MUCET 2008

MUCET 2008

towards enhancement and
university industry collaboration

15 - 16 March 2008
Putra Palace, Kangar
PERLIS

Organized by:

U MAP

SCHOOL OF MANUFACTURING ENGINEERING
UNIVERSITI MALAYSIA PERLIS

In Collaboration With:

Universiti Malaysia Pahang
UMP

Universiti Tun Hussein Onn Malaysia
UTHM

Universiti Teknikal Malaysia Melaka
UTeM

volume 2

http://publicweb.unimap.edu.my/~MUCET2008/

MUCET 2008

MALAYSIAN TECHNICAL UNIVERSITIES CONFERENCE ON ENGINEERING AND TECHNOLOGY 2008

15 – 16 MARCH 2008

PUTRA PALACE, KANGAR

EDITORIAL BOARD

MOHAMAD SHAIFUL ASHRUL ISHAK

BADRUL AZMI ABDUL HOLED

MOHD. KHAIRI WAHID

ROSHALIZA HAMIDON

SITI AISYAH ADAM

SUHAIREZA MD. ESA

VOLUME 2

M04: Manufacturing
(manufacturing support systems)

O01: Others

S01: Social Science & Management
(social science, technical & vocational education)

Simulation Modeling for Balancing and Optimizing a Digital Measuring Device (DMD) Production Line

Rohana Abdullah, Adi Saptari, Nor Akramin Mohamad, Isa Halim, Effendi Mohamad

Abstract— In today's competitive manufacturing environment, companies are constantly looking for ways to improve. Because of this, many companies are striving to reduce waste by implementing lean manufacturing, which is a difficult process. Line balancing is part of the lean manufacturing. To aid in the implementation, simulation can be used to reduce the trial-and-error process in balancing and optimizing the production line. Towards achieving a lean assembly line, the optimum amount of resources in terms of the workstations and labor will need to be determined. In addition, the identification of the bottleneck area is critical before opportunities for balancing the production line can be determined. Using Witness simulation modeling, these objectives were able to be achieved and the details of the results will be presented in this paper. Through this study, the SME participating in this study was able to confidently manage their equipment capacity more efficiently and attain a highly productive workforce.

Keywords: Line balancing, Lean Manufacturing, Productivity, Simulation

I. INTRODUCTION

Lean principles are fast becoming the preferred method being utilized by companies to achieve optimum production systems. Lean is all about eliminating waste and Rawabdeh [1] defined waste as "anything other than the minimum amount of resources which are absolutely essential to add value to the product". Dennis [2] asserted that this can be achieved by utilizing the productivity improvement techniques and Toyota is an example of a company that has successfully proven that this method really works.

Rohana Abdullah, Adi Saptari, Nor Akramin Mohamad, Isa Halim and Effendi Mohamad is with the Faculty of Manufacturing Engineering, Universiti Teknikal Malaysia Melaka
(email: rohana_abdullah@utem.edu.my, adi@utem.edu.my, akramin@utem.edu.my, isa@utem.edu.my, effendi@utem.edu.my)

Standardized work at each manufacturing and assembly process also ensures high level of productivity, quality, and safety to the employees [3].

Line balancing is a lean tool that can be used to optimize the workstation or assembly line throughput. This tool will assist in the reduction of the production time and maximizing the output or minimizing the cost. Assembly line is a flow oriented production system where the productive

units performing the operation referred to the workstation and the work pieces move from one station to one station with some kind of transportation system.

Normally there will be a problematic area in an assembly line or technically known as the bottleneck workstation. Bottleneck is based on the analogy of the shape of a bottle. When liquid is poured into a bottle, the liquid will flow slowly at the bottlenecks that have a smaller parameter compare to the wider body. That is the concept or application that is used for the term bottleneck in assembly line. At an assembly line, bottleneck is will create a queue and a longer overall cycle time. The example of the bottleneck concept can be referred at figure 1.
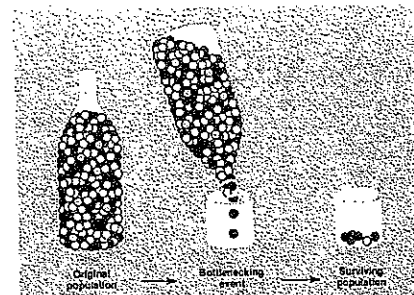
Figure 1: Bottleneck Concept [4]

Cycle time, number of machine, number of workers, and shift pattern are the basic data required in order to perform the line balancing activity. The cycle times of each process in the factory were gathered to give a better understanding of the bottlenecks that might exist and of the work content at each station. Gathering detailed information on cycle times and work content for all workstation is important in order identify the bottleneck of the entire operation.

Standridge and Marvel [5] argued that Lean is a necessary but not a sufficient approach to analyzing production systems issues since Lean employs deterministic methodology. They suggested that simulation must be used to include random and structural variation to evaluate the different alternatives solutions for a good production system. Simulation has a unique ability to accurately predict the performance of a system and ideally suited for systems planning [6]. This thesis will utilize the simulation software to mimic the real world production system of a SMI producing digital measuring device (DMD) in order to determine the process that has the lowest performance or the bottleneck workstation. With the validated model, different alternatives were developed in order to balance and optimize the production line. Through simulation modeling, the company can save cost to improve the assembly line performance and determine the best production line configuration for their expansion plan as compared to the traditional way of trial and error on the actual system.

II. THE DMD PRODUCTION LINE

The SMI production line under study assembled DMD for various overseas customers especially in the UK, Bahrain, UAE and Qatar and planning to triple the existing production rate in order to support its business expansion to other markets in South East Asia, and the European countries in the next five years. There were a total of twelve major processes consisting of a combination of semi-automatic and manual processes subdivided into three sections. The line operated 5 days a week and 8 hours per day which was already the productive time after giving allowance to the personal, fatigue and delay (PFD) of the operators.

The three sections of the production line were used as the basis of the conceptual framework of the model (figure 2). In section one, the processes involved were manual activity of sensor cleaning, magnet insertion, potting which is the process where resin was injected into the DMD, semi-automatic leak and passivation testing. The leak testing equipment required about 30 minutes of set-up time and at any one time randomly 5 parts will be tested for any leakages. The second section is a subassembly process of printed circuit board (PCB) testing and installing the PCB into an enclosure. The semi completed parts from section one and two will be manually combined together at section three in the process flow and testing of the completed parts are done and finally packed to be delivered to the customers.

A successful model requires a good quality and quantity of input data to produce a result that is close to the real system [7]. Thus, a team of Universiti Teknikal Malaysia Melaka (UTeM) lecturers and final year students spent many hours to gather data on the process flow, process times, resources (labor, material, equipment) and product (lot size, demand, rejection rates). These data were crucial in order to measure the significant production measures such as:

    i. Production throughput (number of DMD produced for the planning period analyzed)

    ii. Production cycle time
    iii. Resources utilization

Witness 2006 Simulation software from Lanner Group [8] was used to develop the model for DMD production line. Work measurement was considered to be essential in providing a good cycle time data input for the simulation model [9]. The cycle time used in the model for the manual process has already included the PFD allowances for the operators. The set-up time and equipment breakdown information was only required for the semi-automated processes. The number of operators in the model was represented by the number of workstation. The model was verified by tracing the model process by process in order to ensure there is no error during the development of the model and correct data was entered for each element. The model animation and each process output were also checked in order to avoid major debugging effort during the model validation stage. The historical performance data of an identified planning period were selected to be compared to the model production throughput in order to test the validity of the simulation model.

The unique characteristic of a simulation model is with the animation features where the production systems can be graphically displayed as the model evolves through time [10]. The animation feature as presented in figure 3 together with the discussions with the company's representative provided a tremendous help during the model verification and validation effort. As a result, the model was confirmed to be 91.88% close to the actual production throughput.
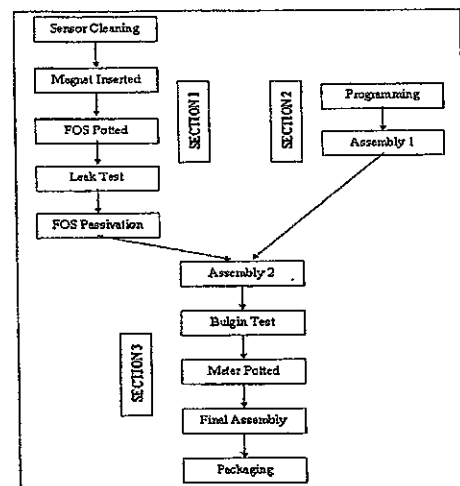

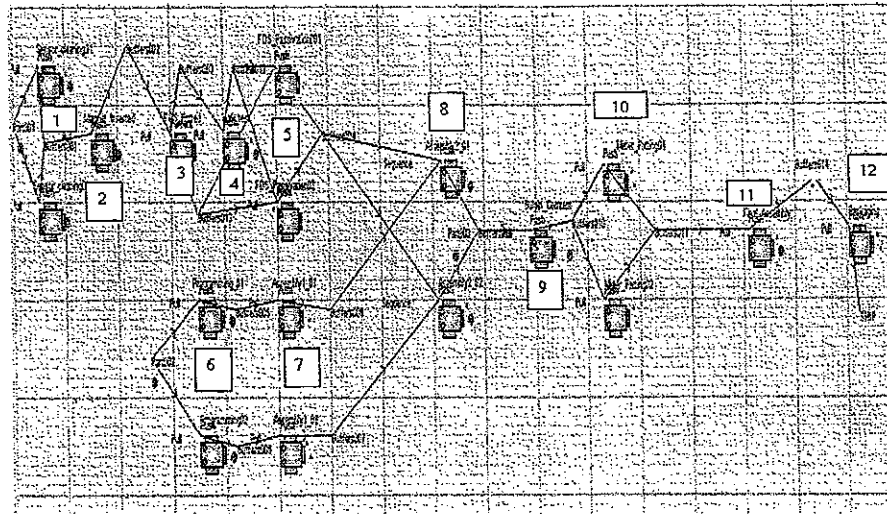Figure 2: Simulation model conceptual framework

Figure 3: DMD simulation model animation feature

III. SIMULATION ANALYSIS

The validated model was showing that the existing production line was unbalanced with bottleneck areas appearing at various areas in the production line such as the PCB programming, leak test and final assembly. This is due to the very high utilization of the resources at these areas. For example, figure 4 shows the result of the existing production line simulation and the operator at the PCB programming section was 100% utilized and causing the assembly 2 area having to wait for the parts or idling 77.23% of the time.

Through further analysis, the factors affecting the production line balance were identified due to:

i. Insufficient workstations for desired capacity expansion due to high utilization (green bar) at the critical operations such as sensor cleaning, PCB programming, leak test and final assembly.
ii. High cycle time for bottleneck operations. Reducing the cycle time for these processes will help improve the overall cycle time of the production line.
iii. High idle time (yellow bar) of the assembly 1, assembly 2, meter potting and bulging test. Reducing the non-value added workstations will help to improve the overall resource utilization while still achieving the desired capacity.

Analysis 1: Add new workstation at the critical processes

In order increase the production line capacity, one PCB programming workstation, one leak test workstations and two final assembly workstations were added in the simulation model. Consequently, the production throughput was found to increase by 161.25%. The packing area has become the new bottleneck process for the production line but is not necessary to be added at the moment to support the capacity expansion to double the size of the existing production line.

Analysis 2: Reduce critical area process time

Another opportunity to be explored in order to increase the production line capacity is by reducing the process time for the semi-automatic leak test station. The idea to reduce the process time was put forth to the production line engineer and he advised that the process time can be reduced by 20% without affecting the product quality. Consequently, production throughput for this particular process was able to be improved.

Analysis 3: Eliminate unnecessary workstations to reduce idle time

The assembly 1, assembly 2, and meter potting were found to have high idle time and the workstation quantity can be reduced in order to eliminate the waste on high waiting time for material to be processed without affecting the existing production throughput. One workstation was reduced for each process and the result showed a significant improvement in terms of the idling time for these processes. The improvement in the idle time was shown in table 1 which clearly showed that the assembly 1 idle time was improved by 22.85%, assembly 2 idle time was improved by

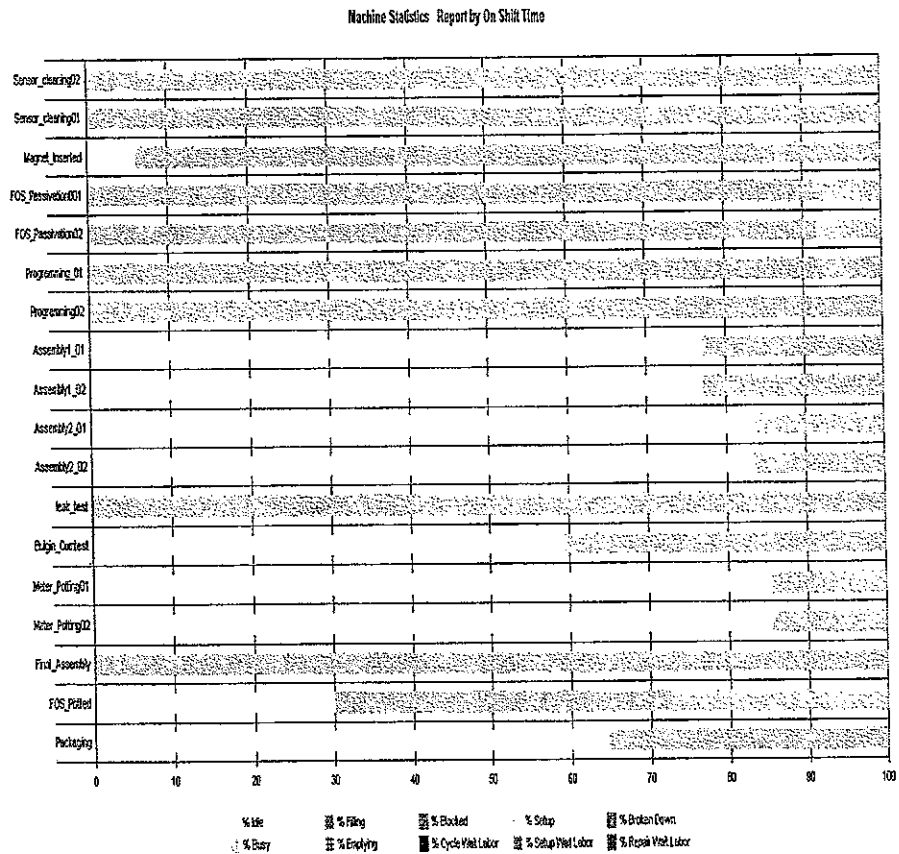16.29% and the meter potting idle time was improved by 14.15%.

Machine Statistics Report by On Shift Time

Figure 4: Existing production line simulation result

### Analysis 4: DMD Line Balancing And Optimization

With the addition of the critical process workstations, reduction of the leak test station's process time and the removal of non-value added workstations, the DMD production line balance was able to be achieved. In addition, the capacity was able to be optimized to meet the existing demand and also prepare for the company's near future expansion. The result of a balanced DMD production line is shown in figure 5. The overall process utilization (green bar) had improved tremendously and the overall productivity of the production line were also improved by more than 50% of the existing production throughput.

Table 1: Comparison on idle time improvement after reducing the number of workstations

Process		Before (%)	After (%)	Improvement (%)
1	Sensor Cleaning	0.00	0.00	-
	Sensor Cleaning	0.00	0.00	-
2	Magnet Inserted	6.11	6.11	-
3	FOS Potted	30.07	30.07	-
4	Leak Test	0.00	0.00	-
5	FOS Passivation	0.00	0.00	-
	FOS Passivation	0.00	0.00	-
6	Programming	0.00	0.00	-
	Programming	0.00	0.00	-
7	Assembly 1	77.23	54.38	22.85
	Assembly 1	77.23		
8	Assembly 2	83.63	67.34	16.29
	Assembly 2	83.63		
9	Bulgin Test	59.44	59.44	-

10	Meter Potting	85.33	71.18	14.15
	Meter Potting	85.33		
11	Final Assembly	0.00	0.00	-
12	Packaging	64.87	64.87	-

further optimization in terms of the product lot size, the daily production schedule and the lead time to deliver products to customers.

Machine Statistics Report by On Shift Time
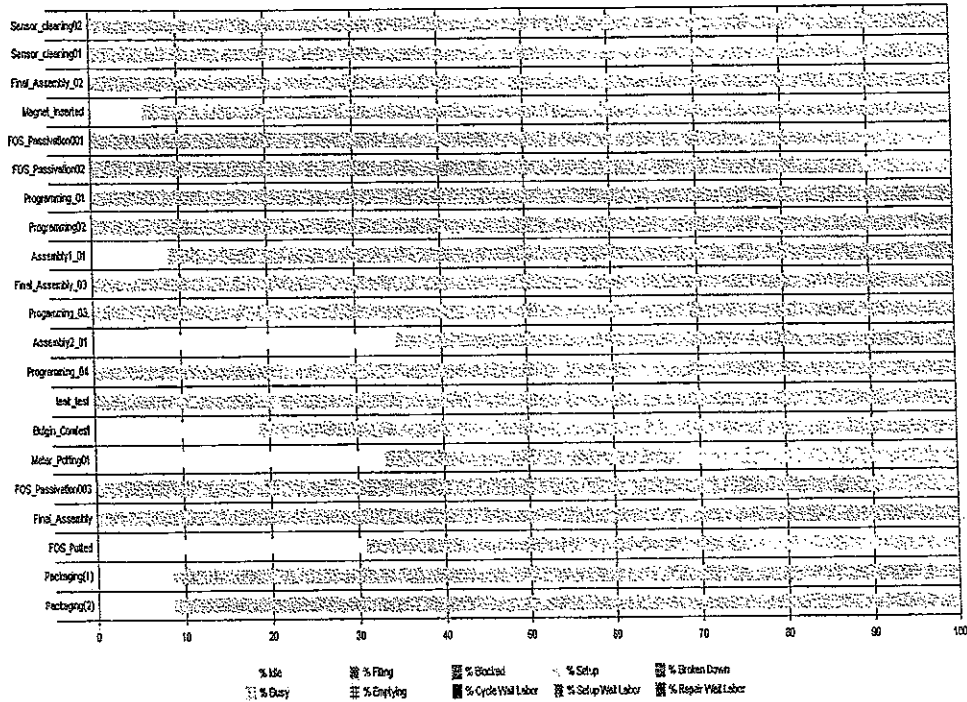
IV. CONCLUSIONS AND FUTURE WORKS

In this study, lean tools primarily the line balancing has proven to be useful for the company management to characterize the DMD production line capacity towards their goal in achieving lean manufacturing while meeting the desired expansion plan. Simulation as a method utilized in this study is an alternative for a cost efficient way to evaluate the production line existing performance. Simulation model results also were able to provide a clear picture on the production line's bottlenecks and enabled for different analysis to be done without disrupting the existing production activities. Thus, achieving a more balanced and optimized production line.

The simulation model developed for this study can be expanded to capture the random variations due to customer demands, parts inter-arrival time to be used for the company's production and man power planning activities. Further experimentations with the model will allow for

REFERENCES

[1] Ruwabdeh, Ibrahim. 2005. A Model for Assessment of Waste in Job Shop Environment. International Journal of Operations and Production Management. Vol 25. No 8. 800-822

[2] Dennis, Pascal. 2002. Lean Production Simplified. New York: Productivity Press. 57-59

[3] Tapping, Don., Luyster, Tom., Shuker, Tom. 2002. Value Stream Management. New York: Productivity Press. 60-61

[4] Mesut D Jodge, A. 2001. Simulation Approach in Balancing Discrete Mass Production Flow System and Application. Management Journal. Vol 4. 113-116

[5] Standridge, Charles R., Marvel. Jon H. 2006. Why Lean Needs Simulation. In Proceedings of the 2006 Winter Simulation Conference, ed. L.F. Perrone, F.P.

[6] Harrel, Ghosh, Borden. 2000. Simulation using Promodel (3rd Edition). McGraw-Hill Higher Education. 2,8-10.

[7] Leemis, L.1999. Simulation Input Modelling, ed. P.A Farrington, H.B Nembhard, D.T. Sturrock and G.W. Evans. Proceedings of the 1999 Winter Simulation Conference. 14-23

[8] Lanner (2006). Lanner Product [Online]. Available http://lanner.com/products/why_simulation.php (20 July 2006)

[9] Longo, F., Giovanni, M., Papoff, E. 2006. Effective Design of an Assembly Line Using Modeling and

[10] A.R Mendes, A.L. Ramos, A.S. Simaria and P.M Vilarinho. 2005. Combining Heuristic Procedures and Simulation Models for Balancing a PC Camera Assembly Line. Computer and Industrial Engineering. Elsevier. Vol 49. Issue 3. 413-131