Improving Productivity and Efficiency of Assembly Line In A Small Medium Industry (SMI) Manufacturing Company using Witness Simulation

M.S.M.Sani
M.F.F.A.Rashid
T.N.B.B.Khan

ABSTRACT

In this competitive world, manufacturing company is one of the sectors which is competing to gain demand and satisfactory from customers. Dealing with continuous competition, companies not only need to produce quality products, but excellent production system and management also play an important role. The aim of this paper is to improve the productivity and efficiency of a manual assembly line in a Small Medium Industry (SMI). Various industrial engineering techniques and tools are implemented in this study in order to investigate and solve the problem that occurs in the production line. This assembly line is studied using time study techniques, and analyzed and solved using line balancing and simulation approach. The time study techniques applied are using stopwatch time study and identifying operation process procedures. Simulation provides the best solution for comparing, predicting and optimizing the performance of a system without affecting the existing system or cost of implementing a new actual process. This project presents the application of Witness as a simulation tool for manipulation of the data. Initially, the current layout of existing assembly line did not achieve the targeted output. Therefore, three new layouts are discussed and one layout which has the highest improvement in terms of productivity and efficiency is chosen. Simulation definitely plays a vital role in design and operation of nowadays' manufacturing production line system.

Keywords: *Efficiency, productivity, simulation, small-medium industry, witness*

Introduction

Small Medium Industry (SMI) plays an important role in modern economies because of its flexibility and ability to innovate. It also plays an important role in providing employment opportunities and supporting large scale manufacturing firms. Considering this importance of SMI, this research has been carried out to find ways to improve productivity and efficiency in Small Medium Industry. The need for the productivity improvement in the manufacturing industry is due to the high level of worldwide competition in this sector which supports the large scale industry. While the definition of what SMI is varies, it is generally based on the number of employees and financial turnover. In practice, SMI firms are usually characterized by simple organization structures with facilitate rapid decision making (Gunasekaran et al., 2000).

Since SMI sectors play a significant role in the national economy, there is a need to help them improve their competitiveness. Most of SMI firms operate with poor forecasting and planning systems and long cycle time. In order to overcome this problem, SMI companies must increase the productivity and efficiency, and at the same time need to implement management systems based on line balancing process with WITNESS simulation software. The other important issue for any productivity improvement program is the management of people. Job satisfaction is important to have productive workers, so any improvement in the working environment especially in the assembly line production where tasks are repetitive but critical for product quality, should be taken into account (Mehra & Hoffman, 1999). In manufacturing system nowadays, there are large application areas for simulation modeling as the time constraints that we have for production (Averill & McComas, 1998). Most organizations that simulate the manufacturing systems use a commercial simulation software product. The two most important criteria for selecting the simulation modeling are based on modeling flexibility and ease of use. Through this simulation, the need for and the quantity of equipments and personnel, performance evaluation, and the evaluation of operational procedures can be determined. The performance measured by simulation is commonly based on throughput of production, time in system for part, time parts spend in queues, queue sizes, timeliness of delivery and the utilization of equipment or personnel.

Objective and Scope

The main objective of this project is to improve productivity and effectiveness of existing assembly line and propose a new layout. Furthermore, when the productivity increases, automatically this manufacturing company can meet the unpredictable customers' demand. The scope of this project mainly focuses on the case study in SMI using WITNESS, a simulation tool used for manufacturing productivity. Markt and Mayer (1997) said that by using WITNESS, the bottleneck area can be identified at current production lines and new design of production lines can be built. Malaysian SMIs can be grouped into three categories which are Micro, Small, or Medium Industry. Simulation can be defined as the imitation of a dynamic system using a computer model in order to evaluate and improve system performance. By studying the behavior of the model, we can gain insights about the characteristics of the actual system. During the simulation, the user can interactively adjust the animation speed and even make changes to model parameter values to perform 'what if' analysis on the spot (Harrell et al., 2000).

Case Study

The performances of most production lines nowadays are rarely up to design expectations. Manufacturing managers, schedulers, and engineers constantly try to overcome the effects of equipment breakdowns, quality problems, line changeovers, bottlenecks and many other problems that contribute to low productivity. This study helps to improve the performance of a selected local manufacturing production line which experiences the same problems, with the aid of simulation software. The selected small medium industry for this case study is Nexus Electronics Sdn. Bhd. Productivity is a measure of output divided by input. In terms of labor productivity, it consists of developing a number of units of production per hour worked. Productivity can also be increased by maintaining the output constant or reducing the number of people (Meyers & Stephens, 2005). Productivity is the value of output (such as goods or services) that is produced, and divided by the value of input resources (wages, cost of utilities, and cost of equipment).

Results and Discussion

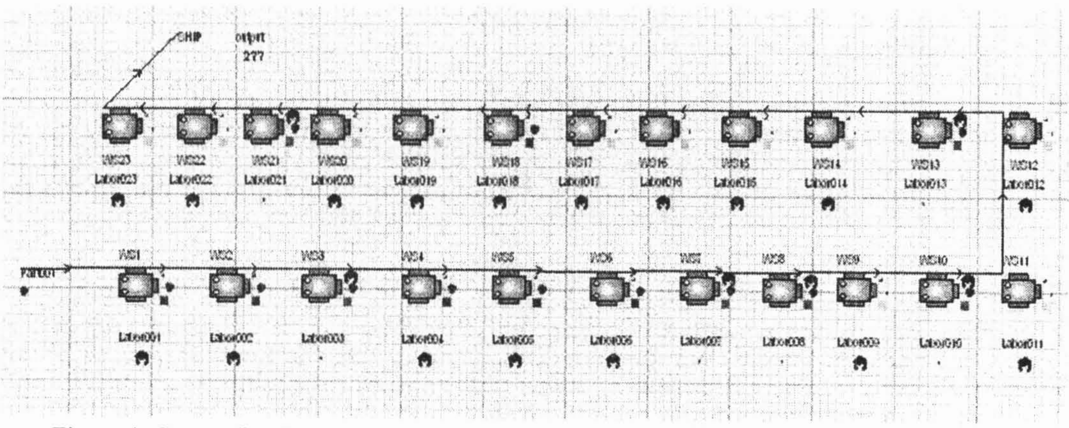

Figure 1: Suggestion Improvement Assembly Line with 23 Workstations (Current Layout)

Table 1: Time Study for Current Layout

NO.	ELEMENTS	WORKSTATION NAME	TASK TIME (s)	CYCLE TIME (s)
1.	Preparations	WS1	6.24	6.24
2.	P-p marking	WS2	9.44	9.44
3.	Strip	WS3	40.83	40.83
4.	First Bend	WS4	27.78	27.78
5.	Bend 45°	WS5	5.31	5.31
6.	Tinning	WS6	17.75	17.75
7.	Tapping	WS7	32.16	32.16
8.	Winding P1	WS8	101.89	101.89
9.	Cutting + Green dotting	WS9	21.44	21.44
10.	Core Tapping + Blue dotting	WS10	94.87	94.87
11.	1st Inductance	WS11	4.25	4.25
12.	1st Hipot	WS12	2.12	2.12
13.	Cemidine	WS13	12.85	12.85
14.	Curing	WS14	43.20	43.20
15.	Inkjet Printing	WS15	3.48	3.48
16.	Final Touch Up + PCB Check + Green dotting	WS16	7.08	7.08
17.	Final Inductance + White dotting	WS17	5.19	5.19
18.	Final Hipot + Red dotting	WS18	18.17	18.17
19.	Final QC + Blue dotting	WS19	6.49	6.49
20.	Packing	WS20	4.64	4.64
21.	OQA Visual	WS21	31.86	31.86
22.	OQA Inductance	WS22	7.13	7.13
23.	OQA Hipot	WS23	7.34	7.34

Justification and Validation of Current Layout

In order to verify that the data of time study and simulation are almost similar, a few justifications can be made to compare both such as:

i) Actual output from Nexus Electronics = 250 – 300 pieces per day.
ii) Average output= 275 pieces per day
iii) By calculation – using cycle time from highest task time pieces per day can be seen in Table 4.2. To get the output per day, actual work time which is 28800 seconds is divided by 101.89. Referring to the calculation below,

$$Output \;\; by \; manual \; = \frac{28800}{101.89} = 284 \;\; Units$$

So, the percentage of error can be calculated as,

$$Percentage \;\; Of \;\; Error \; = \frac{284 \; - 275}{275} \times 100 \; = 3.27\%$$

iv. From the simulation result, the output is 277 pieces per day. Referring to the calculation below,

$$Percentage\ Of\ Error = \frac{277 - 275}{275} \times 100 = 0.72\%$$

Based on the calculation, the percentage of error for both manual and simulation is small, which is less than 5%. Therefore, the data can be validated.

Suggestion for Improvement

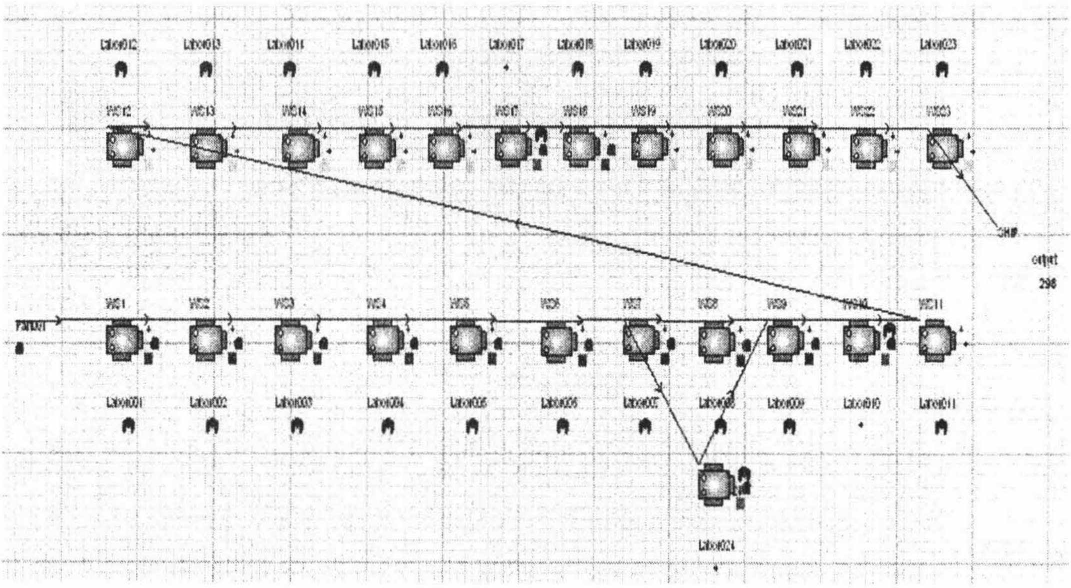

Figure 2: Suggestion Improvement Assembly Line with 24 Workstations (Alternative 1)

Table 2: Time Study for Alternative 1

No.	Elements	Workstation Name	Task Time (s)	Cycle Time (s)
1.	Preparations	WS1	6.24	6.24
2.	Marking	WS2	9.44	9.44
3.	Strip	WS3	40.83	40.83
4.	First Bend	WS4	27.78	27.78
5.	Bend	WS5	5.31	5.31
6.	Tinning	WS6	17.75	17.75
7.	Tapping	WS7	32.16	32.16
8.	Winding	WS8	101.89	50.95
9.	Winding	WS9	101.89	50.95
10.	Cutting + Green dotting	WS10	21.44	21.44
11.	Core Tapping + Blue dotting	WS11	94.87	94.87
12.	1st Inductance	WS12	4.25	4.25
13.	1st Hipot	WS13	2.12	2.12
14.	Cemidine	WS14	12.85	12.85
15.	Curing	WS15	43.20	43.20
16.	Inkjet Printing	WS16	3.48	3.48
17.	Final Touch Up + PCB Check + Green dotting	WS17	7.08	7.08
18.	Final Inductance + White dotting	WS18	5.19	5.19
19.	Final Hipot + Red dotting	WS19	18.17	18.17
20.	Final QC + Blue dotting	WS20	6.49	6.49
21.	Packing	WS21	4.64	4.64
22.	OQA Visual	WS22	31.86	31.86
23.	OQA Inductance	WS23	7.13	7.13
24.	OQA Hipot	WS24	7.34	7.34

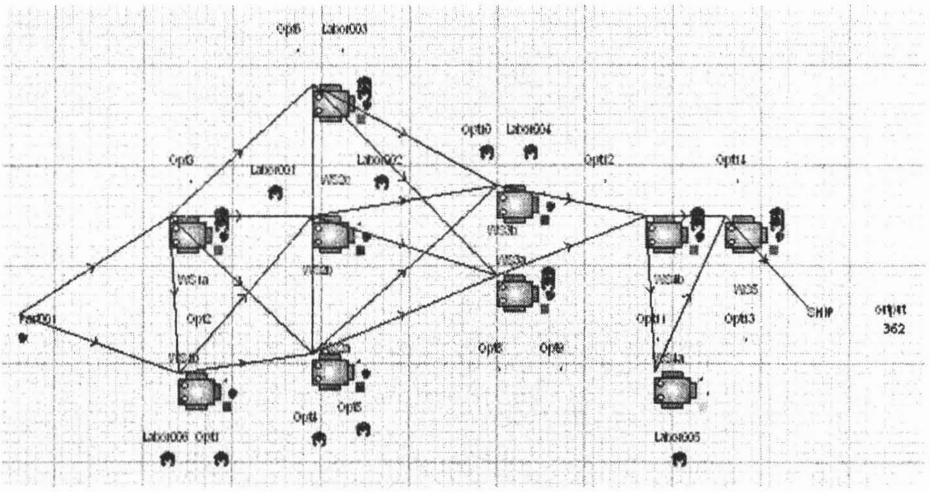

Figure 3: Suggestion Improvement Assembly Line with 10 Workstations (Alternative 2)

Table 3: Time Study for Alternative 2

NO.	ELEMENTS	WORKSTATION NAME	TASK TIME (s)	TOTAL TASK TIME (s)	CYCLE TIME (s)
1.	Preparations Marking Strip First Bend Bend Tinning	WS1	6.24 9.44 40.83 27.78 5.31 17.75	107.35	53.68
2.	Preparations Marking Strip First Bend Bend Tinning	WS2	6.24 9.44 40.83 27.78 5.31 17.75	107.35	53.68
3.	Tapping Winding	WS3	32.16 101.89	134.05	44.69
4.	Tapping Winding	WS4	32.16 101.89	134.05	44.69
5.	Tapping Winding	WS5	32.16 101.89	134.05	44.69
6.	Cutting + Green dotting Core Tapping + Blue dotting	WS6	21.44 94.87	116.31	58.16
7.	Cutting + Green dotting Core Tapping + Blue dotting	WS7	21.44 94.87	116.31	58.16

Continued (Table 3),

NO.	ELEMENTS	WORKSTATION NAME	TASK TIME (s)	TOTAL TASK TIME (s)	CYCLE TIME (s)
8.	1st Inductance 1st Hipot Cemidine Curing Inkjet Printing Final Touch Up + PCB Check + Green dotting Final Inductance + White dotting	WS8	4.25 2.12 12.85 43.20 3.48 7.08 5.19	78.17	39.09
9.	1st Inductance 1st Hipot Cemidine Curing Inkjet Printing Final Touch Up + PCB Check + Green dotting Final Inductance + White dotting	WS9	4.25 2.12 12.85 43.20 3.48 7.08 5.19	78.17	39.09
10.	Final Hipot + Red dotting Final QC + Blue dotting Packing OQA Visual OQA Inductance OQA Hipot	WS10	18.17 6.49 4.64 31.86 7.13 7.34	75.36	75.36

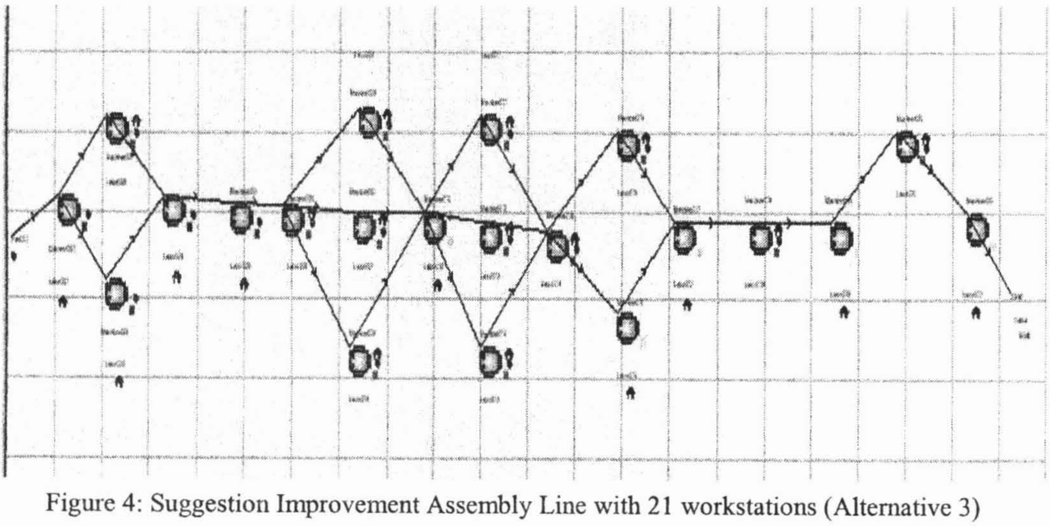

Figure 4: Suggestion Improvement Assembly Line with 21 workstations (Alternative 3)

Table 4: Time study for Alternative 3

No.	Elements	Workstation Name	Task Time (s)	Total Task Time (s)	Cycle Time (s)
1.	Preparations Marking	WS1	6.24 9.44	15.68	15.68
2.	Strip	WS2	40.83	40.83	20.42
3.	Strip	WS3	40.83	40.83	20.42
4.	First Bend	WS4	27.78	27.78	27.78
5.	Bend Tinning	WS5	5.31 17.75	23.06	23.06
6.	Tapping	WS6	32.16	32.16	32.16
7.	Winding	WS7	101.89	101.89	33.96
8.	Winding	WS8	101.89	101.89	33.96
9.	Winding	WS9	101.89	101.89	33.96
10.	Cutting + Green dotting	WS10	21.44	21.44	21.44
11.	Core Tapping + Blue dotting	WS11	94.87	94.87	31.62
12.	Core Tapping + Blue dotting	WS12	94.87	94.87	31.62
13.	Core Tapping + Blue dotting	WS13	94.87	94.87	31.62
14.	1st Inductance 1st Hipot Cemidine	WS14	4.25 2.12 12.85	19.22	19.22
15.	Curing	WS15	43.20	43.20	21.60
16.	Curing	WS16	43.20	43.20	21.60
17.	Inkjet Printing Final Touch Up + PCB Check + Green dotting Final Inductance + White dotting	WS17	3.48 7.08 5.19	15.75	15.75
18.	Final Hipot + Red dotting	WS18	18.17	18.17	18.17
19.	Final QC + Blue dotting Packing	WS19	6.49 4.64	11.13	11.13
20.	OQA Visual	WS20	31.86	31.86	31.86
21.	OQA Inductance OQA Hipot	WS21	7.13 7.34	14.47	14.47

Comparison and Justification of Selecting Layout

Table 5: Comparison Result between Existing and Alternative Layouts

Measurement	Current	Alternative 1	Alternative 2	Alternative 3
Actual work time (s)	28800	28800	28800	28800
No. of Workstation	23	24	10	21
Input	289	311	371	850
Output	277	298	362	834
No. of operator	23	24	20	21
Line Efficiency (%)	21.827	18.83	35.86	45.28
Productivity $\dfrac{Output}{Labor \times hour}$	1.51	1.55	2.27	4.96

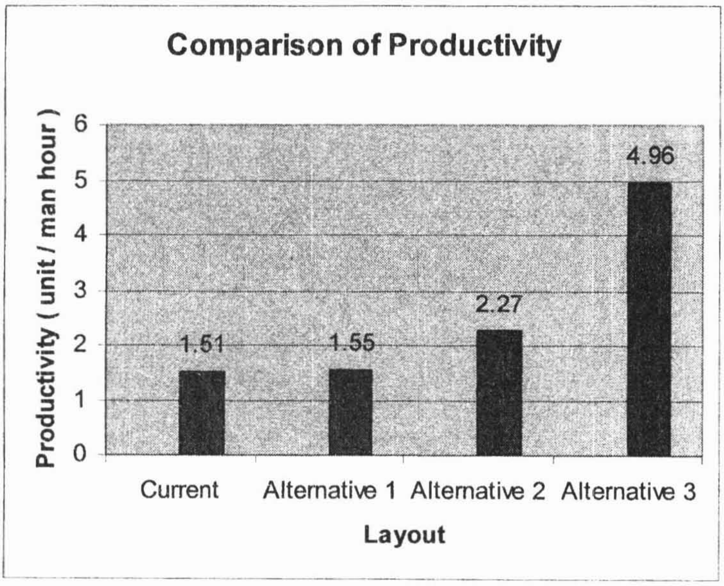

Figure 5: Comparison of Productivity (unit/ man hour)

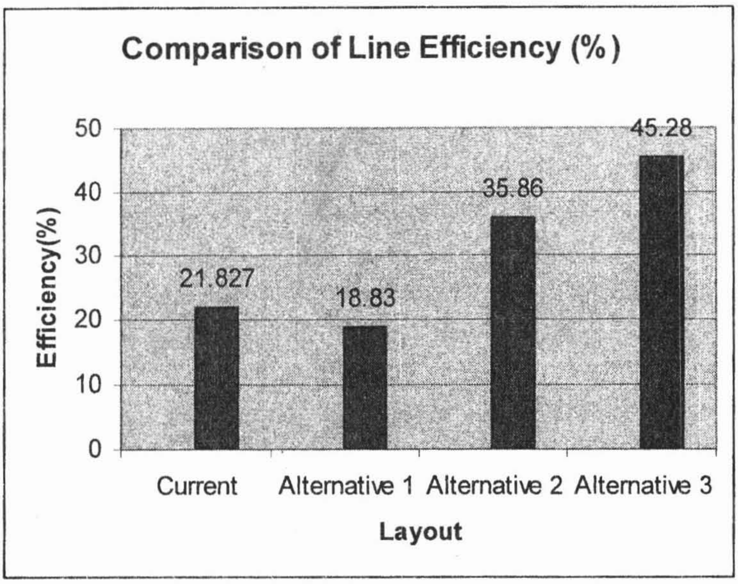

Figure 6: Comparison of Line Efficiency (%)

Based on the table of comparison between the current line and the three alternatives of suggested new assembly lines, Alternative 3 is the most appropriate one. Therefore, it is chosen as the best line among the three. It is because the efficiency on line has increased from 21.827% to 45.28%, which contributes to 1.07% of improvement. Besides, the productivity has also improved from 1.51 to 4.96, and this contributes to 2.78% of improvement. Other than that, the number of operators has also reduced from 23 to 21 only. This will indeed save the cost of manpower and labor to the company. The number of workstations operating in Alternative 3 is 21 which is less than the current layout of 24. This can save up space in the factory area. It is noticeable that the number of output has also increased tremendously from 277 for current layout to 834 pieces per day, and the contribution for improvement is 2.01%. This is able to cope with the unpredictable customers' demand per day. Besides, the productivity and the efficiency graph comparisons are presented in Figures 5 and 6. The cycle time pattern for this layout is also almost equal, which means that the idle time is minimized and every workstation in this line is working at the maximum level of operation. This will reduce bottleneck, blocks and also waiting problems. Therefore, Alternative 3 is selected because it is the best alternative among all the layouts discussed.

Conclusion

The research is carried out in order to solve the line balancing problem existed in the manufacturing company. It was identified that the poor current layout has many weaknesses such as bottleneck and waiting problems that contribute to low productivity and efficiency. So, a time study was developed with the aid of simulation and three new alternatives have been designed and discussed in order to solve the problems of the existing layout. Thus, the new alternative selected has balanced workload which will reduce idle time. The targeted objectives are successfully achieved based on these two observations; firstly, the demand for this model is capable to be met by the increased number of output that is achieved via the new layout and secondly, improvement in terms of productivity and efficiency is also identified.

Based on the main objectives of this project, it can therefore be concluded that:

i. the unpredictable customers' demand of this model can be solved;
ii. the productivity and effectiveness of the existing assembly line is improved by proposing a new layout.

In relation to the research objectives, the significant contribution is that the proposed solution is capable of solving the problem arises in the selected assembly line. The new alternative is able to cope with the current demand better than the existing layout and large improvement in terms of productivity and efficiency is identified.

Recommendation

Based on the research that has been carried out on the assembly line in a selected SMI company, which is Nexus Electronic Sdn. Bhd., there are several recommendations made in order to further establish this project in the future. Below are the recommendations for future work:

i. Perform similar research on a variety of models in a mixed-model assembly line. This is because most of the production plants nowadays are likely to produce multiple products in a single assembly line. It will be challenging to set up the schedule and do planning in order to get the optimum output per day for each model produced.
ii. Enhance the analysis by using WITNESS Optimizer because it significantly reduces the time spent experimenting, by automatically finding the optimum solution to satisfy chosen performance criteria which is fully customizable, by setting the parameters that are allowed to change and the optimizer will perform experiments intelligently to find the best solutions.
iii. Implementation of the chosen alternative layout will be another experimental research in order to prove that the selected solution which is previously studied using simulation research is acceptable and able to function according to reality.
iv. Use other software for simulation tools such as PROMODEL, ARENA, CIMFACTORY and so on. Nowadays, there are various types of microcomputer-based simulation packages in the market. This will help to produce better result in terms of other criteria which cannot be covered by WITNESS software itself.

Acknowledgment

The authors would like to express their thanks to Universiti Malaysia Pahang for funding this project.

References

Gunasekaran, A., Forker, L., & Kobu, B. (2000). Improving operations performance in a small company: Case study. *International Journal of operation & management*, *20*(3), 316-335.

Averill, M.L., & McComas, M.G. (1998). Simulation of manufacturing systems. *Proceeding of the 1997 Winter Simulation Conference*, pp. 86-89.

Harrell, C., Ghosh, B.K., & Bowden, R. (2000). *Simulation using ProModel*. New York: McGraw Hill.

Markt, P.L., & Mayer, M.H. (1997). Witness simulation software a flexible suite of simulation tools. *Proceeding of the 1997 Winter Simulation Conference*, pp. 711-715.

Mehra & Hoffman, J.M. (1999). Operationalizing productivity improvement program through total quality management. *International Journal of Quality & Reliability Management, 16*(1), 72-84.

Meyers, F. E., & Stephens, M.P. (2005). *Manufacturing facilities design and material handling (3rd Edition)*. USA: Prentice Hall Inc.

M.S.M.SANI, M.F.F.A.RASHID & T.N.B.B.KHAN, Faculty of Mechanical Engineering. Universiti Malaysia Pahang. mshahrir@ump.edu.my, toffee_shocks@yahoo.com,ffsaisae@ump.edu.my