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Investigation of Effect of Machine Layout on Productivity and Utilization Level: What If Simulation Approach

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ABSTRACT

Designing and selecting the material handling system is a vital factor for any production line, and as result for the whole manufacturing system. Poor design and unsuitable handling equipment may increase the risk of having bottlenecks, longer production time and as a result the higher total production cost. One of the useful and effective tools are using "what if" simulation techniques. However, this technique needs effective simulation software. The main objective for this research is to simulate different types of handling system using what if scenario. To achieve the objective of the research, Delmia Quest software has been used to simulate two different systems: manual system and conveyers system for the same production line and analyses the differences in terms of utilization and production rate. The results obtained have been analysed and appraised to induce the bottleneck locations, productivity and utilizations of the machines and material handling systems used in the design system. Finally, the best model have been developed to increase the productivity, utilizations of the machines, material handling systems and to minimize the bottleneck locations.

Keywords: Handling systems, What if simulation, Productivity, Utilization, Delmia Quest

1 INTRODUCTION

Organizations now days are struggling to increase quality and productivity level while reducing costs associated with production process [1]. One of the essentials parts of the production process is material handling system which considers as critical stage in design process of a manufacturing facility. Facilities layout of manufacturing has received attention where it has an essential role in manufacturing productivity in terms of cost and time [2]. Poor selection of material handling system will lead to poor utilization of labour, increase the number of final product, enhance the production process, and possibly increasing the system's flexibility [3][4]. In addition to that, a balanced utilization will reduce the risk of having bottlenecks in the manufacturing system.

Mohsen & Hassan [5] claimed that a well-designed material handling system "would improve the logistics facilities and their productivity, enhance quality of products, and reduce production" costs. There are different techniques and methods to decide and select the best and optimal material handling systems for each individual production line. However, one of the most common methods used is by simulation due to the easiness especially with the availability of new advanced software such as Delmia and Delmia Quest.

Simulation studies had been used broadly to gain a clear view of the production process before implementing the decision regarding layout and machines handling. Many researchers used different types of simulation to improve and modelling the material handling systems and enhancing manufacturing system by taking critical decisions such as [6][7].

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Narsingh [8] said that simulation environments helped the industries in simulating and understanding the behaviour of the new decisions before implementing it. This will decrease the risk of investment; reduce the risk of lost, shortage and bottle nick issues. The new software gives the decision makers the knowledge in evaluating analysing the effectiveness and check the performance of the material handling systems of a factory. The simulation gives the possibility to enhance and improve the factory layout and offers the opportunity to create" an innovative environment.

One of the common used software for designing simulations of manufacturing system is the Delmia quest software. The software is 3D discrete simulation software used for simulating discrete events in manufacturing processes. It provides simulation environment based on the delivery of materials, processing and storage [9. It contains material element for rapid modelling such as machine tool, treatment process, failure rate, maintenance, operator, path and material export, which can help users simulate and analyse the process flow in 3D factory environment [10]. However, many researchers have used the simulation to evaluate and improve the facility layout in order to improve the productivity using different techniques. In this research a simulation based method using Delmia quest software have been used to analyses the effect of facility layout and the type of handling system on the productivity and utilization level.

2 WHAT IF SIMULATION

In this research, what if simulation approach has been used to study the effect of factory layout and material handling system type using one of the advanced discrete events simulation software's: Delmia Quest. Golfarelli and Rizzi [11] claim that (What-if analysis) can help the decision makers to simulate and inspect the behaviour of a complex system before any critical decision using past data as well any available data to reduce the risk for any un expected results.

The new development of advanced software for modelling and simulating discrete events in manufacturing gives the opportunity to the decision makers in industry to evaluate, analyse and take the suitable actions to improve their systems in productions line. One of the most important systems to the manufacturer is the material handling systems. An effective and suitable handling system will lead to decrease the bottlenecks in production line, reducing the transportation cost for semi-finished parts and as result improve the smoothness of flow inside the production area. Therefore, implementation of different scenarios on designed case in manufacturing in order to investigate and highlights the important of What-if simulation in improving the material handling system and the facility layout.

In this research different factors have been considered: cycle time, types of machines, two different handling systems and different types of facility layout. All scenarios considered the flow of the production, starting from the raw material to the final product. To achieve the objectives of the research different steps have been conducted. Figure 1 concluded the research methodology.

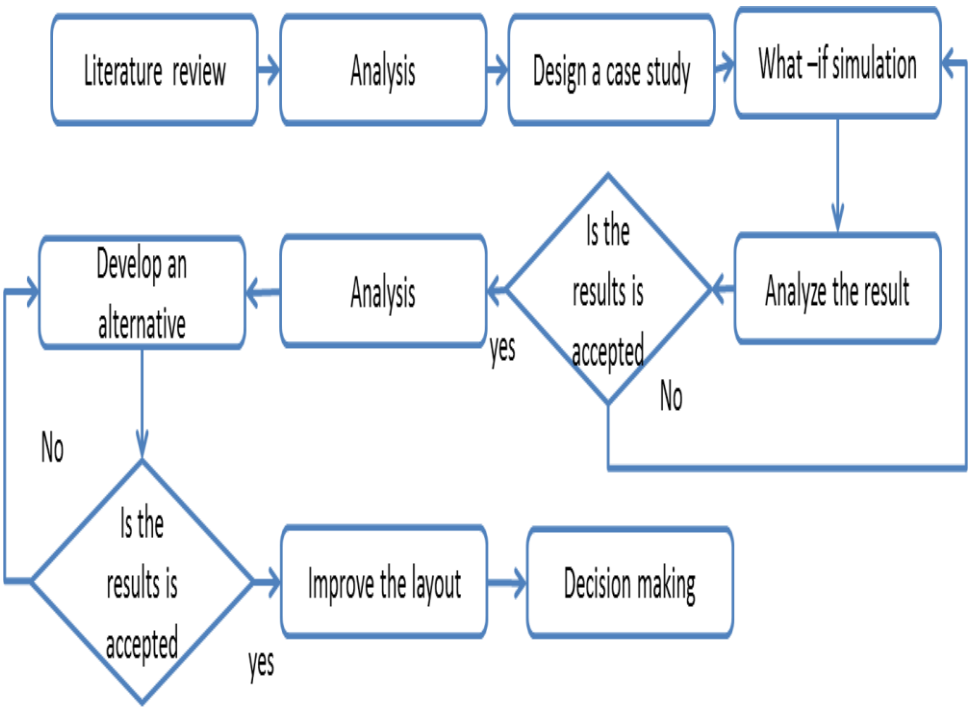

Figure 1: Research methodology flow chart

A case study has been designed to evaluate and highlighted of the importance factory layout and material handling systems type in reducing the bottlenecks and increasing productivity. The final product needs to be machined in different types of processes as shown in Figure 2. This Figure shows two sources of raw materials (S_1-S_2) need to pass through 10 different machines (M_1-M_{10}). The line also contains two buffers B_1-B_2). The first and second scenarios are using manual and automated handling system respectively.

3 RESULTS AND DISCUSSIONS

To investigate the effect of Machine Layout on Productivity and utilization level a Delmia quest simulation technique implemented and the results obtained show improvement on the production process. Particularly, significant enhancement for the production line through improving the average production rate of labour from 67 per hour to 85 per hour in the conveyers' system. However, the proposed model shows an increasing of production rate up to 148 parts per hour. In Figure 3 shows a manual handling system by using labour in the production line.

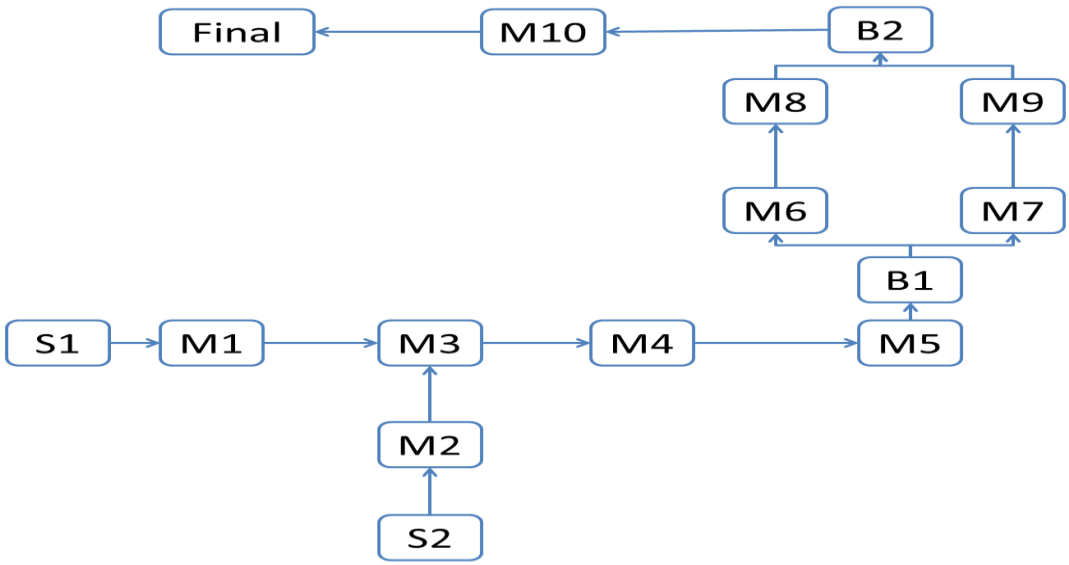

Figure 2: Design of the production line (M: Machine; S: Source; B: Buffer)

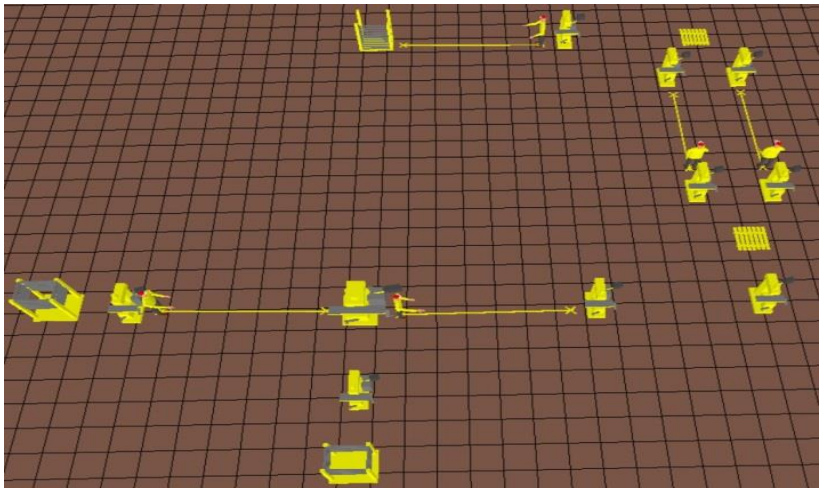

Figure 3: Manual handling system

After running the simulation the utilization for each machine and production rate have been concluded in Table 1 and Table 2. Which show seven machines used in the production line and 5 labours for handling parts. The utilization and the total distant movement for each labour is concluded in Table 2

From both Tables 1 and 2 it was clear that the average utilization for all machines is below 50% except machine 3, where the utilization is about 78%. On the other hand the labour utilization are also have the same values below the 50% except labour 1, where the utilization is about 75%. Figure 4 shows the utilization of the different labours. Second scenario is by adopting automation approach for the same design which will use conveyer instead of using labours for the same design and same sequence a as shown in Figure 5. After running the simulation the utilization for each machine and production rate have been concluded in Table 3. The utilization of each conveyer is concluded in Table 4.

Table 1: Utilization and production rate for the manual handling system

Name	Utilization (%)	Production Rate
Machine1_1	40.556	72
Machine2_1	30.278	72
Machine3_1	79.167	71
Machine4_1	23.393	70
Machine5_1	44.722	70
Machine6_1_1	24.306	35
Machine6_2_1	24.087	34
Machine7_1_1	15.111	34
Machine7_2_1	15.111	34
Machine6_1	26.444	68

Table 2: Utilization, parts transferred, and distance travelled for the manual system

Name	Utilization (%)	No. of Parts Added	Distance Travelled
Labor1_1	75.039	72	664736.6
Labor2_1	34.988	71	674819.6
Labor3_1	44.814	35	266559.8
Labor4_1	43.778	34	267343.7
Labor5_1	33.596	68	651793.5

Figure 4: Utilization of labours

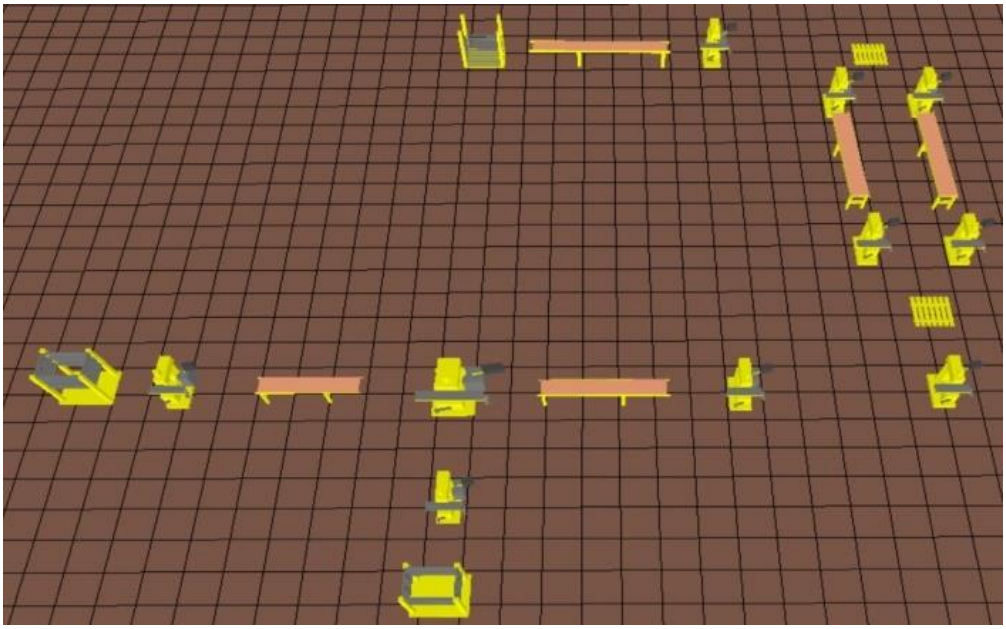

Figure 5: Conveyers handling system

Table 3: Utilization and production rate for the conveyer's system

Name	Utilization (%)	Production Rate
Machine1_1	50.889	91
Machine2_1	37.833	90
Machine3_1	99.222	89
Machine4_1	29.389	88
Machine5_1	56.222	88
Machine6_1_1	30.556	44
Machine6_2_1	30.056	43
Machine7_1_1	19.222	43
Machine7_2_1	19.111	43
Machine6_1	33.444	86

Table 4: Utilization of conveyer system

Name	Utilization (%)	Transport Rate
Conveyor1_1	99.111	90
Conveyor2_1	24.722	89
Conveyor3_1	22	44
Conveyor4_1	21.5	43
Conveyor5_1	47.611	85

From Table 3 and Table 4 it can be concluded that the utilization of all machines have be increased. However, it can be mentioned that machine 3 shows about 99% of utilization, which indicate a bottleneck in the production system. Moreover, the utilization of the conveyer that feeds to the machine 3 show as well 99% of utilization. The utilization of both manual and conveyers are compared in Figure 6. To improve the production system productivity and eliminate the bottleneck a new scenario has been proposed by adding a new machine and conveyer to enhance the production rate and to avoid any bottlenecks issue as shown in Figure 7.

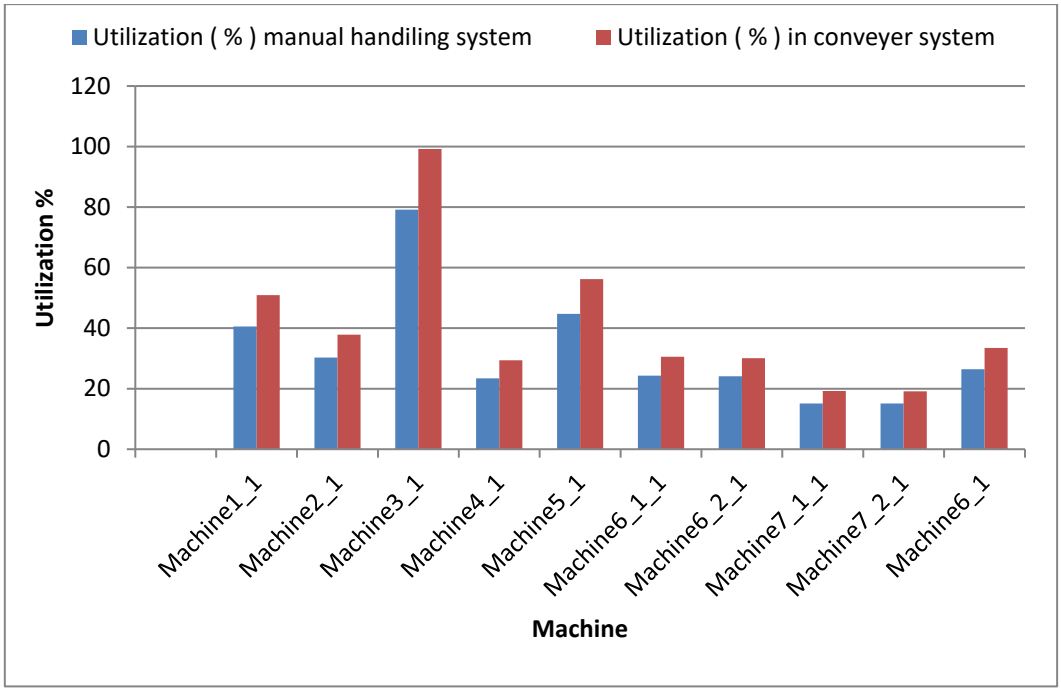

Figure 6: Comparison of utilization

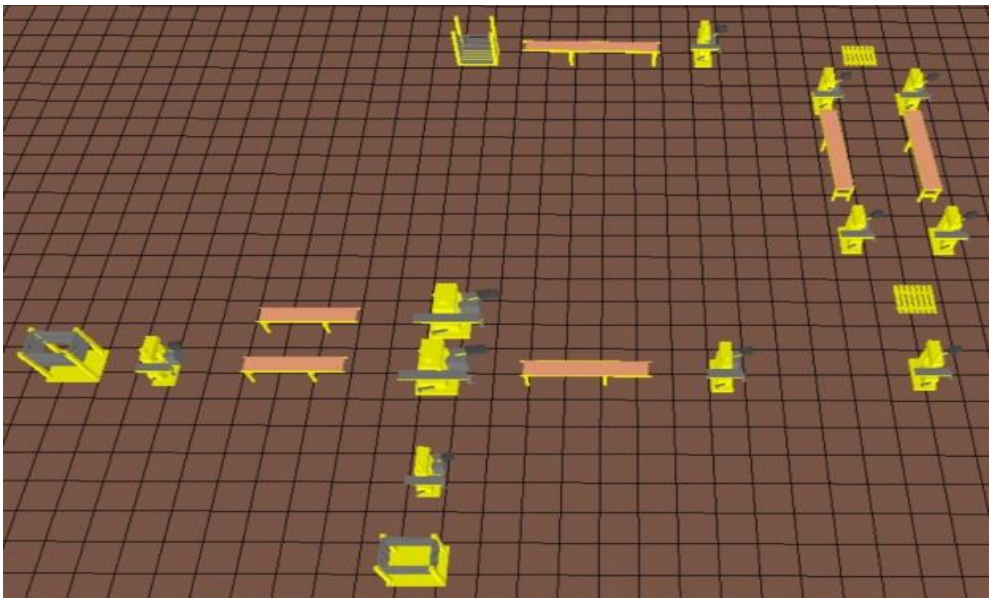

Figure 7: Proposed system

After running the simulation, the results were concluded in Table 5. Where it show that machine 3 shows about 87% of utilization, which indicate no more bottleneck in the production system. Moreover, the utilization of the conveyer that feeds to the machine 3 show as well 92% of utilization. The utilization and the transport rate was concluded in Table 6.

From the results, it was found the proposed system show a high production rate compared as shown in Figure 8. Where at the first scenario with manual handling system the production rate per hour was approximate 52 unit, in the second scenario with conveyers show improvement in the production rate and increase utilization level for some machine and conveyers as consequence of the in-bottleneck issues where led to propose a solution of add extra conveyer and handling machine to reduce the utilization and bottleneck.

Table 5: Utilization and production rate for the proposed system (Fig. 7)

Name	Utilization (%)	Production Rate
Machine1_1	88.722	159
Machine2_1	65.806	157
Machine3_1	87.056	78
Machine4_1	51.333	154
Machine5_1	97.5	152
Machine6_1_1	52.778	76
Machine6_2_1	52.472	75
Machine7_1_1	33.333	75
Machine7_2_1	33.333	75
Machine6_1	57.972	149
Machine7_1	86.583	77

Table 6: Utilization and transport rate for the proposed system (Fig 7)

Name	Utilization (%)	Transport Rate
Conveyor1_1	92.167	79
Conveyor2_1	96.5	154
Conveyor3_1	37.833	75
Conveyor4_1	37.5	75
Conveyor5_1	82.5	148
Conveyor1_2_1	92.083	78

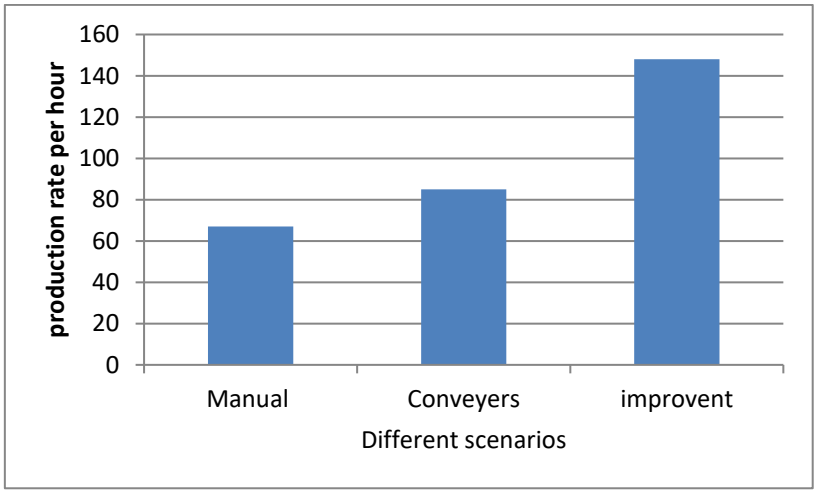

Figure 8: Production rate for the three different scenarios

4 CONCLUSIONS

What if simulation approach using Delmia Quest software is found to be suitable to simulate the manufacturing process with consistency [17]. In this research the results of different scenarios using Delmia QUEST software were analysed. It was found that a significant enhancement for the production line through improving the average production rate of labour from 67 per hour to 85 per hour in the conveyers system. Moreover, the proposed model showed an increase in production rate of up to 148 part per hour. Finally, it can be concluded that the "what if" simulation approach in Delmia Quest software have resulted the followings:

- Reducing the total distance of movement for labours,
- Reducing number of labours,
- Increasing the number of final products,
- Determine the bottleneck based on buffer size, and eventually
- All these achievements are to minimize the cost related to the production process.

Moreover, what if simulation can be used for any discrete event model to improve and detect the weakness in that model, reduce the required time to implement real life model as well as reduce the related expenses such as purchasing new handling system hardware and hire more employees. Moreover, decision makers in operation can reduce the risk associated with decision of handling system. However, the limitation of this improvement was the high cost of changing the handling system and cost associated with Delmia quest purchase which consider costly. However, from the productivity point of view, the investment of changing the handling system become a need to survive in the market. Particularly, replacing or updating the handling system will gain organization competitive advantage in regards of quality, time required, productivity and utilization.

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