

# **Simulation Modeling and Analysis for Stitching Line of Footwear Industry**

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## **Abstract**

This research presents simulation modeling to justify the usage of 2-lines and 4-lines of stitching area in footwear factory which commonly used on footwear industry. Despite the common practice there are no investigation about benefit and drawback of using those two configurations. Therefore, this research aims to justify which line configuration has better impact for the company. Unit per Man Hour (UPMH) is selected as research's performance parameter. Other factors that exist on the real system are also included in the model. Simulation model was constructed based on collected data from observed company, with regards to selected performance parameter and design factors. Experimental simulation was done for all 72 scenarios and UPMH is analyzed. Factorial design analysis shows that the usage of 2-lines is more beneficial than 4-lines as it yields higher UPMH. The other experimental factors also have significant effect on UPMH with its own respective level. The results of the experiment can provide useful information to the operation managers of the factory.

## **Keywords**

Simulation modeling, footwear, stitching line, line configuration

## **1. Introduction**

### **Background**

Footwear is a massive industry. Production of footwear on 2011 reaches 21 billion pairs, roughly valued more than USD 157 billion. Worldwide, this sector employs more than 7 million workers. Yet, this industry is facing a tougher competition in the future. There are abundant number of players, with top eight companies are only accounts for 8% of total revenue in the sector. As the industry is a labour-intensive one, nowadays most of manufacturers set their production base in Asia. 87% of footwear products are manufactured in 7 Asian countries, with China took the largest proportion of 60.5% world's production. India is on the second place, contributes as much as 10.4%. Aside of tough competition, increasing labour cost is also a major issue. It contributes around 16.5% - 25% of footwear production cost. This level is expected to increase in the near future as government in

China and India set to increase minimum wage level. Presumably, most of footwear manufacturers in Asia will also be challenged by the same situation of increasing labour cost issue.

As most of companies have to struggle to be the most efficient in order to win the competition. Improvement and innovation is needed to increase efficiency of the operation. Company seeks how to cut as much as production cost. Footwear industry is a labour-intensive industry with most of production processes are done manually. It will be a big gain if companies able to find and set a condition where operator employment can generate more output. One of the process in typical footwear manufacturing facility is stitching. Stitching is a very manual operation which heavily depends on operator. It consists of sequential processes, requires higher operator skills and relatively needs longer time compared to other shoes processing. Stitching line serve as assembly process to form upper-part of footwear. By practice, there are 2 kind of stitching line configuration: 2-lines and 4-lines. 2-lines is usually used for fulfilling small order and 4-lines is for the larger order, but actually there are no investigation about benefit and drawback of using those two configuration. Therefore, this research aims to justify which line configuration has better impact for the company. Specifically, in term of operator productivity.

The challenge is, it is quite troublesome to conduct an experiment in the real production floor. Schedule is tight and resource is limited. Also due to multiple variables to be involved in the experiment, not all of them may be able to be observed in the real experiment. One of the method that can be selected is through simulation. By using simulation, experiment is able to be done using variables that practitioners wished to observe. It enable to mimic the real system as long as required data is valid and collectable. Constructed simulation model will mimic the stitching process in detail. Performance parameter that is used to see the effect of several involved factors is unit per man hour. As the simulation is constructed based on problem existed in observed company, which is mainly producing sports shoes, the method of building the simulation may be need to be justified if intended to be used on different type of footwear industry. As there is not much simulation-based research for footwear industry, this research is expected to fill the gap in the practical simulation modeling for footwear factory, specifically for stitching line.

### **Objective**

Objective of this research are:

- To construct simulation model for stitching line of footwear factory.
- Justifying which line configuration has better impact to performance parameter through experimental simulation.

### **Assumption**

Some assumption that used on this research are explained in this subsection:

- No limitation on shop floor dimension.
- Only consider two kind of resources: workstation and operator.
- There are no limitation on the number of resources.
- Run the simulation based on operational practice.
- Output that will be rejected or re-worked are neglected.

## **2. Literature Review**

There are not too many research that touch operational level of footwear manufacturing. Subramanian (2004) using heuristic procedure to solve cell loading and scheduling problem on injection moulding machine of shoes manufacturing facility. Zangiacomì (2004) constructed Analytical-Hierarchy-Process-based decision support system for planning and scheduling short-term order of mass-customized shoes manufacturing. There is one research that also focusing on stitching line of footwear factory. Conducted by Parwananta (2012), it uses heuristic procedure to determine resources assignment of stitching line in footwear manufacturing facility. Eryilmaz (2012) using simulation to determine optimum production policy over various produced shoes styles.

Simulation is a tool that extensively used in manufacturing system design and analysis for more than 40 years, as mentioned in a research by Smith (2003). This research conducts a survey on simulation in manufacturing field and states that simulation as an extremely useful analysis tool. During the years, simulation has been used in diverse problem in manufacturing field. Gelenbe (2003) use Flexsim to analyse classes of Flexible Manufacturing System (FMS) by incorporating relational database management system as a input and data storage for the simulation. Um (2009) analyses Flexible Manufacturing System with an Automated Vehicle Guided System (AGVs) using simulation. The simulation also combined with optimization technique that is Multi-Objective Non-Linear Programming (MONLP) and Evolution Strategy (ES). Simulation also used in high-tech-industry research, such as in colour-filter fabs of TFT-LCD (2011). The former uses AutoMod simulation software to evaluate production

policy in order to increase throughput of colour-filter fabs. The later assess implementation of look-ahead-release planning in colour-filter fabs.

### 3. Simulation Modeling for Stitching Line

#### Problem Definition

Behaviour of stitching line will be assessed based on several factors by using the method of simulation. Data collection, along with workstation and operator assignment, were conducted in the beginning of the process. Then it was used as input to construct the simulation model. Once the model is valid, the model was run on several scenarios. In the end, design of experiment was involved to analyze the results. Flow chart of research methodology is show on Figure 1.

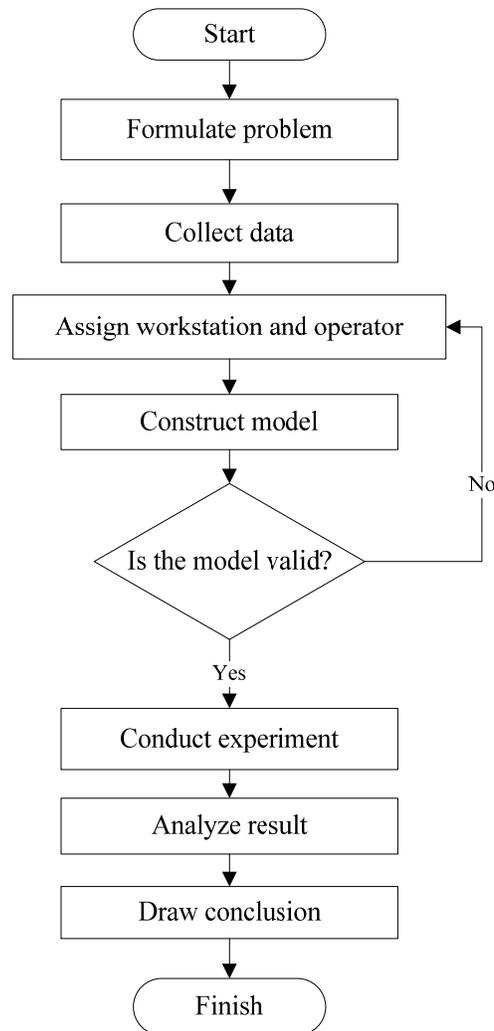


Figure 1: Flowchart of research's methodology

This research use Units per Man Hour (UPMH) as performance parameter. The UPMH measures how many product produced per one man-power in an hour. It also represents productivity of operator in term of output per hour. The higher the value, it means operator employment is more efficient. UPMH is calculated by following formula :

$$\text{UPMH} = \text{output} / (\text{number of operator} * \text{working hours})$$

Complete design factor and performance analysis of this research is shown in Figure.2.

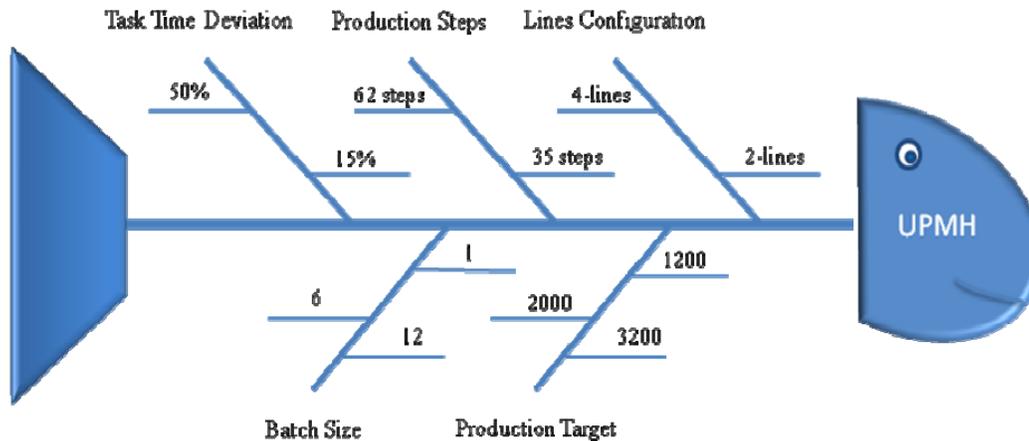


Figure 2: Diagram of critical factors identification to UPMH

### Data Collection

Data is collected based on how detail the simulation model is expected in representing the real system. Data collection also refers to selected performance parameters and factors in order to make sure that experimental simulation will be able to be conducted.

### Workstation and Operator Assignment

The process repeated for several scenarios that is planned for this research. The *production steps* factor has 2 level, shoes style with 35 steps and 62 steps. Production output is set at 3 level : 1200, 2000 and 3200 pairs per day. The choice of lines configuration are 2-lines and 4-lines.

### Model Construction

Simulation model was built using Flexsim 5.1.2 with educational license. This software offers wide-range of simulation function and enable users to mimic appearance of the real system. Explanation of simulation modeling will be presented by explaining the used Flexsim modules.

#### a. Source

This module provides flow item for the whole system. Amount of flow item, item types and attributes of flow item are set through source. In this research, amount of flow item entering the system is determined by arrival schedule of flow item. Tighter arrival schedule means more flow item entering the system and vice versa.

#### b. Processor

Workstation is modelled by using processor, which able to process task with specified time and operator. Each processor is set that it requires operator in order to be able to process a flow item. Processor refers to global table which stores task time for task. To determine which row and column of global table it should refers to, processor reads item type and attributes value of each flow item. The updating of attributes value is done every time a flow item entering a processor.

#### c. Queue

Queue is a module that is used to store flow item when other modules, e.g. processor, cannot accept flow item yet. Function of queue in the built model is similar with rack that is used to store work-in-process materials. Queue is set to work in first-in-first-out manner.

#### d. Operator

Operator acts as worker that doing task on determined processor. Each processor and its assigned operator is connected by using a connection that called centre connection. Operator will do task based on processor request and processor would not be able to process an item flow if there is no available operator.

#### e. Dispatcher

When a set of operator working on a set of processor, a dispatcher will control how they are working. Operator request is sent by processor to dispatcher. By selected rules, dispatcher will delegates available operator to work on the task. In the model, task delegation will be passed to operator which has shortest distance from requesting processor.

#### f. Combiner

As previously mentioned, selected shoes styles have medium precedence shape which include some assemblies during the process. To work with it, combiner is used to merge multiple flow item on the assembly point. Combiner is placed right after a process that intended as the assembly point. Inside the combiner, flow item that going to be assembled is not subjected to any task time as the assembly task is actually have been done on the previous process.

g. Separator

The usage of separator is in accordance of batching size scenario needs. In the modelling of batching, one flow item represents a batch size (1, 6 or 12). Number of flow item given to the system is divided by number of batch. In the other hand, task time is multiplied by number of batch. In the end of the stitching line, separator splits one flow item into certain number, depend on the batch size. Therefore, the output count will be back in pairs.

h. Global Table

Global table is a multi-purpose table that in the model is used for storing task time data. For every flow item, processors read task time value in global table through flow item's item type and attribute value. Item type correlates with row and attributes value correlates with column of global table.

i. Sink

Sink is the final destination that used to destroy flow item. This model refers to number of flow item that entering sink as the output of simulation.

**Validation and Verification**

After model construction is completed, validation and verification process is conducted to make sure that the model is already representing the real system. Conceptual model validation is done to determine that theories and assumptions which acts as referrals for the conceptual model are consistent with specified model details. Therefore, conceptual model as representation of the system is assured as reasonable model for the intended purpose. Implementation verification is assuring that the model is built in accordance with developed conceptual model. Both of mentioned validation and verification process was conducted in assistance of personnel from observed company.

**4. Experiment Results and Analysis**

**Simulation Experiment Design**

The simulation model was run for 10 working days. The first 5 days is the warming-up state, where the simulation will not obtain any data on this stage. The length of warming-up state is calculated by summing up all of the task time in one shoes style. That value is the minimum value of warming-up time. The next another 5 days regarded as the steady state period. Data of simulation result is gathered on this stage of simulation. The simulation was done using high-performance personal computer. Length of simulation time is depend on the scenario being run, varied from 5 minutes to one hour per scenario. Scenario with more resources and smaller number of batch size requires the longer running time and vice versa. Each of the scenario was run for 2 times to get 2 data replication. Summary of the simulation output is shown on Appendix B (in the form of output and UPMH).

**Analysis**

Result of simulation experiment was statistically analyzed. As this research using more than 2 experiment factors, it can be considered as factorial experiments. Effect of each factor, along with interaction between them, is able to be examined by using factorial experiments. To help in analyzing the results, factorial design feature of Minitab 15.1.3 was used. Minitab output can be seen on Table 1.

Table 1: Summary of Minitab results on design factor analysis

<b>Factors</b>	<b>F-Value</b>	<b>P-Value</b>	<b>Remarks</b>
Lines Configuration	1567.16	0.000	Significant
Production Steps	19986.90	0.000	Significant
Production Target	826.05	0.000	Significant
Batch Size	22.09	0.000	Significant
Task Time Deviation	4.64	0.033	Significant

The Minitab result shows that all of p-value for 5 employed factors are lower than 0.05. it means that all factors are significant to the UPMH. From observed factors interaction, some of them have significant interaction which are: ProductionSteps - ProductionTarget, ProductionSteps - NumberOfLines, ProductionSteps - BatchSize and ProductionTarget - NumberOfLines.

## 5. Conclusion and Suggestion

### Conclusion

Detailed simulation model for stitching line of footwear manufacturing was constructed. The model was built in step-by-step based on given specification from observed company. Validation and verification process was conducted in assistance of company personnel and by comparing results with specified design. It is proven that the model able to mimic the real system under several justification and able to be further used for conducting planned experiment.

The experiment aims to investigate the effect lines configuration, as well as other selected factors, on UPMH. Experiment result shows that all of the factors have significant effect to UPMH. Each factor has different effect magnitude on UPMH. In sequence, factors from strongest to weakest magnitude are as following: of production steps, lines configuration, production target, batch size and task time deviation. Based on main effect plot, which level of each factor yields higher UPMH is also known:

- Product with lower production steps will enable to reach higher UPMH.
- Usage of 2-lines is more favorable as it resulting in higher UPMH.
- When the system aims for higher production target, UPMH also increased. But, the increasing magnitude from 2000 to 3200 is not as high as from 1200 to 2000.
- Higher batch size will also increase UPMH. Here, batch size of 6 is more recommended to use.
- Lower task time deviation is slightly better than the higher one.

Interaction plot shows consistent result with main effect plot. It shows that combination of pre-mentioned favorable level for each factor yields in higher UPMH. In further analysis, it is found that batch size of 6 is recommended to use as it has higher UPMH and to comply with lean management concept. Presumption of higher output in 4-lines configuration is confirmed. But due to higher operator needs in 4-lines configuration, this benefit is vanished in term of UPMH. Increasing magnitude of UPMH is much smaller compared with increasing magnitude of production target. It is caused by increasing needs of operator that follows the magnitude of increasing production target. Operation managers can know how to set the level of those factors in order to increase output (or UPMH) of the factory.

### Suggestion

Suggestion for future research is as follow:

- Addition of performance parameters.
- Involve more varied styles of shoe.
- Add some details to the simulation.
- Run the simulation based on operational practice.
- Involve method to optimize workstation and operator assignment.

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