International Journal of Engineering Inventions
e-ISSN: 2278-7461, p-ISSN: 2319-6491
Volume 12, Issue 4 [April. 2023] PP: 165-173

Identify Bottlenecks in Production Use Tecnomatix Plant Simulation Software

H. T. Hai,N. D. Khanh, N.V.Son,P. Q. Viet, T.D.Thang, N. H. Phan
Faculty of Mechanical Engineering, Hanoi University of Industry

Abstract:
Production bottlenecks (bottlenecks) are a critical issue for optimizing and increasing the efficiency of production processes. Detecting and analyzing bottlenecks is a fundamental challenge for modern manufacturing enterprises. Enterprises cannot ignore issues that significantly impact process efficiency. Those responsible for the production process need to find ways toeliminate bottlenecks and reduce wait times on the production line. The productivity of bottlenecks that disrupt process flow limits the capabilities of production lines. When classical methods fail to apply to complex cases, computer simulations are the appropriate choice.The article presents the results of an analysis of simulation models related to the operation of machines in the selected technological line of enterprises in the steel pipe production field. The primary goal of this paper is to determine the possibility of solving production bottlenecks through simulation software. The problem analysis is related to the application of Siemens Tecnomatix Plant Simulation software.

Date of Submission: 06-04-2023 Date of acceptance: 18-04-2023

I. Introduction

Modern production involves selecting products and reducing production cycles,costs and the time between product design and delivery. Strong competition among enterprises and changes in customer requirements have shortened production cycles, which forces manufacturers to make changes. To improve their operations, it is necessary to identify weaknesses in production processes and make appropriate changes.Every business faces limitations related to bottlenecks, which can negatively impact productivity. Localizing bottlenecks is a criticalissue in production system. The study of bottlenecks in manufacturing is also a frequent topic of scientific studies. Production bottlenecks can lead to various consequences [1]. They can cause two significant problems in the manufacturing process. First, the loss of customers due to failure to meet the needs adequately. Second, the accumulation of excess inventory in front of workstations where bottlenecks exist, resulting in additional storage costs.

The development of computer science and enormous computing power has made the popularity of simulations that use appropriate software to predict changes on real objects and situations before making any changes. Advanced computer simulation technology is becoming important and becoming one of the most important elements of production management. The reason for this development is the need for companies to solve complex problems as soon as possible [2]. The development of programs to simulate processes makes it possible for any business to use them, regardless of configuration. This software is used for a number of examples in table design, management and storage [3]. Building a simulation model is a daunting task and requires a lot of information about reality (production).

Simulation models allow evaluating different production options and their effectiveness. In addition, simulation enables the use of new strategies and processes, verification of production in the modified system, identification of bottlenecks in material flow, increased productivity while reducing inventory and reducing the cost of changes made [4].

II. Literature Review

The document provides definitions of bottlenecks and will give different ways of dealing with them. According to the definitions mentioned the handling of bottlenecks in production and the fact that bottlenecks are formed in production with a production station or stage having to operate at 100% capacity [5]. If according to the knowledge we learn, using a certain tool up to 100% is extremely good and will exploit the full capacity of the machine, but to evaluate according to system techniques, this production process is having problems, inefficiency at work.

A manufacturing station or machine that has a bottleneck is when it is operating at the highest level outside the permitted range, which risks causing disruptions in production [6]. From there, it will lead to problems arising such as: Delayed goods, congestion, time and costs are pulled up,…

A bottleneck is defined as a machine or production station that causes limitations in terms of production and output requirements of an entire system. Machines and production stations with bottleneck problems will often have extremely low production parameters, but the operating level of the machine is always extremely high, from which it can be seen that the working performance is not satisfactory [7].The bottleneck is often confused with the quality and capacity of a machine or workstation, and in practice manufacturing to handle this problem is extremely difficult without supporting tools. The bottleneck also entails an increase in the production time of the product, causing the stalling of an entire system. The bottleneck in normal life is very easy to determine, for example, when we are moving on the highway and encounter a toll booth, then the vehicles will have to slow down. If there are more toll booths on the highway, the time for us to reach the destination will be longer than originally calculated.

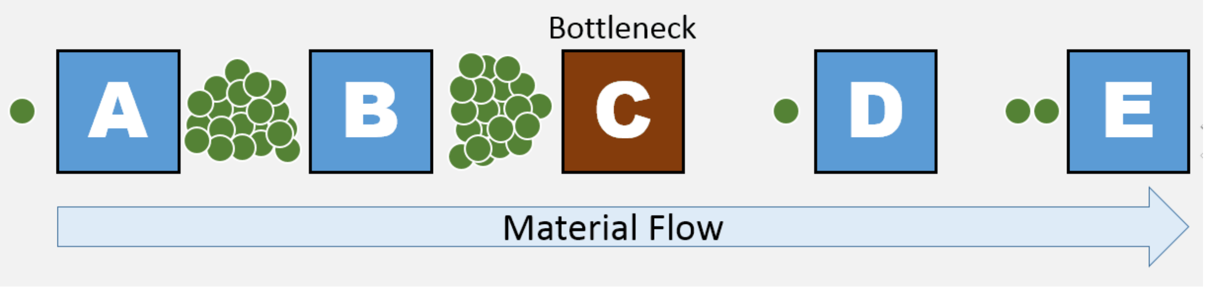


Figure 1.

Improving the manufacturing process and untangling bottlenecks to the production process is extremely important (Figure 1 presents the idea of bottlenecks). Before proceeding with that, it is necessary to find out where the bottleneck occurs to localize and make preliminary and specific assessments.

After identifying the bottleneck in the system, the first stage in the process of removing the bottleneck in production [8]. Properly identifying bottlenecks helps us list the limitations of the system. The phases of defining bottlenecks will have constraints and these constraints are manageable on simulation software. Constraints:

- Make decisions to use to remove bottlenecks
- List the factors that depend on the choice of decision to remove the bottleneck
- Eliminate bottlenecks
- Go back to step 1 (If the bottleneck is removed) and overcome system limitations

Because every system has its own constraints. So defining and removing some of those constraints means giving birth to new constraints, replacing old ones.

Currently, the literature has methods to detect bottlenecks. But there are few specific studies in production and application of practical engineering simulation applications. So the problem here is that there are further studies related to simulation software.

III. Research methodology

The study of production systems is a familiar topic in many research programs. To carry out research, there are many different methods and it is necessary to rely on actual surveys and data analysis evaluations. With the development of IT today, research has also become easier with computer simulation software [9].

This allows the researcher to build a simulation model that most resembles reality. It helps reduce risk, avoid failures or waste when making changes to the production system.

With the above points of view and purposes, simulation can be used for two purposes:

• Describe how the system works, understand the production process, identify system limitations.

• Support researchers in decision-making.

Production process modeling involves the creation of a virtual production process that allows simulations to be conducted and statistics to be collected. Statistics facilitate the execution of reports and a comparison of selected settings of parameters characterizing the production station. Computer simulation models can be freely improved and can change according to theresearcher's needs

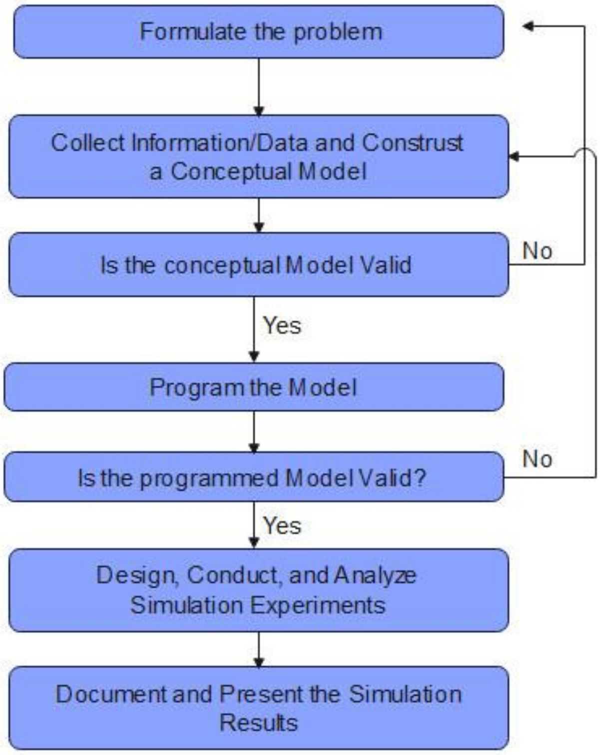


Figure 2. Seven Steps to Conduct Successful Scientific Research [10].

System simulation provides an answer to the question of how the productionsystem will perform under different situations, according to previously calculated methods. The application of simulation models allows enterprises to choose more efficient production strategies. Simulation models are often used when it is difficult to find solutions to problems. This is arguably the best and most recommended method in researching and addressing the limitations of the system.

IV. Simulation by Plant Simulation Tecnomatix

The use of computer modeling and simulation in identifying production bottlenecks notes that creating a simulation model requires full knowledge of the object being modeled. Success in applying computer simulation to solve research problems lies in creating appropriate models and fully executing simulation experiments. Building a production system model and conducting an appropriate simulation experiment helps researchers successfully apply simulation models to solve research problems. To create a production system, it is necessary to compile the information and data necessary for the establishment of methods that can be used to solve problems. Simulation applications must also be carefully selected.

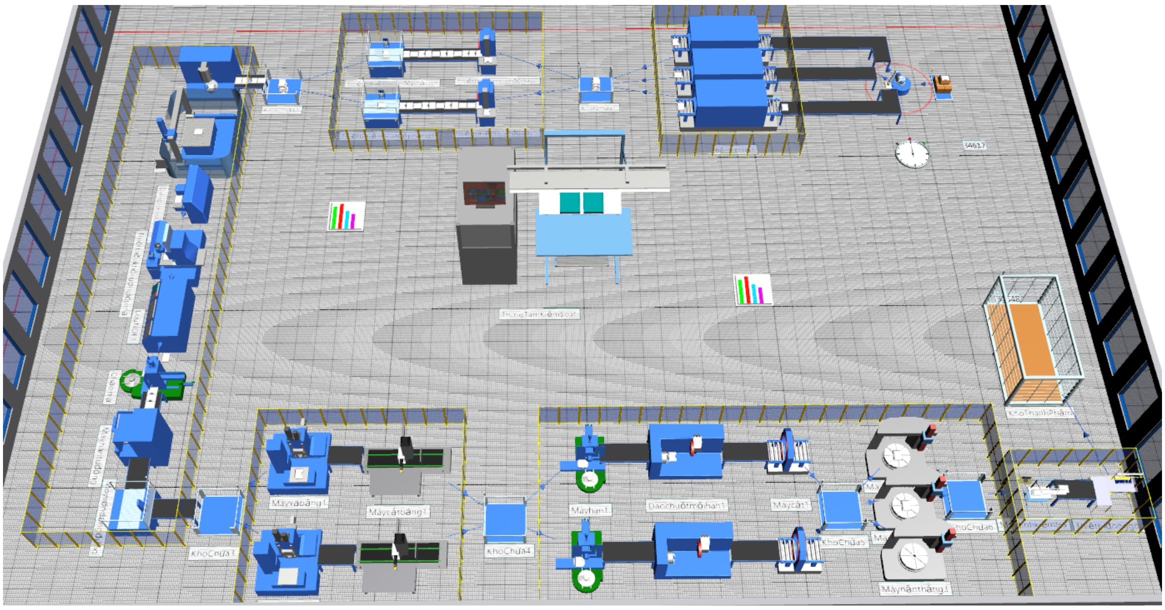
The study involved the use of Siemens' Plant Simulation Tecnomatix software. The choice of application is based on its ability to meet the requirements of system simulation. In addition, there are also other simulation software on the market to simulate the production process, including [11]:

• Arena
• Matlab Simulink
• ShowFlow

Plant Simulation Tecnomatix was chosen due to the availability of resources for the software. This application allows simulation and analysis of products throughout the entire production process. This ensures sustainable planning of a production process prior to implementation as well as conducting analysis and optimization of existing processes. It combines the fields of technology, production engineering, and logistics. It also covers issues related to planning and design, through simulation and verification of processes.

The goal is to achieve the simplest and most efficient model possible. However, it should be borne in mind that excessive simplification can lead to false simulation results, i.e., results that differ from the real state of the system under certain conditions. Simulations need to stick to real conditions..

a) Modeling of Process Planning in 2D Environment



b) Modeling of Process Planning in 3D Environment

Figure 3. 2D and 3D models created by Plant Simulation Tecnomatix of the analysis process

Model of a steel pipe production system (photo) was created with the use of Plant Simulation Tecnomatix software. Input data was determined based on known technological data of the process and data related to material flows during production. It is especially necessary to reflect the activities involved in the processing of individual components.

Properly defining the basic properties of the system is crucial to achieving the right analysis results. The information collected was used to create virtual manufacturing processes and define their basic tasks. The creation of simulation models is based on approved assumptions regarding simulation..

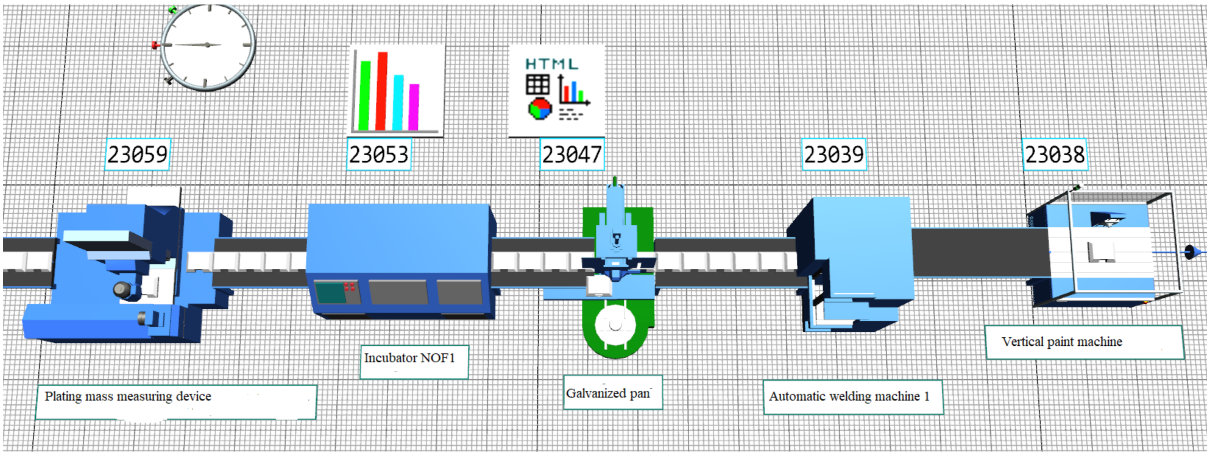


Figure4. Considering the necklace has a bottleneck

Table 1. Processing time component in the workplace (seconds)

Machine work	Processing time (s)
Plating mass measuring device	25
Incubator NOF1	50
Galvanized pan	45
Automatic welding machine	75
Vertical paint machine	45

The research process consists of five workstations and auxiliary infrastructure used to transport semi-finished products. Analysis performed during a shift (6:00–14:00).
An initial analysis of the chart led to the conclusion that the "Automatic Welding Machine" station was the bottleneck of the process being analyzed. Table 2 provides detailed performance results for specific stations.

Table 2. Detailed statistics in the basic model

Work stations	Working time (%)	Standby time (%)	Time congestion (%)
Plating mass measuring device	33.53	0.2	66.2
Incubator NOF1	66.8	0.1	32.9
Galvanized pan	60.0	0.2	39.7
Automatic welding machine	99.7	0.2	0.0
Vertical paint machine	59.8	40.1	0.0

Detailed data analysis confirms that the bottleneck in the studied example is the station "Automatic welding machine", which is used with 99.7% strength, while the rest of the time is spent on pre-planned breaks in the production process. It can be observed that the "Automatic Welding Machine" station causes significant deadlock at the "Plating Pan" station, reaching 39.7% of the simulation time. Furthermore, the bottleneck was identified causing an increase in active stocks as well as the gradual blocking of the "Plating Pan" terminal. It also enforces the waiting time for semi-finished products at the Vertical Paint Machine station.

Table 3. Statistics, capacity and maintenance information of production machines in November 2022

Machine Distribuition	$\bar{X}$	s	Capacity	Availability	MTTR	Cycle time
Plating mass measuring device	25	1,02	75	99,96%	870	4,8
Incubator NOF1	50	0,531	62	99,08%	620	6,3
Galvanized pan	45	1,3	47	99,83%	980	7,4
Automatic welding machine	75	1,6	64	99,92%	881	5,1
Vertical paint machine	45	1,23	85	95,83%	652	6,5

The dashboard provides statistics on variance, capacity, time to evaluate the performance of each machine, and issues to be fixed.

where $\bar{X}$ is the variance is the average operating time of the machine through measurements.

MTTR = $\frac{Maintenance \quad time}{Maintenance \quad quantity}$ this value will be in different intervals depending on the specific requirements of each system, which when calculated, will give appropriate assessments.

V. Results and discussion

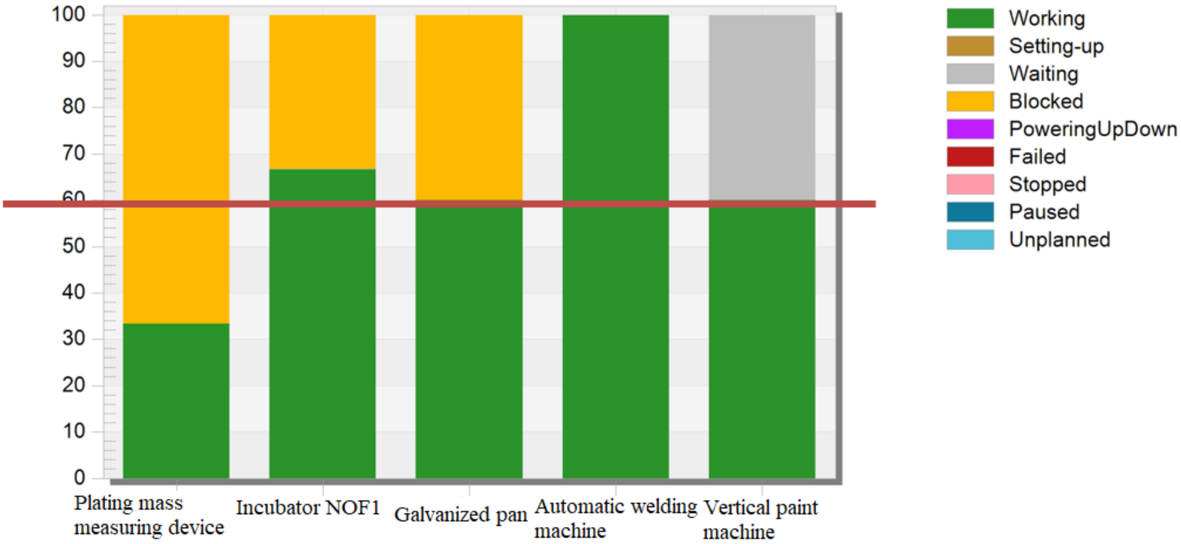


Figure5. Graph % operation of machine assemblies before removing bottlenecks

Figure 5 shows the congestion in the machines and with the red line in the image showing the actual operability of the model compared to the available time is only 60% and positions such as the NOF1 Incubator and the Plating Pan are the two locations that are blocked. This is the bottleneck that needs to be addressed. And Table 4 shows the percentage of actual uptime at locations vs. available time.

Table 4. The percentage of real production uptime, lag time compared to available time is.

Object	Working	Set-up	Waiting	Blocked	Powering up/down	Failed	Stopped	Paused	Unplanned
Plating mass measuring device	33.36%	0.00 %	0.00%	66.64%	0.00%	0.00 %	0.00%	0.00%	0.00%
Incubator NOF1	66.70%	0.00 %	0.00%	33.30%	0.00%	0.00 %	0.00%	0.00%	0.00%
Galvanized pan	60.02%	0.00 %	0.01%	39.97%	0.00%	0.00 %	0.00%	0.00%	0.00%
Automatic welding machine 1	99.99%	0.00 %	0.01%	0.00%	0.00%	0.00 %	0.00%	0.00%	0.00%
Vertical paint machine	59.99%	0.00 %	40.01%	0.00%	0.00%	0.00 %	0.00%	0.00%	0.00%

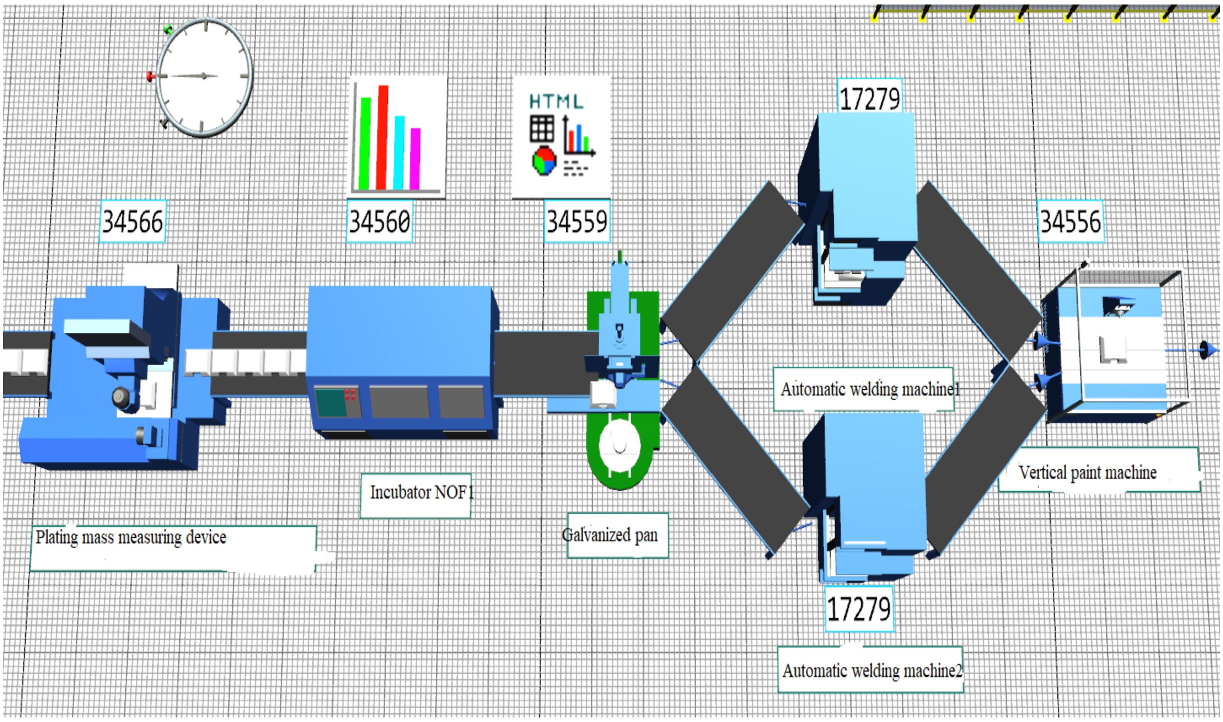


Figure6. Extended model of the analysis process

The extended (improved) model as shown in Figure 6 when adding an Automatic Welding Machine aims to address the bottleneck in Figure 5.

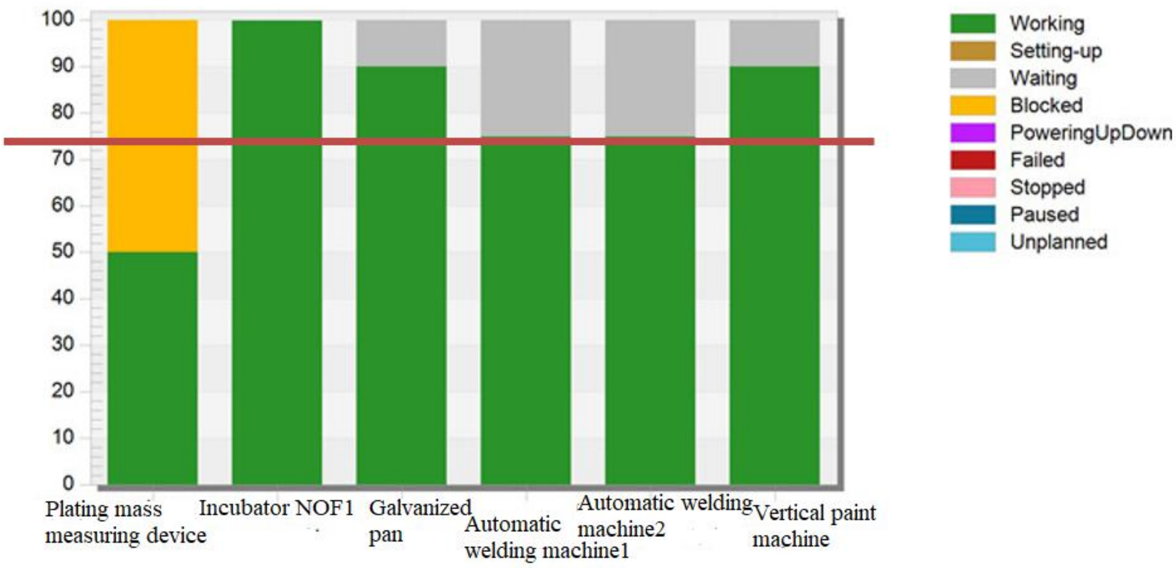


Figure7. Expansion pattern efficiency chart (after removing the bottleneck)

According to Figure 7, the red line shows that expanding the pattern helped us solve the bottleneck. The actual operating time of the model compared to the available time has increased by more than 70%, the congested positions have been resolved (except for the Mass Measuring Device position: this is an area where the working time is much shorter than other positions so it always ends earlier than other jobs). Table 5 shows the percentage of actual uptime at locations vs. available time.

Table 5. Detailed statistics in the extended model

Work stations	Working time (%)	Standby time (%)	Time congestion (%)
Plating mass measuring device	50.0	-	49.9
Incubator NOF1	99.9	-	-
Galvanized pan	89.9	10.0	-
Automatic welding machine1	74.9	25.0	-
Automatic welding machine2	74.9	25.0	-
Vertical paint machine	89.9	10.0	-

Comparing Tables 4 and 5 we see an increase in real time (real production time) between before and after expansion. According to Table 6, thanks to the increase in time, the output (capacity) of the machine also increases.

Table 5.3. Compare output (output, input), machining time at the machine

Machine (cluster)	Before	After	Uneven
Plating mass measuring device	23059	34566	11507
Incubator NOF	23053	34560	11507
Galvanized pan	23047	34559	11512
Automatic welding machine	23029	34558	11529
Vertical paint machine	23038	34556	11518
Plating mass measuring device	23059	34566	11507

Through the two cases before and after removing the bottleneck as above, we clearly see the output, the operating time of the machine has been significantly improved. Avoid wasting resources and costs when producing.

VI. Conclusions

The study aims to show the problem of bottlenecks and how big of a bad impact it has on the production system. And our team has also found the right solution for this problem. That is the application of Plant Simulaiton simulation software.

The research conducted confirms the applicability of Plant Simulation software in simple production process analysis. The use of computer simulation tools allows to predict the operation of the production line and provide some system behavior.

This also confirms that the influence of IT and science on production is in fact increasingly large and important.

Modeling and simulation of production systems using by using Tecnomatrix Plant Simulation helps manufacturers to increase the productivity and maximize the utilization of resources.

.

Funding information: This research was surpported by the Smart Factory Reseach Center of Faculty of mechanical engineering, of Hanoi university of industry, Hanoi, Viet Nam. The involvement of Industry system engineering course students at the Hanoi university of industry in the evaluation of the presented programs is gratefully acknowledged.

References

[1]. José Henrique da Costa Queiroz Gonzalez, Nelson Kuwahara, Production Line Virtualization Process Using Plant Simulation Tool, International Journal for Innovation Education and Research, Vol:-9 No-9, 2021

[2]. Daneshjo, Naqib; Pajerská, Erika Dudaš; Klimek, Miroslav, Danishjoo, Enayat. (2018). Software support for optimizing layout solution in lean production. TEM Journal, Vol. 7, No. 1, pp. 33 -40.

[3]. Chiang, S. Y., Kuo, C. T., & Meerkov, S. M. (2001). c-Bottlenecks in serial production lines: identification and application. Mathematical Problems in Engineering, 7(6), 543-578.

[4]. Debevec, Mihael; Herakovic, Niko; Simic, Marko. (2014). Virtual Factory as an Advanced Approach for Production Process Optimization. International Journal of Simulation Modeling, Vol. 13, No. 1, pp.66-78.

[5]. Ciszak, O. (2007a). Komputerowo wspomagane modelowanie i symulacja procesów produkcyjnych [Computer aided modelling and simulation of production processes]. Zeszyty Naukowe Politechniki Poznańskiej, 6, 39-45.

[6]. Siderska, Julia. (2016). Application of Tecnomatix Plant Simulation for Modeling Production and Logistics Processes. Business, Management and Education. pp. 64 - 73.

[7]. Rohan Ashok Shintre1, Dr. Girish R. Naik, Mayur Bhujbal, Facility and Plant Layout using Tecnomatrix Plant Simulation, International Research Journal of Engineering and Technology (IRJET) .

[8]. Ćwikała, G., & Gołda, G. (2005). Modelowanie i symulacja jako narzędzie poprawy wydajności produkcji wyrobów wielkogabarytowych [Modeling and simulation as a tool to improve the efficiency of the largescale production]. In R. Knosala (Ed.), Komputerowo zintegrowane wytwarzanie [Computer-integrated manufacturing], (pp. 235-245). Warszawa, Poland:

[9]. Zhong, Ray Y .; Xu, Xun, Klotz, Eberhard, Newman, Stephen T. (2017). Intelligent Manufacturing in the Context of Industry 4.0: A Review. Engineering. Vol 3, Issue 5, pp.616-630, ISSN 2095-8099.

[10]. Ekonomia i Zarzadzanie, Identification of production bottlenecks with the use of Plant Simulation software, Economics and Management, Volume 8 • Issue 4 • 2016

[11]. Marta Rostkowska, Simulation of production lines in the education of engineers: how to choose the right software?, Management and Production Engineering Review, Vol 5(4), 2014, pp. 53–65. DOI: 10.2478/mper-2014-0036