Performance evaluation of the support bush manufacturing line by modeling and simulation

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Abstract. Improving the performance of manufacturing systems is the objective of management activities. The paper presents how this objective can be achieved by modeling and simulation. Base on the manufacturing process of the part support bush it is modeled the production line. Modeling is done using the TECNOMATIX PLANT SIMULATION program. Using the first model, by simulation, it was found that the resulting production after eight hours was relatively reduced: 28 pieces. Under these conditions, an additional welding post was introduced in the second model. It results in double the production and also in narrow places. The third model is designed in such a way that bottleneck is eliminated, and there is also an increase in production.

1. Introduction

Modeling and simulation are tools commonly used in designing, realization and improving the performance of manufacturing systems. Thus, in [1] is a synthesis of how the modeling and simulation of flexible manufacturing systems were presented in the specialty literature. The paper focused on the literature survey of the use of flexible manufacturing system design and operation problems on the basis of simulation tools and their methodology which have been widely used for manufacturing system design and analysis.

The paper [2] proposes a new approach to model and simulate manufacturing systems in order to rapidly respond to the changes of the manufacturing environment, including the enhancement of the manufacturing processing, reconfiguration of the manufacturing resources and the dynamic control. In [3] the authors discuss how simulation is used to design new manufacturing systems and to improve the performance of existing ones.

In the paper [4] is presented the practical application of the modeling and simulation in managing and planning of machines' setup. There are described principles and stages of the production system improvement with the theory of constraints and illustrated by the example of the analysis of the whole production line, which aim was the bottleneck determining, and the analysis of operations, which are realized in the bottleneck. The problem of the bottleneck is also discussed in [5].

This paper shows how using modelling and simulation procedures can put in evidence the bottleneck in the manufacturing flow. Using modeling and simulation (TECNOMATIX PLANT SIMULATION- software) it is also possible to identify the solutions to allow equilibration of the lines of the manufacturing process.

2. Presentation of support bush

The piece whose manufacturing line will be modeled is the *support bush*. The figure 1 shows the part drawing. In the figure is presented the support bush in the conveyor assembly.

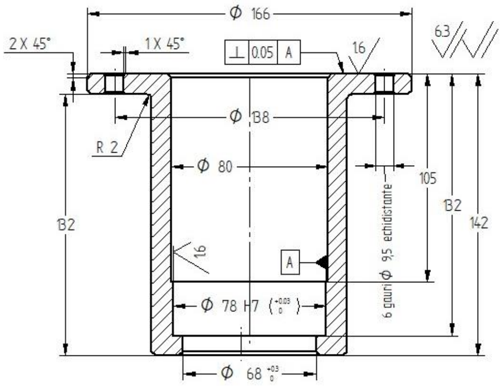

Figure 1. *Support bush* part drawing.

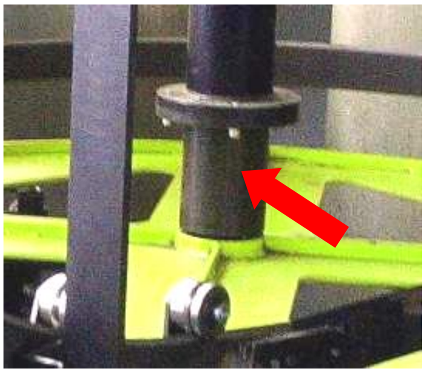

Figure 2. *Support bush* part in conveyor assembly.

Table 1 presents the process sheet of the support bush with the corresponding operations and times.

Table 1. Process sheet of the *support bush*

Nr. op.	Operations order	Machine	Number of parts made simultaneously	Time (min)	Symbol model
10	Welding		1	15	Welding_1(2)
20	Facing	Parallel lathe	1	4	Facing
30	Rough turning OD_ Ø166	Parallel lathe	1	1	R_OD_166
40	Rough turning ID_ Ø67.3	Parallel lathe	1	6	R_ID_67
50	Rough turning ID_ Ø76.5	Parallel lathe	1	5	R_ID_76
60	Rough turning ID_ Ø78.5	Parallel lathe	1	4	R_ID_78
70	Finish turning ID_ Ø78.4	Parallel lathe	1	7	F_ID_78
80	Finish turning ID_ Ø79.8	Parallel lathe	1	2	F_ID_79
90	Chamfer	Parallel lathe	1	1	Chamfer
100	Facing 142	Parallel lathe	1	2	F_142
110	Drilling Ø9.5x6	Drilling machine	1	4	Dr_9x6
120	Grinding ID_ Ø78H7	Round grinding machine	4	8	Gr_ID_78
130	Grinding ID_ Ø80H7	Round grinding machine	1	3	Gr_ID_80

3. Modeling and simulation of manufacturing line for the support bush using Plant Simulation

Plant Simulation, Siemens Industry Software's simulation software solution treats events in a discreet, step by step manner. The application is object-oriented, allowing greater flexibility and ease of modifying and maintaining complex models. The model is built from a collection of objects that interact with each other. Each object can receive, process, and send data. Also, each object can be seen as an independent machine. Simple objects can be used as blocks to build more complex objects.
Plant Simulation uses an object-oriented interface similar to other Windows applications, which means that the object or objects you want to work must be selected before the relevant options become available.

3.1. Version I

In a first model version, every single operation in the manufacturing process was associated with a SingleProc block. Each operation is done at one workstation. Figure 3 shows how the manufacturing line model is made. For each operation, it was set the duration and other workstation specific features.

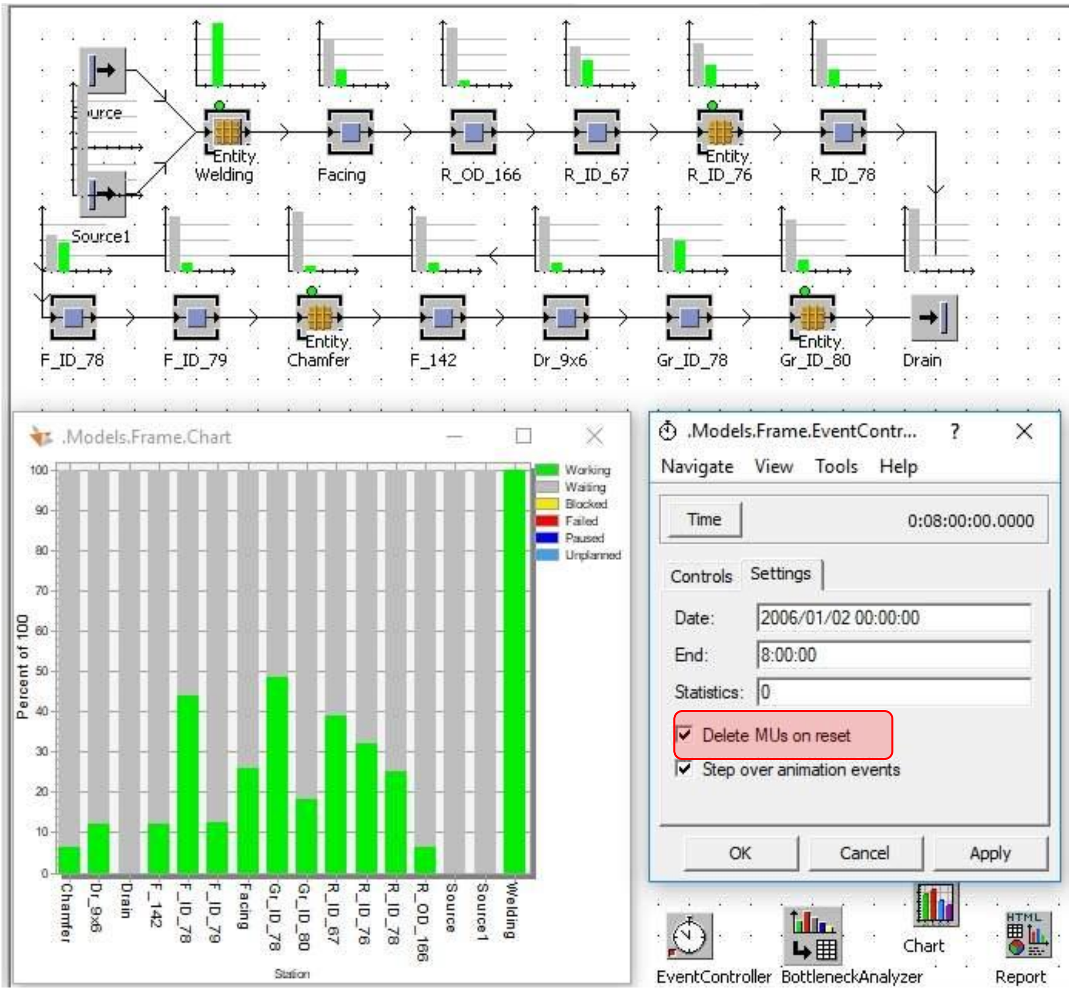

Figure 3. The model of the manufacturing line for the part support bush in TECNOMATIX PLANT SIMULATION after simulation. Version 1

System inputs are modeled through the Source block (figure 4). The interval between two successive entries is expected to be 15 minutes.

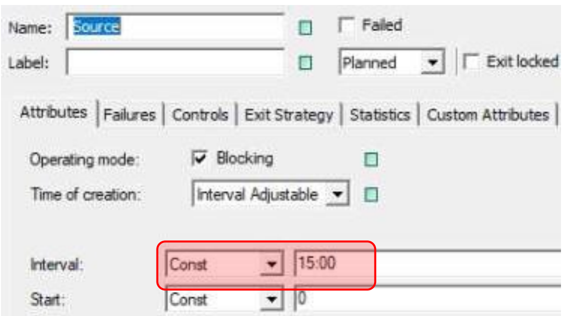

Figure 4. Source block - input modeling

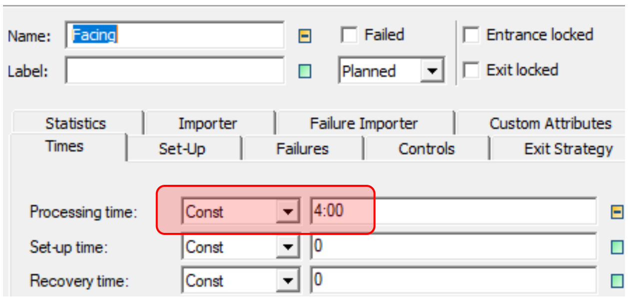

Figure 5. Block for *Facing operation*

Regarding the actual processing operations, their modeling is exemplified by the way in which the settings for the *Facing* operation are made. The figure 5 shows the window corresponding to this operation (workstation): Name – *Facing*; Processing time- 4 minute. The processing time is considered constant.

The figure 3 shows the manufacturing system after the simulation (the version I). Using the *BottleneckAnalyzer* option, it can be described the states that characterize each workstation (operation), and their weights reported to the time considered (8 hours).

Thus, the blockages that occur during the manufacturing process are marked with the yellow bar. Also, normal working hours (green color), waiting times (gray color) are highlighted. During the reference time, workstations may be broken (red), may be in pause (blue color), or not in the work schedule (blue color). There are no blockages.

The Chart option allows you to get an overview of the states that characterize the workstations of the system during the simulation. In figure 3, by activating the *Chart option*, the statuses of the stations were recorded during the 8 hours of operation. It can be noticed that much of the time they are waiting.

Regarding the actual machining operations, their modeling is exemplified by the way the settings for the *Finishing Turning* operation Ø78.4- F_ID_78 are made. After simulation it is found that out of the 8 hours - the reference time - it functioned normally 43.75% and it was 56.25% waiting. Also 30 bushes have been processed.

If the block corresponding to the drain is analyzed, it is noted that 28 bushes have been processed in the system for 8 hours.

3.2. Version II

To increase the number of bushes made, it is supplemented the production line with a welding post. The model of this version (Version 2) of the manufacturing line is shown in figure 6.

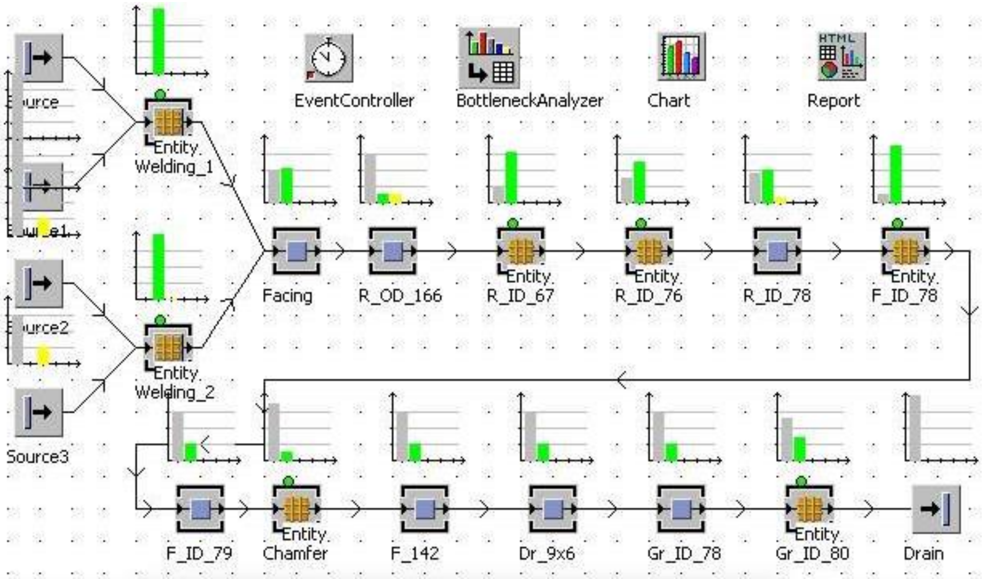

Figure 6. The manufacturing line model for the part support bush in TECNOMATIX PLANT SIMULATION after simulation. Version 2

Analyzing the block corresponding to this *Finish turning operation Ø78.4*- F_ID_78 after simulation (Version 2), it is found that out of the eight hours - the reference time - it functioned normally 86.67% and was waiting 13.33%. In addition, 59 bushes were processed.

Analyzing the block corresponding to the drainage system (Drain), it is found that 57 units have been processed in the system during 8 hours (version 2).

The Chart option allows you to get an overview of the states that characterize the workstations of the system during the simulation. It can be noticed that the workstations *Rough turning* OD_ Ø166 and *Rough turning* ID_ Ø78.5 are blocked (yellow color) for part of the reference time.

3.3. Version 3
To remove bottleneck, more workstations will be allocated for operations with longer processing times than previous operations. Thus, the operations: *Rough turning* ID_ Ø67.3 (R_ID_67) and *Finish turning* ID_ Ø78.4 (F_ID_78) will be executed at two positions. *ParallelProc blocks* are used to model this situation.

Analyzing the *ParallelProc* block corresponding to this *Finish turning operation Ø78.4*- F_ID_78 the block modeling the *Finish turning* operation ID_ Ø78.4 (F_ID_78), it is found that the two posts work 74.58% of the reference time, and wait for 25.42% of the 8 hours.

The figure 7 shows the result of the simulation of the manufacturing system in version 3. It is noticed that there are no longer any blockages in the process operations. Analyzing the block corresponding to the drainage system (*Drain*), it is noticed that 58 units were processed during the 8 hours (figure 7).

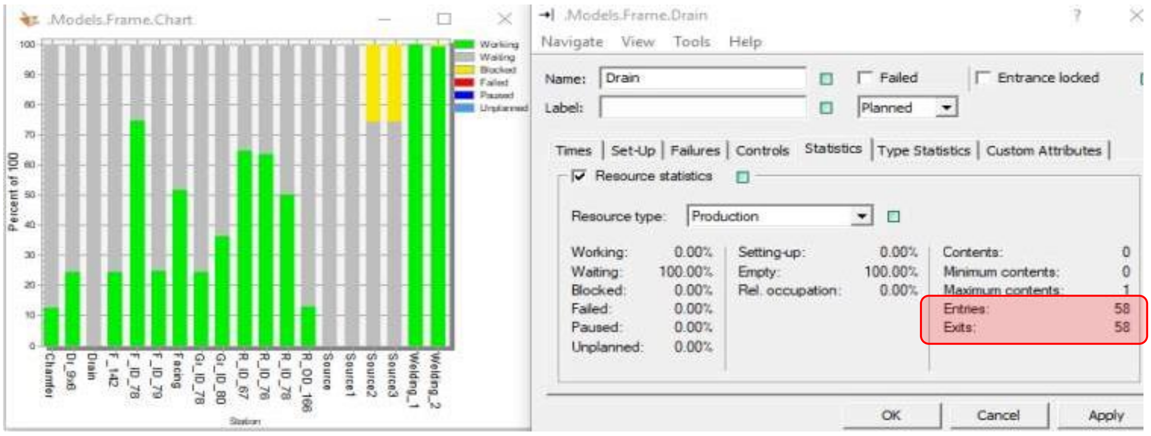

Figure 7. The result of the simulation of the manufacturing system. Version 3.

4. Conclusion
The dynamics of the manufacturing systems development is highly accentuated. The decision makers responsible for the management of these systems have to take decisions in a short time about how these systems are going to evolve. The evolution of manufacturing systems must be guided so as to meet the requirements of the market. Under these conditions, modeling and simulation can be useful.

The paper presented is a concrete example of solving the problems that appear in the manufacturing of a component part (*support bush*) from a complex product: a conveyor transfer system. Through an iterative process of model improvement, these being validated by simulation, the best structure of the fabrication system was made to make the part support bush.

5. References

[1] Saren SK and Vesselenyi T 2016, ed. Grebenisan *ANNALS OF THE UNIVERSITY OF ORADEA, Fascicle of Management and Technological Engineering* ISSUE #1 (Oradea) p 113

[2] Xiaofeng H and Ruxiao A 2011 *Proceedings of the World Congress on Engineering,* eds. Ao SI, Gelman L, Hukins DWL, Hunter A and Korsunsky AM (London, UK), p 601

[3] Law AM and McComas MG 1998, *Winter Simulation Conference. Proceedings*, vol.1 (Washington DC, USA: IEEE), p 49

[4] Gregor M, Matuszek J and Plinta D 2013 *Adv. in M. Sc. and Tech.* **37** (1), p 7

[5] Blaga F, Stanăşel I, Hule V and Pop A, 2017 *MATEC Web of Conferences 112, 06012, IManE&E 2017*, eds Slătineanu L, Nagit G, Dodun O, (Iasi, Romania: EDP Sciences), pp 7

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