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SIMULATION LAYOUT PROPOSAL IN A BRAZILIAN TEXTILE INDUSTRY

PROPOSTA DE LAYOUT DE SIMULAÇÃO EM UMA INDÚSTRIA TÊXTIL BRASILEIRA

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RESUMO

A indústria têxtil analisada é um dos principais ramos de produção da cidade e região há muito tempo, principalmente na fabricação de lingerie e acessórios. Devido às demandas do cenário econômico nacional e à vasta competição local, a obtenção de um bom planejamento de produção e ferramentas que ajudam a reduzir custos tornam-se objetos essenciais para a empresa permanecer no mercado. Com base nessas questões e no desconhecimento dos recursos tecnológicos disponíveis, este trabalho tem como objetivo realizar um estudo de layout nos setores industriais, buscando reduzir a movimentação e transporte dos colaboradores. O método de pesquisa apresentado refere-se a uma modelagem e simulação, utilizando ferramentas como o IDEF-Sim e o software de computador ProModel®, que oferece a possibilidade de identificar ineficiências no processo de produção e, a partir dessa identificação, propor melhorias na empresa, utilizando com mais eficiência os recursos disponíveis. Como resultado, houve uma melhoria no modelo simulado modificado de mais de 45% na produção final do recipiente, além da redução da movimentação que gerou a redução de funcionários no setor, a otimização do espaço fabril e melhoria da qualidade.

ABSTRACT

The analyzed textile industry has been one of the main branches of production in the city and region for a long time, mainly in the manufacture of lingerie and accessories. Due to the demands of the national economic scenario and the vast local competition, obtaining good production planning and tools that help reduce costs become essential objects for the company to remain in the market. Based on these issues and the lack of knowledge of available technological resources, this work aims to carry out a layout study in the industrial sectors, seeking to reduce the movement and transportation of employees. The research method presented refers to modeling and simulation, using tools such as the IDEF-Sim and the ProModel® computer software, which offers the possibility of identifying inefficiencies in the production process and, based on this identification, proposing improvements in more efficiently using available resources. As a result, there was an improvement in the modified simulated model of more than 45% in the final production of the container, in addition to the reduction in the movement that generated the reduction of employees in the sector, the optimization of the manufacturing space and quality improvement.

INTRODUCTION

Currently, organizations are inserted in a totally dynamic environment and with future uncertainties about the economic environment, requiring the search for constant improvement of management practices (Rodrigues, et al., 2019). The layout is the physical distribution of machines and equipment of an organization that, through calculations and definitions established according to the manufacturing process, organizes itself so that the work is carried out with the least waste of time and in the best possible way. For an efficient work to structure the layout, it is essential to obtain a good tool so that it does not require major changes in the physical environment and large investments to carry out machinery movements on the factory floor (Kikolski, & Ko, 2018; Ikeda, 2020).

According to Bremer (2019), computational simulation is one of the techniques to assist in the positioning of more efficient machines and people. Computer simulation is the process of creating and experimenting a physical system using a computerized mathematical model, where it can be defined by a set of interactions between processes that receive input and offer results aiming at some specific purpose (Davydov, Antonov, & Angelina, 2018). Corroborating this, Sherman and Craig (2018) mentions that a model is an external and explicit representation of part of the reality seen by the person who wants to use that model to understand, change, manage and control part of that reality.

Elucidating the object of the research, the chosen company faces difficulties related to the production capacity to meet the demand, which leads to longer process time, generating delays in the delivery of orders to customers. The analyzed company always worked in a traditional way and did not seek new production methodologies. Always using inefficient ways to solve production problems, increasing the hours worked, and the labor of effort. The company has always been afraid to make changes to the physical layout and seeks the solution through computer simulation models, proposing changes to efficiently solve the company's current problems.

The purpose of this work is to present, through a simulation model, a proposal to change the company's productive layout that achieves results in reducing product transport time in the printing and shipping sectors. Specifically following the following steps:

- To make a proposal to change the production layout;
- Create the simulation model for the current scenario in which the sector to be studied is located;
- Study the best layout to be applied in the sector;
- To develop versions of the models with different scenarios, changing the layout and features.

Regarding the procedures for carrying out the research in question, the project can be classified as Modeling and Simulation. The tools chosen to carry out the project were the IDEF-Sim for the conceptual model and the Promodel® software for the computational, finally using Excel tabs for the analysis. Thus it was possible to simulate the events in production without the real need to make any physical movements on the factory floor, or even to stop the production

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process. Montevechi, et al., (2016) emphasize that the fundamental objective of the research is to find answers to problems through the use of certain scientific procedures.

LITERATURE REVIEW

2.1 MODELING AND SIMULATION

Different authors refer in various ways to the meaning of simulation. For Santos et al (2019), the simulation consists of a process where the construction of a computational model replicates the functioning of a real or idealized system, with the aim of achieving a better understanding of the study problem and testing different alternatives for the operation. Already for Oliveira, Pinho and Lima (2013), the modeling and simulation tools help to visualize, analyze, and optimize complex production processes, established in a certain amount of time and investment. Also according to the authors, a change also optimizes the resources used in the search for improvements and quality of products and services, allows to test different changes in the scenario and, thus, execute the changes that are caused in the existing processes and currently expand knowledge of how the system works (Alves, 2018; Davydov, et al., 2018; dos Santos, et al., 2019; Rodrigues, et al., 2019)

Systems modeling using computer simulation has become a great ally for quality improvement work and production management. The technique of this use makes it possible to view the functioning of systems in scope of analysis, assisting analysts in decision making based on the results obtained in the research (Apter, 2018; Goytacazes, & Aragão, 2011; Rodrigues, et al., 2019). Gaziero, et al., (2014) to approach which means of simulation it is possible to replicate on the computer a hypothetical sequence of events of a studied system over time. The great versatility of the method allows the model to be executed in detail and meeting the needs of each occasion (Medojević, & Medojević, 2017).

Still as a management tool, simulation also plays an important role in the area of operational research, allowing professionals from different areas to solve the most complex problems. It allows the application of modeling and simulation to more different areas (Law, 2019; Santos Filho, et al., 2016).

Santos Filho et al., (2016) they also highlight the use of modeling and simulation as a tool to aid decision making, where its main characteristic is to work with complex systems and to allow the analysis of its dynamic behavior, mainly due to its versatility, flexibility, and great power of analysis. Also according to the authors, the simulation can bring advantages such as the creation of diversified production scenarios, obtaining indexes and values aimed at assisting decision making, providing precise information on how the system would react with the implementation of the idealized modifications. The same authors argue that the advantages of simulation can be summed up in the possibility of visualizing the system, implementing changes and answering the doubts and questions existing in the real system, in order to be able to understand, manipulate and verify the system's behavior safely and with much lower costs if the deployment was carried out in the real environment (Dos Santos, et al., 2019).

2.2 PRODUCTIVE LAYOUT

According to Saraswat, et al., (2015), the purpose of the layout is to carry out the physical positioning of the transformation resources, where their poor dimensioning and distribution can result in long and unnecessary flows, impairing the company's productivity, which may directly or indirectly affect its costs. According to Ripon, et al., (2013) and Liu, et al., (2018), the development of a layout in an organization is used and solves problems in positioning machines, equipment, and workstations, deciding which is the most appropriate position, in order to make the flow of materials and work more efficiently.

For the preparation of the positioning of machines and equipment, it is possible to obtain information about the product specifications and resources, the quantities of products and materials, the sequences of operations and assembly, the space required for each equipment, the space for the operator, conveyors, and maintenance, and information on receiving, shipping, storage of raw materials and finished products and transport (M. Liu, et al., 2017; Martins, & Fernando, 2005).

Aided by the fundamentals of the Toyota Production System, Chiarini, et al., (2018) declare that the implementation of a production mechanism that works, companies should seek to reduce the seven possible changes in the production flow, being the best method of studying the layout. This waste is overproduction, waiting, transportation, processing, stock, defects, and movement.

Focusing on the waste of movement becomes one of the essential points to be worked on within the changes that occurred in the layout. In order to identify movement waste, it is necessary to compare the pre-defined times with the times measured during the process, where it is later possible to analyze whether there are activities that can be performed differently, with the intention of making the execution time shorter and more efficient (Caldera, Desha, & Dawes, 2018).

2.3 TEXTILE INDUSTRY

Hossain; Sarker and Khan (2018), defines the textile industry as a group of companies and sectors that transform fabrics made from natural, synthetic, or artificial fibers into personal and household products, among others.

The steps commonly found in the textile industry are: product creation and development; Modeling of pieces in different sizes and molds; the risks where parts of parts for manufacturing and sewing are divided; Cut, where the pieces are formed by cutting the cuts - overlapping the cloths; Finishing, where cleaning is performed and, if necessary, adding accessories; and finally, assembly, where the parts are ironed and packed for shipment to the customer (Santos Filho, et al., 2016).

RESEARCH METHOD

For the development of the work, the Modeling and Simulation methodology was used. Computer simulation itself consists of the use of certain mathematical techniques, used in computers where it is possible to simulate the operation of almost any type of real system through the creation of systematic computational models. Thus, the simulation method is understood not only as a way to build a model, but also as a possibility to carry out experiments, aiming at describing systemic behavior, raising theories and hypotheses, and making future predictions of behaviors according to the changes made virtually in the system (Rodgers, Madison, & Tikare, 2017).

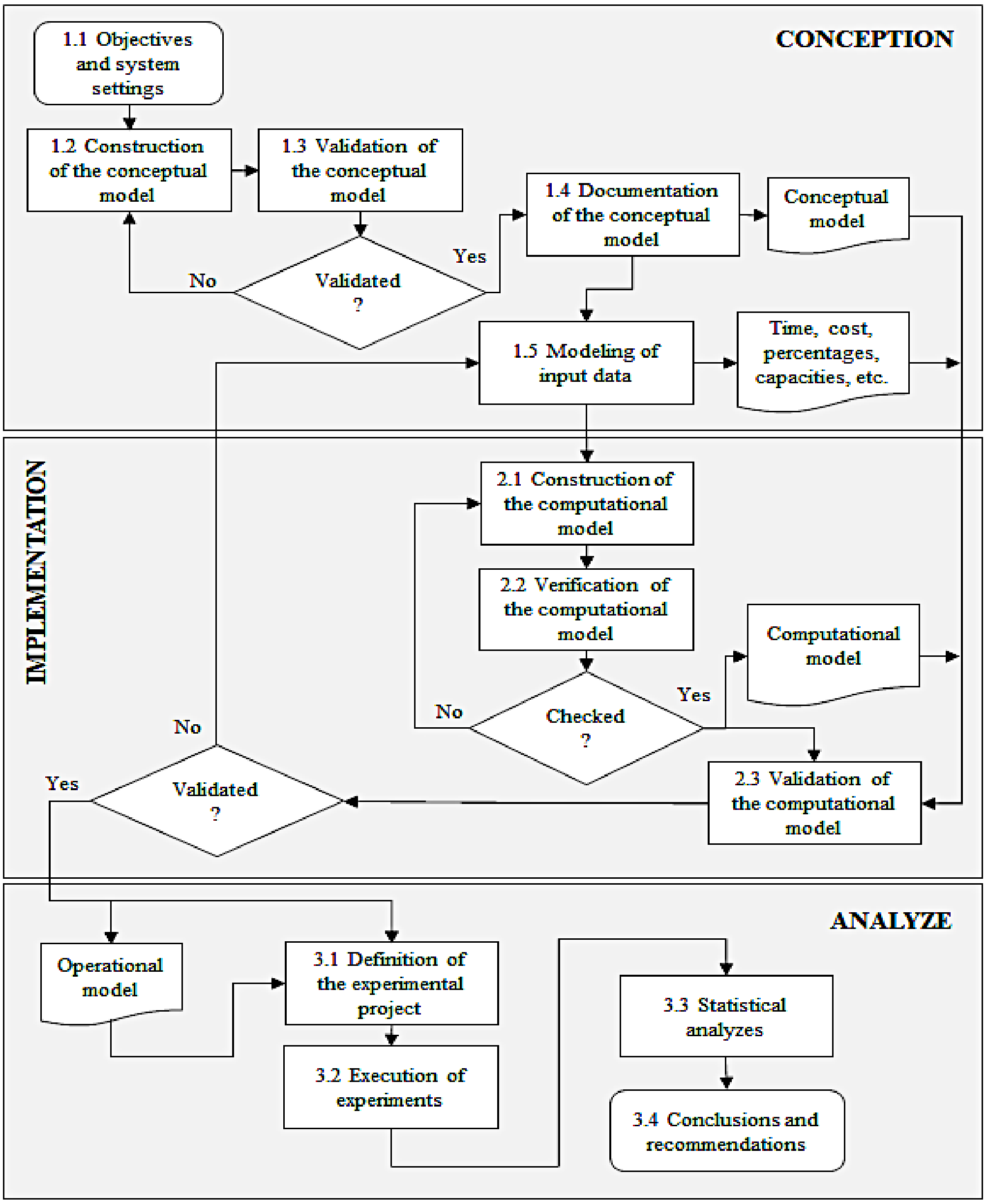
According to De Lima, et al., (2016) a simulation model is developed based on three steps: namely, creating or forming a problem; implement system development; and subsequently analyzing the results obtained at the end of the model execution. Also according to the same authors, each step of the method is described in detail.

In the first phase of the project, the system to be simulated is understood and what its objectives are, this can be achieved by discussing the problem with specialists and observing the real system (Rodrigues, de Jesus, & Oliveira, n.d.). After conception, it is important to illustrate the model to make it understandable to the understanding of others involved in the project. For better illustration, this work uses the IDEF-Sim mapping technique, developed by Mussolini and Gaudêncio (2019) and used by several works in the area.

Subsequently, the implementation stage is performed, where the conceptual model is converted to the computational model by means of simulation language using specific software for such activity. For this work, the ProModel® software was used, which, according to Elukurthi (2016), has several applications and with excellent results in manufacturing companies, as is the case of the object of study.

Finally, in the analysis stage, the computational model will be ready to carry out the experiments, originating from the experimental model. In this phase, several rounds of simulation of the model are carried out, and the results obtained are analyzed and documented. From the observed results, conclusions and recommendations about the system are generated, and if necessary, the model can be changed or modified in order to establish the objectives for obtaining an ideal process. Figure 1 proposed by Montevechi, et al., (2016) demonstrates a system flowchart divided into these three stages.

Figure 1. Sequence of steps of a simulation project.



Source: Adapted from Montevechi, et al., (2016)

DEVELOPMENT: APPLICATION OF SIMULATION TO ADAPT THE PROCESS LAYOUT

Presenting the object of study, the company is located in t southwest Minas Gerais, and operates in the textile sector, specifically in the manufacture of parts and accessories for women's clothing. The company serves nationwide and has a production capacity of 1,000,000 pairs of parts per month. Its main product is cupping for bras and women's bikinis. Its production process still has several flaws, according to direct observations and informal interviews with employees and managers, making this work relevant for presenting future improvements to it.

4.1. CONCEPTION

Initially, a study was carried out on the company, gathering information on sectors and processes in general, so that the authors could obtain a greater knowledge of the company and better understand its processes. In this stage, the following data were collected: the number of sectors existing in the factory; current factory employees; what products are manufactured; production workload.

Subsequently, a specific study was made of the sectors where the work was carried out. This step was aimed at collecting data from the sector as environment and system, and also collected process data, which would be used successively in the development of work activities. As a result of these analyzes, the IDEF-Sim of the current system was developed, together with information on calculated time averages and measured distances. The data collection necessary for the research was carried out by the project members and always with the help of operators and supervisors of the company, where it facilitated the access to the necessary information and increased their reliability.

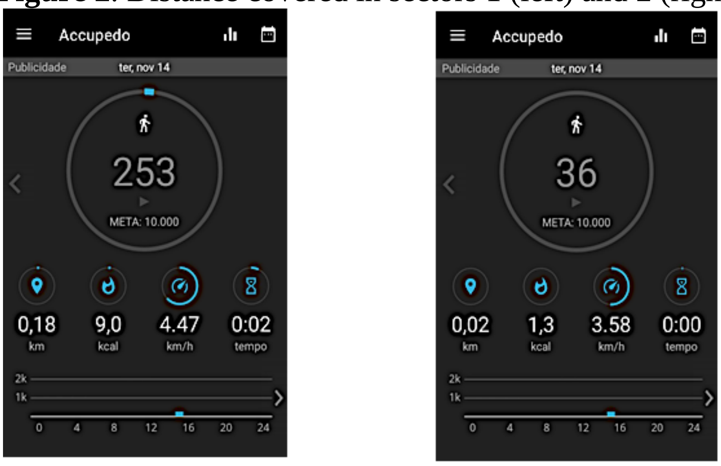
The surveys of the process times were carried out through observation and timing during the processing of the entities. All timings were performed by only one of the members of the workgroup, while production operators performed their activities at their work stations. The calculations were made using simple averages as shown in Table 1.

Table 1. Average Time of Sectors (min)

Measurements	Sector 1	Sector 2	Sector 3	Sector 4	Sector 5
Time 1	9,5	10,5	1,02	1,03	11,06
Time 2	9,6	14,08	1	1,01	10,16
Time 3	9,8	13,39	1,03	0,98	10,21
Time 4	11,56	11,56	1,01	1,04	11,12
Time 5	10,2	14,1	0,98	0,97	9,89
Time 6	11	12,89	1	1,06	9,97
Time 7	9,8	13,9	1,03	0,95	10,1
Time 8	9,6	11,23	1	1,03	10,05
Time 9	11	9,58	0,97	0,96	9,65
Time 10	8,65	9,6	1	1,04	9,24
Average Time	**10,07**	**12,08**	**1**	**1,01**	**10,15**

To survey the distance information between the points, a smartphone's app called Accupedo® was used, which measures the distance by counting the steps. With this application, it was possible to make the route between the desired points and, from the settings entered, counts the steps and provides the distance covered in km, which was later converted into meters. Figure 2 shows the distances covered in the shipping and copying sector.

Figure 2. Distance covered in sectors 1 (left) and 2 (right)



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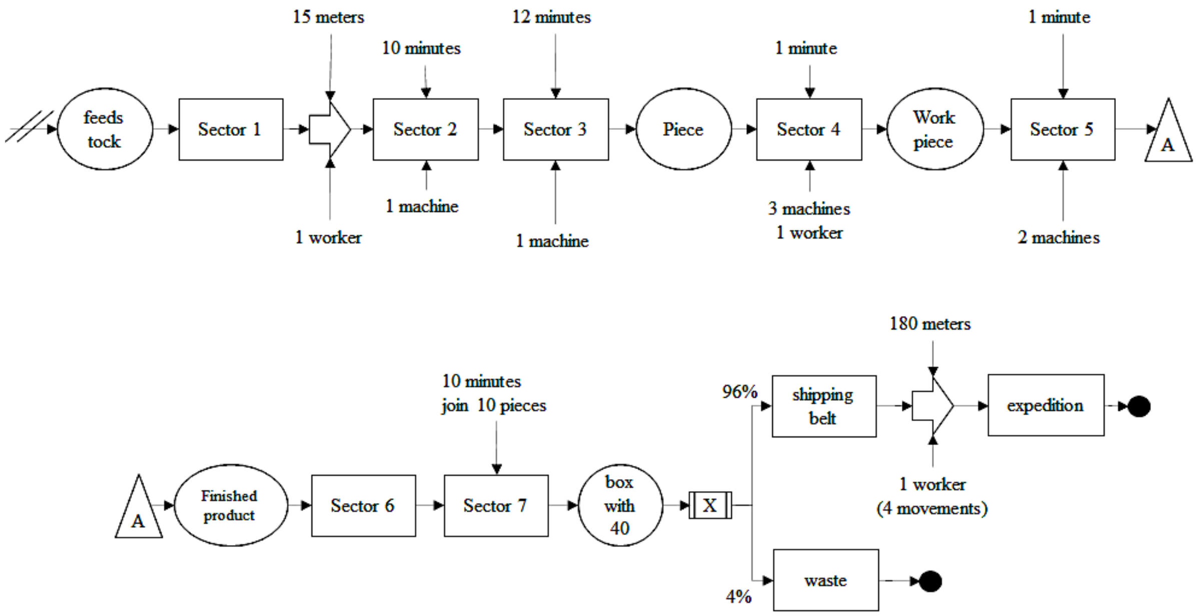
To aid in the design of the models and follow-up during the project, the processes were mapped according to the IDEF-Sim technique, where it is possible to create the conceptual model, documenting, and adding the necessary elements to the computational modeling phase. The conceptual model was validated by the company's production coordinator. In a meeting with him, all items of the diagram and the process flow were presented and explained, and in the end, with some changes, the coordinator confirmed the veracity of the mapping, validating and approving it. Figure 3 shows the final version of the approved company's IDEF-Sim. Subsequent to the conceptual model validation step, it is possible to start building the computational model in the next phase of the method.

Figure 3. IDEF-Sim of the current process.



4.2 Implementation

In the implementation phase, the ProModel® modeling software was used where, based on the conceptual model, the computational model was built, maintaining the distances in meters and times in minutes, which were collected earlier in the design phase. The construction of the model followed the following programming steps:

1. Creation of Locations - locations created from the conceptual model (Figure 3) being: warehouse; Dubbing; cut; press; rocker; review; Assembly; the queue for dispatch; expedition and a place for waste disposal.

2. Entity Creation - from the entities in Figure 3, the following entities were created: raw material; board; molded plate; the bowl and the box 40.

3. Arrival Creation - there is only one arrival in the system, being of raw material in the warehouse.

4. Creation of Variables - the variable "wip" was created to analyze the work in process within the system.

5. Creation of the Path Network - based on the mapping of the process described in Figure 4 and on information provided by specialists in the sectors, the resources were allocated in 3 different path networks, being: network 1, making an interface between the warehouse and

Dubbing; network 2, with an interface between the press and the rocker; and network 3 interfacing the shipment queue with the shipment.

6. Resource Creation - the resources created were as shown in Figure 3, where they were divided into: warehouse, press, cart, and dispatch operator.

7. Creation of Processes - after creating all the necessary items and imputing all important information for the functioning of the system, the processes were programmed according to the conceptual model.

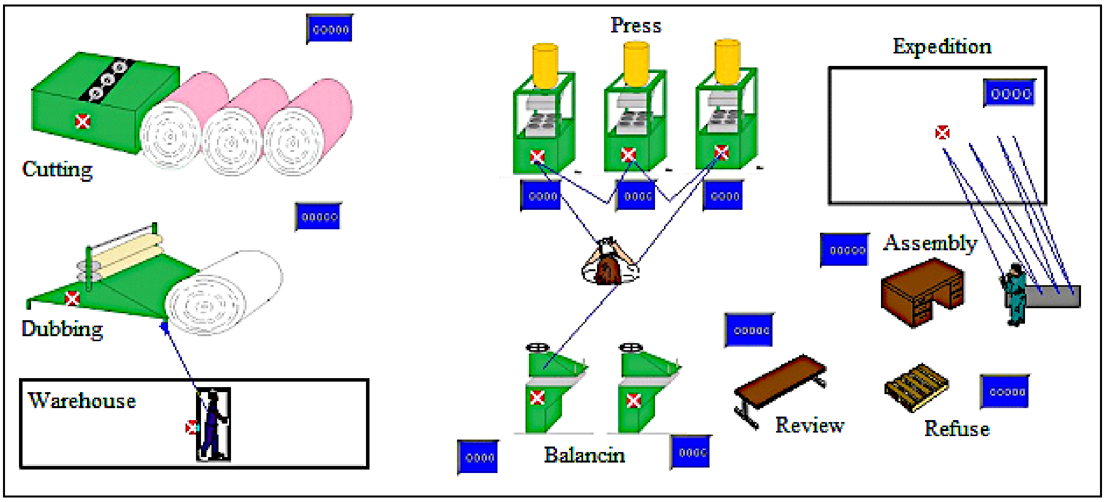
8. Creation of simulation time - for the article no work shift consideration was proposed, due to the lack of specific requirements, 8 hours of the simulation were considered.

For the graphical demonstration, the standard 41 Train software library was used, and also some locations as shown in Figure 4 were developed by the authors simulating as close as possible to the actual equipment existing in the sectors. The computational model was simulated for 8 hours and, after the whole process, the production coordinator and the factory owner were invited, so that both could evaluate and validate the computational model through comparison with real results from the same period. Through the validation by steps and the results at the end of the simulated time, both considered the computer simulation adequate to the current production process of the company.

4.3. Improvement Experiments

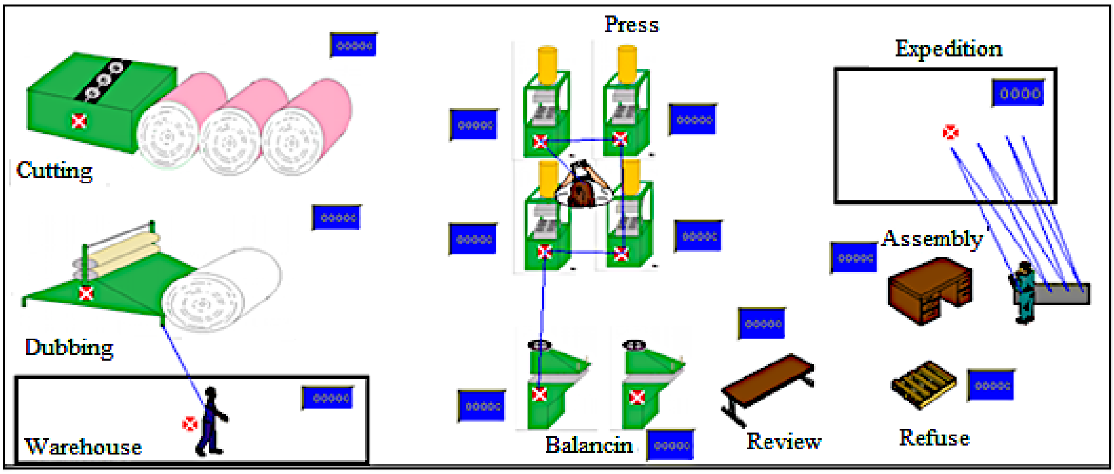
As a suggestion for improvements in the system, the construction of four more models was carried out with adaptations in the process, each with adjustments in different sectors. In the first phase of improvement, adaptations were made in the dubbing and cutting sectors, where both worked one day in advance, anticipating production. This item was translated in the computer simulator as a warm-up time of 8 hours for these sectors, providing an intermediate stock for the next process.

Figure 4. Computationally modeled current layout.



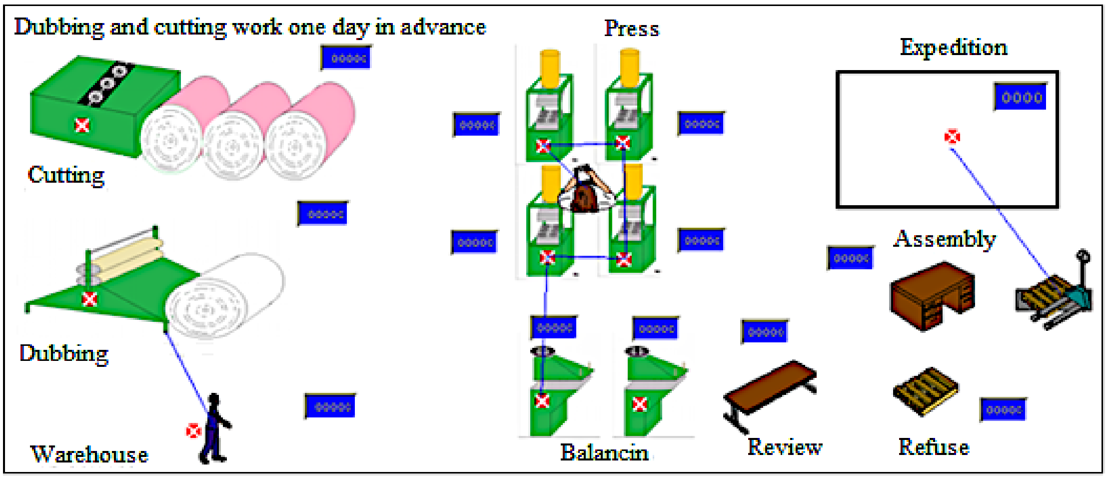
The second improvement proposal was to add a machine in the press sector and change the layout, offering more mobility and agility to the printer. For this purpose, the four machines were arranged in the shape of a functional square, where the operator worked in a U sequence, each hour loading and unloading a machine. Figure 5 shows this insertion and the layout differentiation according to this assumption.

Figure 5. Improvement layout 2.



The third proposal contemplates the changes to be made in the expedition sector. In this model, the dispatch operator responsible for transporting parts from the dispatch queue to the dispatch sector was replaced by an automatic transport cart, carrying the same parts in the same way. This change was created in the simulator, including the cart feature, thus being able to move the operator to other functions to be organized in the future. In the end, a model was built covering all the improvements together, represented by Figure 6, so that it can be analyzed together with the improvement models.

Figure 6. General improvement layout



4.3 Analyze

In this last phase, the focus will be to analyze the results obtained by simulating the improvement models, comparing them with the current model. The models were simulated for 8 hours and the results documented as presented in Tables 2 and 3.

From the results achieved, it can be analyzed that the improvement models presented a better result than the Current Model. Comparing to the total number of exits, there was an increase of 46.47% in cups produced from the Current Model to Model 4, in addition to a higher occupancy rate in each of the sectors and an improvement with the reduction of an operator in the process.

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Table 2. Results of the simulated models

Entity	General panel									
	Total Exits					Average System Time (Hr)				
	Actual model	Model 1	Model 2	Model 3	Model 4	Actual model	Model 1	Model 2	Model 3	Model 4
Feedstock	-	-	-	-	-	-	-	-	-	-
Finish product	702	732	702	1318	1517	3,99	3,79	3,98	4,21	4,04
Box with 40	61	64	61	127	145	0,61	0,61	0,61	0,01	0,01
Piece	-	-	-	-	-	-	-	-	-	-
Work Piece	-	-	-	-	-	-	-	-	-	-

Table 3. Results of the simulated models

Entity	General panel				
	Average Time in Operation (Hr)				
	Actual model	Model 1	Model 2	Model 3	Model 4
Feedstock	-	-	-	-	-
Finish product	0,4	0,03	0,4	0,4	0,03
Box with 40	0	0	0	0	0
Piece	-	-	-	-	-
Work Piece	-	-	-	-	-

Item	Operation (%)					Idleness (%)				
	Actual model	Model 1	Model 2	Model 3	Model 4	Actual model	Model 1	Model 2	Model 3	Model 4
Press 1	12,75	13,18	9,56	23,59	20,40	4,69	0,10	4,70	4,69	0,11
Press 2	12,54	13,10	9,56	23,56	20,38	4,78	0,19	4,80	4,78	0,21
Press 3	12,49	12,96	9,35	23,38	20,19	5,03	0,44	5,03	5,03	0,44
Press 4	0,00		9,35		19,98	0,00		5,28		0,69
Press	12,59	13,08	9,46	23,51	20,23	4,83	0,24	4,95	4,83	0,36
Balancin 1	22,09	23,13	21,89	70,34	80,75	21,01	16,98	18,25	29,66	19,25
Balancin 2	15,51	15,94	15,73			31,74	28,30	28,35	100,00	100,00
Balancin	18,80	19,53	18,81	35,17	40,38	26,38	22,64	23,30	64,83	59,62
Review						33,34	30,04	31,21	100,00	100,00
Refuse	0,00					100,00	100,00	100,00	100,00	100,00
Expedition	0,00					100,00			100,00	

Item	Awaiting (%)					Blocked (%)				
	Actual model	Model 1	Model 2	Model 3	Model 4	Actual model	Model 1	Model 2	Model 3	Model 4
Press 1	67,05	70,24	76,04	71,72	79,49	15,51	16,48	9,30		
Press 2	68,73	72,76	72,33	71,66	79,41	13,95	13,95	13,31		
Press 3	67,64	70,12	72,57	71,59	79,37	14,84	16,48	13,05		
Press 4	0,00		72,36		79,33	0,00		13,01		
Press	67,81	71,05	73,42	71,66	79,41	14,77	15,63	12,17		
Balancin 1	0,00					56,90	59,90	59,86		
Balancin 2	0,00					52,75	55,76	55,92		
Balancin	0,00					54,83	57,83	57,89		
Review	0,00					66,66	69,96	68,79		
Refuse	0,00					0,00				

Expedition	0,00	0,00

In general, the changes provided several benefits for the company. The change in dubbing, anticipating production, and creating the intermediate stock for the presses eliminated the delay time in the sector. The new layout in the press sector reduced the movement of employees, which made it possible to increase productivity and reduce the number of employees and reduce waste rates. As a result, financial expenses were reduced. This change also provided a better allocation of machines and space optimization. Finally, the change in shipping reduced the time needed to transport resources. Thus simple changes can represent significant gains for organizations. Highlighting the importance of the production engineer in the business environment.

FINAL CONSIDERATIONS

The objective of this work was to propose a simulated computer modeling, in order to present the production process of a company that manufactures pieces for women's underwear. Seeking to reduce product transportation time in the printing and shipping sectors.

The simulation application started from the analysis of the production system, with the objective of better understanding the processes and transposing them to a conceptual model and, later, to the computational model, allowing the analysis and creation of new models, enabling improvements in the system processing.

After the simulations and the data obtained were computed and analyzed, it was possible to demonstrate to the company's specialists that the possible changes, if carried out, can generate increased productivity and decrease the idle time of certain locations, as shown in Tables 2 and 3. the authors were willing to assist the company's specialists if they needed to perform other simulations, in order to apply the proposed changes, where new models can be created and analyzed.

The objective of this article was achieved by reducing the time of transport and movement of the expected sectors, and went further, making changes in previous sectors, improving productivity, optimizing the manufacturing space, and reducing the number of employees in the press sector. O reduced product waste and costs.

As future work, we suggest deeper analysis in the application of the improvement model, presented in the company, and also the investigation of whether the results of the real model will be equivalent to the simulated model. As a scientific contribution to this research, the use of an object of study little explored in the literature and the application of computer simulation in new manufacturing segments stand out.

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