work is limited to rules of work at the computer. The proof of cost efficiency can be as lack of need of setup of the real equipment [8].

6. Conclusion

Design of the enterprise in the 21st century is the integral processing of a large number of these productions. The enterprises need to monitor constantly a situation and operations and to use the technological and human resources to become steady in economic, social and ecological sense.

The presented solutions of technical processes give, understanding about efficiency of different types of interaction of objects of the production line to logistics. The methodology of creation of logistic lines is based on cycles of action, a research.

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