International Journal of Engineering Inventions
e-ISSN: 2278-7461, p-ISSN: 2319-6491
Volume 12, Issue 4 [April. 2023] PP: 156-164

Simulation of Production Lines in Soft Drink Company by Tecnomatix Plant Simulation: An Application in the Education of Industry System Engineers

Quyen N. D., Vu N. T., Phong D. H., Thuy D. T. T., *Phan N. H.
Faculty of mechanical engineering, Hanoi university of industry, No. 298 Cau Dien Street, Bac Tu Liem District, Hanoi, Vietnam.
Corresponding author: phanktcn@gmail.com

SUMMARY
Effective management and execution of design, production, and delivery processes are an integral part of modern manufacturing companies or corporations. And to be able to do this, one of the main tools of production planning is simulation model. New and state-of-the-art production equipment used in digital manufacturing will support decision-making in the design of manufacturing systems. Modeling processes is a faster way to find the correct solution from the point of view of generating accurate forecasts, allowing different alternatives to be evaluated. The article discusses the problems of modeling and simulation in the design of production lines, mainly from an educator's perspective.In this paper, it discusses the possibilities of using Tecnomatix Plant Simulation to simulate fruit juice production processes. This tool allows to simulate discrete events and create digital models of fruit juice systems, optimizing the operation of production plants, production lines and processes. individual fruit juices. A review of the implementation of Tecnomatix Plant Simulation for modeling processes in fruit juice and production engineering was conducted and selected simulations were presented.
KEYWORDS: *computer simulation, Tecnomatix Plant Simulation, modeling, fruit juice model*

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

I. Introduction

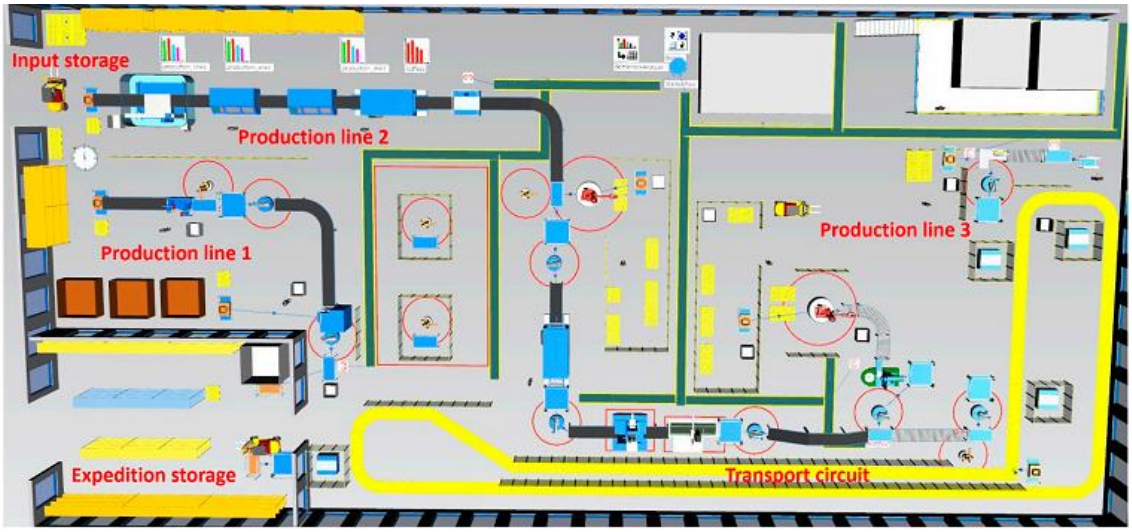
All production lines are usually very complex systems of classical and/or numerically controlled machine tools, assembly stations, a variety of robots, conveyors and transport vehicles. other. Properly designing such a system requires knowledge in several fields and some experience. The industry wants to improve flexibility, competitiveness and reduce costs by cutting the need to produce prototypes and test batches [1]. Detailed planned production involves efficient management of resources. The planning process is done by specifying short-term and long-term tasks. Simulation allows to check the behavior of the system after implementing the proposed solution and eliminate all existing errors. The use of 3D visualization allows for a more precise understanding of the process and interpretation of ambiguities [2]. Computer simulation of the production line allows the designed solution to be tested without prior physical implementation. The digital factory enables the integration of equipment, people and machines, enabling efficient use of plant and process line resources [3]. Simulation deals with efficient resource management [4], including the following: determining the effects of changes in parameters; properties during simulation; System flexibility and capacity; jam; the number of elements of the production system and the types of machines; the required number of employees; job performance; Delivery delay, quality problem, defective equipment; Reduce losses and downtime with maximum synchronization and coordination of all processes involved in material movement and manufacturing processes.

Simulation is a method of representing a real system through a computer program , and the characteristics of the system are presented through a group of time-varying variables to model the dynamic nature of the system.Simulation is the modeling of a real system, often using a computer application with an appropriate software, to perform analysis and evaluation of certain methods that affect the real system through the modeled model. performed on the computer.

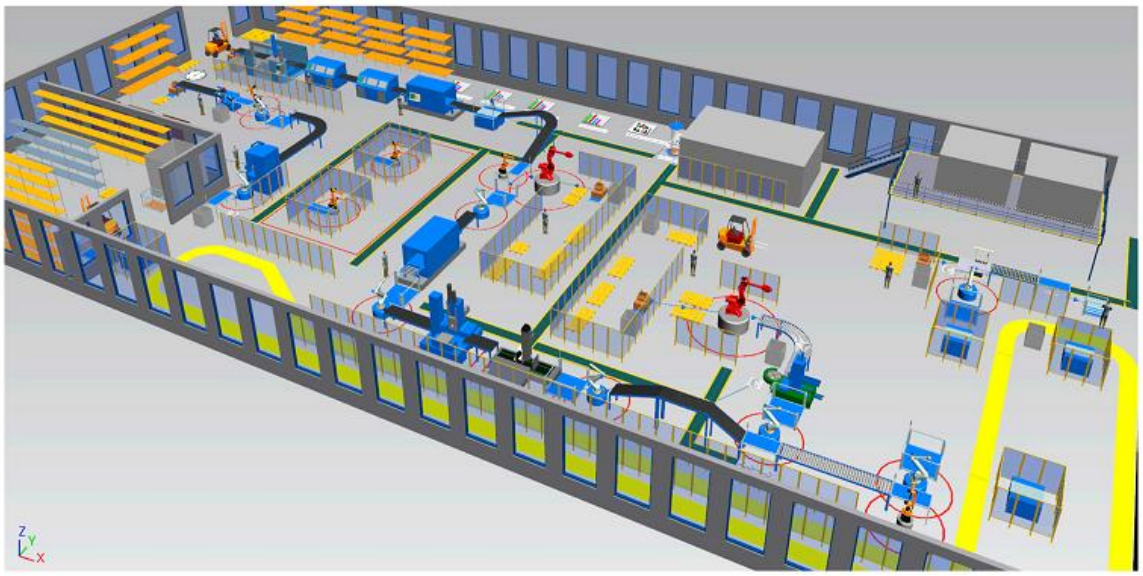
The increasing use of simulation in modernization and production line planning in factories has caused a shift in education in the field. At university, students can gain this experience in two ways. One solution involves the use of small-scale production lines mounted at teaching sites. Examples of such lines are those of Koester [5] and Micro [6]. Although attractive to students, this solution is expensive and allows testing of a limited number of configurations and component types. Another solution is to use simulation software. With simulations, different configurations of equipment on the production line can be easily checked, production

statistics (costs and benefits) can be performed and the optimal solution can be selected. with the structure and composition of the production line under consideration.
Criteria to make a good choice about a simulation program can be based on some of the following evaluation criteria [7]:
• The program will allow simulation of different types of production lines: assembly lines, continuous production lines (e.g. in the food industry), automation lines, participatory lines of humans, etc.,
• The program will allow the user to set the spatial layout of the machine and other parts,
• If possible, the program should simulate both discrete event systems and continuous time dynamic systems,
• Must have a library of predefined components available (machines, robots, conveyors, etc.), as well as the ability to define custom components, including their logic programmed as a file commands, external functions,
• It is recommended to prepare comprehensive reports on production statistics, machine usage, defective products, etc.,
• 2D as well as 3D graphics must be available to represent the layout of the designed system, if possible supported by animation,
• The program should also be available to each student for homework, so a free or educational version should be offered.

FlexSim, Arena and Tecnomatix Plant Simulation are dedicated to logic analysis and diagramming [8]. This is especially a drawback whenever the production line involves robot manipulators (industrial robots). In those programs, we can simulate the work of robots, but cannot program them nor check the validity of their workspaces and trajectories. If you just need to create logic diagrams, Arena from Rockwell offers the easiest and fastest tools to do it. Creating not only production line logic diagrams but also adding some properties to them can be achieved more efficiently in Tecnomatix or FlexSim. All of these programs allow simulation in 3D environments [9].



a) 2D display



b) 3D display

Figure 1. Display of a manufacturing plant in the simulation software Tecnomatix Plant Simulation [10].

In this study, Tecnomatix Plant Simulation was used for training in the smart factory center of the company.Faculty of Mechanical Engineering, Hanoi university of industry, it was used to simulate the juice production system. The change of parts positions in the transmission line has been analyzed, and from that, a modern and reasonable production system has been built.

II. Research method and software supporting modelling and simulations

The process is the goalof many research programs. This involves the application of different methods, starting with practical activities in the form of observations and ending with theoretical analyses. Such procedures require a complete set of maths and simulations. Simulation is an approximate imitation ofOnestudiedphenomenaorbehaviorbelong toonesendsysteminvirtual space with its usesocalled simulationmodel. Thesimulationbelong tomanufactureprocedureto beonetechnology uniqueusedbecausehandleproblemshappenwhileproduction process. It is based on virtual models [10]. As a method, computer simulation is a system of research activities,onestructurebelong tostageactivitiesaim to achieveonestudyobjective, Figure 2.

Simulation studies are applied and used in manyscientistlyfield. The application of a simulation in manufacturing processes constitutes a form of experimentation with a computer model. Its goal is to provide an answer howthemanufacturethe system willreactcome manysituation,according toarrivearranged situations. The application of simulation models allows the choice of production strategy in the enterprise more effectively.

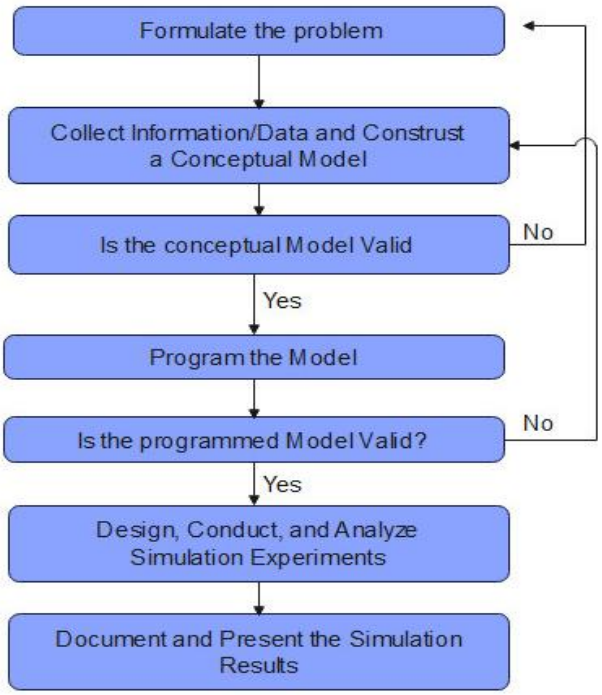


Figure 2 Seven-step approach to conducting a successful simulation study [10]

Tecnomatix Plant Simulation is a collection of technological production line design and optimization programs, and it is designed and developed by Siemens corporation [11]. The foundation of Tecnomatix Plant Simulation is very complex, it includes: Tecnomatix Jack, Intosite, Robcad and Plant Simulation. Tecnomatix Plant Simulation is a discrete event simulation tool, and it can create digital models. In these digital models, the characteristics of the technological lines can be checked, and based on that analysis their performance can be optimized. Currently, this is also software that can represent industrial production line models in 4D, Figure 3.

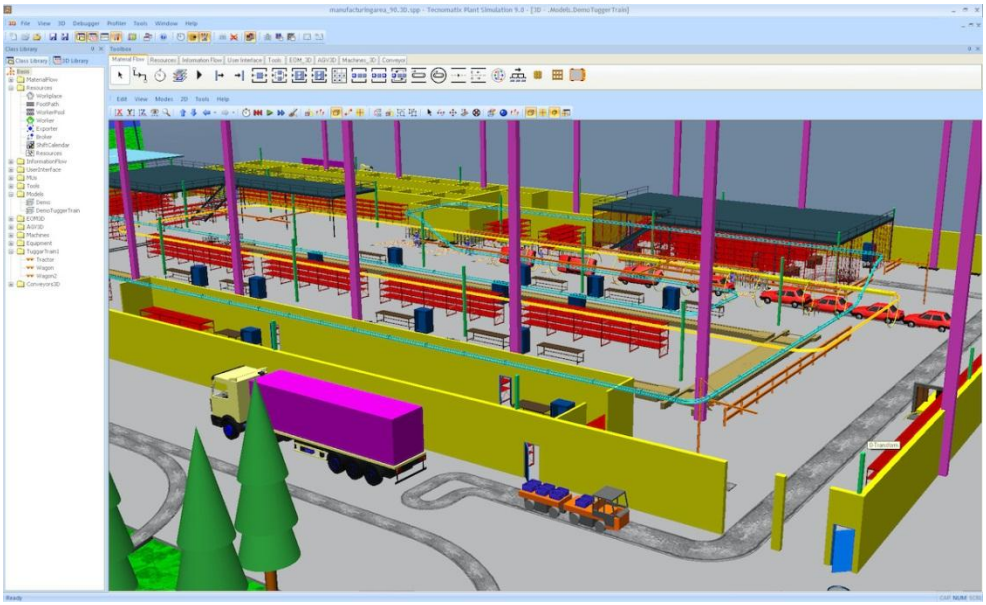


Figure 3. 4D simulation model in Siemens Tecnomatix Plant Simulation [12].

In this article, a virtual simulation of a fruit juice factory will be performed using Tecnomatix Plant Simulation. And this will enable students to model production lines in 2D and 3D, optimizing material flow at every level of planning. Tecnomatix Plant Simulation also has advanced tools to analyze bottlenecks, generate different types of statistics and evaluate different production options.

III. Model of production system in Tecnomatix Plant Simulation

Design simulation of Tecnomatix factory in 3D by changing the view of the screen, Figure 4. The 3D stage represents objects, which are used to create logical models. Users can design and download graphical representations for simulations. During logic simulation, diagnostic and analytical tools can be used. Fruit juice factory simulation has been prepared in this program.

The line consists of working stations (eg: sorting machine, cleaning machine, grinding machine, purifier, sterilizer, degassing machine, ...) arranged in series in a U-shape. for production will be mixed together and then filtered to become an additive (1) . At the same time, the outside fruit will be washed and then sorted by the staff with the sorting machine (2) at the same time as the additive preparation. The fruit will be classified, which is damaged (NG) will be picked out, the qualified fruit will be transferred to the crusher (3) by conveyor. At this time, the additives and fruit juice will be mixed together in the mixer (4) and then transferred to the homogenizer (5) from the homogenizer, the preparations will be transferred to a workstation called the Card machine. Gas (6) to push all excess air out before being sterilized to eliminate all bacteria. Next, they will be poured into bottles (7) , at this stage needing the precision of the robot, also known as the accuracy of the programming engineers , it checks the fullness of the bottle and the degree of accuracy. accuracy of rotation. However, there will still be cases where the philosophies are spilled out (NG) causing waste. Those spills will be moved out. The satisfactory part will continue to pass through the sterilizer (8) again and then passed to the labeling side of the product, at this stage the robot arms will replace humans and have extremely high accuracy. reach 99% perfection. After going through the labeling stage, it will be transferred to the packing area (9) and put the finished products into a carton for packaging and finally will be checked one last time before being sent to storage . That is the final stage .

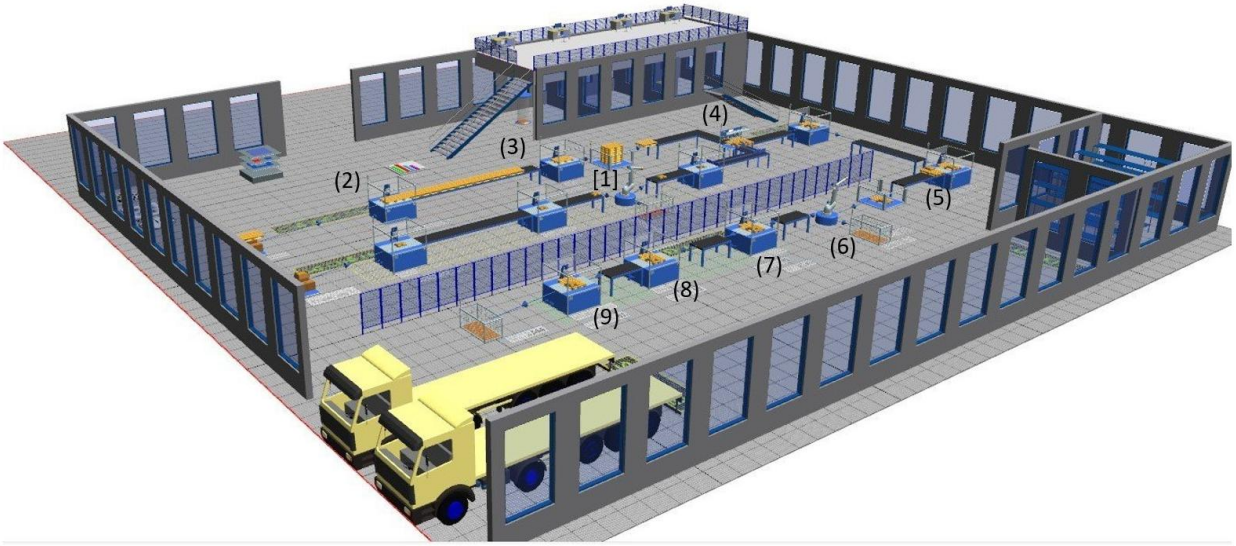
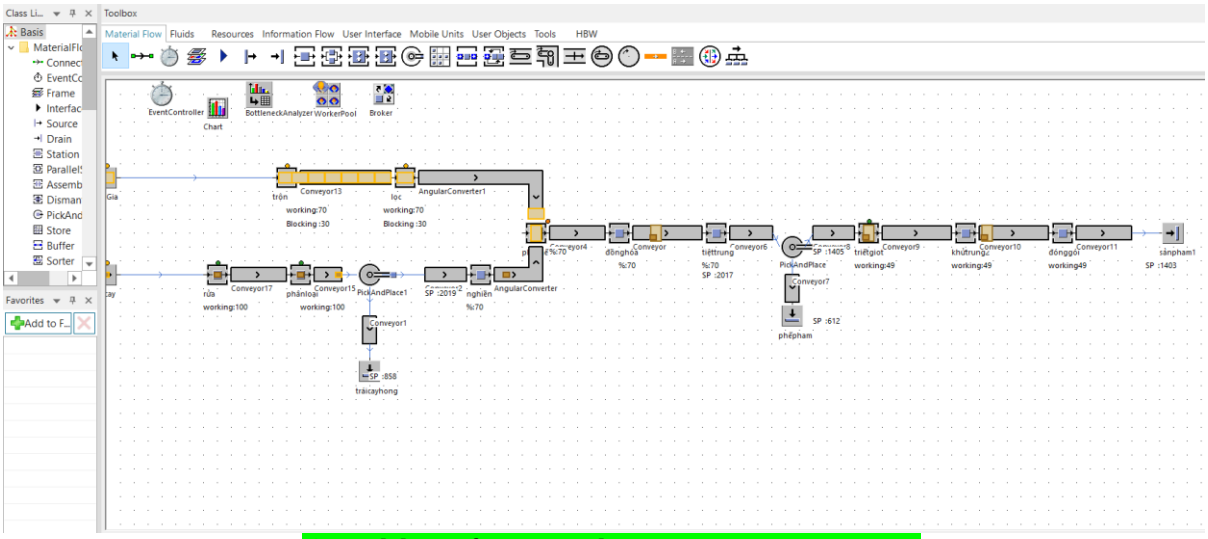


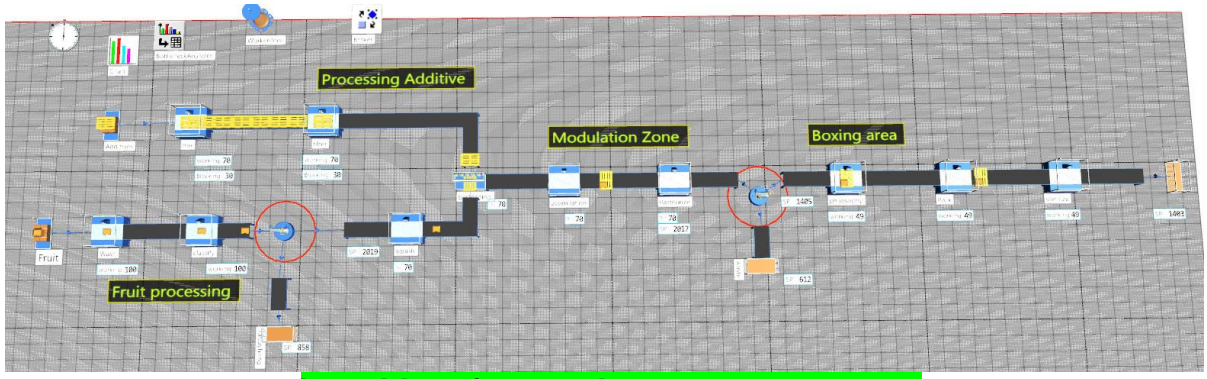
Figure 4: 3D diagram depicting the fruit juice production system using simu lation software

IV. Results and discussion

Tecnomatix Plant Simulation application in fruit juice factory simulationConsider the production line example illustrated in Figure5. This is a simple digital model that demonstrates the nail manufacturing process, designed by the author using Factory Simulation program. Tecnomatix.In the developed model, additive filtration and mixing will be carried out in parallel with the filtration of the fruit, before they are incorporated into the anabolic mix.During the process of canning, the parts will spill out causing waste called waste products. They are then put into packaging.



a) Modeling of Process Planning in 2D Environment

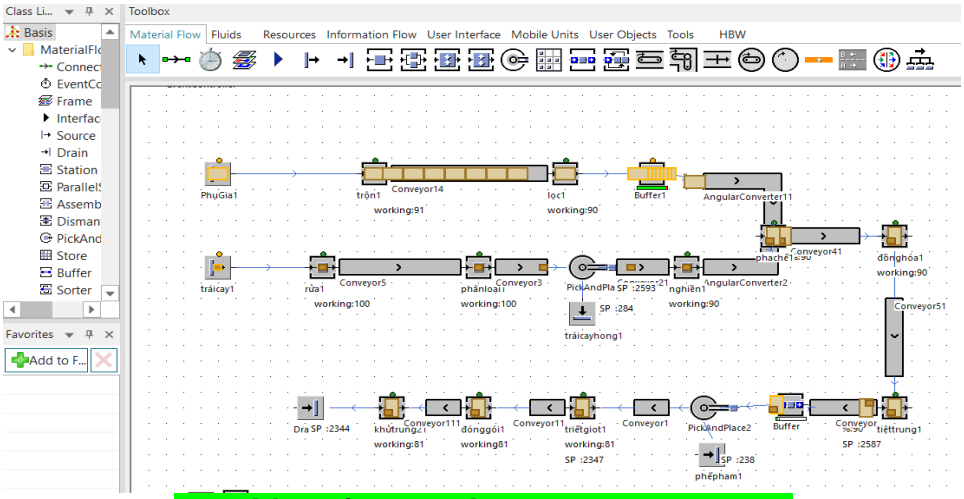


b) Modeling of Process Planning in 3D Environment

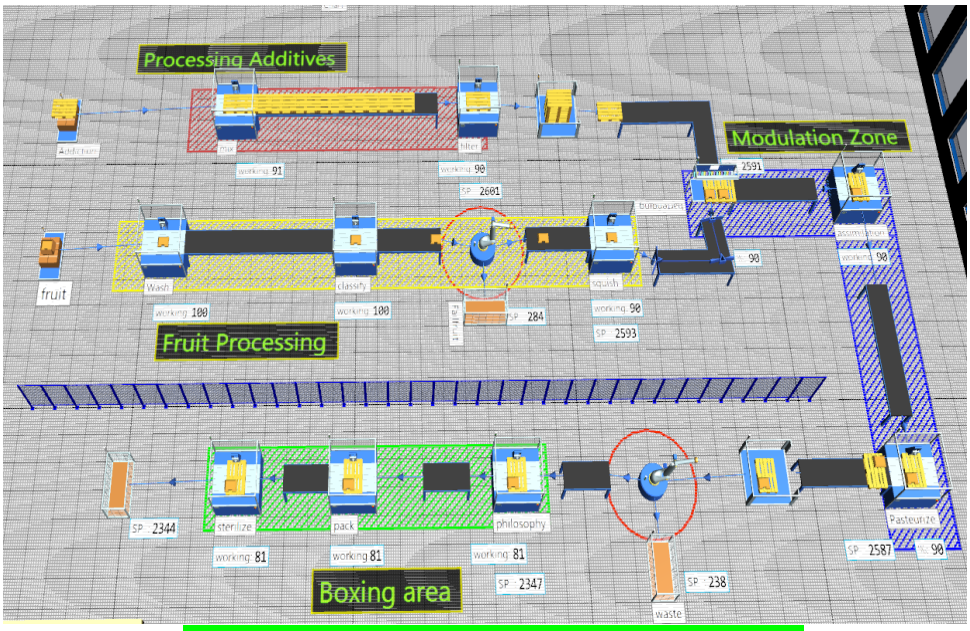
Figure 5. Fruit juice production process designed by Tecnomatix Plant Simulation

A research question is posed here: What are the bottlenecks in the production process as well as why are there so many waste products in the production process and how to increase the factory output?

Experimental results show that most of the bottlenecks occur at the preparation stage when mixing the additive into the fruit juice. The reason here is that the time to prepare the additive is faster than the time to prepare and grind the fruit below, so the additive will be jammed before being put into the mix. The solution here is to add a Buffer station with a certain capacity before the preparation stage (Figure 6) so that the additive will be stored in it waiting for the juice to be crushed and then mixed together to make homogenization. Similarly, a Buffer station is also placed before the pouring process, because this step takes a long time and requires high precision to avoid congestion as well as indirectly reduce waste at this stage. .



a) Modeling of Process Planning in 2D Environment



b) Modeling of Process Planning in 3D Environment

Figure 6. Production line is improved by installing Buffer workstation

In addition, appropriate statistics were determined in the output of the model, which summarizes the manufactured and assembled elements. Within 24 hours of the technological process, the production capacity for machine tools and workstations defined in this way is 862 nail boxes. Figure 7 shows the performance graph of individual workstations in the analyzed manufacturing process.

Statistical analyzes of the work at each work station performed after the entire production process show that only 10% of the wire cutter's capacity is actually used. This station is blocked by the “Tip” machine, which is the bottleneck in this process.

Object	Working	Set-up	Waiting	Blocked	Powering up/down	Failed	Stopped	Paused	Unplanned	Portion
Fruit	0.00%	0.00%	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	
Additives	0.00%	0.00%	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	
Mix	72.95%	0.00%	0.00%	27.05%	0.00%	0.00%	0.00%	0.00%	0.00%	
Wash	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	
Classify	99.61%	0.00%	0.39%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	
Filter	71.04%	0.00%	0.64%	28.32%	0.00%	0.00%	0.00%	0.00%	0.00%	
Squish	71.04%	0.00%	27.00%	1.96%	0.00%	0.00%	0.00%	0.00%	0.00%	
Bartending	70.48%	0.00%	29.52%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	
Assimilation	70.14%	0.00%	29.86%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	
Pasteurize	69.77%	0.00%	30.23%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	
Philosophy	47.70%	0.00%	52.30%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	
Waste	0.00%	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	
Spoiled fruit	0.00%	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	
Sterilize	47.50%	0.00%	52.50%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	
Pack	47.22%	0.00%	52.78%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	
Quantity	0.00%	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	

Figure 7. Analysis of machine performance and congestion

To answer the next question how to reduce the amount of waste in the production process. During the research, it was found that most of the waste products of the production process are in the input fruit classification as well as in the pouring stage. Waste disposal is handled by the PickAndPlace machine. Here, I adjusted the PickAndPlace machine to reduce the amount of waste as low as possible. It can be seen that the amount of waste in the pouring stage at 612/1405 has decreased to 238 (Table 1).

Table 1 . Amount of waste before and after changing the Pick And Place machine

Stage name	Amount of Waste Before	Amount of Waste
Classify	858	284
Philosopher's	612	238

After solving the above two questions, the final question of how to increase the factory's output will automatically be answered. Research evidence (Table 2) has shown that the parameters change after applying Lean to solve the main problems for the factory. Total production has increased from 1403 to 2344, an increase of nearly 67% from the original.

Table 2: Difference parameters before and after changing Lean application

Station Name	Before		After	
	Quantity	% Working (%)	Quantity	% Working (%)
Filter	2021	70	2601	90
Bartending	2018	70	2591	90
Philosophy of pouring	1405	49	2347	81
Pasteurize	2017	70	2587	90
Squish	2019	70	2593	90
Total production	1403		2344	

V. Conclusion

Computer simulations using IT tools have recently become essential activities that aid in the design of new production and logistics systems or the streamlining of existing ones. Simulation methods are also used to evaluate various aspects of the production system. Repeatability is an important feature of computer simulation. By defining certain parameters and assigning them specific numerical values, the same process can be repeated many times.

This paper introduces the implementation of the Tecnomatix Factory Simulation to model the fruit juice production process. The simulations conducted showed the bottlenecks of the entire production process and allowed some optimizations to be tested and possibilities for increasing factory output. By adding an additional machine to the discussed production process as well as by adjusting the machine to reduce the amount

of waste it is possible to increase the low capacity of the entire process. This solution produces a very satisfying effect, as it allows to increase production by almost 67%.

Analysis of Tecnomatix Plant Simulation's past applications for modeling and simulation of manufacturing processes allows it to be considered as an efficient IT tool, used to increase the efficiency of existing systems, maximizing efficiency. optimize resource consumption, limit inventory and shorten production time.

The author's recent research interests include the implementation of simulations and digital models to assess the health of manufacturing companies . Manufacturing and supply enterprises need to continuously monitor the situation and operations and use human resources and technology to become economically, socially and ecologically stable. The technical process solutions presented provide insights into the effectiveness of different types of interactions between production line objects and logistics. This will generate logistic flows based on the analysis and study of its action cycle. The author's future research will focus on simulating production and logistics processes and optimizing them using genetic algorithms and artificial neural networks. Implementations with artificial intelligence tools will be the basis for the author's next commitments. And this is extremely important to the design of businesses in the 21st century.

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 Hanoiuniversity of industry in the evaluation of the presented programs is gratefully acknowledged.

References

[1]. Gregor M., Medvecky S., Application of digital engeenering and simulation in the design of products and production systems, Management and Production Engineering Review, 1, 1, 71–84, 2010.
[2]. Dobrzanska M., Dobrzanski P., Simulation modelling of material handling using AGV, IOP Conf. Series: Materials Science and Engineering 1199, 2021. 012015.
[3]. Palajova S., Figa S., Gregor M., Simulation of manufacturing and logistics systems for the 21-th century, Simulation, emulation, metamodelling, cloud computing, 7, 2, 47–60, 2012.
[4]. Krajcovic M., Plinta D., Comprehensive approach to the inventory control system improvement, Management and Production Engineering Review, 3, 3,34-44, 2012.
[5]. 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
[6]. Kormin T. G., Ovchinnikova V. A., Tsumbu J-D B. Simulation modeling of manufacturing, IOP Conf. Series: Materials Science and Engineering 1047, 2021, 012090. doi:10.1088/1757-899X/1047/1/012090
[7]. Siderska J., Application of tecnomatix plant simulation for modeling production and logistics processes Business, Management and Education, 2015, 64-73
[8]. Milan J., Modeling with tecnomatix plant simulation International Journal of SimulationModeling, 2017,11 12-5
[9]. Pekarcikova, M.; Trebuna, P.; Kliment, M.; Dic, M. Solution of Bottlenecks in the Logistics Flow by Applying the Kanban Module in the Tecnomatix Plant Simulation Software. Sustainability 2021, 13, 7989. https://doi.org/10.3390/su13147989.
[10]. Dante C, Luis E, Villagomez, Jhonattan M, Arturo M, Rafael B, Inti G, Emilio G and Jaime P 2018 A mothodology to support manufacturing system design using models and simulations: an automotive supplier case study IFAC PapersOnLine 51 1598-603.
[11]. https://4dsysco.com/siemens-plm/tecnomatix/tecnomatix-plant-simulation
[12]. https://4dsysco.com/what-is-plant-simulation