Implementation of lean manufacturing using waste assessment model (WAM) in food industry (case study in usaha mikro kecil menengah (umkm) xyz)

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Abstract. The waste occurring on the production line leads to inefficient production and loss to the company. Based on the results of brainstorming with UMKM XYZ owners, it is known that there is a reduction in the production time of up to 20% of the production time is 4 hours per cycle. The waste that occurs will be identified and minimized using methods of Waste Assessment Model (WAM) and Fault Tree Analysis (FTA) for proposed repairs. The purpose of the research is to calculate the percentage of waste and know the dominant waste, knowing the repair to minimize the largest waste, and calculating the amount of production time. The results showed that the dominant waste was the transportation of 17.09% with improvements was to change the layout of the production, change the design of tools, expand the production floor, implement a more integrated fixed contract system and minimize the production process. The average time that can be minimized for donut products, bread, and molen is 490 seconds per cycle or 8.167 minutes per cycle.

1. Introduction
The production process is a stage of transforming inputs into outputs. The production process involves the entire resources of the company to be able to manage the production process becomes more efficient and effective. There are so many methods that can be used in managing effective and efficient production processes, such as scheduling [1], improving design facilities, or minimizing the waste that occurs on the production line led to the production process becomes inefficient and cause losses to the company.

Lean manufacturing is an approach that can identify and eliminate waste at the production process, so the output can be optimized and increased [2]. The concept of lean manufacturing requires the identification of waste classification to determine which activities are included in the value-added
activity, non-value-added activity, and necessary but non-value-added activity. The next stage after the lean manufacturing concepts such as the identification of waste is planning improvements that can be made by the company such as eliminating some activities that are not needed at the production process.

UMKM XYZ is a small business operating in the food industry in Cilegon. UMKM XYZ products are donut, bread, brownies, sponge cake, and molen. The most produced product in UMKM XYZ that was the object of this research was a donut, bread, and molen. The production process in UMKM XYZ still used a simple and conventional production. Donut production takes 4 hours per cycle, while the bread requires 5 hours per cycle and molen takes 3 hours per cycle.

But the owners of UMKM XYZ, stated that the production time of three products decreased by 20% from the average time of the three products per cycle, or a decrease of 0.8 hours per cycle for each product.

Based on the problems, it is necessary to do an improvement in UMKM XYZ to reduce the decrease in production time. The focus of this research is the improvement in waste that often occurs in UMKM XYZ. The waste will be identified using Waste Assessment Model (WAM) methods and will be minimized using Fault Tree Analysis (FTA) [3] for improvements that can be done. WAM, the chosen method, can identify the dominant waste thoroughly, not only can identify the waste itself but also the identification based on the relationship between waste [4] [5].

This research begins by determining the standard time of each work element using a stopwatch. After that, the distribution of lean manufacturing questionnaires was carried out using the WAM method, and the most dominant waste was found in the UMKM XYZ. After learning the most dominant waste, the researcher will analyze the waste use VALSAT [6] and find the improvements using FTA (Fault Tree Analysis). The final result of this research is the proposed improvements that can be made to minimize waste and provides an illustration of the VALSAT future state of production in UMKM XYZ. The research objective to be achieved through this research are as follows:

1. Calculating the percentage of each waste that occurs in the production process in UMKM XYZ.
2. Knowing the most dominant waste from production processes in UMKM XYZ.
3. Knowing suggestions for improvements to minimize the largest existing waste in production processes in UMKM XYZ.
4. Calculating the amount of production time can be minimized when suggestions for improvements made.

2. Methodology

This research was used in qualitative and quantitative research. The qualitative research approach is an effective research approach to obtain specific information like cultural values, opinions, attitudes, and social context in a population [7]. While the approach of quantitative research is research that emphasizes the numerical data (numbers) processed with statistical methods.

The use of both of these approaches is caused by a data processing method used is the method Waste Assessment Model (WAM). WAM method using qualitative input (human perception) and changing the values obtained qualitative to quantitative for further processing using quantitative tools [5]. The object under investigation is the process of implementing lean manufacturing in production processes in UMKM XYZ.

From figure 1 we know that there are 5 data needed to be collected, they are sales data, production process data, flow diagrams, process maps, and data operations of observation time. The following is a flowchart of a lean manufacturing method WAM on research conducted in UMKM XYZ.
3. Result and Analysis

3.1. Waste Assessment Model (WAM)

3.1.1. Waste Relationship Matrix (WRM)

Waste Relationship Matrix (WRM) is a matrix that is used to analyze the measurement criteria. The waste matrix describes the real relationship between the types of waste [8]. The recapitulation of the weighting of the Waste Relationship Matrix of this research can be seen in Table 1

| Notation     | Respondents | Average | Conversion |
|--------------|-------------|---------|------------|
| O_I          | 11 4 11     | 9       | O          |
| O_D          | 7 12 5     | 8       | O          |
| O_M          | 14 14 9    | 12      | I          |
| O_T          | 11 18 9    | 13      | E          |
| O_W          | 5 8 6      | 6       | O          |
| I_O          | 11 4 10    | 8       | O          |
| I_D          | 8 4 3      | 5       | O          |
| I_M          | 6 6 8      | 7       | O          |
| I_T          | 9 10 7     | 9       | I          |
Table 2. Weighted recap of WRM (Continue)

| Notation | Respondents | Average | Conversion |
|----------|-------------|---------|------------|
| D_O      | 6           | 18      | 5          | 10         | I          |
| I_N      | 8           | 5       | 4          | 6          | O          |
| D_M      | 7           | 11      | 6          | 8          | O          |
| D_T      | 9           | 18      | 4          | 10         | I          |
| D_W      | 4           | 10      | 4          | 6          | O          |
| M_I      | 7           | 6       | 8          | 7          | O          |
| M_D      | 15          | 16      | 6          | 12         | I          |
| M_P      | 15          | 20      | 18         | 18         | A          |
| M_W      | 8           | 9       | 3          | 7          | O          |
| T_O      | 13          | 16      | 11         | 13         | E          |
| T_I      | 11          | 9       | 7          | 9          | I          |
| T_D      | 11          | 11      | 5          | 9          | I          |
| T_M      | 13          | 15      | 16         | 15         | E          |
| T_W      | 7           | 9       | 10         | 9          | I          |
| P_O      | 14          | 17      | 6          | 12         | I          |
| P_I      | 4           | 6       | 6          | 5          | O          |
| P_D      | 12          | 18      | 6          | 12         | I          |
| P_M      | 12          | 18      | 18         | 16         | E          |
| P_W      | 12          | 8       | 7          | 9          | I          |
| W_O      | 6           | 6       | 5          | 6          | O          |
| W_I      | 8           | 4       | 6          | 6          | O          |
| W_D      | 7           | 9       | 4          | 7          | O          |

From the table above it can be seen the weighted average of Waste Relationship Matrix (WRM) of a third of respondents in every relationship of waste.

3.1.2 Waste Matrix Value

Waste Matrix Value is the matrix that contains letters from the conversion of weighted average WRM [9]. Waste Matrix Value of this research can be seen in Table 2.

Table 3. Waste conversion letter matrix value.

| F / T | O | I | D | M | T | P | W |
|-------|---|---|---|---|---|---|---|
| O     | A | O | O | I | E | X | O |
| I     | O | A | O | O | I | X | X |
| D     | I | O | A | O | I | X | O |
| M     | X | O | I | A | X | A | O |
| T     | E | I | I | E | A | X | I |
| P     | I | O | I | E | X | A | I |
| W     | O | O | O | X | X | X | A |

In Table 3 we know the relationship between waste with other waste. Letters in the second column of the third line are the relationship of waste from O (Overproduction) to I (Inventory) or could be interpreted waste affect waste Overproduction Inventory the relation is I (Important).
Each relationship between waste which is symbolized by the letter as shown in Table 5 is converted into a value based on Table 1 so that the results are as follows:

| F / T | O | I | D | M | T | P | W | Total | % |
|-------|---|---|---|---|---|---|---|-------|---|
| O     | A | O | O | I | E | X | O | 36    | 15%|
| I     | O | A | O | O | I | X | X | 28    | 12%|
| D     | I | O | A | O | I | X | O | 34    | 14%|
| M     | X | O | I | A | X | A | O | 34    | 14%|
| T     | E | I | I | E | A | X | I | 44    | 18%|
| P     | I | O | I | E | X | A | I | 40    | 17%|
| W     | O | O | O | X | X | X | A | 22    | 9% |
| Total | 38| 36| 40| 30| 20| 34| 238| 100% |
| %     | 16%| 15%| 17%| 17% | 8%| 14%| 100%|       |

From the table above is known from Overproduction waste percentage value of 15% means that the influence given Overproduction waste to other waste is 15%. While the percentage of waste to Overproduction of 16% means that the effect obtained Overproduction waste from other waste is 16%.

3.2. Waste Assessment Questionnaire (WAQ)

Waste Assessment Questionnaire (WAQ) was made to identify and allocate the waste that occurs in the production line [2] [5]. This questionnaire consists of 68 questions with the aim of determining the waste that occurs.

The final calculation of the Waste Assessment Questionnaire in this study is shown in Table 5. From Table 7 is known that the sequence of the most dominant waste in the production process of UMKM XYZ to the lowest is transportation (17.09%); motion (17.05%); defect (16.91%); overproduction (16.69%); inventory (13.60%); process (10.37%) and waiting (8.30%). Then, the most dominant waste that occurs in UMKM XYZ is waste transport as much as 17.09%.

| Score (YJ) | O   | I   | D   | M   | T   | P   | W   | Total |
|------------|-----|-----|-----|-----|-----|-----|-----|-------|
| 0.5709     | 0.6312 | 0.5818 | 0.5864 | 0.6056 | 0.6063 | 0.5188 |       |

| Pj factor  | O   | I   | D   | M   | T   | P   | W   | Total |
|------------|-----|-----|-----|-----|-----|-----|-----|-------|
| 0.0242     | 0.0178 | 0.0240 | 0.0240 | 0.0233 | 0.0141 | 0.0132 |       |

| Results (YJ Final) | O   | I   | D   | M   | T   | P   | W   | Total |
|--------------------|-----|-----|-----|-----|-----|-----|-----|-------|
| 0.0138             | 0.0112 | 0.0140 | 0.0141 | 0.0141 | 0.0086 | 0.0069 | 0.0826 |

The final result (%) 16.69% 13.60% 16.91% 17.05% 17.09% 10.37% 8.30% -

| Ranking | 4   | 5   | 3   | 2   | 1   | 6   | 7   |
|---------|-----|-----|-----|-----|-----|-----|-----|

3.3. Value Stream Analysis Tools (VALSAT)

Selection tools on VALSAT performed by linkage of the seventh waste that was observed in UMKM XYZ used Waste Assessment Questionnaire (WAQ) method.
Table 6. Value stream analysis tools (VALSAT)

| Weight of Waste | Waste | Process Activity Mapping | Supply Chain Matrix | Product Variety Funnel | Quality Filter Mapping | Demand Amplification Mapping | Decision Point Analysis | Physical Structure |
|-----------------|-------|--------------------------|---------------------|------------------------|------------------------|-----------------------------|-----------------------|------------------|
| 0.1669          | O     | 0.1669                   | 0.5008              | 0.1669                 | 0.5008                 | 0.5008                      | 0.1669                |                  |
| 0.0830          | W     | 1.5024                   | 1.5024              | 0.1669                 | 0.5008                 | 0.5008                      | 0.1669                |                  |
| 0.1709          | T     | 1.5024                   | 0.1669              | 0.5008                 | 0.5008                 | 0.1669                      | 0.1669                |                  |
| 0.1037          | P     | 1.5024                   | 0.5008              | 0.1669                 | 0.5008                 | 0.5008                      | 0.1669                |                  |
| 0.1360          | I     | 1.5024                   | 0.5008              | 1.5024                 | 0.5008                 | 0.5008                      | 0.1669                |                  |
| 0.1705          | M     | 1.5024                   | 0.1669              | 0.5008                 | 0.5008                 | 0.5008                      | 0.1669                |                  |
| 0.1691          | D     | 1.5024                   | 0.1669              | 0.5008                 | 0.5008                 | 0.5008                      | 0.1669                |                  |

| Amount          | 6.8442 | 3.6725 | 1.1685 | 1.8363 | 2.5040 | 2.0032 | 0.3339 |
|-----------------|--------|--------|--------|--------|--------|--------|--------|
| Ranked          | 1      | 2      | 6      | 5      | 3      | 4      | 7      |

The results of the calculation of the Value Stream Analysis Tool (VALSAT) above, the biggest weighting result was obtained in the Process Activity Mapping (PAM) tools section. Besides the use of tools Process Activity Mapping (PAM) is strongly correlated to waste Transportation of 1.5 and is very useful to eliminate waste Transportation.

3.4. Fault Tree Analysis (FTA)

Fault Tree Analysis (FTA) is an analysis method that can describe failures which is the cause of an undesired event and the probability of an undesired event [10].

![Figure 2. FTA of transportation waste in UMKM XYZ.](image)

Based on the picture above it can be seen that the events that are not expected to cause waste transport of which is no improvement of the layout of the start of production, design tools have not changed from the start of production, a narrow place, there is no fixed contracts system and many production processes. The improvement can be given to minimize wastage of transport such as changing the layout of production, change the design of tools becomes larger capacity, expanding the
production floor, applying a fixed contract system more clearly and integrated for employees and minimize the production process.

3.5. Recaps before and after improvement
Proposed improvements made to minimize waste by minimizing the production process can reduce the time of production of donuts, bread, and molen per cycle. Results improvement using Big Picture Mapping (BPM) tools and PAM of donuts, bread, and molen.

| Product | Total Work Element (Event) | Lead Time (Second) | % Decrease |
|---------|---------------------------|--------------------|------------|
|         | Before  | After   | Difference | Before  | After   | Difference |
| Donuts  | 42      | 37      | 5          | 19.865  | 19.327  | 538        | 2.7%       |
| Bread   | 36      | 33      | 3          | 36.777  | 36.266  | 511        | 1.4%       |
| Molen   | 34      | 31      | 3          | 121.970 | 121.549 | 421        | 0.3%       |

From Table 6 we know that recaps before and after improvements in UMKM XYZ for donut product have a difference of 5 elements of work (weigh the raw materials at the station weighing of raw materials, bring raw materials to the WIP kneading station 2, check the dough at the dough station, check the dough setting on the floured board at the rounding station and the perforation station) with a time of 538 seconds, bread product has a difference of 3 elements of work (weigh raw materials in the station weighing of raw materials, bring raw materials to WIP station weighing of raw materials 2 and check the dough at the dough station) with a time of 511 seconds, while the molen product has a difference of 3 elements of work (check dough at dough station, take the raw material in the winding station and set up raw material in the winding station) with a time of 421 seconds. The average time for all three products can be minimized until 490 seconds or 8.167 minutes per cycle.

4. Conclusion
The conclusion that can be taken from the research in UMKM XYZ are as follows:
1. The percentage of each waste that occurs in the production process in UMKM XYZ using methods Waste Assessment Model (WAM) is overproduction 16.69%, 13.60% inventory, defects 16.91%, 17.05% motion, transportation 17.09 %, process 10.37%, 8.30% waiting.
2. The most dominant waste among seven waste from production processes in UMKM XYZ is transportation, motion, defects, overproduction, inventory, process, and waiting.
3. Suggested improvements can be done to minimize waste transportation in UMKM XYZ is changing the layout of production, change the design of tools, expanding the production floor, applying a fixed contract system more clear and integrated for employees and minimize the production process.
4. The amount of production time can be minimized when the improvement suggestions made are donut product 538 seconds, bread product 511 seconds, molen product 421 seconds. The average time for all three products that can be minimized is 490 seconds or 8.167 minutes per cycle.

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6. References

[1] A Irman, E Febianti, and U Khasanah 2019 Minimizing makespan on flow shop scheduling using Campbel Dudek and Smith, particle swarm optimization, and proposed heuristic algorithm doi: 10.1088/1757-899X/673/1/012099

[2] F Pasqualini and P A Zawislak 2005 Value stream mapping in construction: A case study in a Brazilian construction company.

[3] B Vesely 2002 Fault tree analysis ( fta ): concepts and applications

[4] E Amrina, N T Putri, and D M Anjani 2019 Waste assessment using lean manufacturing in rubber production doi: 10.1088/1757-899X/528/1/012051

[5] I A Rawabdeh 2005 A model for the assessment of waste in job shop environments Int. J. Oper. Prod. Manag. doi: 10.1108/01443570510608619.

[6] N Zahrotun and I Taufiq 2018 Lean manufacturing: waste reduction using value stream mapping doi: 10.1051/e3sconf/20187307010.

[7] A P Pradana, M Chaeron, and M S A Khanan 2018 Implementasi konsep lean manufacturing guna mengurangi pemborosan di lantai produksi OPSI doi: 10.31315/opsi.v11i1.2196.

[8] H Henny and H R Budiman 2018 Implementation lean manufacturing using waste assessment model (wam) in shoes company doi: 10.1088/1757-899X/407/1/012077

[9] S B M Carneiro, I B Campos, D M De Oliveira, and J P B Neto 2012 Lean and green: a relationship matrix

[10] W E Vesely, F F Goldberg, N H Roberts, and D F Haasl 1981 Fault tree handbook doi: NUREG–0492