Implementation lean manufacturing using Waste Assessment Model (WAM) in shoes company

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Abstract. The purpose of this research was to measure the level of lean performance. Lean manufacturing is a concept that implements waste elimination that can improve effectiveness and efficiency. Implementation of this research using waste relationship matrix to know the relationship between seven waste and last use waste assessment questionnaires to get the final weight of the rank of seven waste. Defect is the number waste (21.57%) and then waste of waiting (16.67%). By using this method, we can be using quantitative data by objective factor. It can be easier to reduce waste and improve industrial productivity. The impacts of ineffective and inefficient production processes are poor performance and not smooth production. Producing products effectively and efficiently is one of the goals of manufacturing companies.

1. Introduction
Lean has been using by many productions in many countries. In the last decade lean manufacturing becoming tool can improve company productivity. Quality, control and delivery is the most important in industrial [1] Business investment in the industrial sector is increasing, each manufacturer must increase the value of product by improving its performance. Level of performance become an important part for manufacturing companies to keep it business moving forward and sustainable. Each company can measure the level of performance to find out how effective and efficient the production system it runs. The company’s production system is more effective and efficient, then the resulting product is also more qualified and more competitive to compete in the market [2]. There is a waste which cannot be seen because they look like activity in production but there is no value added of product. This is worse if we no realize there is a waste everywhere, every time and every one.

Problems that often arise in the industry not smooth flow of production is not smooth flow of production that makes waiting time for consumers. Value Stream Mapping aims to describe the flow of product which consist of material and information flow [3]. The company has unbalanced operating times so often experience a bottleneck. To overcome this, the company increased the amount of raw material and semi-finished materials, but this just makes the waiting time become longer. Refers to the perfect supply management concept, this condition makes the company is less responsive and at risk of losing customers [4]. However, delivery is the focus of industrial competitiveness [1]. Lean thinking is the principle of thinking to do more but with a little manpower, a little equipment, a short time, and minimum space while still providing what customers want [5].

Implementation lean has been used in small line production to eliminate waste [6] or one production systems such as in food and beverage industries [7] garment [8]. There are several
solutions to overcome this problem, one of them by applying lean manufacturing concept. Lean manufacturing concept has a goal to eliminate waste in the company. A long waiting time and excess of raw material or work in process are part of the waste so it takes effort to eliminate it or at least reduce it. By applying lean thinking framework of course, the problem of waiting time and the excess of WIP can be resolved, therefore need to look for methods that are in accordance with the lean principle. Value stream mapping (VSM) method is an important part in the application of lean manufacturing.

We have observed from the production process that this company has some waste just cannot be known big or small. This study will measure how much waste was happen in the company and the waste has come from. There are several methods that can be used for measurement and Waste assessment model (WAM) approach can facilitate the process of identifying the impact of seven types of waste is one of the newest methods [9]. In addition, in this study to analyze the use of these methods.

2. Methodology
This research was conducted using descriptive method by using some data to represent actual condition. The main focus of this research is to analyze seven types of waste and its impact. The steps of this study are described in the points below. Field observations are made to observe the current situation in the company as a reference to get the right method. The objectives of the study were made in response to the formulation of the problem and became the basis for the outcomes that would result from this study. Data were collected using the four methods described in the observation, interview and questionnaire. The data has been process using Waste assessment model (WAM), Waste relationship matrix (WRM) and Waste assessment questionnaire (WAQ).

3. Result and discussion
3.1. Waste Assessment Model (WAM)
The reason companies make the amount of inventory of raw materials and work in the process in large quantities is because the raw materials are often returned to the supplier because it is not appropriate or reject. For that reason, the company did so to avoid cessation of production due to lack of raw materials. This policy makes lead time become longer (42 days), while cycle time is not affected (22.18 sec). Waste assessment model (WAM)

The WAM approach consists of two main steps below.
- Using WRM to determine the level of relationships between waste in the company.
- Using WAQ to assess each type of waste and determine the weight of each waste.

3.1.1. Waste relationship matrix (WRM). WRM is used to measure the level of relationship of seven types of waste. All types of relationships are shown using rows and columns. Each row shows the effect of the other six types of waste. Likewise, each column shows the waste that is affected by the other six wastes. Results from WRM can be seen in Table 1. For simplification of the matrix in Table 1, the symbol is converted to a number with reference (A:10, E:8, I:6, O:4, U:2, X:0) [9]. And Table 2 shows that the defect score has the highest percentage (21.57%) followed by waiting with the percentage (16.67%).

Table 1. Waste relationship matrix (WRM).

| F/T | O | I | D | M | T | P | W |
|-----|---|---|---|---|---|---|---|
| O   | A | U | U | O | X | O | O |
| I   | U | A | O | A | U | X | X |
| D   | U | A | A | A | U | X | A |
| M   | X | O | U | A | X | A | O |
| T   | U | U | U | U | A | X | U |
| P   | U | O | O | U | X | A | U |
Table 2. Waste matrix values.

| F/T | O | I | D | M | T | P | W | Score | %  |
|-----|---|---|---|---|---|---|---|-------|----|
| O   | 10| 2 | 2 | 2 | 4 | 0 | 4 | 24    | 11.76|
| I   | 2 | 10| 4 | 10| 2 | 0 | 0 | 28    | 13.73|
| D   | 2 | 10| 10| 10| 2 | 0 | 10| 44    | 21.57|
| M   | 0 | 4 | 2 | 10| 0 | 10| 4 | 30    | 14.71|
| T   | 2 | 2 | 2 | 2 | 10| 0 | 2 | 20    | 9.80 |
| P   | 2 | 4 | 4 | 2 | 0 | 10| 2 | 24    | 11.76|
| W   | 10| 10| 4 | 0 | 0 | 10| 10| 34    | 16.67|
| Score| 13.73 | 20.59 | 13.73 | 17.65 | 8.82 | 9.80 | 15.69 | 100.00 |

The process also has a large enough effect that causes other wastage. While in the column, inventory has the highest percentage of 20.59%. This indicates that inventory is mostly caused by other wastes. Based on these results it can be seen that the wasting affects each other in the company's production system.

3.1.2. Waste assessment questionnaire (WAQ). WAQ approach consists of 68 different questions, which are introduced to allocate waste. Each question represents the activity, condition, or behaviour that may cause waste. Some questions state "From", meaning this question represents the type of waste that might cause other waste with references from WRM. Some other questions state "To", meaning this question represents the type of waste that might be caused by other waste. The full result of WAQ results can be seen in Table 3.

In Table 3 it can be seen that the biggest waste that occurred was a defect with a percentage of 22.46%. In the second sequence is to wait with a percentage of 19.21%. While inventory is in third with the percentage of 14.20%. Lean manufacturing can reduce waste and elimination non-value-added activities using various techniques such as Kaizen or Six Sigma [10].

Table 3. Tabulation of waste assessment questionnaire (WAQ) results.

| Information | O | I | D | M | T | P | W |
|-------------|---|---|---|---|---|---|---|
| Yj          | 3.61| 4.15| 4.39| 3.46| 2.76|    | 2.28| 3.44 |
| Pj factor   | 161.48 | 188.39 | 296.04 | 201.85 | 134.56 |    | 161.48 | 228.76 |
| Yj final    | 583.24 | 780.89 | 1300.53 | 697.63 | 371.38 | 368.09 | 787.03 |
| Percentage  | 11.93%| 15.97%| 26.60%| 14.27%| 7.60%| 7.53%| 16.10%|

For more details the waste rating can be seen in Figure 1 which is sorted by the largest rank. This result can be used as a consideration to eliminate waste based on the root cause. Multiple dimensions like supplier management, shop floor management, new product development, customer relation can be used to reduce waste in small and medium enterprise [11].
Based on the identification result using WAM approach also gives the same result. The root cause of waste is known to come from defects or more precisely defects in raw materials. The results of these two methods and approaches prove that both yield the same results so that both of these methods and approaches can be combined for identification of waste. Lean manufacturing is the most importance to implementation in industrial. It can be affects the performance of the industry, but there is a challenging in production system such as executive, cultural, management, implementation and technical issue [12].

By implementation lean we can increase productivity, eliminated waste, increase employee motivation, improve cultural company [13]. SMED can be using to improve performance production time and eliminating waste also [14]. People development system to increase employee’s capability in term of production, marketing, delivery and quality [15].

4. Conclusion
The result of identification using WAM approach is obtained that WRM method is known the biggest cause of waste coes from defects (21.57%) which cause inventory (20.59%) and WAQ method shows the root cause of waste that must be eliminated is defect (26.6%), wait (16.1%) and inventory (15.97%). The results of both methods and approaches show defect to be the root cause of waste. Both methods and approaches can be combined for waste identification. Because the defect of raw materials into the root cause of the company need to make improvements to the method of delivery of raw materials with suppliers so that no more defects of raw materials.

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