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Application of Computer Simulation for Productivity Improvement of Welding Unit in a Heater Manufacturing Industry: A Case Study Based on Arena

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Abstract. Firm's efficiency and competitiveness are two important challenges in today's global market that have motivated many manufacturing firms to plan novel manufacturing management strategies. Nowadays, simulation models have been used to assess different aspects of manufacturing systems. This paper introduces a welding unit of a manufacturing line of heater production as a case study and the basic application of the ARENA software. The main goal of this paper is increasing the productivity of the production line by using computer simulation. To achieve this goal, three various scenarios are compared and suggested to obtain the better improvement in productivity.

1 Introduction

In the manufacturing industry, managers and engineers are seeking to find methods in order to eliminate the common problems in manufacturing systems such as bottlenecks and waiting times[1]. This is because that all of these kinds of problems impose extra cost to the companies [2]. In addition, manufacturing companies are striving to sustain their competitiveness by improving productivity, efficiency and quality of manufacturing industry for instance high throughput and high resource utilization [3]. Managers and engineers define the planning horizon for these aims. In the operative aims one of the most challenging is the bottlenecks. Companies try to identify and eliminate the bottlenecks in the production line [2]. Simulation is the computer-modeled emulation of a real system, for improvement the evaluation of system performance. In fact by using the computer simulation the reality world alters to a controlled environment in order to study system behavior under different in a cost effective manner and lowest risk [3]. Computer simulation has a significant effect on

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financial and operational parameters by saving monetary cost of investment, decreasing process cycle time, increasing resource utilization and enhancing throughput [2]. Benefits of a Simulation modelling are [4]: 1. to deal with large and complicated decisional issues that cannot be handled with the application of other approaches, 2. to find an answer to the "what-if...?" questions – simulation experiments help to assess different decisional alternatives scenarios. So this paper aims at improving the productivity of the welding unit of a manufacturing system in a heater company as a case study using computer simulation. To achieve this goal three various alternatives are developed and suggested to obtain the better improvement in the productivity.

2 Literature review

Computer simulation is one of the most effective approaches that can be used to deal with the operational difficulties to increase productivity in different fields, such as production line [5], port and transportation industry [6], supply chain management [7], healthcare system [8] as well as construction industry [9], all of which are not easy to model. There are many researches have been done that to evaluate the manufacturing systems by using the simulation. Basler et al. [10] discussed the application of artificial intelligence approaches and simulation to enhance productivity in the wood industry. Furthermore, Ramis et al. [11] applied simulation in order to recognize and decrease bottlenecks at a sawmill industry. Qayyum and Dalgarni [12] created a simulation model take into consideration constraints systems and process time. Indeed they made change in manufacturing process, system limitations, and capital investment for enhancing the capacity of system. Hatami et al. [13] assessed the importance of different parameters on a production line using simulation and design of experiments (DOE) to improve productivity. In another study, the statistical Taguchi method and computer simulation were combined to investigate the impacts of main and uncontrollable parameters on the overall production output in the paint factory [14]. Dengiz et al. [15] showed how the combination of regression meta-modeling techniques and simulation modeling can be applied to design and improve a real automotive manufacturing system. Based on these investigations, computer simulation has improved the productivity of manufacturing processes and reduced trials and errors to find the best solution [16].

3 Materials and methods

3.1 Case study

In this paper one heater factory was selected as the case of study. This factory has four sections including welding, framing, painting and assembly. Based on the managers and engineers comments the welding unit was chosen to simulate and evaluate the production process. In this station, the main frame of heater fount is produced and then transported to the assembly station. Table 1 shows the number of equipment and operators used in this unit. It should be noted that, there is one operator in source preparation test station and three in coal grinding stations. Therefore, total number of operators can be reached to 26 people.

Table 1. Details of equipment and operators

Row	Machine Type	Number of Machine	Number of Operator
1	Impact Press Machine	1	1
2	Rolling Machine	1	1

3	Welding Machine	15	15
4	Hydraulic Machine	2	2
5	Test Compressor	2	2
6	Cutting Machine	1	1

3.2 Building simulation model

One of the most significance parameter for developing a computer simulation is collecting the desired data. The necessary data in this paper are gathered in the factory during the manufacturing process. The "stop watch" method is applied for collecting some needed data. After collecting the data related to duration of all of activities, a probability distribution function should be fitted to every activity since the variability of the activities. Having determined the different resources involved in the manufacturing process along with their relationship and their duties and also the fitted probability distribution of each data sample of activity duration, the simulation model of the considered manufacturing system should be developed. In order to construct the simulation model, simulation software, Arena 13.9 is selected. Figure 1 shows the logic view of simulation model.

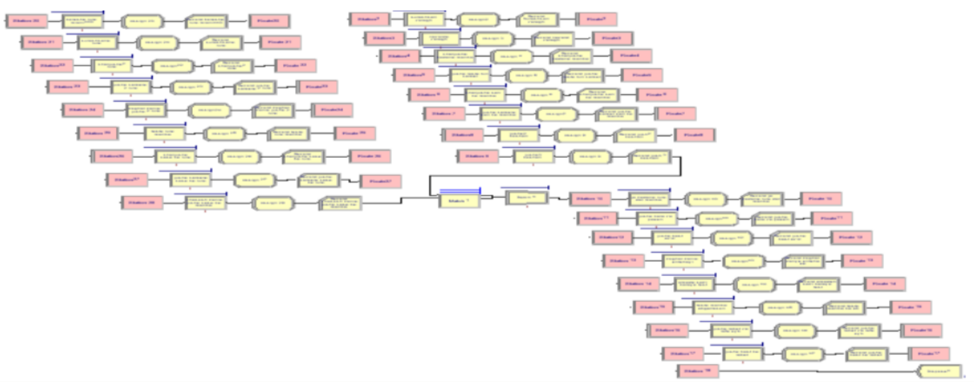

Fig. 1. Logic view of simulation model

3.2.1 Simulation model validation

As it is shown in the Table 2, some obtained results of the simulation and the actual data are accurate up to approximation of 90%.

Table 2. Result of simulation model validation

Items	Actual data	Simulation data	Accuracy ratio
Number of Out put	10100	9506	0.941
Number of input	115	109	0.947

4 Results and discussion

4.1 Improvement

After simulating the welding unit of production line, three different scenarios are suggested and developed to analyze and improve the production line productivity.

4.1.1 Scenario 1

Due to long lines at stations related to welding machines and second line of assembly, also creating consecutive bottlenecks at the stations that have an impact on the amount of final product, in this scenario, adding two workers and two welding machines have proposed in order to help other stations that have long lines. The result after apply this scenario for output of final product and station lines has shown in Table 3 and 4 respectively.

Table 3. The results of scenario 1 for the amount of output product

Row	The rate of output product in scenario 1	The rate of output product in main model
1	11333	9509

Table 4. Comparions of the average waiting parts in line in the main model with scenario 1

Station / Model	fillet wield along the length of tank	Spot welding the body of tank	Spot welding bowl to pipe	Welding two pipes	Second line of assembly
Scenario 1	8	13	17	16	17
Main Model	263	272	266	277	377

4.1.2 Scenario 2

As it is considered by developing scenario 1, the rate of production was increased and the average of welding machines lines lowered significantly. But this scenario may cause long lines at stations of water heating supply testing, test of tank pipes and assembled first line that this problem has been solved in scenario 2. In scenario 2, due to long lines in test stations, adding one testing operator and one testing compressor has been proposed in order to help test stations. The results indicate a significant reduction in assembly and test lines and following an increase in output product in the model (Table 5). Table 6 summarizes the results of comparison of the average of cited lines:

Table 5. Comparions of the rate of output product in the main model with scenarios 1 and 2

Row	The rate of output product in scenario 2	The rate of output product in scenario 1	The rate of output product in main model
1	12506	11333	9509

Table 6 Comparions of the average of parts waiting in line in the main model with scenarios 1 and 2

Station / Model	Test of water heating tank	Test of tank pipe	First line of assembly
Scenario 1	1	1	3
Scenario 2	633	589	649
The main model	38	51	12

4.1.3 Scenario 3

In this scenario, it has been tried to change the number of coal grinding sector workers from 4 to 3 people in order to reduce them because they have low average of tasks. These workers also contribute to each other in order to produce. Table 7, 8 and 9 show the comparison of rate of output product, average tasks of coal grinding operators and average waiting time in the line in scenarios 2 and 3 respectively. The average waiting time in the line at these stations has increased.

Table 7. Comparions of the rate of output product in scenarios 2 and 3

Row	The rate of output product in scenario 3	The rate of output product in scenario 2
1	13009	12506

Table 8. Comparions of the average tasks of coal grinding operators in scenarios 2 and 3

Row	The average of coal grinding operator working in scenario 3	The average of coal grinding operator working in scenario 3
1	0.7445	0.5479

Table 9. Comparions of the average waiting time in the line in scenario 2 and 3 individually

Station / Model	Hammering the weld of pipe to bowl	Final coal grinding	Weld coal grinding two pipes	Preparing for test
Scenario 3	0.6550	0.7386	07031	0.7887
Scenario 2	0.2006	0.2987	0.2856	0.3410

4.2 Discussion

In this paper different scenarios were assessed by using Arena software. In scenario 1, according to reports obtained from the crowded lines in the welding workstations, it was suggested to add 2 welding machines and 2 welding operators which led to a considerable reduction of the line at weld stations. In scenario 2, looking to improve scenario 1 and reduce the line in test stations, adding one compressor machine and one testing operator was proposed that led to reduce the line in addition to increase the production. In Scenario 3, for improving the scenario 2, it was tried to reduce current idle times by reducing the number of coal grinding operators (specific operators in each station) from 4 to 3 people who help each other, and subsequently increase the rate of output product. After the final results, some recommendations were suggested to the company managers as follow: 1. Increase the percentage of welding operators as well as welding machines, 2. Increase the number of testing operators and compressor machines in order to reduce line particularly in assemble station, 3. Improve the ergonomics condition of operator's worktable and workplace, 4. Increase the amount of operator training in order to improve in order to help other stations have high components traffic, 5. Use the fixtures in welding stations

5 Conclusion

This case study presented the details of a production system, simulated by using the Arena simulation software. A better design of the production system at the company was proposed. This was done by adding 2 welding machines and 2 welding operators which led to a considerable reduction of the line at weld stations. Moreover, it was suggested for adding one compressor machine and one testing operator that led to reduce the line in addition to increase the production as well as it was proposed to reduce existed idle times by reduce the number of coal grinding operators (specific operators in each station) from 4 to 3 people who help each other, and subsequently increase the rate of output product. This paper showed the approach of modelling and designing a production system so that others can do the same. As a future study it is proposed to use other simulation software such as Witness, Show FLOW etc, and compare its result with the results obtained from Arena.

References

1. S. M. Zahraee, M. Hatami, J. M. Rohani, H. Mihanzadeh, and M. Haghighi, *Comparison of different scenarios using computer simulation to improve the manufacturing system productivity: Case study* vol. **845**, pp. 770-774, (2014).
2. S. M. Zahraee, S. R. Golroudbary, A. Hashemi, J. Afshar, and M. Haghighi, Advanced Materials Research, vol. **933**, pp. 744-748, (2014).
3. S. M. Zahraee, J. M. Rohani, and K. Y. Wong, Journal of King Saud University-Engineering Sciences, vol. **30**, pp. 207-217, (2018).
4. M. Kikolski, Procedia Engineering, vol. **182**, pp. 321-328, (2017).
5. S. M. Zahraee, S. Shariatmadari, H. B. Ahmadi, S. Hakimi, and A. Shahpanah, Jurnal Teknologi, vol. **68**, pp. 7-11, (2014).
6. A. Shahpanah, S. Poursafary, S. Shariatmadari, A. Gholamkhasi, and S. Zahraee, Advanced Materials Research, vol. **902**, pp. 431-436, (2014).
7. A. Memari, S. M. Zahraee, A. Anjomanshoae, and A. Rahim, Caspian Journal of Applied Sciences Research, vol. **2**, pp. 48-56, (2013).
8. S. M. Zahraee, J. M. Rohani, A. Firouzi, and A. Shahpanah, Procedia Manufacturing, vol. **2**, pp. 1--5, (2015).
9. S. M. Zahraee, G. Rezaei, A. Shahpanah, A. Chegeni, and J. M. Rohani, Jurnal Teknologi, vol. **69**, pp. 17-24, (2014).
10. F. F. Baesler, M. Moraga, and F. J. Ramis, *Proceedings of the 34th conference on Winter simulation: exploring new frontiers,* pp. 1095-1098, (2002).
11. F. J. Ramis, J. L. Palma, F. F. Baesler, J. A. Sepúlveda, and R. Moraga, *Winter Simulation Conference: Proceedings of the 38th conference on Winter simulation*, pp. 2291-2291, (2006).
12. A. Qayyum and K. Dalgarno, *Technical Report, School of Mechanical and Systems Engineering*, Newcastle University, (2012).
13. M. Hatami, S. M. Zahraee, A. Khademi, A. Shahpanah, and J. M. Rohani, Applied Mechanics and Materials, vol. **606**, pp. 199-203, (2014).
14. S. M. Zahraee, A. Chegeni, and J. M. Rohani, Jurnal Teknologi, vol. **72**, pp. 77-82, (2015).
15. B. Dengiz, Y. T. İç, and O. Belgin, Mathematics and Computers in Simulation, vol. **120**, pp. 120-128, (2016).
16. J. A. B. Montevechi, A. F. de Pinho, F. Leal, and F. A. S. Marins, *Proceedings of the 39th conference on Winter simulation*, pp. 1601-1609, (2007).