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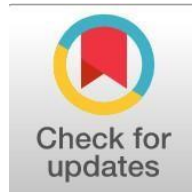
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Material Flow Cost Accounting and Its Role in Reducing Loss Costs and Enhancing Product Sustainability: An Applied Study in the General Company for Textile and Leather Industries

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Abstract

General Background: Industrial manufacturing processes are increasingly challenged by rising resource costs and growing environmental responsibilities regarding production waste. **Specific Background:** Conventional costing systems typically fail to trace or report the specific costs of losses and non-productive material flows separately. **Knowledge Gap:** Detailed empirical tracking of physical material and energy movements across successive textile manufacturing stages using standardized environmental accounting remains limited. **Aims:** This study aims to examine the role of Material Flow Cost Accounting (MFCA) in identifying loss costs and evaluating potential reductions to promote product sustainability. **Results:** Applying MFCA revealed that loss costs accounted for 3.288% of total material flow costs, and proposed improvements could reduce these costs by approximately 15.46% while raising the material utilization rate to 91.791% . **Novelty:** The implementation of ISO 14051-based material flow cost accounting within the Iraqi textile and leather sector specifically pinpoints distinct production stage loss burdens. **Implications:** Manufacturing enterprises can systematically optimize resource efficiency and strengthen both economic and environmental dimensions of product sustainability by utilizing MFCA data.

Key Findings Highlights

Material flow cost accounting successfully isolates and reveals non-productive loss costs separately from conforming finished product expenses.

Cutting and knitting stages exhibit significant loss quantities and financial burdens that require prioritized corrective action.

Proposed optimization measures can significantly decrease overall loss rates while simultaneously improving material utilization efficiency and economic performance.

Keywords Material Flow Cost Accounting, Loss Costs, Negative Product, Cost Reduction, Product Sustainability

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Introduction

Controlling production costs has become increasingly linked to how materials and energy are used within the production process, particularly as input prices rise and greater attention is paid to waste and the environmental impacts of industrial activity. Attention is no longer confined to the cost of the finished product; it also extends to identifying the resources lost during manufacturing, where these losses occur, and the costs they impose on the economic entity.

In this context, material flow cost accounting (MFCA) offers an approach to tracing the movement of materials through production stages and measuring the amounts converted into products and those lost during the process. This approach reveals costs that may not be reported separately in traditional costing systems, particularly those associated with losses and waste, providing clearer information when seeking opportunities to reduce costs and improve resource use.

This is particularly relevant to the textile and leather industries, where multiple production stages generate offcuts, spoiled materials, and waste in varying quantities. The study was therefore applied at the General Company for Textile and Leather Industries to trace physical flows and determine the cost of the unused portion, then establish the potential reduction in loss costs and improvement in resource-use efficiency and their implications for the economic and environmental dimensions of product sustainability.

1-1 Research Methodology

First: Research Problem

Production processes generate losses and waste that cause the economic entity to incur a share of material, energy, and other resource costs. Traditional costing systems, however, do not always separate these costs from the cost of the finished product. This makes it difficult to determine the losses attributable to each production stage and limits the ability to identify more precisely where losses are concentrated. The issue is particularly evident in the textile and leather industries, given their multiple manufacturing stages and the associated offcuts, spoiled materials, and waste. The research problem therefore concerns the possibility of using material flow cost accounting to trace these flows, measure their costs, and identify potential reductions that support product sustainability.

Accordingly, the research problem is expressed in the following question:

“To what extent does material flow cost accounting contribute to reducing loss costs and enhancing product sustainability in the company under study?”

Second: Significance of the Study

The significance of the study lies in its focus on material flow cost accounting as an approach that provides a clearer understanding of loss and waste costs and their implications for resource-use efficiency and production cost reduction. Its practical significance also lies in examining this approach within the General Company for Textile and Leather Industries and using the resulting information to support decisions concerning production, waste reduction, and product sustainability.

Third: Research Objectives

The study seeks to achieve the following:

1. Explain the role of material flow cost accounting in tracing the movement of materials and measuring their costs throughout production stages.
2. Identify the costs of losses, waste, and non-productive flows in the company under study.
3. Examine the possibility of reducing production costs by improving the efficiency of material and resource use.
4. Explain how material flow cost accounting contributes to enhancing product sustainability by reducing waste and its associated environmental impacts.

Fourth: Research Hypothesis

Given the applied nature of the study and its reliance on the analysis of company data, the research hypothesis is as follows:

“Applying material flow cost accounting contributes to identifying and measuring the costs of losses and non-productive flows, creating opportunities to reduce costs and enhance product sustainability in the company under study.”

Fifth: Research Boundaries

Spatial boundaries: The General Company for Textile and Leather Industries.

Temporal boundaries: Temporal boundaries: The financial year 2025, as it is the year used to analyze material flow data and costs associated with the production process in the company under study.

Sixth: Research Approach

The study adopts a descriptive approach in its theoretical part and an applied analytical approach in its practical part through the analysis of cost and material flow data in the company.

Seventh: Data Collection Methods

Arabic and foreign sources, research papers, periodicals, and standards for the theoretical part.

Records, reports, cost and production statements, and material and waste quantities for the applied part.

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Eighth: Analytical Methods

These include tracing material flows , identifying inputs and outputs , measuring positive products and losses , and then allocating material , energy , system , and waste management costs to them in accordance with the MFCA approach.

Ninth: Previous Studies

1. Study by Nishitani et al. (2022)

"Material Flow Cost Accounting (MFCA) for the Circular Economy: An Empirical Study of the Triadic Relationship between MFCA , Environmental Performance , and the Economic Performance of Japanese Companies".

The study examined the relationship between MFCA implementation and environmental and economic performance in Japanese companies. It showed that its implementation helps improve resource productivity and reduce waste , positively affecting productivity and profitability and supporting companies' transition toward a circular economy.

2. Study by Bux & Amicarelli (2022)

Material Flow Cost Accounting (MFCA) to Enhance Environmental Entrepreneurship in the Meat Sector: Challenges and Opportunities.

The study applied MFCA to analyze material and energy flows and loss-related costs in the Italian meat sector. The results showed that this approach reveals economic and environmental costs that are not clearly visible in traditional reports and provides information that helps reduce waste and improve sustainability decisions.

3. Study by Yoddee & Chompu-inwai (2023)

"Loss Analysis in Bread Production Process Using Material Flow Cost Accounting Technique".

The study aimed to analyze losses across bread production stages using MFCA by identifying the inputs and outputs of each quantity center and measuring them in physical and monetary terms. The results showed that negative products accounted for 25.19% of total costs. The application helped identify the stages contributing most to losses and direct improvement opportunities toward them.

4. Study by Chetanraj & Senthil Kumar (2024)

"Material Flow Cost Accounting for Aluminum Gravity Die Casting in Electrical Products Manufacturing".

The study applied MFCA in an Indian manufacturing enterprise to reveal negative product costs and identify areas for improvement. The results showed that negative product costs amounted to approximately 27.38% , demonstrating the approach's ability to reveal loss costs that are not readily visible in traditional costing systems and to improve resource efficiency.

5. Study by Dierkes & Siepelmeyer (2025)

" Material Flow Cost Accounting with Multiple Inefficiency Factors and Recycling".

The study aimed to develop material flow cost accounting by incorporating inefficiency factors , rework , and recycling into the material flow model. It concluded that MFCA provides more detailed information on the costs of losses , waste , and recycling at the enterprise , quantity center , and product levels , supporting cost management and sustainability.

1-2 Theoretical Background of Material Flow Cost Accounting and Its Relationship with Cost Reduction and Product Sustainability

First: Conceptual Framework of Material Flow Cost Accounting (MFCA)

Material Flow Cost Accounting (MFCA) is an environmental management accounting tool that traces the movement of materials and energy through production processes and links physical flows to their associated monetary values. The tool was initially developed in Germany and subsequently attracted considerable interest in Japan , leading to the issuance of the international standard ISO 14051 in 2011 to standardize the principles and general framework for its implementation (Schmidt & Nakajima , 2013: 360–361).

1. Concept of Material Flow Cost Accounting

ISO 14051 defines material flow cost accounting as a tool that helps economic entities better understand the financial and environmental consequences of material and energy use and identify opportunities for improvement by changing how these resources are used (ISO 14051 , 2011: 9). May & Guenther (2019: 3) also view it as a tool for recording physical and financial information to support decisions concerning production processes and material flows , while Nurullah (2021: 255) emphasizes its role in the integrated measurement of product and waste costs in physical and financial terms.

The researchers consider the essence of MFCA to extend beyond measuring the cost of the finished product to determining the amount of resources that did not become conforming products and reporting their costs separately. Waste and losses thus become flows whose costs can be measured and whose causes can be analyzed , instead of remaining embedded in total production costs.

2. Objectives and Significance of Material Flow Cost Accounting

The significance of material flow cost accounting lies in increasing the transparency of material and energy movements and their associated costs. Some waste costs may be concealed within overheads in traditional costing systems , whereas MFCA reveals them and links them to the stage at which they arose (Tran & Herzig , 2022: 43). Its principal objectives can be identified as follows (Huang et al. , 2019: 7):

- a. Identify the movement of materials and energy within production stages and detect points of loss and waste.
- b. Measure the cost of material losses rather than only the cost of conforming products, providing a more accurate picture of production process costs.
- c. Improve resource-use efficiency by providing information that helps management reduce material and energy consumption.
- d. Support production and environmental decisions concerning production planning, process improvement, quality control, product design, and supply chain management.
- e. Achieve simultaneous economic and environmental benefits by reducing losses and their costs and limiting their associated environmental impacts.

The literature cited in the uploaded dissertation indicates that MFCA is useful not only for measuring losses but also for helping management identify processes that can be improved and providing information on opportunities to reduce resource use and improve financial and environmental performance (Schebek et al., 2019: 90).

3. Basic Principles of Material Flow Cost Accounting

MFCA implementation rests on four interrelated principles defined by ISO 14051, which can be summarized as follows (Tachikawa, 2014: 8):

- a. Trace material flows and energy use: By tracking the movement of materials and energy in each quantity center during the production process.
- b. Link physical and monetary data: By associating the quantities used and lost with their corresponding financial values.
- c. Ensure the accuracy, completeness, and comparability of physical data: By identifying and measuring inputs and outputs in a way that allows discrepancies and their causes to be detected (ISO 14051, 2011: 4).
- d. Allocate material loss costs: By assigning to losses the resources and costs they actually consumed, making **loss costs more visible to management (Tachikawa, 2014: 7).**

4. Quantity Centers and Material Balance

A quantity center is a fundamental element of MFCA. It is a defined part of the production process in which inputs and outputs are measured in physical and monetary units. It may be a warehouse, a production unit, a processing stage, or a shipping point (ISO 14051, 2011: 19). These centers help identify where losses occur and link their costs to the stage responsible for them.

This is related to the concept of material balance, which requires the quantity of materials entering a quantity center to be matched by an equivalent quantity of outputs, whether converted into positive products or material losses. This can be expressed in simplified form by the following equation:

Material inputs = Positive products + Material losses

This balance makes it possible to determine the quantity of materials that did not enter the finished product, measure their costs, and identify the stage at which the loss occurred (Kokubu & Kitada, 2015: 1280).

5. Types of Costs in Material Flow Cost Accounting

MFCA classifies costs into four main types (May & Guenther, 2019: 3):

- a. Material costs: These include the costs of raw materials, auxiliary materials, and other materials entering the production process.
- b. Energy costs: These include electricity, fuel, steam, heat, and other energy sources used in quantity centers.
- c. System costs: These include wages, depreciation, maintenance, and other costs associated with material processing and flows.
- d. Waste management costs: These are the costs associated with treating, storing, disposing of, or recycling material losses.

Measurement is not limited to determining the total of these costs; they are allocated to positive products and material losses in proportion to material flows in each quantity center. This makes loss costs more transparent than under traditional costing systems (ISO 14051, 2011: 17).

6. Steps in Implementing Material Flow Cost Accounting

The implementation steps can be summarized in a manner suited to the practical part of the present study as follows (Al-Zubaidi, 2024: 129–132):

- a. Define the implementation boundaries, time period, and process or product to be measured.
- b. Identify the quantity centers through which materials pass during the production process.
- c. Identify inputs and outputs and measure material flows quantitatively.
- d. Apply the material balance to determine positive products and material losses.
- e. Determine material, energy, system, and waste management costs and allocate them to the outputs of each quantity center.
- f. Analyze loss costs and identify the centers accounting for the largest share, then seek opportunities to reduce them and improve resource-use efficiency.

Material flow cost accounting thus provides a framework that brings together material movement, its cost, and the location of losses. This yields more relevant information for identifying cost reduction opportunities and provides a transition to examining its role in enhancing product sustainability.

Second: Cost Reduction and Product Sustainability

In an industrial setting, cost reduction is linked to efficient resource utilization and the limitation of losses, making it closely connected with product sustainability requirements, particularly in industries that rely heavily on materials and energy.

Cost reduction means seeking opportunities to reduce resource consumption and unnecessary costs without compromising product quality. Reducing losses and waste is one of its most important areas, since reducing lost materials lowers both production and waste treatment costs (Doorasamy & Garbharran, 2015: 80–82).

Product sustainability refers to a product's ability to generate economic value for the enterprise while limiting its adverse effects on the environment and society throughout its life cycle, balancing economic benefits with sustainability requirements (Dyllick & Rost, 2017: 346–348).

The economic dimension involves reducing material, energy, and loss costs and improving production efficiency, while the environmental dimension focuses on reducing resource consumption, waste, and product-related emissions. Improving either dimension can therefore support the other when it is associated with waste reduction and better resource use (ISO 14051, 2011: 9).

In light of the foregoing, efficient material and energy use contributes to product sustainability by obtaining greater production outputs from fewer resources and reducing wasted quantities and their associated costs and environmental impacts. Tracking material and energy flows is therefore an important approach to improving the economic and environmental efficiency of the production process (Huang et al., 2019: 7).

Third: The Role of Material Flow Cost Accounting in Reducing Costs and Enhancing Product Sustainability

Material flow cost accounting links resource movements to their costs, making it a suitable tool for identifying waste and guiding cost reduction measures in line with sustainability requirements.

1. Identifying Positive and Negative Product Costs

MFCA distinguishes between the cost of positive products, which represent the intended outputs, and the cost of negative products, which comprise losses and waste. This separation helps reveal the actual cost of resources consumed without becoming saleable products, rather than leaving these costs within total production costs (Dierkes & Siepelmeyer, 2025: 58). A recent application also demonstrated the possibility of identifying material, energy, and system costs associated with negative products separately (Chetanraj & Senthil Kumar, 2024: 2556).

2. Identifying Locations of Losses and Non-productive Flows

Dividing the production process into quantity centers and tracing inputs and outputs at each stage makes it possible to identify locations with high material losses and direct improvement measures toward them. Joel et al. (2025: 31) showed that applying the material balance across production stages helps identify inefficiencies and opportunities to reduce waste and improve resource use.

3. Reducing Material and Energy Consumption and Waste Costs

Identifying non-productive flows helps guide management toward reducing material and energy consumption and lowering waste treatment or disposal costs. The results of MFCA implementation showed the possibility of achieving actual savings by reducing losses, reusing some waste, and improving resource efficiency (Joel et al., 2025: 29).

4. Implications of Loss Reduction for Product Sustainability

The effect of loss reduction extends beyond the financial dimension to reducing resource and energy depletion and the waste generated by production, supporting the economic and environmental dimensions of product sustainability. Recent evidence indicates that MFCA supports sustainability by combining improved resource efficiency with reductions in waste, costs, and associated environmental impacts (Dierkes & Siepelmeyer, 2025: 83).

1-3 Practical Application of Material Flow Cost Accounting in the Company under Study

First: Overview of the Research Sample and the Product Selected for Application

The research sample comprises the General Company for Textile and Leather Industries, an entity affiliated with the Iraqi Ministry of Industry and Minerals. It took its current form following the merger of several industrial companies specializing in cotton, textile, leather, wool, and ready-made garment industries. It currently includes several factories across different governorates, including the Wasit Textile and Knitting Factory.

Men's undershirts were selected for the application because they are among the company's actual products. The company's product range includes a men's sleeveless undershirt made from single-cylinder knitted fabric. Its official data also indicate that the Wasit Textile and Knitting Factory supplies quantities of undershirts in various sizes as part of its production and marketing activities.

This product is suited to the application of material flow cost accounting because its production involves successive stages through which material movements can be traced, inputs and outputs measured, and the quantities of losses and waste identified at each stage. These can then be linked to their associated costs, providing a basis for measuring positive product and loss costs and identifying opportunities to reduce them.

1. 2025 Data Used in the Application

Table (1): Basic Production Data for Men's Undershirts for 2025

No.	Description	Unit of measurement	Production in 2025
1	Finished production quantity	Undershirt	300 , 000
2	Average weight per undershirt	kg	0.180
3	Finished production weight	kg	54 , 000
4	Quantity of main material inputs	kg	60 , 000
5	Quantity of losses and waste	kg	6 , 000
6	Loss rate relative to material inputs	%	10.00
7	Material utilization rate	%	90.00

Source: Prepared by the researchers based on Cost Department data for 2025.

The table shows that men's undershirt production in 2025 reached 300 thousand undershirts , with a finished production weight of 54 thousand kg , compared with 60 thousand kg of material inputs. Losses and waste amounted to 6 thousand kg , or 10% of total inputs , while the material utilization rate reached 90%. This provides a suitable basis for tracing losses and measuring their costs using material flow cost accounting.

2. Identifying Production Stages and Quantity Centers

Material flow cost accounting requires the production process stages to be identified and divided into quantity centers through which material movements can be traced and inputs and outputs measured at each stage. Based on the nature of men's undershirt production , the main production stages were identified as quantity centers in preparation for measuring losses and non-productive flows , as shown in the following table.

Table (2): Physical Flows of Men's Undershirts by Quantity Center for 2025

No.	Quantity center / Production stage	Inputs (kg)	Positive outputs (kg)	Losses and waste (kg)	Loss rate %
1	Knitting	60 , 000.000	58 , 743.600	1 , 256.400	2.094
2	Preparation and dyeing	58 , 743.600	57 , 626.750	1 , 116.850	1.901
3	Cutting	57 , 626.750	55 , 032.410	2 , 594.340	4.502
4	Sewing and finishing	55 , 032.410	54 , 000.000	1 , 032.410	1.876
Total		60 , 000.000	54 , 000.000	6 , 000.000	10.000*

* Represents the overall loss rate relative to the quantity of material inputs at the beginning of the production process.

Source: Prepared by the researchers based on production data for 2025 for the purpose of applying material flow cost accounting.

The table shows that material losses are distributed unevenly across production stages. Cutting recorded the largest loss quantity , at 2 , 594.340 kg and a rate of 4.502% , while rates were lower in the other stages. Total losses reached 6 , 000 kg , equivalent to 10% of material inputs , identifying the stages most in need of analysis when measuring loss costs under MFCA.

3- Measuring Material Flow Costs for Men's Undershirts Using MFCA

After identifying physical flows and loss quantities in the quantity centers , monetary measurement is undertaken to determine the costs associated with these flows. Under material flow cost accounting , costs are classified into material , energy , system , and waste management costs in preparation for allocating them between positive and negative products in each quantity center.

Table (3): Material Flow Costs by Quantity Center for Men's Undershirt Production for 2025
Amounts in Iraqi Dinars

Quantity center	Material costs	Energy costs	System costs	Waste management costs	Total cost
Knitting	487 , 632 , 840	18 , 742 , 615	72 , 486 , 330	1 , 684 , 920	580 , 546 , 705
Preparation and dyeing	73 , 418 , 560	31 , 865 , 740	66 , 924 , 510	4 , 278 , 360	176 , 487 , 170
Cutting	4 , 986 , 420	6 , 328 , 950	54 , 817 , 260	3 , 115 , 680	69 , 248 , 310
Sewing and finishing	41 , 765 , 380	14 , 582 , 695	93 , 671 , 840	1 , 896 , 570	151 , 916 , 485
Total	607 , 803 , 200	71 , 520 , 000	287 , 899 , 940	10 , 975 , 530	978 , 198 , 670

Source: Prepared by the researchers based on production activity data for 2025.

The table shows that material costs accounted for the largest share of total material flow costs , particularly in the knitting stage , while energy , system , and waste management costs were distributed in varying proportions among quantity centers. Total costs reached 978 , 198 , 670 dinars , providing a basis for distinguishing the portion associated with positive products from loss costs in the subsequent stage of the application.

4- Allocation of Material Flow Costs between Positive and Negative Products

After determining the total costs associated with each quantity center , these costs are allocated between positive and negative products (losses) based on the physical flows at each stage , with the aim of revealing the actual loss costs that may not be reported separately under the traditional costing system.

Table (4): Allocation of Material Flow Costs between Positive and Negative Products by Quantity Center for 2025 / Amounts in Iraqi Dinars

Quantity center	Total center cost	Positive product cost	Negative product cost (losses)	Loss cost ratio %
Knitting	580 , 546 , 705	566 , 740 , 419	13 , 806 , 286	2.378
Preparation and dyeing	176 , 487 , 170	168 , 935 , 121	7 , 552 , 049	4.279
Cutting	69 , 248 , 310	63 , 155 , 339	6 , 092 , 971	8.799
Sewing and finishing	151 , 916 , 485	147 , 205 , 541	4 , 710 , 944	3.101
Total	978 , 198 , 670	946 , 036 , 420	32 , 162 , 250	3.288

Source: Prepared by the researchers based on data for 2025 and in accordance with the material flow cost accounting approach.

The table shows that total material flow costs for men's undershirt production amounted to 978 , 198 , 670 dinars , comprising 946 , 036 , 420 dinars for positive products and 32 , 162 , 250 dinars for negative products. Loss costs thus represented approximately 3.288% of total costs. This indicates that some of the resources bearing material , energy , system , and waste management costs did not become finished products. Material flow cost accounting reports these costs separately rather than leaving them within total production costs.

A comparison of production stages showed that knitting incurred the highest loss cost , at 13 , 806 , 286 dinars , which can be linked to the high costs accumulated at this stage. Cutting ranked first in the ratio of loss costs to quantity center costs , at 8.799% , although its loss costs were 6 , 092 , 971 dinars. In preparation and dyeing , loss costs amounted to 7 , 552 , 049 dinars , or 4.279% , while sewing and finishing recorded 4 , 710 , 944 dinars , or 3.101%.

These results show that the quantity of material losses alone does not reflect the magnitude of the loss , since the financial impact varies with the costs and resources assigned to materials during each production stage. Costs are also affected by the nature of the resources and costs assigned to materials within each quantity center. This analysis therefore provides a basis for directing improvement measures toward the stages with the greatest impact , particularly knitting in terms of loss costs and cutting in terms of the ratio of loss costs to center costs , in preparation for measuring potential reduction opportunities and their implications for product costs and resource-use efficiency.

5- Assessing the Relative Importance of Loss Costs

Determining loss quantities or their total value is insufficient to judge which stage has the greatest impact , since a stage may have a high loss quantity without having the highest cost per unit lost. Loss costs per kilogram and each stage's relative share of total loss costs were therefore calculated to help establish priorities for corrective action.

Table (5): Loss Cost Indicators across Men's Undershirt Production Stages for 2025

Production stage	Loss quantity / kg	Loss cost / dinars	Loss cost per kg / dinars	Stage share of total loss costs %
Knitting	1 , 256.400	13 , 806 , 286	10 , 989	42.927
Preparation and dyeing	1 , 116.850	7 , 552 , 049	6 , 762	23.481
Cutting	2 , 594.340	6 , 092 , 971	2 , 349	18.944
Sewing and finishing	1 , 032.410	4 , 710 , 944	4 , 563	14.647
Total	6 , 000.000	32 , 162 , 250	—	100.000

Source: Prepared by the researchers based on the results of measuring physical flows and negative product costs for 2025.

The table shows that the distribution of loss costs across production stages does not necessarily correspond to the distribution of loss quantities. Cutting recorded the highest loss quantity , at 2 , 594.340 kg , yet its share of total loss costs was only 18.944% . Knitting ranked first in terms of the financial burden , with loss costs of 13 , 806 , 286 dinars , representing 42.927% of total loss costs. It also recorded the highest cost per kilogram lost , at 10 , 989 dinars.

Preparation and dyeing and sewing and finishing accounted for 23.481% and 14.647% of total loss costs , respectively. These percentages show that losses cannot be assessed solely by quantity , because the costs assigned to materials before they are lost differ from one stage to another. Priorities for corrective action should therefore be determined by the financial impact as well as loss quantities.

6- Analysis of Opportunities to Reduce Losses and Their Costs

After determining negative product costs in each quantity center , the analysis can focus on the stages where loss costs are concentrated and estimate the potential for reducing them by improving material-use efficiency and limiting waste in the production process. This makes it possible to measure potential savings and explain their effect on product costs.

Table (6): Opportunities to Reduce Losses and Costs across Men's Undershirt Production Stages for 2025

Loss location	Current loss cost / dinars	Target reduction rate %	Loss cost after reduction / dinars	Savings / dinars
Knitting	13 , 806 , 286	15	11 , 735 , 343	2 , 070 , 943
Preparation and dyeing	7 , 552 , 049	12	6 , 645 , 803	906 , 246
Cutting	6 , 092 , 971	25	4 , 569 , 728	1 , 523 , 243
Sewing and finishing	4 , 710 , 944	10	4 , 239 , 850	471 , 094
Total	32 , 162 , 250	—	27 , 190 , 724	4 , 971 , 526

Source: Prepared by the researchers based on the results of applying material flow cost accounting and the opportunities.

The table shows that loss reduction opportunities vary by production stage. The highest reduction rate , 25% , was assigned to cutting because it is among the stages most susceptible to losses , followed by knitting at 15% , preparation and dyeing at 12% , and sewing and finishing at 10%. These measures reduced loss costs from 32 , 162 , 250 dinars to 27 , 190 , 724 dinars , generating savings of 4 , 971 , 526 dinars , equivalent to approximately 15.46% of current loss costs. This result indicates that directing improvement measures toward locations with higher losses can produce a tangible financial effect without requiring a complete change in the production process.

7- Implications of Loss Reduction for Product Sustainability

The analysis indicates that reducing losses across men's undershirt production stages has several implications. In addition to financial savings , it improves material utilization efficiency and limits the waste generated during production. This effect can be shown more clearly by comparing indicators before and after the proposed reduction measures.

Table (7): Effect of Loss Reduction on Men's Undershirt Sustainability Indicators for 2025

Indicator	Before reduction	After reduction	Improvement
Loss quantity / kg	6 , 000.000	4 , 925.692	1 , 074.308
Material loss rate %	10.000	8.209	1.791 points
Material utilization rate %	90.000	91.791	1.791 points
Loss cost / dinars	32 , 162 , 250	27 , 190 , 724	4 , 971 , 526
Total production cost / dinars	978 , 198 , 670	973 , 227 , 144	4 , 971 , 526
Average unit cost / dinars	Approximately 3 , 261	Approximately 3 , 244	Approximately 17

Source: Prepared by the researchers.

The table shows that the proposed loss reduction measures helped improve sustainability indicators associated with men's undershirt production. Loss quantities fell from 6 , 000 kg to 4 , 925.692 kg , an improvement of 1 , 074.308 kg. The loss rate also declined from 10% to 8.209% , while the material utilization rate increased from 90% to 91.791%.

Financially , loss costs declined from 32 , 162 , 250 dinars to 27 , 190 , 724 dinars , generating savings of 4 , 971 , 526 dinars , which was reflected in total production costs and average unit cost. The comparison shows that the effect was not solely financial , as it was accompanied by more efficient material use and lower waste volumes , reflecting an economic and environmental impact on product sustainability.

Second: Evaluation of the Application Results in Light of the Research Hypothesis

The application results showed that material flow cost accounting made it possible to identify where losses occurred and link them to their costs across the different production stages. It also helped identify stages that warranted priority for corrective action. The proposed reduction measures showed improved material utilization and lower losses and waste , supporting the research hypothesis concerning MFCA's contribution to reducing loss costs and supporting product sustainability.

1-2 Conclusions and Recommendations

First: Conclusions

1. Applying material flow cost accounting made it possible to separate loss costs from the costs of conforming products. Loss costs represented 3.288% of total material flow costs , making their effect clearer when analyzing the production process.
2. Tracing physical flows revealed that losses amounted to 10% of material inputs , although the loss rate varied across stages , highlighting the importance of measuring each stage separately.
3. The results showed that the stage with the highest loss quantity does not necessarily have the highest loss cost , making it essential to combine physical and monetary measurement when setting priorities for corrective action.
4. The proposed improvement measures showed that loss costs could be reduced by approximately 15.46% , indicating scope for improving production efficiency by addressing the most consequential loss locations.
5. The reduction measures affected material-use efficiency: the loss rate fell from 10% to 8.209% , while the material utilization rate increased from 90% to 91.791%.
6. Applying material flow cost accounting provided information that helps distinguish between waste locations in terms of their scale and financial impact , supporting the direction of improvement efforts toward the stages most in need of corrective action.
7. The application results were consistent with the research hypothesis , showing that MFCA can contribute to reducing loss costs and improving resource utilization , thereby supporting the economic and environmental sustainability of the product.

Second: Recommendations

1. Introduce material flow cost accounting into the company's existing costing system so that the costs of losses and non-productive flows can be reported separately from the costs of conforming products.
2. Give greater attention to tracking material movements between production stages , particularly those with high loss rates , to identify the causes of waste and address them at an early stage.
3. Combine quantitative and monetary measurement of losses when assessing the efficiency of production stages , so that the assessment considers their financial impact as well as their volume.
4. Give greater priority to stages that offer larger reduction opportunities , focusing on improving operating , cutting , and knitting procedures , reducing spoilage , and making possible use of reusable waste.
5. Use a set of periodic indicators to monitor the loss rate , material utilization rate , and loss costs , and link their results to production performance evaluation and the monitoring of improvements achieved.
6. Use material flow cost accounting results to support sustainability decisions , so that corrective measures address not only cost reduction but also more efficient resource use , waste reduction , and improved environmental efficiency.

7. Strengthen the capabilities of staff in the cost , production , and control departments through training in MFCA implementation and the collection of the physical and financial data it requires , helping establish it as an ongoing practice within the company.

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