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SIMULATION ON LINE BALANCING IN MANUFACTURING OF CAR HEADREST PIECE

Reddy Ahemed K[a], P. Venkataramaiah[b]

[a]*PG Student, Department of Mechanical Engineering, SVUCE, Tirupati, 517502, India*
[b]*Professor, Department of Mechanical Engineering, SVUCE, Tirupati, 517502, India*

Email:ahemed07@gmail.com

Abstract

The presented work has been done with the purpose of optimizing and balancing a manufacturing line as well as choosing suitable probability distributions of a cycle time for each machine of a typical car headrest piece layout using Delmia QUEST Software. Probability distributions for cycle time, inter-arrival time, process times, recovery time, and failure time are chosen from the available options in the simulation software for this work to represent the input process. The simulation on the model Car headrest support work piece has been done to determine bottleneck locations and to offer an alternative for improving the manufacturing line.

***Keywords*:** Probability distribution, QUEST software, Cycle time, Optimization.

1. Introduction

In this competitive world, many companies have to manage their enterprises and manufacturing operations. The key to sustainable success consists in innovation and systems adaptability with the aim to increase the productivity. For an enhanced productivity, the companies need new innovative assembly concepts and technologies. Simulation is an innovative tool and it is used in industrial projects. This method solves problems in a virtual way when the complex production systems cannot be represented mathematically. And the results of simulation are applied in the real experimental processes with visible results concerning the productivity and the product cost. By changing the input parameters of a model, simulation provides insights solutions without the need for actual and expensive modifications. The model can test a lot of ideas and alternatives using the concept What if? By the means of modeling and simulation the scrap is reduced. The use of simulation provides benefits to customers both in planning new production systems and in mapping and optimizing existing production systems. The present work focused on optimization of manufacturing line of a car headrest piece, which is an important component in car seat for comfortable resting of passenger's head. The headrest piece is shown in Fig.1

Fig. 1: car headrest work piece

1. 2. Literature Review

Z. M. Bzymek, M. Nuez had described a case study of analysis and optimization of the mechanical parts machining sequence in a manufacturing cell using Quest computer simulation model with graphical representation of the manufacturing processes. The simulation model objective was to determine bottleneck locations and what the optimal batch size should be [1]. C. Wang presented the application of virtual simulation to the design of job shop scheduling system based on QUEST software [2]. S Sneha had proposed a new design of integration between material handling and layout by investigating the influences of layout and material handling system in order to improve the automotive assembly line performance [3]. Masalina Alia had modelled a Handwork Area using QUEST simulation to analyse and optimise the production flow efficiency [4]. F. E., Meyers, M.P. Stephens had determined Cycle time for each workstation depending on the target product demand [5].

2. Delmia QUEST

Quest provides 3-D simulation environment for the analysis of production process flow and production efficiency. The Quest model must be established before simulation and analysis. The following three steps are basic steps to establish a Quest model. Firstly, three-dimensional geometrical model of production resources object such as processing equipment, logistics equipment and operator must be established, making production line in virtual environment similar to real production line. Quest contains initial model of common production equipment and logistics equipment, such as processing equipment, buffer station, feed station, AGV, crane, conveyor, labor and so on. Secondly, object behavior, technological process and system operation rules of production resources should be defined. The object behavior refers to the loading, processing, and unloading behaves of the processing equipment. Logical order of work piece is defined by technological process of manufacturing system, making independent device in the system connected into a whole process logical System operation rules can ensure the normal operation of the simulation model and avoid conflict in the system. Finally, production line is simulated based its model, real-time utilization and average utilization of the key equipment and labors can be obtained. The data of logistics production beat and stacking situation can also be seen clearly. According to these data, the bottlenecks in the production line can be found and then the layout of the production line and logistics scheme can be optimized.

3. Optimization procedure based on Simulation

Today it is inconceivable to design only by classical method. For designing flexible manufacturing system, one of the software used is Quest, from Delmia. In the present work, Delmia QUEST (Queuing Event Simulation Tool) software has been employed to carry out Discrete Event Simulation activities on manufacturing systems. QUEST provides a complete solution for all aspects of manufacturing planning from the evaluation of strategies and plant floor layout to the programming of automation equipment. This simulation technology can be applied to flexible manufacturing systems, Just-In-Time, business re-engineering, team labor, cost. Delmia Quest software provides simulation environment based on the delivery of materials, processing and storage. It contains material element for rapid modeling such as machine tool, buffer, treatment process, failure rate, maintenance, operator, path and material export, which can help users simulate and analyze the process flow in 3D.

3. 1. Simulation Model

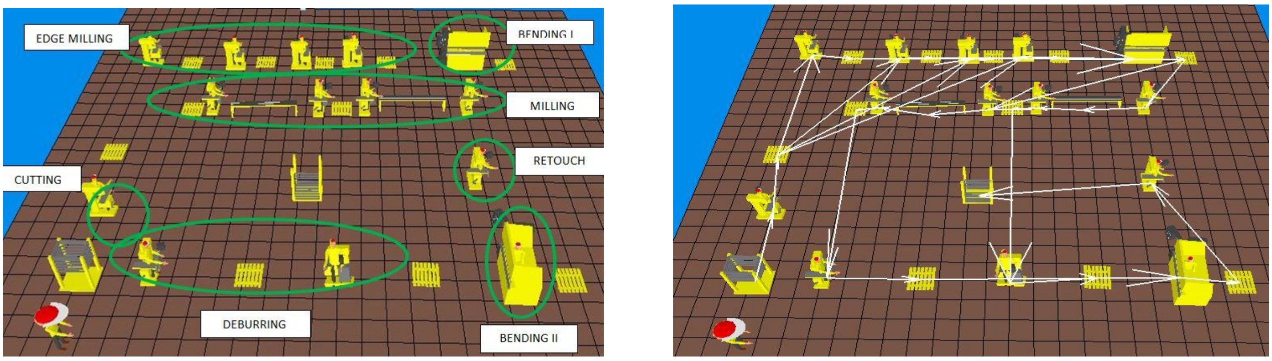
The case study of a manufacturing line of a car headrest support work piece using Delmia QUEST (Queuing Event Simulation Tool) software tool has been employed to carry out Discrete Event Simulation on the manufacturing system. Structural elements are model in the manufacturing line such as parts, source, buffers, machines, workers and sink in Quest simulations software. Having all structural elements, the manufacturing parameters are introduced into the system, considering the required manufacturing processes. There are number of operation to be done on machines as shown in table 1. Every part has to move through each machine as shown in Fig. 2 for the given simulating time per shift.

A schedule downtime can be used to describe be the effective working time of a machine and the time of repair or maintenance. This schedule can then be applied to all the possible model elements to define the downtime patterns of these elements. The distributions to describe the time between failures and the time to correct these failures are defined. The time for failure is defined using Exponential Distributions, with a Mean value of 1 hour. The time for repairing is defined using Uniform Distributions, with a Minimum Value of 180 sec and a Maximum Value of 300 sec.

Table 1: Sequence of Operations

Operation name	Number of Machines	Cycle Time(min)
Length cutting	1	0.077
Edge milling	4	0.565
Bending I	1	0.200
Milling B	2	0.343
Milling A	2	0.343
De-burring	2	0.600
Bending II	1	0.220
Retouch	1	0.190

In order to analyze the system behavior in terms of production flow, the simulation model of the system was set up with the layout as shown in Fig.2 and the elements are connected based on the part moving between the Stations.



(a) (b)

Fig. 2 (a) Layout using Delmia QUEST (b) Connection of elements

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Before starting the simulation, length of operating shift and breaks during shift is need to be defined.

Simulation period of time is 8 hours (28800 sec)/per shift and two breaks of 10 minutes each or 20 minutes break per shift is given for refreshment of the employees.

Total work time duration without brake time is,

$$WT=WST-B$$

Where, *WT*: Work Time, *WST*: Work Shift Time, *B*: Breaks

$$WT= 28800-1800 = 27,000 \text{ sec}$$

A comparison between three distributions: Constant, Exponential and Poisson Distributions is done by using QUEST software. After the simulation, the three simulation scenarios are presented in a Table 2.

Table 2: Comparison among Constant, Exponential and Poisson distributions

Scenarios	Cycle Time (min.)	Distribution	Production rate/shift
Scenario 1	Cutting Machine	Constant Distribution	1968
	Edge Milling Machine		1966
	Bending Machine I		1962
	Milling Machine ROD B		1960
	Milling Machine ROD A		1958
	De-burring Machine		1583
	Bending Machine II		1581
	Retouch		1581
Scenario 2	Cutting Machine	Exponential Distribution	1947
	Edge Milling Machine		1945
	Bending Machine I		1945
	Milling Machine ROD B		1942
	Milling Machine ROD A		1940
	De-burring Machine		1540
	Bending Machine II		1538
	Retouch		1538
Scenario 3	Cutting Machine	Poisson Distribution	1922
	Edge Milling Machine		1918
	Bending Machine I		1909
	Milling Machine ROD B		1907
	Milling Machine ROD A		1904
	De-burring Machine		1587
	Bending Machine II		1587
	Retouch		1586

Analyzing the above table it can be seen that the maximum number of finished parts is achieved quickly by using a Poisson distribution model with equal intervals among arrivals. The optimized choice after performing several simulations consists in changing the distributions of the machines to Poisson distributions.

3.2 Bottleneck Location

A bottleneck may be defined as a machine whose performance affects the most the overall system performance. A bottleneck is defined as the most sensitive machine for the overall system performance. To see how the machine times affect the line of productivity, the bottleneck needs to be evaluated.

The bottlenecks in this study are:

- Machines idle in the manufacturing process.
- Machines overloaded and sequential inputs.

- Parts passing to their operation from one cell to another.

By analyzing the simulation results, several possible issues were identified in order to improve the productivity and efficiency of the manufacturing line through its reconfiguration. The bottleneck of the system is easily identified as the element having the highest utilization as shown in Fig. 3

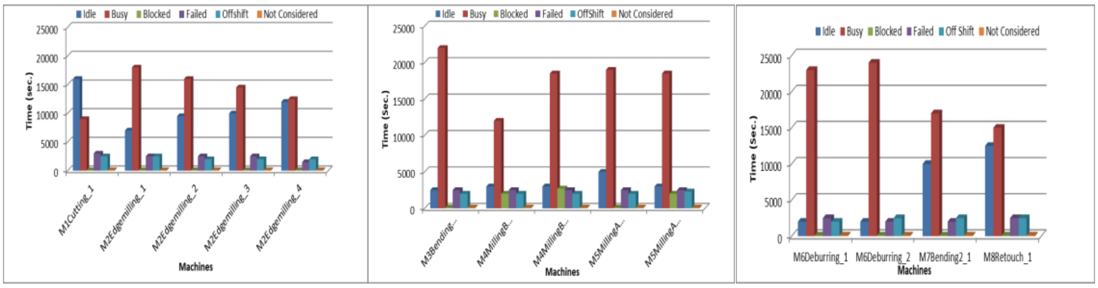


Fig. 3 Machine utilizations

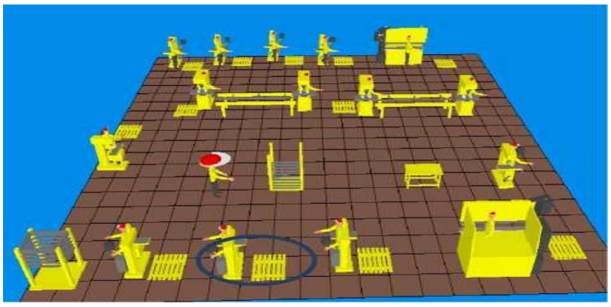
3.3 Optimization of Manufacturing Line

It is not known from the beginning if the simulation is profitable but if we make 10 simulations, one of them would generate gains superior to other nine. By analyzing the simulation result several issues are identified in order to improve the productivity and efficiency of the manufacturing line by reconfiguration.

As this is a linear system where every part has to go through a number of operations in a specific order, the bottleneck is simply the place where the parts get piled up. The pile appears indirectly in front of the de-burring machine. So it was very easy to determine that the de-burring machine is the bottleneck in the line.

The recommendation is to add a new workstation to the bottleneck station in order to reduce the buffer quantity. In this way, one more de-burring machine is added to the simulation model in order to simulate the new production system as shown in Fig. 4

Result of Simulation after implementing the De-burring machine is shown in Fig. 5



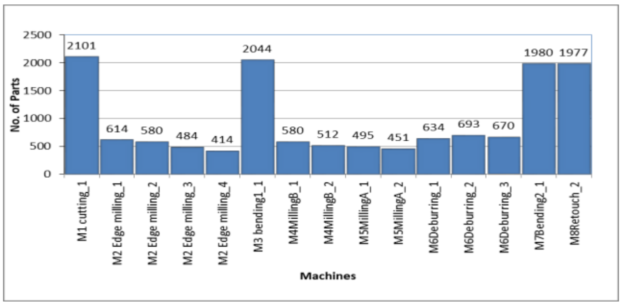


Fig. 4 Optimized line after recommendation Fig. 5 Output of element after Simulation

4. Conclusions

A simulation model for a manufacturing line has been presented. The model is realized by using Delmia Quest software.

A comparison among the three distributions (Constant, Exponential, and Poisson) in order to increase the productivity is carried out and by analyzing the data, it is noted that if Poisson distributions is used as cycle time on the machines, the productivity will increase to 1586 parts/shift by comparison to 1581 parts/shift in Constant distribution, 1538 parts/shift in Exponential distribution.

The solution found for better organizing the production line is to add a de-burring machine that can increase the productivity by 24.65%.

Using Quest to simulate the production flow one can get a good understanding of how the manufacturing line behaves and how it responds to the changes. The software gave the possibility to compare one result to another. To get proper results using simulation software Delmia Quest, the recommend is to have a very good understanding of the study case production line and good knowledge of the flow simulation theory using discrete events.

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