



Proposed productivity increase in sandals production process with Green Productivity approach

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ABSTRACT

Productivity stands as a pivotal determinant of a company's success within the intensifying competition of the industrial world. It signifies the efficiency with which a company utilizes its existing resources. One such company, IKM Permata, generates substantial waste daily while producing hotel sandals. The increasing demand for these sandals corresponds directly to the escalating waste accumulation. Presently, the existing waste remains inadequately managed. In light of these challenges, this study aims to enhance company productivity while concurrently reducing waste. The research seeks to elevate the efficiency of hotel sandal production and address waste generated during the production process. Employing a green productivity approach and a pairwise comparison method, the study yielded results indicating that the optimal alternative could potentially eliminate 1275 kg or 100% of EVA (Ethylene Vinyl Acetate) sponge waste, consequently boosting the GPI (Green Productivity Index) value to 0.0302.

1. Introduction

Competition within a company serves as the primary driver of progress across industries, encompassing both food and non-food sectors. Companies need the skills to confront the challenges posed by globalization, standardization, and government regulations. Consequently, every industry must consistently enhance its performance to excel and surpass other sectors. Achieving this goal involves a focus on increasing productivity, a pivotal factor in every industry. Productivity holds immense significance as it enables the production of high-quality and diverse products at more competitive costs. It stands as a cornerstone of a company's sustainability, signifying success in achieving productivity [1].

Green productivity arises from the amalgamation of two activities: augmenting productivity and safeguarding the environment. It capitalizes on qualitative advantages through the utilization of state-of-the-art and safer materials, enhanced processing and production efficiency, and improved working conditions [2], [3]. Waste refers to a collection of refuse present at a specific time and place, considered

unwanted by the environment due to its lack of economic or other value [4], [5].

IKM Permata, a medium-sized industry specializing in crafting hotel sandals, operates across 8 workstations: raw material cutting, embossing, shaping, drop cutting, screen printing, stitching, assembly, and pressing. Almost all workstations generate solid waste, with the drop cutting station being the highest contributor. Despite significant waste production each month from its production processes, IKM Permata hasn't effectively managed waste. At the heart of its operations, IKM Permata's role in balancing production targets with environmental responsibility can elicit a positive market response. Green productivity fosters production processes with lower environmental impact, higher efficiency, and minimal to zero waste generation [6], [7].

This research aims to enhance the productivity of hotel sandals production at IKM Permata by identifying factors contributing to low productivity using a fishbone diagram and analyzing the types of waste generated in the production process. It utilizes total productivity, considering all input resources used in sandal production.

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Calculating the Green Productivity Index (GPI) helps determine the productivity-to-environmental impact ratio. The study then proposes suitable alternative solutions to bolster productivity and mitigate waste through the Green Productivity method at IKM Permata. Pairwise comparison is employed to pinpoint the most suitable alternatives capable of enhancing productivity while reducing environmental impact at IKM Permata's premises.

2. Material and method

In this research, the researcher employs both quantitative and qualitative approaches. The qualitative approach involves direct field observations and interviews with the owners and workers at each workstation at IKM Permata to identify the hotel sandals production process and determine the waste generated during production. Meanwhile, the quantitative approach is used to calculate productivity levels and the Green Productivity Index value. This research falls under the category of cross-sectional research, conducted at a specific point in time.

Data collection in this research uses a population-based approach, examining the entire subject of the study. The data consists of primary and secondary sources. The research begins by gathering information on labor data, production input (raw materials), company overhead costs, production output (results), waste generation, and employee details based on interviews. Subsequently, a production process flowchart is created, and mass balances are generated for each station. Following this, the researcher constructs the GVSM current state to identify waste types. The existing EI (Environmental Impact) value is then calculated from the three waste categories, used to compute the existing GPI (Green Productivity Index) by dividing productivity by EI.

Next, the researcher analyzes the root causes using a fishbone diagram and selects the best improvement solution based on pairwise weighting. Finally, the researcher will create the GVSM future state based on the best alternatives.

3. Results and discussions

3.1. Total productivity existing

Productivity refers to the comparison between the results or outputs generated by a company and the amount of input utilized in the production process over a specific period [8], [9].

3.2. Mass balance

Mass balance represents an accurate calculation of all components entering and leaving a system over a specific period. The mass introduced into a process will always remain in a constant amount, without needing an understanding of the underlying operational mechanisms [10]. Fig. 1-9 show the mass balance.

Table 1.
Total productivity at IKM Permata

Month	Input (ID)	Output (IDR)	Productivity
January	2,382,569	2,754,500	1.16
February	1,993,650	2,061,500	1.03
March	1,939,892	1,977,500	1.02
April	1,701,671	1,680,000	0.99
May	2,426,297	2,891,000	1.19
June	1,767,146	1,771,000	1.00
July	2,497,985	2,975,000	1.19
August	2,252,243	2,544,500	1.13
September	2,065,034	2,205,000	1.07
October	2,239,600	2,478,000	1.11
November	2,629,394	3,181,500	1.21
December	2,678,362	3,230,500	1.21
Total	26,573,843	29,750,000	1.12

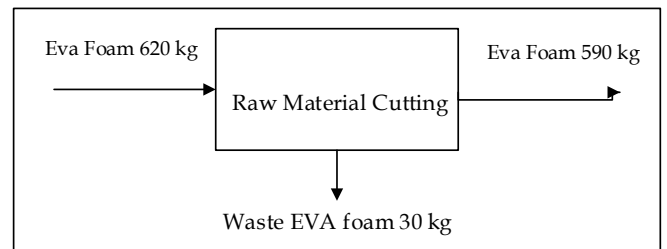


Figure 1. Mass balance for raw material cutting

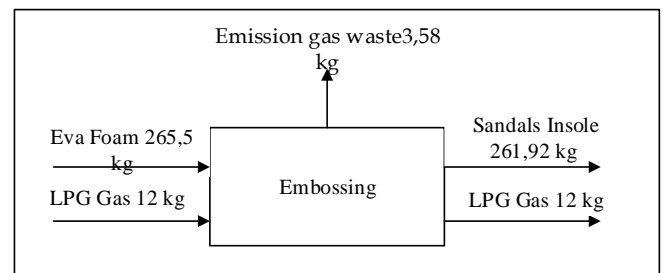


Figure 2. Mass balance for embossing

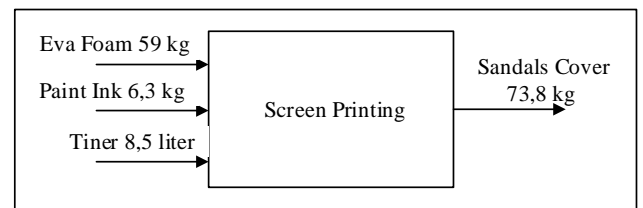


Figure 3. Mass balance for screen printing

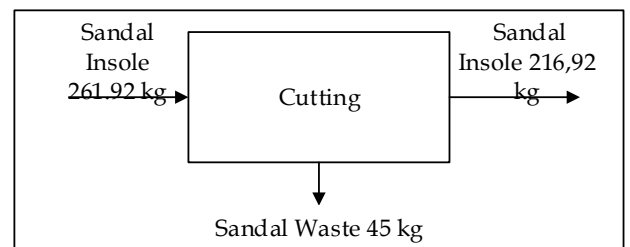


Figure 4. Mass balance for cutting

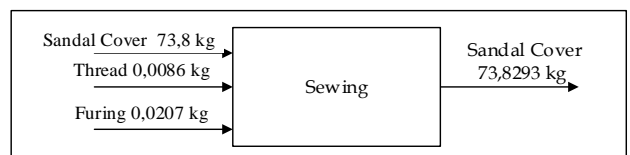


Figure 5. Mass balance for sewing

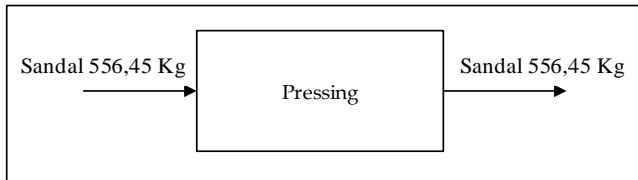


Figure 7. Mass balance for pressing

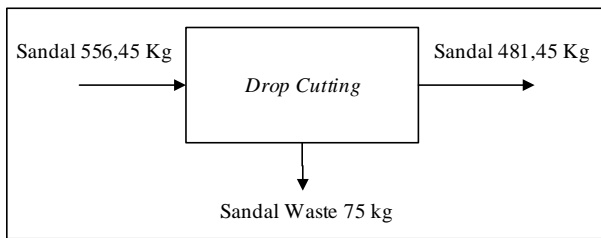


Figure 8. Mass balance for drop cutting

Table 2.

Total waste of IKM Permata

Month	Waste		
	Energy (kwh)	Waste (kg)	Emission (kg CO2)
January	566.16	118.05	9.44
February	542.36	88.35	7.07
March	533.46	84.75	6.78
April	458.46	72.00	5.76
May	540.96	123.90	9.91
June	474.68	75.90	6.07
July	566.16	127.50	10.20
August	547.61	109.05	8.72
September	538.97	94.50	7.56
October	567.76	106.20	8.50
November	587.36	136.35	10.91
December	608.56	138.45	11.08
Total	6532.50	1275.00	102.00

3.3. Green Value Stream Mapping current state

This GVSM diagram illustrates every form of waste occurring in a specific process sequence. GVSM is useful for identifying activities that impact efficiency levels, with the ultimate goal of measuring seven types of ecological waste [11], [12]. Fig. A1 (see Appendices) shows the GSVM diagram of IKM Permata. In the GVSM, 7 sources of green waste are identified, including energy consumption, water usage, materials, waste, transportation, emissions, and biodiversity. In IKM Permata, there is only energy waste, totaling 352.8 Kwh, which is derived from the use of sewing machines, embossing machines, and cutting machines. There is also 150 kg of waste generated from leftover EVA foam at the raw material cutting station, trimming station, and drop-cutting station, as well as 12 kg of CO₂ emissions resulting from the use of LPG gas stoves.

3.4. The calculation of the existing environment

Impact (EI) is determined by adding weights to each green productivity indicator [13], [12]. The larger the EI value, the greater the environmental impact generated by the production process [2], [12], [14]. In Table 2, it shows that the total waste generated from the production process of hotel sandals at IKM Permata in

2022 is 2998.80 kWh for energy, 1275 kg for waste, and 102 kg of CO₂ emissions.

Gaseous Waste Generation (GWG) calculation indicates the amount of CO₂ emissions produced from the consumption of LPG gas in the embossing station. The mass of LPG gas emissions is 102 kg per year. Solid Waste Generation (SWG) at IKM Permata is obtained by summing the mass of waste from the leftover EVA sponge in the processes of raw material cutting, slitting, and drop cutting. The total mass of SWG at IKM Permata in one year is 1275 kg. Waste Consumption (WC) required during the production process. At IKM Permata, no water is used in the production process of hotel sandals, so the mass of WC is 0.

Therefore, the existing EI value generated from the hotel sandals production process is:

$$\begin{aligned} EI &= 0,5 \text{ GWG} + 0,33 \text{ WC} + 0,17 \text{ SWG} [10] \\ &= (0,5 \times 102) + (0,33 \times 0) + (0,17 \times 1275) \\ &= 267,75 \text{ kg} \end{aligned}$$

3.5. The calculation of the existing GPI

The Green Productivity Index (GPI) is defined as the ratio of productivity to environmental impact. This index estimates the level of green productivity of a product or process system, facilitating comparison with competitors. GPI is calculated as the ratio of productivity to the EI value, expressed as $GPI = \text{productivity}/EI = 1.12/267.75 = 0.0042$.

3.6. Identifying Problems with Fishbone Diagram

The use of a cause-and-effect diagram is employed to identify elements that trigger errors or discrepancies. Its purpose is to provide the most detailed analysis of the factors causing the issue. Problem-solving actions become more manageable when the relationship between the cause and effect of a problem is known.

3.7. Proposed alternative improvement

The proposed alternative improvement solutions are based on the issues identified in the fishbone diagram.

- *Alternative Improvement Solution 1.* Implement strict rules for employee attendance, including punctuality and working hours. Enforce penalties for late arrivals or early departures. Increase daily supervision by the owner of IKM Permata.
- *Alternative Improvement Solution 2.* Establish a schedule for machine inspection and maintenance. Conduct weekly checks and maintenance of machines by IKM Permata employees to reduce machine inefficiencies.
- *Alternative Improvement Solution 3.* Develop Standard Operating Procedures (SOP) for receiving goods from suppliers to minimize the acceptance of defective or unusable sponge eva products.
- *Alternative Improvement Solution 4.* Implement precise color mixing measurements at the screen printing station, especially for secondary colors like

maroon. This eliminates the need for repeated testing to achieve the desired color.

- *Alternative Improvement Solution 5.* Develop a waste management solution, particularly for unused sponge waste. Crush and process the unused sponge waste into small pieces through polymerization to create bonded foam. This material can find applications in sofas, spring beds, mattresses, etc.

3.8. Pairwise comparison

The pairwise comparison method is used to assign weights to each criterion by considering the predetermined level of importance for each criterion. In the comparison process, this method is used to evaluate each pair of alternatives or types to determine which one performs better [15], [16]. The questionnaire is filled out by the owner of IKM Permata, who is more experienced in the company's conditions.

Based on Table 3, it shows that the alternative solution with the highest priority is the fifth alternative, which receives a weight of 0.594, which is crushing the unused sponge waste into small pieces and processing it so that the crushed sponge foam can merge perfectly. This indicates that recycling the waste sponge into consumer goods is the best alternative. The selection of this alternative solution is considered because it is estimated to reduce waste the most during the production process.

3.9. Green Value Stream Mapping future state

According to Figure A2 (see Appendices), significant changes in waste generation occurred post-implementation of the alternative solution. The waste amount has been entirely reduced to 0 kg by reprocessing all sponge waste into rebonded foam. This reduction was accompanied by increased energy consumption, rising from the initial 352.8 to 813.6 due to the incorporation of additional machinery. The strategy of recycling waste sponge into consumer goods is projected to enhance the economic value of IKM Permata through the sale of rebonded foam.

Initially, the waste generated from the production process annually stood at 1275 kg of SWG, and the utilization of this waste effectively reduced 100% of Eva sponge waste. The EI value at IKM Permata initially measured 267.75 kg but has since dropped to 51 kg.

Regarding inputs, the initial annual cost at IKM Permata was IDR 26,573,843, which escalated to IDR 186,573,843 due to the purchase of additional machinery and hiring more employees. Conversely, the annual output that initially amounted to IDR 29,750,000 has surged to IDR 287,750,000, elevating the overall productivity at IKM Permata from the initial 1.12 to 1.54. Furthermore, the GPI value at IKM Permata has also seen a significant rise, shifting from the initial 0.0042 to 0.0302.

The management of EVA sponge waste has not only reduced the environmental impact but also bolstered the economy of IKM Permata.

Table 3.

Results of alternative weighting

Improvement	Weighting	Priority Ranking
Alternative 1	0,065	5
Alternative 2	0,146	2
Alternative 3	0,068	4
Alternative 4	0,126	3
Alternative 5	0,594	1

4. Conclusions

The initial total productivity level for the hotel sandals adhesive product at IKM Permata in 2022 stood at 1.12. Two types of waste were generated in the production process of the hotel sandals adhesive at IKM Permata in 2022: solid waste, in the form of leftover Eva sponge cuttings, and gas waste, emitted as CO₂ gas from the combustion of LPG gas at the embossing station. The GPI value in the initial production process of hotel sandals adhesive at IKM Permata in 2022 was 0.0042.

The alternative solution identified for enhancing productivity and reducing waste, utilizing the green productivity method based on pairwise comparison assessment, is the second alternative: recycling waste sponge into rebonded foam for consumer goods. This alternative demonstrates the potential to reduce Eva sponge waste by 1275 kg, effectively eliminating 100% of the waste, and concurrently increase the GPI value to 0.0302.

Declaration statement

Evi Febianti: **Conceptualization, Methodology, Software and Resources, Supervision.** Ade Irman S. Mutaqqin: **Supervision, Visualization, Investigation.** Erien Amelia: **Writing-Original Draft, Data Processing, Editing.** Yusraini Muharni: **Supervision.**

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The authors report there are no competing interests to declare.

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Data availability statement

The data that support the findings of this study are available from the corresponding author, [EF], upon reasonable request.

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Appendices

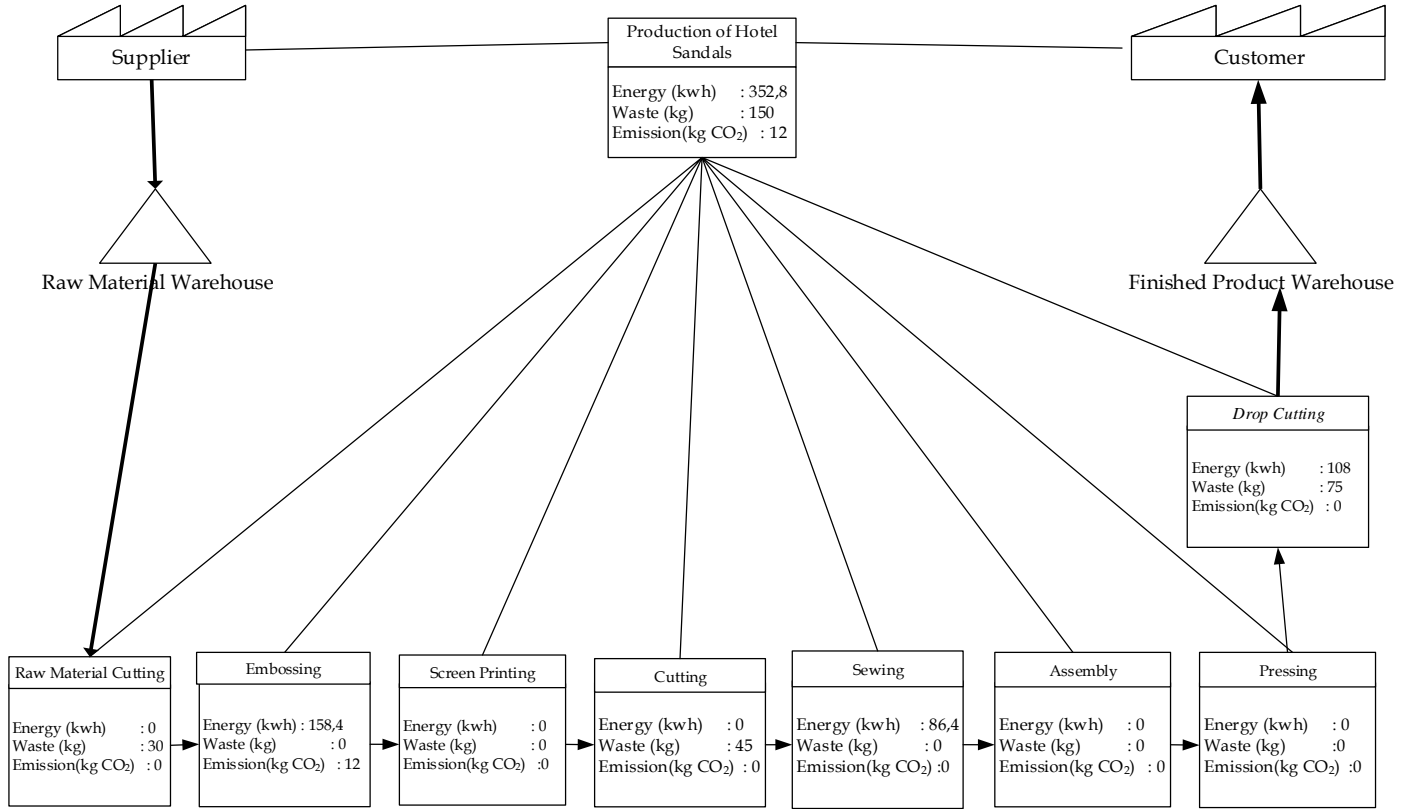


Figure A1. GVSM current state

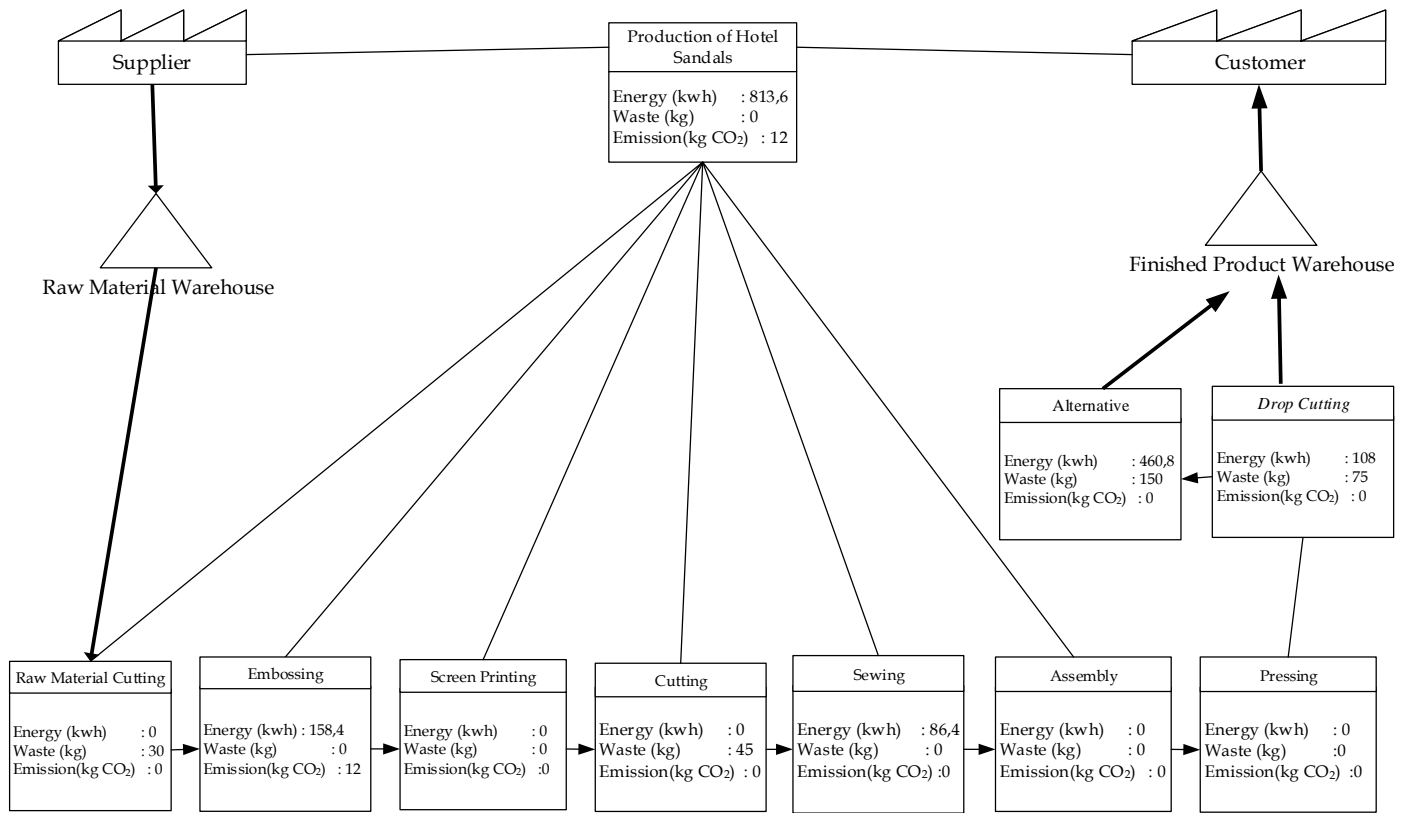


Figure A2. GVSM future state