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# Manufacturing Facility Simulation Using Tecnomatix PLM by Siemens

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## Abstract

This paper describes the use of Tecnomatix in the final year project to simulate a manufacturing facility that manufactures footballs. Various literature have shown how Tecnomatix plant simulation have been used in different fields of the manufacturing industry and proven itself useful in all stages of manufacturing. The simulation created has revealed several bottlenecks like long waiting times at the assembly station and long blockage times at several stations ranging between 10% and 70%. The use of simulation software can help in analysing the system and improving it through adjusting working times, amount of resources, or even conveyor speeds

## Keywords
Simulation, Manufacturing Facility, Tecnomatix, Operations, Optimization.

## 1. Introduction
Siemens' Tecnomatix PLM (Product Lifetime Management) is a full-featured software suite created to optimize and streamline the whole product lifetime, from design and conception to production and upkeep. Tecnomatix PLM is a leading solution in the area that provides a variety of tools and functions to improve productivity, creativity, and cooperation in a variety of sectors (Plant Simulation Foundation).

Tecnomatix simulates production and logistics operations. Siderska, J. (2016) defined the Tecnomatix program as allowing the simulation of discrete events, the creation of digital models of logistical systems (such as production), and the optimization of the operation of production plants and production lines, in addition to individual logistics operations. The article also included applications for simulating factories for modelling processes in production engineering and logistics services, and some selected examples of simulation processes were presented (Siderska 2016).

All things considered, Siemens' Tecnomatix is a complete digital manufacturing solution that gives organisations the ability to innovate, optimize, and succeed in the competitive market of today. Tecnomatix was used in this project to simulate a manufacturing facility that produces footballs.

In this paper, Tecnomatix was used to address the use of simulation in manufacturing facility design. Throughout our work, we were able to simulate a basic manufacturing facility that fabricates footballs, analyse our results and understand the efficiency of our processes.

### 1.1 Objectives
The objectives of this paper are:
- Use Tecnomatix to design a manufacturing Facility
- Simulate the manufacturing facility and analyse the results
- Test how different parameters can affect throughput and resource statistics.

## 2. Literature
The simulation program has been used in various industrial, logistical and manufacturing organisations. For example, it was used to simulate the process of handling sea containers, where each container undergoes an entry inspection upon its arrival at the company and is opened, unloaded, its contents are transferred, and other operations. It simulated a fleet of autonomous vehicles, and containers, of which their quantity varies according to need (Fedorko 2018). Other companies use the program in customized production according to the customer's request. For example, companies that process ferroalloys and produce cylinders, rotating bodies, assembly and automatic packaging systems are simulated. The energy simulation module is also used to determine production capacities and equipment usage. Therefore, energy consumption, productivity, processing times, operating times, failures, faulty outputs, etc. are monitored and tested in the simulation model (Pekarcíková 2023).

The main focus of some companies is to use the TX Plant Simulation software environment to evaluate Lean tools on a created simulation model. A cutting-edge approach to improving the effectiveness of production and logistics operations in an economically beneficial way using lean manufacturing tools and practices. It entails disposing of different types of waste, which requires in-depth research and industry expertise. Pekarcikova, M et al (2022), discusses specific lean manufacturing techniques to enhance logistics flows addressed in a case study, including value stream mapping, Milk Run, and Kanban. Improved logistical processes related to the provision of workspaces in reducing work in progress were the result of the case study carried out (Pekarcikova 2022). The program has also been used in urban transportation, with a focus on simulating and visualizing traffic patterns in a traffic node. Fedorko, G. M. (2022), provides examples of the implementation of a traffic light simulation model and outlines the approach that allowed the creation of the program. The proposed approach will allow the use of Tecnomatix Plant Simulation technology to build a simulation model of complex logistics operations. It will primarily allow the simulation of both city logistics and production logistics within a single simulation model (Fedorko 2022).

In manufacturing, Chetan (2021) proposed the use of robotic arms alongside the workers in the installation of front and rear windshields. He used Tecnomatix to study the feasibility and productivity of the installation of robotic arms prior to installation. He concluded that adding the robotic arms would increase the cycle time but provide a safer working environment and fewer human errors. This indicates that Tecnomatix can be a powerful tool in the hands of engineers in their planning and design stages. Furthermore, Sujova et al. (2020), developed a simulation model for a machine-building company to understand the current productivity and efficiency of the production line and then proposed improvements using robotic arms for material handling. Their research concluded with the reduction of production time, and costs, and improved production quality. This proves the efficacy of the implementation of simulation in maximising a production line's productivity and efficiency.

## 3. Methods
This section describes the simulation modules used to simulate the manufacturing facility of our study. The modules used for this simulation were: Source, Station, Assembly Station, Buffer, and Drain. The software used is called Tecnomatix. Plant Simulation in the Tecnomatix® portfolio is part of the Siemens Xcelerator portfolio, the comprehensive and integrated portfolio of software, hardware and services. Plant Simulation is software to enables the simulation, visualization, analysis and optimization of production systems and logistics processes (Plant Simulation Foundation). Important assumptions were made prior to the design and building of the Tecnomatix model: 1. the model to run for 8 hours replicating an 8-hour shift. 2. During these 8 hours no failure occurs on the machines. The Manufacturing process simulation starts at various sources that generate the entities (called MUs in Tecnomatix). After that different parts go through different stations to be processed to eventually reach the assembly station. All the parts are assembled at the assembly station and a new part is generated which is the ball. We have a source for cloth,

which comes in the form of pieces, each piece measuring 12 inches. It is then transferred to the cutting station, and the cutting process takes (3 Min) for each piece so that the cloth pieces are ready for the next stage. The plastic source produces pieces measuring 12 inches and goes to the cutting stage in the cutting station, which takes (2min) to be ready before the assembly stage. The leather also goes through two stages after leaving the source, which is that each piece measuring 12 inches comes out of the source. The leather goes to the cutting station and this process takes (4 min) so that after cutting it takes the hexagonal shape of the leather and then moves to the design station. The design station involves giving the outer design to the hexagonal pieces through colouring and other designs that give the ball its outer shape after assembly, and the design process takes place (1 min). On the other hand, the rubber goes through two stages after leaving the source. The rubber, which is 12 inches in size, moves to the cutting station, which takes (2.50 min) for each piece. After completing the cutting and producing the final shape of the spool rubber, the rubber samples go to an inflating rubber station, and this process takes about (0.45 min), after which the piece of rubber is ready. We have the laces that come at the source in the form of spools, and each spool comes with a length of 80 ft, which moves to the lace cutting station, which later cuts the sewing materials for the ball and makes the laces ready. This process takes (1 min). Finally, we have one source that sends MUs immediately to the assembly station, which is the valve source. Then all parts are collected at the assembly stage after the materials are completed and prepared. Here we have the most important station, which is the one that produces the ball's final shape. It is the assembly station where everything that was previously prepared is collected, which is the cloth, plastic, laces, rubber, leather, and valve. They all come together to produce a complete football with all its parts, and it takes (0.5min) to be assembled. After assembling the ball and giving it its final shape, the ball samples are transferred to the quality control station to ensure that the ball is suitable for use and conforms to FIFA's international specifications (Youth Football Specification Recommendations) and that the balls do not have manufacturing defects or assembly defects or other matters that reduce the quality of the ball. This process takes (2 min). The last station is the packaging station. After ensuring that the ball is fit for use and conforms to international FIFA specifications, the ball is moved to the packaging station. This process takes (2min) to complete, and then it goes for shipment outside the factory and is transported to sales stores or international leagues and others. Figure 1 illustrates the flow of material inside our factory.

Two machines were used in the cutting stations. Eastman: Blue Streak II was used in the cloth, leather, and lace cutting stations (Blue Streak II). Eastman: Plastic Master was used in plastic and rubber cutting stations. (Plastic Master)

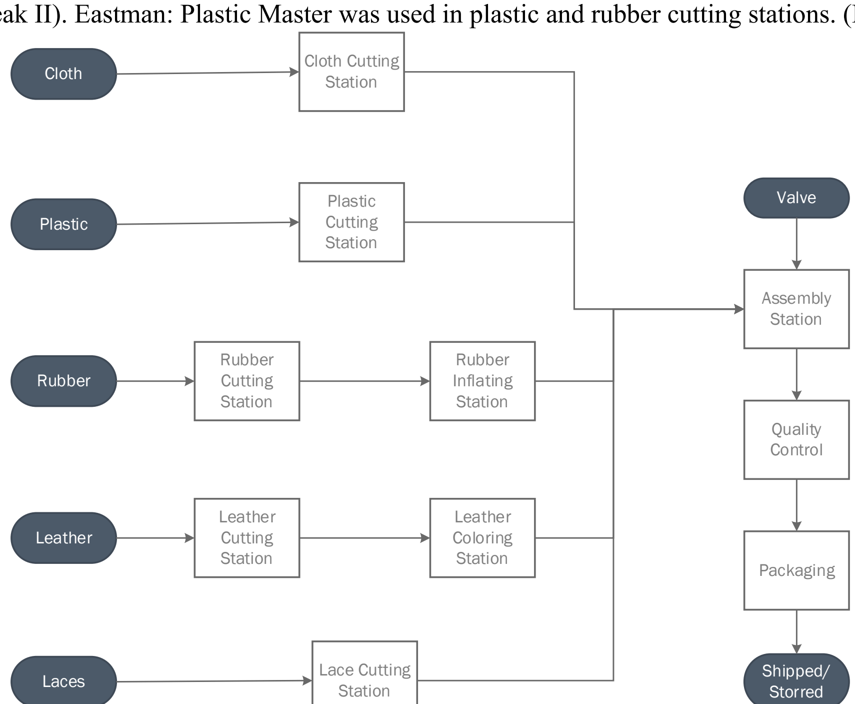


Figure 1. Flowchart describing the material flow in the manufacturing facility

Workers have been added to the simulation to better describe real-life conditions. Each station has a worker. A worker pool was used to spawn workers

The modules used are:

Source: used to generate entities into the system (Figures 2 to 5)

We have seven different sources each source represents a part. For instance, source 1: Rubber, source 2: Cloth, Source 3: Valve, Source 4: Plastic, Source 5: Laces, Source 6: Leather.

Drain: was used to remove entities from the system. (Figure 6)

Buffer: can temporarily hold MUs from the predecessor object when the successor object is unavailable to receive them. Buffer dimensioning is one of the main use cases for the simulation study, as a sufficient buffer dimension is required to prevent production stops. A buffer can either be a queue (FIFO – First In First Out) or a stack (LIFO – Last In First Out). In our simulation, we used the buffer hold Mus from the predecessor.

Station: is a single station that can process one Entity at a time. (Figures 7 to 10)

Assembly station: Assembles MUs received from multiple predecessor objects together. You can create an Assembly Table to define the number of parts required from each predecessor to create the final product. (Figure 11)

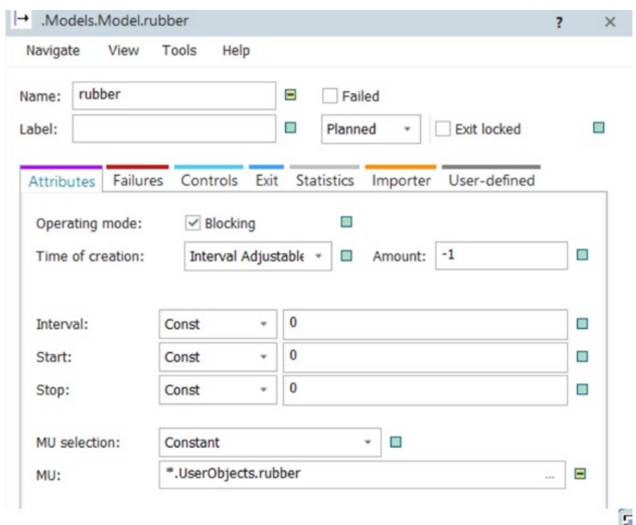


Figure 2. Rubber Source

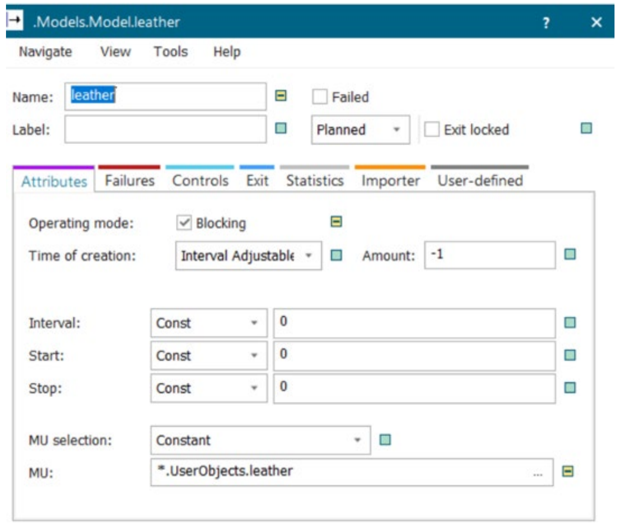


Figure 3. Leather Source

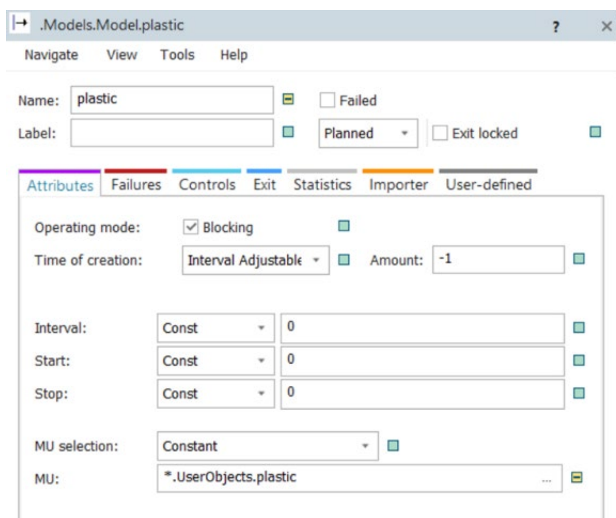


Figure 4. Plastic Source

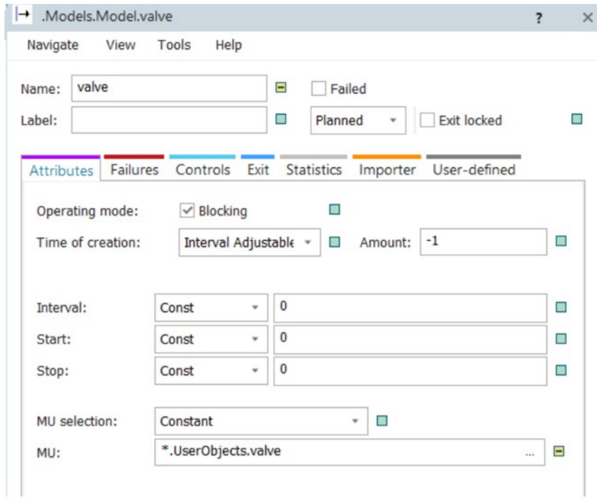


Figure 5. Valve Source

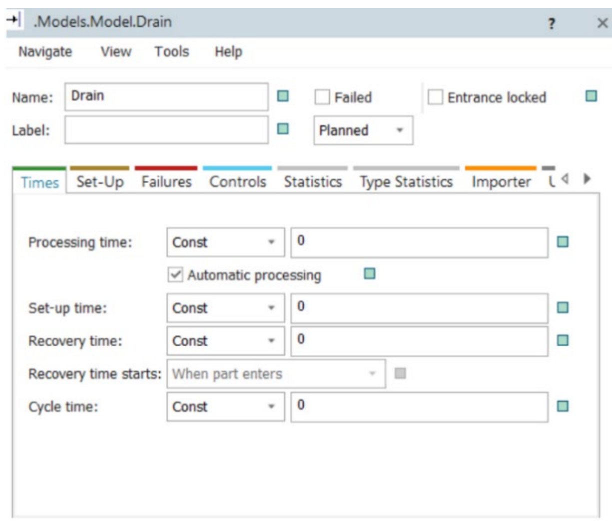


Figure 6. Drain

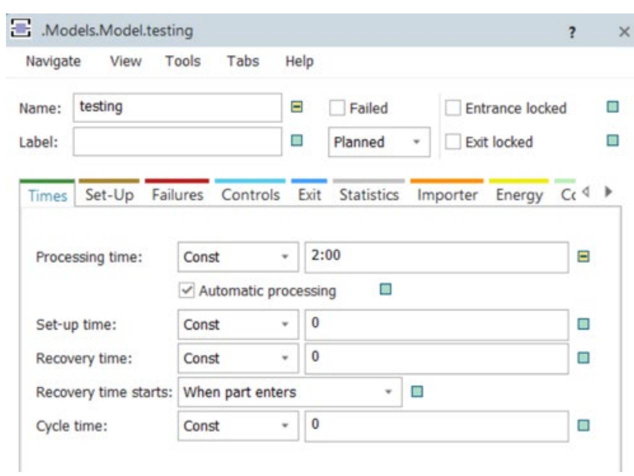


Figure 7. Testing Station

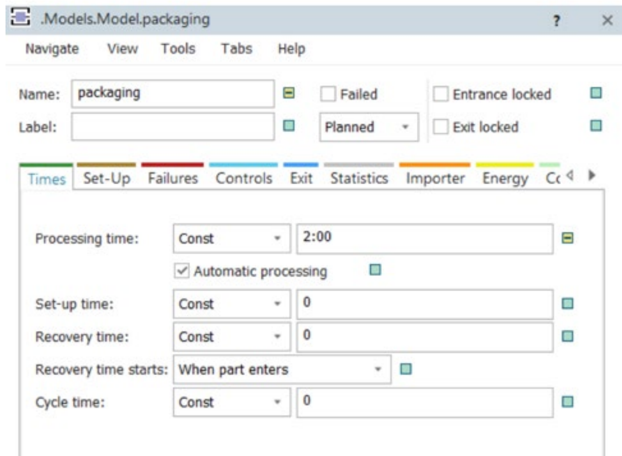


Figure 8. Packaging Station

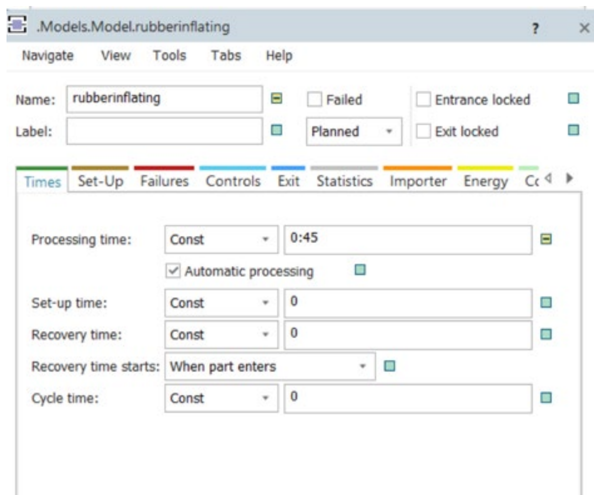


Figure 9. Rubber Inflating Station

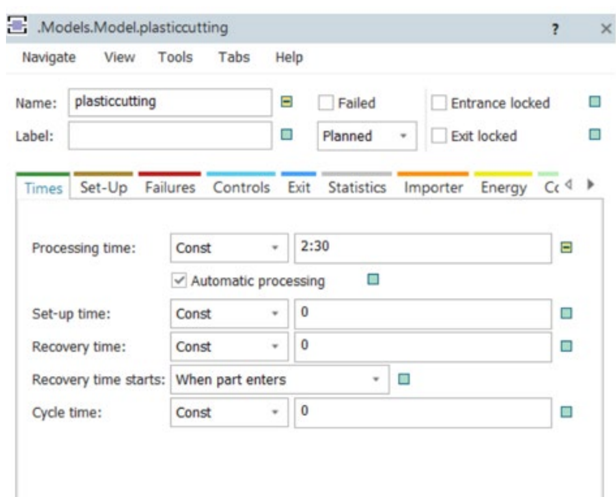


Figure 10. Plastic Cutting Station

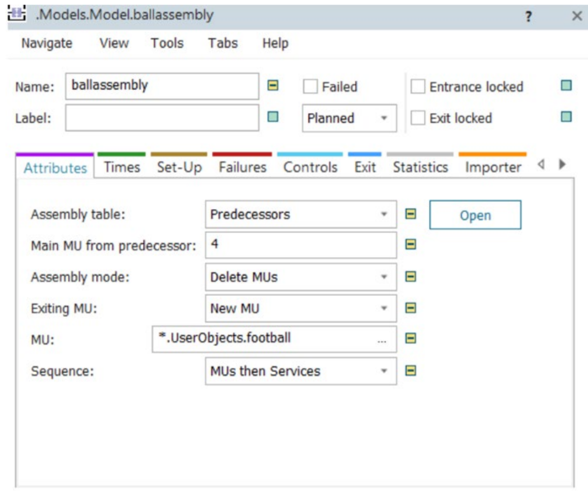


Figure 11. Assembly Station

# 4. Results and Discussion

## 4.1 Numerical Results

The first analysis conducted was the effect of the number of workers on the resources statistics and throughput. It has been observed that having one worker on each station will result in a throughput of 118 footballs. The number of workers was then reduced gradually until it reached 5 workers where the throughput dropped and 114 and when 4 workers were utilised the throughput dropped to 94. Furthermore, it proves that this drop in throughput is due to stations waiting for available workers which can be observed in Figures 12 to 14. It is noticed that when changing the number of workers from 9 to 6 the working percentages did not change and only the waiting and blockage times have varied depending on the state of the resource whether it is waiting for the worker or is blocked. Both states are considered unproductive states which is why the throughput stayed 118.

In addition to the above, the simulation of the manufacturing processes proves some bottlenecks, specifically blockage at the Plastic cutting station (49.11%), cloth cutting (18.50%), rubber inflation (78.36%), and lace cutting (72.58%) which can be observed in Figures 12 to 14. It was learned that the assembly station got an overall average waiting time of approximately 87.60% which can be observed in Figure 15. The reason for the delay was the assembly of product materials. While other stations got less delay time, which makes the workflow seem unbalanced because of delay time, and waiting time. For more fluid traffic and fewer delays, it is of the essence to reconsider and improve the manufacturing plan. The simulation used six main sources, with some going into the assembly station by the conveyors, and some sources having their stations. Then, we did the quality control checks, which took additional time, and the results were 118 balls produced during an 8-hour shift (Figure 16).

## 4.2 Graphical Results

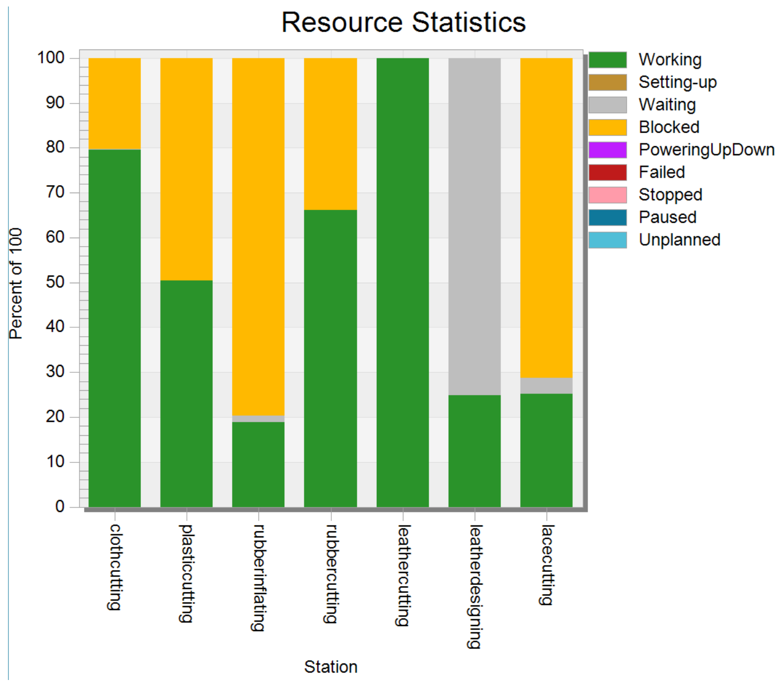


Figure 12. Graph showing the resource statistics of the processing stations before the assembly station with 9 *workers*


Figure 13. Graph showing the resource statistics of the processing stations before the assembly station with 5 workers

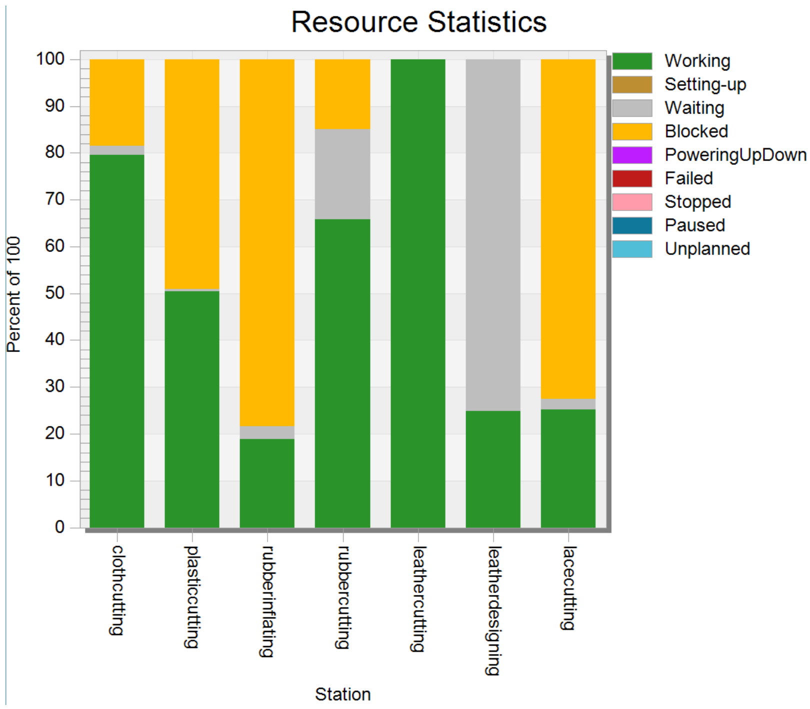


Figure 14. Graph showing the resource statistics of the processing stations before the assembly station with 6 workers

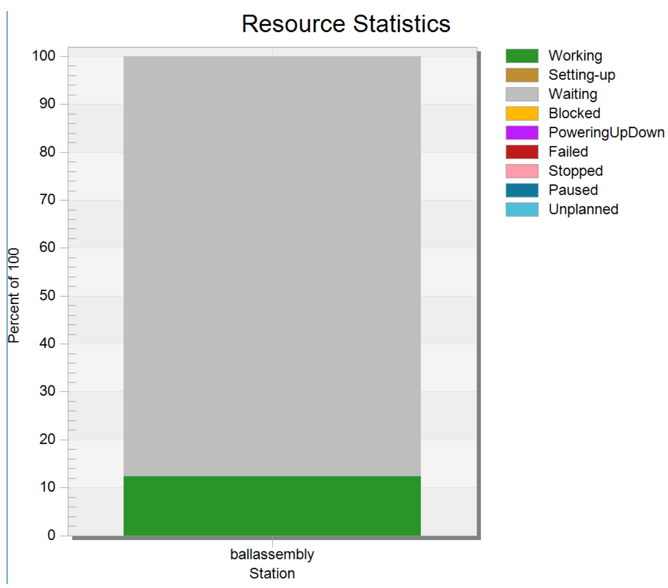


Figure 15. Graph showing the resource statistics of the assembly station

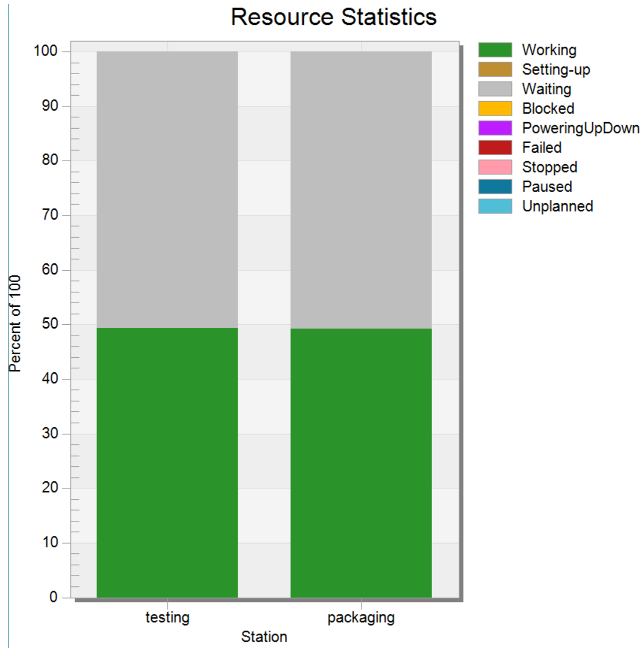


Figure 16. Graph showing the resource statistics of the processing stations after the assembly station

### 4.3 Proposed Improvements

After observing the above results, we can propose the following improvements:
Waiting time reduction by improving the material flow to avoid the assembly, testing and packaging stations from idling. Material flow improvement can occur by decreasing the blockage in the predecessor stations of the assembly stations. These improvements can be reduced by either increasing the number of resources working on each station, increasing the arrival time of the MUs from the source or decreasing the working time.

### 4.4 Validation

The simulation model was built with the initial assumption of having one worker for each station. This model had 9 stations which meant 9 workers were needed according to the initial hypothesis. The hypothesis in this paper checked if we can decrease the number of workers and maintain the same level of throughput and not affect the productivity of the production line. By observing the graphical and numerical results, we can state that decreasing the number of workers from 9 to 6 workers and having workers share the stations when needed, will maintain the same level of throughput. However further studies can be conducted to study the efficiency of the production line when decreasing the number of workers, and its effect on their health and safety

## 5. Conclusion

In conclusion, the simulation contributed greatly to our perception of manufacturing, recognizing areas of modification and elements to be centred on. The way to go with issues such as long queues and turnarounds is to automate the flow of work and increase efficiency. Through the analytical data and the inspection, we can use multiple paths for a more efficient flow of the process and a more efficient use of assets. Periodical evaluation of the manufacturing process and the implementation of continuous modernization are key factors in getting a full advantage from it by producing high-quality products as originally set. Observing literature that used Tecnomatix for testing production lines or manufacturing facilities, revealed the significant use of simulation as an Industry 4.0 solution.

Our work on Tecnomatix was a significant contributor to the design of our manufacturing facility. The model built helped us grasp a better understanding of the material flow, worker flow, and resource statistics. By adjusting different parameters in the model we were able to identify the effect between the number of workers and the throughput. More studies can be carried out on our model in the future to increase productivity and efficiency showing the prominence of simulation tools in the manufacturing industry (Figure 17- Figure 18).

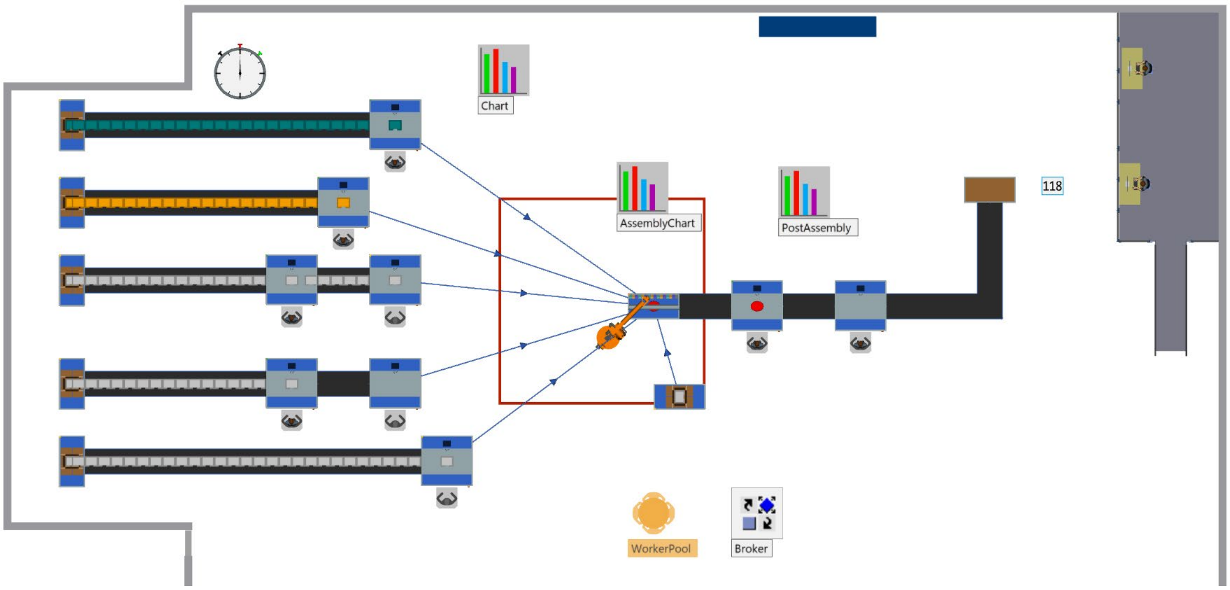


Figure 17. Top view of the simulation model. On the left there are 5 sources generating the MUs, these MUs can be seen entering processing stat stations. In the middle, the assembly station collects all processed parts. After the assembly station, there are the testing station and the packaging station. The production line ends with the drain with a counter screen next to it.

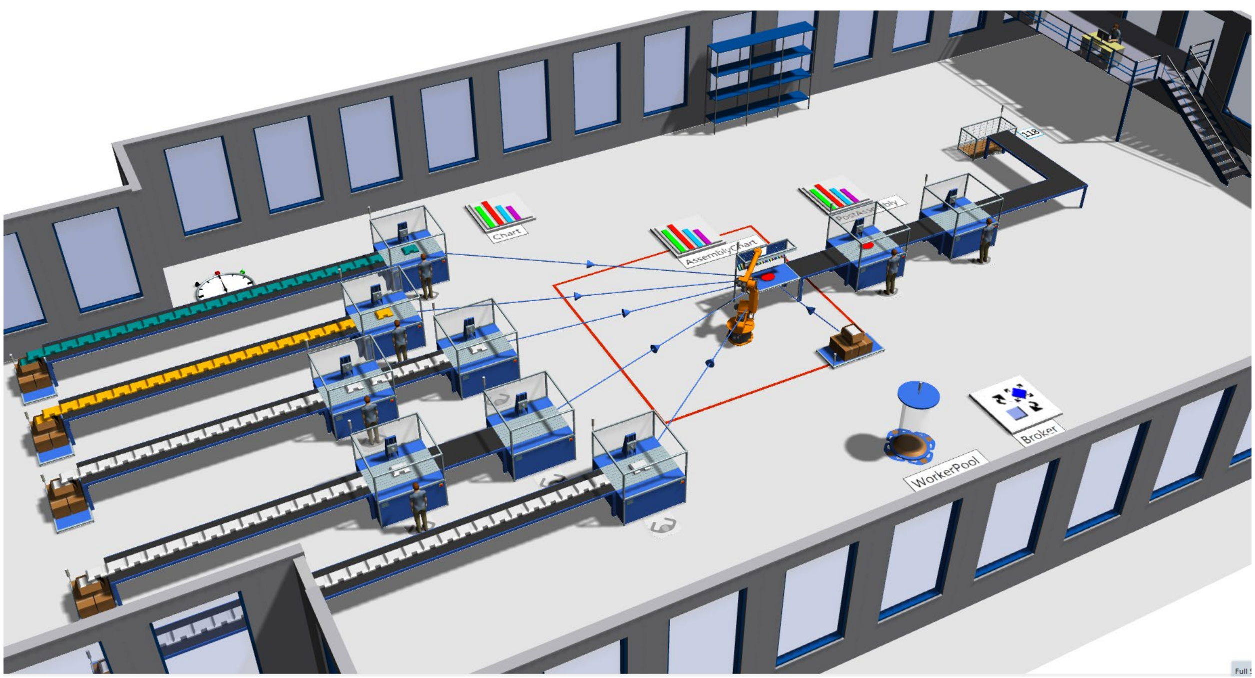


Figure 18. 3D view of the simulation model

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