Analysis Of The Implementation Of Material Flow Cost Accounting At Pt Xyz (Car Manufacturer)

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Abstract.

This research discusses implementation analysis Material Flow Cost Accounting (MFCA) at PT XYZ which is one of the car manufacturers in Indonesia. The formulation and aim of this research is to analyze potential calculations material loss and material waste produced by the method Material Flow Cost Accounting (MFCA) and evaluate management's response to management material loss and material waste from the calculations carried out. The research method used is quantitative descriptive method and case study. Resource persons in this study include: 1) Press Shop Manager 2) Body Shop Manager 3) Paint Shop Manager and 4) General Assembly Shop Manager. The data used includes primary data collected by observation and interviews. The data analysis method is carried out through five implementation stages Material Flow Cost Accounting (MFCA) in ISO 14051 and thematic analysis from sources as well as drawing conclusions and recommendations. The research results show that with implementation Material Flow Cost Accounting (MFCA) PT XYZ is able to map all material flows in detail and provide information regarding waste that can be used to increase efficiency and support environmental sustainability in the car production process.

Keywords: *Material Flow Cost Accounting, Sustainability,Automotive Industry, Waste Management and ISO 14051.*

I. INTRODUCTION

A car is a four-wheeled vehicle powered by engine power using fuel such as petrol or diesel. This vehicle is designed with a specific shape and has become people's leading choice for traveling comfortably while protecting themselves from unfavorable weather conditions such as rain and heat. Along with increasing public demand for cars, competition in the car manufacturing industry is getting tougher. Although competition for a larger market share continues, serious attention must be focused on emerging issues, especially those related to increasing waste from car production.In the last 17 years, there has been a 32.1% increase in waste car production. This phenomenon raises concerns about the environmental impact, production efficiency, and sustainability of the automobile industry. Therefore, strategies to increase profitability are faced with additional responsibilities for production waste management. Waste management of car production is also a step towards a circular economy. One approach that can be taken is implementing Material Flow Cost Accounting (MFCA). Penerapan Material Flow Cost Accounting (MFCA) can be a relevant and potential reduction strategy for material loss and waste at every production stage. This approach not only provides a deep understanding of material flows but also opens up opportunities to identify and address sources of waste that can be detrimental in terms of costs within the company and environmental impacts. (Reiner and Thomas, 2019). Hopefully, this research can contribute to the academic understanding of the application of Material Flow Cost Accounting (MFCA) in calculating potential material loss and material waste in the automotive manufacturing industry, especially at PT XYZ.

This research is also expected to provide input for PT XYZ in responding to and managing potential material loss and material waste generated during the production process. A deeper understanding of the extent to which Material Flow Cost Accounting (MFCA) can provide information regarding material waste. PT XYZ is expected to increase the efficiency of material use, reduce waste, and optimize production. In addition, it can provide valuable insight into the company's strategic decision-making. Alfian's research

(2020) shows the results of implementing MFCA at PT. Unipres Indonesia shows that companies can identify material loss costs from energy costs, system costs, and material costs for each spare parts product produced. In Nurani's research (2022) shows that Material Flow Cost Accounting (MFCA) can identify food loss and food waste at the warteg. Based on previous research, Material Flow Cost Accounting (MFCA) is crucial in optimizing production, especially in car manufacturing companies such as PT XYZ. Therefore, this research hoped to provide concrete solutions for PT XYZ regarding the effectiveness of material use and waste management to produce the desired profit level and compete in Indonesia's car manufacturing industry.

II. LIBRARY STUDY

2.1 Circular Economy

A circular economy is an economic system that aims to generate economic growth by maintaining the value of products, materials and resources in the economy for as long as possible. (Ellen MacArthur Foundation, 2015)

2.2 Waste Management

Waste Management is collecting, transporting, processing, and disposing of waste. Collection is the process of collecting waste from its source. Transportation brings waste from a collection point to a processing or disposal site. Disposal is an effort to dispose of waste that cannot be safely processed or recycled. Waste management aims to protect human health and the environment, as well as to minimize the value of waste. The value of waste can be seen from many factors, namely material loss and material waste. (Richard A, 2015). Material loss is the loss of materials during a product's production, distribution, or use. Various factors, including human error, material damage, and theft, can cause this. Material loss can hurt a business, both financially and environmentally. Financially, material loss can lead to increased production costs, decreased productivity, and reduced profitability. Environmentally, material loss can cause environmental pollution. At the same time, material waste is material that cannot be reused because it no longer has economic value. Material waste can occur at various stages of the product life cycle, from production and distribution to use. (Philip Smith, 2017)

2.3 Material Flow Cost Accounting

Material Flow Cost Accounting (MFCA) is an accounting method that measures, analyzes, and manages material flows and their costs. MFCA combines physical and monetary information to provide a comprehensive picture of the flow of materials and their costs within an organization. MFCA can be used for various purposes, such as identifying and reducing material waste, increasing material use efficiency, reducing environmental impacts, and increasing transparency and accountability. (Reiner and Thomas, 2019)

2.4 Basic Elements Material Flow Cost Accounting

MFCA brings both environmental impacts and cost reductions to organizations. In order for MFCA to be implemented effectively in an organization, the concepts of quantity center, material balance, cost calculation, and material flow model (ISO 14051, 2014)

2.4.1 Basic Element 1: Quantity Center

A quantity center usually consists of one or several process units, where material accounting is carried out physically and financially. This center is the point where the balance of materials will be calculated. Depending on the number of material losses identified in that production unit, a quantity center can cover one process or several processes.Additionally, quantity centers in the context of MFCA can be based on existing production management information, cost center records, and other readily available data. Quantity centers are generally established in all processes where material losses or relevant system costs, such as energy for transportation, oil, or air pressure leaks, can be identified. Then, the appropriate process is selected as the additional quantity center, and its inputs and outputs are determined. Examples of quantity centers involve places where materials are stored or processed, such as warehouses, production units, waste management, and shipping/receiving points.Once inputs and outputs are identified for each quantity center, this information can be used to relate the quantity centers in a broader context so that data from the quantity centers can be linked and evaluated across the system. It is essential to ensure the balance of materials to

assess the efficiency of materials in physical and monetary aspects. The material balance concept will be explained further in Basic Element 2: Material Balance. (ISO 14051, 2014)

2.4.2 Basic Element 2: Material Balance

In MFCA, all materials entering and leaving the quantity center must be balanced.Therefore, to ensure all materials targeted in an MFCA analysis are accounted for, material inputs and outputs need to be confirmed by comparing input quantities with outputs and changes in inventory to identify any data gaps. Missing materials or other data discrepancies can help organizations identify areas that need improvement.
The quantities of input and output must be measured in physical units for each quantity center. All physical units should be convertible to a single standard unit (such as mass) to ensure material balance for each quantity center. It is better to use basic units already on site for production management.Material balance requires that the total amount of output (both product and material losses) equal the total amount of input, taking into account changes in inventory within the quantity center. All materials in the context of the MFCA should be tracked and measured. However, materials with minimal environmental or financial impact may be excluded in practice. (ISO 14051, 2014)

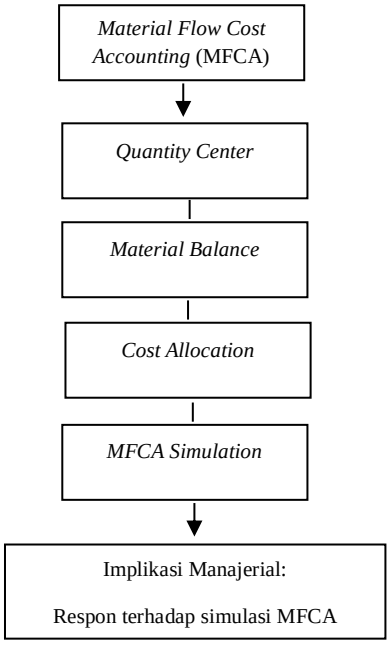
2.4.3 Basic Element 3: Cost Calculation

During the decision-making process, financial considerations are often included. Through MFCA, the material balance of inputs and outputs is linked to monetary units by allocating and calculating costs for all products and material losses. MFCA considers four types of costs allocated to both product and material losses: material costs, energy costs, system costs, and waste management costs. (ISO 14051, 2014)

2.4.4 Basic Element 4: Material Flow Model

It refers to a visual representation of a process that shows all quantity centers where materials are changed, stored, or used, as well as the flow of these materials within the system boundaries. (ISO 14051, 2014)

2.5 conceptual framework



In PT XYZ's business operations, four production processes are the centers of quantity that produce material loss and material waste. Material loss and material waste produced can be seen from material balance and cost allocation. Next, Financial quantification calculations are carried out using calculations via Material Flow Cost Accounting (MFCA) to explain the potential losses from material loss and material waste. The results of these calculations are used to determine managerial implications for how management responds to the impact of material loss and material waste produced.

III. METHODS

3.1 Research Approach

This research approach uses quantitative descriptive methods and case studies. The research will also use literature study by exploring theories from books, literature and previous research. Research was carried out by collecting and analyzing data in depth

3.2 Method of collecting data

The data used in preparing this final work is primary data. This primary data was obtained in two ways, namely:

1. Interview, namely by asking questions orally to obtain the required data
2. Observation, namely by making direct observations of the object of writing, by taking production data from production activities (Press Shop, Body Shop, Paint Shop and General Assembly Shop).

3.3 Data Management and Data Analysis Techniques

3.4.1 Quantitative Descriptive Analysis

Quantitative descriptive analysis is used to create objective images and descriptions through numbers. Starting from data collection, data interpretation, and results. (Arikunto, 2011) Quantitative descriptive analysis in this research applied ISO 14051 guidelines regarding MFCA calculations.In the method of Material Flow Cost Accounting, There are five implementation steps (ISO 14051, 2011; Christ & Burritt, 2017):

1. The first step determines the limits and centers of quantity. In this research, the waste process, namely from the production process, is identified to calculate material loss and material waste at PT XYZ.
2. The second step builds the flow and determines the physical value of the rupiah. This research was carried out by field observation and looking at internal data System and Application (SAP) in the form of transactions good receipt, good issue and scrap as well as reports scrap manuals and reports standard cost.
3. The third step determines the balance of values. This research carried out this process to ensure the number of inputs, methods, and outputs in car manufacturing at PT XYZ.
4. The fourth step is to allocate costs. This research classified costs into four categories based on the implementation of MFCA at PT XYZ: raw material costs, system costs, energy costs, and waste management costs.
5. The fifth step is management implications. This process is the final stage for evaluating and suggesting improvements made by management based on the results of the MFCA calculations.

3.4.2 Thematic Analysis

The author uses interview analysis techniques in the form of thematic analysis. Thematic analysis is a qualitative data analysis method used to identify patterns or themes across qualitative participant data. This technique is often used to analyze interviews. (Braun & Clarke, 2006). Interviews were conducted with 6 (six) respondents.

Responden Key	Work Location	Title	Age	Last Education
R1	Press and Body Shop	Manager	42 years old	Master Degree
R2	Body Shop	Team Leader	43 years old	Bachelor Degree
R3	Paint Shop	Team Leader	41 years old	Bachelor Degree
R4	Paint Shop	Manager	38 years old	Bachelor Degree
R5	GA Shop	Manager	52 years old	Bachelor Degree
R6	GA Shop	Team Leader	41 years old	Bachelor Degree

IV. RESULTS AND DISCUSSION

4.1 Quantitative Descriptive Analysis

Quantitative descriptive analysis was carried out using calculations material loss and material waste using the MFCA method is done by separating total product, product uses, nonproduct (material loss and material waste) each shop. Cost allocation, among others material cost, system cost, energy cost, dan waste disposal cost. Allocation material cost obtained from material balance for a year from each shop, and allocation system cost, energy cost, and waste disposal costs are carried out using data from each shop for 2023.

Material Balance PT XYZ

Production Flow Process	Jobs	Input	Process		Output	
		Raw Material	Material Loss (Storage)	Material Loss (Production)	WIP/FG	Material Waste
Press Shop	Pressing	125,208,021,523	1,777,267,828	-	123,408,203,094	22,550,600
Body Shop	Welding Sub-assembly	94,252,908,065	19,259,733	184,557,557	94,012,743,880	36,346,895
Paint Shop	Pre-treatment Electrophoresis Sanding breathes Sealing Spraying (Base, Main, Clear Coat)	336,083,678,923	39,287,317	279,177,162	265,601,383,696	70,163,830,748
General Assembly Shop	Full Assembly Filling (Fuel, Brake Oil, Engine Oil) Testing	9,279,612,618,694	2,345,262,511	4,341,025,518	9,129,410,407,694	143,515,922,972

Table data material balance explaining the material balance of PT XYZ, can be seen material loss and material waste PT XYZ produces in one production year 2023 which is measured in rupiah before continuing with the next process.

Allocation Cost PT XYZ

Production Flow Process	Jobs	Material Cost	System Cost	Energy Cost	Waste Disposal Cost
Press Shop	Pressing	125,208,021,523	296,333,986,030	1,434,049,387	-
Body Shop	Welding Sub-assembly	94,252,908,065	162,927,140,517	1,092,463,178	-
Paint Shop	Pre-treatment Electrophoresis Sanding breathes Sealing Spraying (Base, Main, Clear Coat)	336,083,678,923	478,898,591,845	3,086,387,225	917,494,286
General Assembly Shop	Full Assembly Filling (Fuel, Brake Oil, Engine Oil) Testing	9,279,612,618,694	236,656,158,697	106,087,156,848	4,126,904,571

Table data allocation costs are costs obtained through primary research data from System and Application (SAP) are analyzed. Material cost is obtained through the amount of raw material input into production. System Cost comprises labor, depreciation, fixed production, and variable production costs. Energy Costs are produced from electricity, water, and gas. The final cost is waste disposal, the cost incurred for waste management. At PT XYZ, waste management costs are paid to other parties who manage waste.
Next, a calculation analysis uses Material Flow Cost Accounting (MFCA). In its application at PT XYZ, the following calculations were obtained:

Analysis Material Loss and Material Waste at PT. XYZ in MFCA Method

Activity	Cost	Total Cost	Press Shop (Q1)	Body Shop (Q2)	Paint Shop (Q3)	General Assembly Shop (Q4)
Input	Material Cost	9,835,157,227,205	125,208,021,523	94,252,908,065	336,083,678,923	9,279,612,618,694

	System Cost	1,174,815,877,089	296,333,986,030	162,927,140,517	478,898,591,845	236,656,158,697
	Energy Cost	111,700,056,638	1,434,049,387	1,092,463,178	3,086,387,225	106,087,156,848
	Waste Disposal Cost	5,044,398,857	-	-	917,494,286	4,126,904,571
	Total	**11,126,717,559,789**	**422,976,056,939**	**258,272,511,760**	**818,986,152,279**	**9,626,482,838,811**
Product	Material Cost	9,612,432,738,364	123,408,203,094	94,012,743,880	265,601,383,696	9,129,410,407,694
	System Cost	839,341,095,836	187,265,563,305	156,671,700,036	335,458,378,169	159,945,454,326
	Energy Cost	105,616,180,573	1,355,942,186	1,032,960,875	2,918,283,484	100,308,994,027
	Total	**10,557,390,014,772**	**312,029,708,586**	**251,717,404,791**	**603,978,045,349**	**9,389,664,856,047**
Non-Product	Material Cost	222,724,488,841	1,799,818,429	240,164,185	70,482,295,227	150,202,211,001
	System Cost	335,474,781,253	109,068,422,724	6,255,440,482	143,440,213,676	76,710,704,371
	Energy Cost	6,083,876,065	78,107,201	59,502,303	168,103,741	5,778,162,821
	Waste Disposal Cost	5,044,398,857	-	-	917,494,286	4,126,904,571
	Total	**569,327,545,016**	**110,946,348,354**	**6,555,106,969**	**215,008,106,930**	**236,817,982,764**

The table data above is a calculation analysis of material loss and material waste that happened to PT. XYZ. The input process was generated from material costs with a total cost of IDR 11,126,717,559,789. The total cost of producing the product is assembly parts, cars that are ready to be sold, and non-product output as a waste product. The number of assembly parts and cars ready for sale amounts to IDR 10,557,390,014,772, and waste products amount to IDR 569,327,545,016. Waste costs come from the production process viz material loss nor material waste from Press Shop amounting to IDR 110,946,348,354, Body Shop amounting to IDR 6,555,106,969, Paint Shop amounting to IDR 215,008,106,930 and General Assembly Shop amounting to IDR 236,817,982,764

Matriks Production Material Flow PT XYZ

Component	Material Cost	System Cost	Energy Cost	Waste Disposal Cost	Total Cost
Product	9,612,432,738,364	839,341,095,836	105,616,180,573	-	10,557,390,014,772
	97.74%	71.44%	94.55%	0.00%	94.88%
Material Losses	222,724,488,841	335,474,781,253	6,083,876,065	5,044,398,857	569,327,545,016
	2.26%	28.56%	5.45%	100.00%	5.12%
Total	9,835,157,227,205	1,174,815,877,089	111,700,056,638	5,044,398,857	11,126,717,559,789
	100.00%	100.00%	100.00%	100.00%	100.00%

The table above explains that the total material losses generated by PT XYZ during the car production process for a year were IDR 569,327,545,016 or 5.12%. Of this amount, the amount of material inefficiency was recorded at 39.12% of the total waste costs, namely IDR 222,724,488,841.Based on calculations at PT XYZ carried out using the MFCA method, there is potential for material inefficiency in the car production process. Quantification of MFCA, which has produced 5.12%, is caused by the large volume of raw materials processed and high demand from sales forecast, but it fell when it was realized. The output will be even greater with more extensive raw materials, material loss, and material waste. Material loss and material waste in car manufacturers' manufacturing are unavoidable. However, if there is potential material waste and material loss, If done well, it can have a positive impact on the economy and the environment.

4.2 Thematic Analysis

4.2.1 Press Shop

Previously, department press shops needed to learn what a circular economy is and the concept of MFCA. Even though R1 doesn't know how to do this press shop to measure and identify raw material and energy losses before MFCA calculations, R1 said:

"To measure and identify raw material and energy losses during the car production process, we use Cost of Quality, namely costs incurred due to repairs of raw materials and products that do not meet standards. By monitoring and recording each repair cost, we can identify areas that require improvement to reduce waste and increase efficiency. In addition, we realized that overordering raw materials required additional storage in the warehouse, which resulted in additional costs. Therefore, we manage raw material stocks based on accurate sales forecasting to minimize the need for extra storage warehouses and reduce associated costs. We also focus on efficient energy use. For example, a cooling tower machine, which functions for water circulation and engine cooling, is more efficient when JPH (Jobs Per Hour) increases. The higher the JPH, the more optimal the use of this machine, thereby reducing energy consumption per unit of product. In this way, we save energy costs and increase overall productivity."

FWaste management is carried out during the car production stage based on the results of measurements and identification of raw material and energy losses. R1 said:

“In managing materials for car production, we are committed to implementing the FIFO (First In, First Out) principle. This means the raw materials will be used first to avoid stockpiling and ensure that raw materials are used in the best condition. This implementation is also carried out by per unit consumption standards, which ensures that each material is used efficiently and according to production needs. Apart from that, in terms of energy management, we try to maximize production when energy is on. This means we schedule production activities at times when the energy supply is optimal to take maximum advantage of energy efficiency. This way, we can reduce energy consumption per product unit and minimize operational costs. This strategy helps us save costs and contributes to environmental sustainability. Periodically, we also carry out measurements for factory waste and emissions. This monitoring is carried out by strict environmental standards and is supervised by authorized institutions. We ensure that all waste and emissions generated are within the limits set by government regulations, and we are always looking for ways to reduce the environmental impact of our operations. These steps demonstrate our commitment to environmental responsibility and sustainability in production.”

There are also efforts made by the department Press Shop to manage raw materials and energy at PT XYZ. R1 said:

"In managing raw materials, we implement an ordering system based on sales forecasts for local parts. This way, we can minimize the risk of unnecessary material buildup, reducing storage costs and potential waste. Apart from that, we also focus heavily on energy efficiency. First, we completely shut down the equipment when there is no production schedule. This helps us reduce unnecessary energy consumption. Second, we ensure that energy use, especially gas, remains within the maximum threshold PGN sets. By closely monitoring and regulating gas usage, we can avoid additional costs due to excessive usage. These steps help us save money and support environmental sustainability efforts."

In its efforts and management, of course, the press shop faces certain obstacles and challenges in managing materials and energy during the car production stage. R1 said:

"In the car production process, we face several significant material and energy management challenges. One of the main challenges for materials is coordinating with overseas suppliers for KD (Knock Down) components. We ordered materials for production needs in the next three months. However, when demand drops suddenly during the month, materials that have been ordered have already arrived, resulting in backlogs. This situation increases storage costs and creates a risk of waste if the materials are not used immediately. On the energy side, we also need help with several problems, including the limitation on gas use imposed by PGN. We must ensure that gas use does not exceed the specified limits to avoid penalties or additional costs. Apart from that, we face a minimum payment policy for electricity use and still have to pay

the minimum fees. "This policy challenges us to optimize production so that electricity costs remain efficient, especially when production decreases."

From the statements above, the department press shop can learn what a circular economy is and the concept of MFCA. However, press shops already have methods for measuring and identifying raw material and energy losses before MFCA calculations. The press shop uses the concept of Cost of Quality, namely costs arising from repairs of raw materials and products that do not meet standards. By monitoring and recording every repair cost, the press shop can identify areas that require improvement to reduce waste and increase efficiency. However, with the implementation of MFCA, the press shop can be more detailed in calculating potential material loss and waste. MFCA helps the press shop identify inefficient material flows and estimate costs associated with materials that do not contribute to the final product. Through the MFCA, the press shop can map the entire material flow in the production process, identify areas where material loss occurs, and calculate the costs of wasted materials. This includes damaged materials, scraps, and unused waste. With this data, press shops can focus more on reducing waste and optimizing material use.

4.2.2 Body Shop

Body Shop already knows the concept of a circular economy because the company has implemented ISO 14001 regarding environmental policies. However, body shops need to learn the MFCA concept. Like the press shop, the body shop measures and identifies raw material and energy losses with the cost of quality. To manage material and energy waste in the body shop. R2 said:

"To manage material and energy waste during the car production stage, we identify and fix potential bottlenecks in each production area. By closely monitoring bottleneck points, we can make the necessary improvements to achieve production targets within the specified working time."

In an effort to manage waste of material and energy, there are challenges and obstacles faced. R2 said:

“In managing material and energy waste during the car production stage, we faced several significant obstacles. One of them is frequent delays in material supply, which forces management to extend working hours.”

The body shop has tried to manage materials and energy during production. R2 said:

“To optimize production costs and efficiency in managing raw materials and energy, the company has carried out several activities in each department. One way is through the Continuous Improvement (CI) cost reduction competition, where each department competes to identify and implement cost reduction initiatives. These activities help us to continually look for ways to improve operational efficiency and reduce waste. Apart from that, we also reduce the use of overtime for non-critical activities. This step aims to optimize the use of human resources and reduce additional costs associated with additional working hours. By managing working time more effectively, we can reduce production costs without sacrificing productivity.”Material Flow Cost Accounting (MFCA) identifies and calculates costs associated with material waste in a production process. On body shop, implementing MFCA can help make more informed and strategic decisions in reducing material waste and increasing the efficiency of raw materials used during the car production process. R2, as a representative of the body shop, responds to the results of MFCA calculations to manage material loss and material waste, with the main aim of increasing operational efficiency and reducing the environmental impact of the production processes of the body shop.

4.2.3 Paint Shop

R3 and R4, as representatives of the paint shop, know what a circular economy is but need to learn the concept of MFCA. In the paint shop, measure and identify material and energy losses. R3 said:

"The paint shop measures raw material and energy losses in the car production process by measuring actual consumption and comparing it with set targets. Suppose actual consumption exceeds the target or is above the desired limit. In that case, we systematically look for the root cause and design an action plan to ensure that future consumption can reach the target according to the predetermined schedule."

To manage material and energy losses during the production process, the paint shop has carried out some controls and reviews. R4 said:

"The paint shop manages material and energy waste during the car production stage by carrying out daily controls and reviews through the Business Plan Deployment (BPD). If abnormal conditions occur, such

as waste or consumption that exceeds the set target, the relevant team is responsible for immediately making improvements."

The obstacles and challenges faced by the paint shop in managing material and energy losses in the paint shop at PT XYZ. R3 said:

"Challenges companies face in managing material and energy waste during the car production stage. One of them is when the production volume is small, but the equipment capacity is large, which causes energy use to be disproportionate."

The efforts made by the paint shop to overcome these obstacles. R4 said:

"Special efforts are being made to mitigate raw material and energy losses as well as negative impacts on the environment in the car industry. "One of them is stated in the action plan at BPD, namely coordinating with third parties to measure the environmental impact of SGMW production by ISO 14001 requirements, where the paint shop has obtained this certification regarding environmental sustainability."

With the implementation of MFCA, the paint shop can systematically measure, identify, and calculate material and energy losses to improve operational efficiency. With a targeted response to MFCA implementation, R3 and R4 will be able to ensure that the paint shop at PT XYZ can manage material loss and waste effectively to increase efficiency and reduce the negative environmental impact of their operations.

4.2.4 General Assembly Shop

R5 and R6, as representatives of the general assembly shop, already know what a circular economy is but still need to learn the MFCA concept. Same as the press shop and body shop, on general assembly shop to measure and identify waste of material and energy use cost of quality. R6 said:

"In the company's annual plan, we measure and identify raw material and energy losses by recording waste in the cost of quality that has been determined with estimated targets. All measurements and identification are carried out daily, weekly, and monthly by the production team and audited monthly by the production systems team."

Once measured and identified, the general assembly shop manages the waste of material and energy. R5 said:

"In the company plan, we record waste at the cost of poor quality and implement a problem-solving process to overcome it. Waste control is carried out by the production team and support groups and is reported regularly in monthly work plan meetings. The effectiveness of controls is evaluated regularly to ensure significant reductions in waste."The obstacles experienced by general assembly shops in managing material and energy waste. R6 said:

"The obstacles and challenges we face in managing material and energy waste during the car production stage are uncertainties in production forecasting based on sales forecasts that often change. For example, when sales are expected to decline, but raw materials have been ordered, it causes buildup in the warehouse because the production process is delayed without a definite schedule. Stockpiling of raw materials also results in other challenges in managing warehouse space, especially if we need to rent an external warehouse, which increases costs. In addition, challenges in energy management are related to the system of purchasing energy packages at minimum prices and penalties for actual energy use that is not by agreed provisions."

As for the efforts of the general assembly shop in overcoming these obstacles and challenges. R6 said:

"In the annual work plan, the company sets a cost target per vehicle assembled. Each area is challenged to seek opportunities to optimize operational costs, often realized through continuous improvement competitions throughout production. "This process is routinely carried out by the general assembly every year to ensure operational efficiency continues to be improved."Material Flow Cost Accounting (MFCA) calculates potential material loss and waste in a general assembly shop. MFCA maps the flow of materials from the beginning to the end of the vehicle production process. This involves identifying any points where material could be lost or wasted. For example, this could include leftover pieces from the assembly process, unused materials, or materials damaged during the assembly process. Thus,

implementing MFCA in general assembly shops helps identify and measure material and energy waste and enables coordinated efforts to manage and reduce their negative impact on a company's operational efficiency and sustainability.

V. CONCLUSIONS AND RECOMMENDATIONS

Conclusion

This case study research aims to analyze how Material Flow Cost Accounting (MFCA) calculates potential material loss and material waste produced at PT XYZ to evaluate how management responds to management material loss and material waste generated at PT XYZ and presents recommendations for improvement or effective management strategies to reduce material loss and material waste at PT XYZ. Thus, this research can contribute to the academic understanding of implementing Material Flow Cost Accounting (MFCA) in calculating potential material loss and material waste in the automotive manufacturing industry, especially at PT XYZ.

According to the MFCA method calculations carried out at PT XYZ, it can be concluded as follows:

1. There is a 2.26% loss in material cost from total material cost production for a year at PT XYZ
2. There is a 28.56% loss in system cost from total system cost production for a year at PT XYZ
3. There is a 5.45% loss in energy cost from total energy cost production for a year at PT XYZ

The research results show that material losses generated during one year of the production process at PT XYZ using metode Material Flow Cost Accounting (MFCA) contributed 5.12% of the total production costs. Through observations and calculations, the amount of waste can be identified and calculated so that it can be anticipated to increase profits and the company's environmental performance. Implementing MFCA allows PT XYZ to manage and reduce waste effectively, supporting operational efficiency and environmental sustainability.

According to the analysis of interviews conducted at PT XYZ, it can be concluded as follows:

1. Press Shop: By implementing Material Flow Cost Accounting (MFCA), the press shop can map the entire material flow in detail. This data allows the press shop to focus more on reducing waste and optimizing material use, thereby increasing operational efficiency.
2. Body Shop: Use MFCA to manage material loss and material waste. The main aim is to increase operational efficiency and reduce the environmental impact of the production process in the body shop. This approach helps identify areas that require improvement and corrective action.
3. Paint Shop: Through implementing the MFCA, the paint shop can systematically measure, identify, and calculate material and energy losses. This step is critical to improving operational efficiency and supporting the company's environmental sustainability initiatives.
4. General Assembly Shop: Implementing MFCA in a general assembly shop not only helps identify and measure material and energy waste but also enables coordinated efforts to manage and reduce its negative impact on a company's operational efficiency and sustainability. This approach supports improved overall operational and environmental performance.Implementing MFCA at PT XYZ is an effective tool for reducing waste, increasing efficiency, and supporting environmental sustainability in car production.

Recommendation

1. It is recommended that further research be carried out on a larger scale in various automotive industry types. In addition, it is recommended that the research include comprehensive waste management so that the information obtained is more extensive to support environmental sustainability. Research should also consider the role of government or related agencies to gain additional perspectives in discussing waste issues in the automotive industry. The method development in this research was carried out, focusing only on four production departments. Future research could consider a more specific scale, namely at the stations or activities of each production department, to produce more accurate calculations. Researchers recommend digging deeper into cost awareness and managing culture waste in the automotive industry.
2. Using the MFCA method as a measurement tool can help PT XYZ and other auto manufacturing industries identify the amount of material loss, including material loss, material waste, system cost, energy

cost, and waste disposal cost. This research provides understanding for PT XYZ to play an active role in reducing waste through the following methods:

3. Applying the MFCA Calculation Method in Every Production Shop By applying the MFCA method in every production shop, PT XYZ can know the material flow in detail. This data allows PT XYZ to focus more on reducing waste and optimizing material use, thereby increasing operational efficiency.

4. Make Production Forecast More Accurate: Given that imported goods are ordered three months in advance, more accurate production forecasting is needed. If demand decreases, waste arises in terms of energy and materials. With more precise forecasting, PT XYZ can reduce the risk of accumulating unused material and minimize waste.

5. Reviewing the Minimum Payment Policy for Electricity and Gas Use: The minimum payment policy for electricity and gas use means that regardless of volume production, PT XYZ still has to pay the minimum fees that have been set. By reviewing this policy, PT XYZ can look for more efficient solutions to manage energy costs, especially when production decreases, thereby reducing waste and increasing cost efficiency. By implementing MFCA and appropriate management strategies, PT XYZ and other car and automotive manufacturing industries can significantly reduce waste and increase operational efficiency and environmental sustainability.

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