https://doi.org/10.22306/asim.v9i2.100

Received: 12 May 2023
Revised: 02 May 2023
Accepted: 14 June 2023

Optimization of the production process using simulation modelling

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Keywords: optimization, production process, Tecnomatix Plant Simulation.
Abstract: The aim of this paper is to optimize the production process of graphics card assembly in an unnamed company. For the optimization of the production process, we will use the Tecnomatix Plant Simulation software from Siemens. The first and most important step to optimize the manufacturing process is to analyse the current process so that we can pinpoint where bottlenecks or downtime is occurring. For this reason, the first simulation is dedicated to the current production process. In the second simulation, we have successfully implemented all the proposed changes within the upgraded manufacturing process. These changes included replacing the human workforce with two robots in the tenth stage, which involves the assembly of large components. The implementation of the upgraded process allows 44 graphics cards to be assembled in one hour, an increase of 15 graphics cards compared to the current process. In an eight-hour shift, 353 graphics cards can be assembled, which is 118 graphics cards more than the current production process.

1 Introduction

With regard to maintaining their competitiveness, manufacturing companies are forced to constantly improve the quality of their processes with innovative tools. One such tool is simulation programs, which will be dealt with in this work. Simulations allow a wider range of companies to optimize their internal processes.

The article is divided into four interrelated parts. The aim of the first part is to introduce readers to the context of the issue and provide them with the necessary theoretical knowledge to understand the next part of the article. The second part of the article describes the used methodology, analysis of the current production process, simulation of the current production process and simulation of the innovative production process. In the third part of the article, we analysed the results in detail based on the statistical reports provided by the simulation software TX Plant Simulation. The last part summarizes the contribution of our research.

1.1 PLM

Product Lifecycle Management (PLM) is a concept aimed at managing all information about a product and related processes during its life cycle, from design and production to decommissioning. The main concept is quick access to the necessary and up-to-date information about the product, which is the basis for ensuring quality, reducing time and reducing costs. By PLM system, we do not mean one super product, but a set of software products (also from different suppliers) [1]. The system should exchange data with the project management system and, if necessary, with the customer's or company's information systems. The PLM system can be seen as the basis of Industry 4.0, in which there are several other systems that are mandatory for implementation in production. I will highlight the main systems [2]:

1. PDM system - product data management system.
2. CAD system - product design.
3. CAE system - engineering calculations.
4. CAPP system - development of technical processes.
5. CAM system - development of control programs for CNC machines.
6. MPM system - modelling and analysis of product production.

1.2 MPM system

Manufacturing Process Management (MPM) - production process management, digital production. As a rule, it is a set of technologies, methods and programs used in the production of products [3].

The MPM solution allows companies to create models of technological processes and then subject them to analysis. By combining knowledge management tools and optimizing assembly into a common open. Environments MPM systems reduce lead time, design capacity, and provide greater flexibility for product design changes [4-5].

Acta Simulatio - International Scientific Journal about Simulation
Volume: 9 2023 Issue: 2 Pages: 27-31 ISSN 1339-9640

Advantages of implementing MPM systems:

- Reduction of preparation time to produce new products.
- Reduction of commissioning and production time to achieve projected capacity.
- Optimization of production management.

2 Methodology

In this article, we analysed the manufacturing process of graphics card assembly and identified the key parameters that affect the current production. To evaluate the efficiency of this process, we used the simulation software TX Plant Simulation from Siemens [6]. Using simulation, we compared the current production process with the new, innovative graphics card assembly process.

In the current manufacturing process, we have identified a problematic bottleneck in the manual installation of large components that require special handling. This step is time consuming and can lead to errors and inefficiency [7]. To improve this process, we proposed an innovation that consists in replacing the manual installation of large components with two special robots. These robots will be operated by employees who have been engaged in manual assembly until now.

2.1 Analysis of the current production process

As part of this analysis, we focus on one specific process of assembling a graphics card within production. Throughout the production of graphics cards, there are several complex processes that require a high level of labour and demandingness on the part of the workers. The current production process is divided into thirteen steps, which we describe in detail:

1. Quality control by employees: The first step in the assembly process is quality control performed by employees. This inspection serves to ensure that all components and materials used in the assembly process meet the required standards and norms.
2. Applying the paste to the front side of the PCB: At the beginning of the assembly, the paste is applied to the front side of the PCB (Printed Circuit Board), which is the base plate on which the electronic components will be mounted.
3. Installation of components: Next is the installation of individual electronic components on the front side of the PCB. These components include integrated circuits, resistors, capacitors, and other components necessary for the proper functioning of the graphics card.
4. Soldering the components: After installing the components, a soldering process is performed where the electronic components are permanently joined to the PCB using heat and solder paste. This step ensures a reliable and permanent connection of the components to the board.
5. Second quality control by employees: After soldering is completed, a second quality control is performed, the purpose of which is to verify the correctness and quality of the connection of the components to the PCB. Employees check visually and by means of tests that all parts are correctly positioned and connected.
6. Applying paste to the back of the PCB: Paste is then applied to the back of the PCB, which will serve as a support for other components and ensure proper connection.
7. Component Installation: After applying the paste, other electronic components are installed on the back side of the PCB. These components may include smaller parts and fasteners.
8. Soldering the components: The components on the back side of the PCB are then soldered, which ensures their reliable connection to the board.
9. Third quality control by employees: After soldering, a third quality control is performed, where employees verify the correctness and reliability of the connection of the components on the back of the PCB.
10. Manual installation of large components: This phase involves manual installation of larger components such as connectors or larger parts that require special handling.
11. Installation of the cooler: The next step is the installation of the cooler, which ensures proper cooling of the graphics card and protection against overheating.
12. Testing: After the assembly is completed, thorough testing of the graphics card is carried out, where its functionality and correct functioning in various conditions and loads are verified.
13. Packaging and subsequent shipment: The last step is the packaging of the finished graphics card and its shipment to the destination where it will be distributed and sold to customers.

In the current production of graphics cards, a total of 15 workers works on one shift. These employees have different roles within the production process and their work is essential for the smooth running of production without downtime. Among the busiest and most important employees are inspectors and workers responsible for the manual installation of large components. Controllers have a key role in ensuring production quality. Their work consists in checking and verifying whether all parts and products meet the established standards and requirements. Their job is to ensure that each graphics card is manufactured with the highest possible quality and without errors. Employees responsible for manual installation of large components also have an important role. These workers perform the demanding work of precisely installing larger components that require special handling. Their task is to ensure the correct and reliable connection of these components to the graphics cardboard. Their work requires expertise, care and skill. Paste application, assembly and soldering of components is done using machines.

2.2 Simulation of the current production process

Using the TX Plant Simulation software, we simulated the current production process of graphics card assembly, which consists of 13 points, which are described in detail in subsection 2.1. Table 1 shows the times of individual production operations.

Table 1 Work of all machines in current production

Name of the operation	Process time [s]
Quality control 1	45
Paste application 1	20
Installing components 1	30
Soldering components 1	60
Quality control 2	45
Paste application 2	20
Installing components 2	30
Soldering components 2	60
Quality control 3	45
Installation of large components	200
Installing the heat sink	40
Testing	80
Packaging	20

Table 1 shows that the longest operation of the manufacturing process of graphics card assembly is the installation of large components. This operation takes 200 seconds.

In Figure 1 we can see the current production process in 3D.

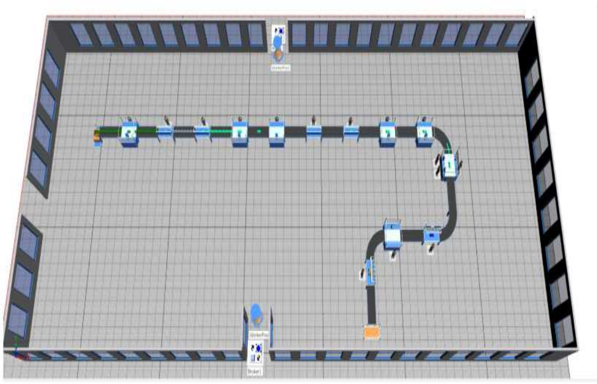

Figure 1 Simulation of current production in 3D

The simulation of the current production process is set up for one work shift that lasts 8 hours.

2.3 Simulation of innovative production process

In the framework of the fourth industrial revolution, the automation of processes is an important goal. In the case of this factory, it was decided to replace the human workforce with two robots for the improvement of the tenth phase, which involves the assembly of large components. This change has the potential to bring several benefits, such as increasing the speed and accuracy of assembly and reducing the risk of error. In Figure 2 we can see the innovative production process, simulated in the TX Plant Simulation software. The yellow rectangle marks the updated place in the manufacturing process of the graphics card assembly.

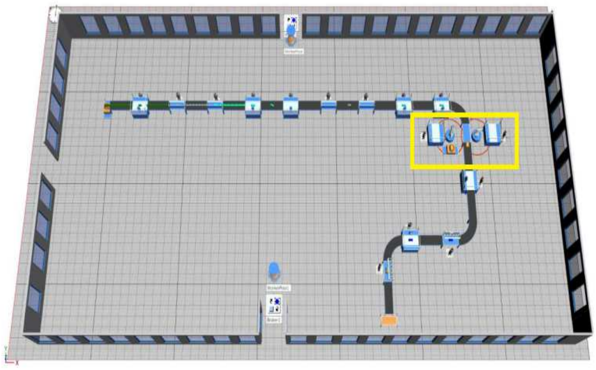

Figure 2 Simulation of innovative production in 3D

In Table 2, we can see the times of each production operation in the innovative production process.

Table 2 Work of all machines in innovative production

Name of the operation	Process time [s]
Quality control 1	45
Paste application 1	20
Installing components 1	30
Soldering components 1	60
Quality control 2	45
Paste application 2	20
Installing components 2	30
Soldering components 2	60
Quality control 3	45
Installation of large components	100
Installing the heat sink	40
Testing	80
Packaging	20

In Table 2, we can see that the process time for installing large components has been reduced to 100 seconds compared to the original 200 seconds in the current production process.

The simulation of the innovative production process is set up for one work shift that lasts 8 hours.

3 Results and discussion

We evaluate the efficiency results of the graphics card assembly production process using the statistical report offered by the Tecnomatix Plant Simulation software.

First, we evaluate the simulation results of the current production process. In both cases, the simulation time is set to 8 hours.

In Figure 3 we see the result of the current production process.

Object	Name	Mean Life Time	Throughput	TPH	Production	Transport	Storage	Value added	Portion
Drain	PCB	30.0000	235	29	66.67%	33.33%	0.00%	0.28%	

Figure 3 Results of current production

Subsequently, in Figure 4 we see the result of the innovative production process of the graphics card assembly.

Object	Name	Mean Life Time	Throughput	TPH	Production	Transport	Storage	Value added	Portion
Drain	PCB	30.0000	353	44	66.67%	33.33%	0.00%	0.19%	

Figure 4 Results of innovative production

Based on the above results, the innovative production process achieved a significant improvement in performance. The current production process allows for the assembly of 29 graphics cards in one hour and 235 graphics cards in an eight-hour shift. After the implementation of the innovative process, performance increased significantly. 44 graphics cards can be assembled in one hour, which is 15 more than in the current process. During an eight-hour shift, 353 graphics cards can be assembled, which is 118 more than at present.

These results indicate that the innovative production process with the use of automation with the help of robots brings a significant increase in efficiency and productivity.

4 Conclusions

When optimizing the production process, it is important to consider all the factors that affect our production process. We must analyse in detail the cause of the bottleneck, how we can remove it, whether removing it will not create a new bottleneck in production. For this reason, it is very important that we think about the smallest details so that we can avoid failure [8].

The implementation of the innovative process makes it possible to assemble 44 graphics cards in one hour, which represents an increase of 15 graphics cards compared to the present. During an eight-hour shift, 353 graphics cards can be assembled, which is 118 graphics cards more than in the current production process.

Such an innovative production process will bring several advantages. First, automating the installation of large components with robots will increase the efficiency and accuracy of this step. Robots will be able to perform tasks faster and with less error. Second, employees now involved in manual assembly will be freed up to attend to other important tasks that require human interaction and expertise.

Overall, the innovative manufacturing process using robots to install large components is expected to significantly improve the efficiency, quality and overall performance of graphics card manufacturing.

Acknowledgement
This article was created by the implementation of the grant projects: APVV-17-0258 Digital engineering elements application in innovation and optimization of production flows, APVV-19-0418 Intelligent solutions to enhance business innovation capability in the process of transforming them into smart businesses. VEGA 1/0438/20 Interaction of digital technologies to support software and hardware communication of the advanced production.

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Review process

Single-blind peer review process.