



National Iranian Oil Refining and Distribution Company
(NIORDC)



Journal of Farayandno

Research Paper



DOI: 10.22034/farayandno.2025.2045043.1974



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Implementation of Material Flow Cost Accounting System to Optimize and Increase Financial Efficiency in a Chlor-alkali Production Complex: Electrolyzer Department

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Received: 5 Sep 2024 Accepted: 23 Oct 2024

1. ABSTRACT

This study examines the implementation of Material Flow Cost Accounting (MFCA) in a chlor-alkali complex, focusing on the electrolyzer section in chlorine production. By use of the MFCA method, the research aims to reduce waste and improve productivity. Analyzing material flows and associated costs reveals hidden inefficiencies related to negative products or waste and their costs, creating opportunities for optimization. Calculations indicate that 72% of the product's weight is negative, corresponding to a 71% financial loss. It is predicted that implementing MFCA-based improvements will result in a 4% reduction in waste and a significant increase in product output. These findings not only highlight the effectiveness of MFCA in waste reduction but also emphasize its positive economic impact, enhancing resource efficiency and overall profitability in the electrolyzer sector. The results of this study have the potential to be applied to other enterprises and contribute to the development of sustainable industrial practices.

Keywords: Material Flow Cost Accounting, Waste reduction, Productivity increase, Chlor-alkali, Electrolyzer.

2. INTRODUCTION

Numerous studies in recent years have demonstrated the effectiveness of Material Flow Cost Accounting (MFCA) as a tool for improving efficiency and reducing waste in various industries, particularly the chemical industry. This method, by identifying weaknesses in the production process and allocating costs to waste, enables the provision of practical suggestions for improvement. Studies conducted at the Tabriz Petrochemical Complex in 2014 [1] showed that MFCA can contribute to improved production processes by identifying the costs of waste and byproducts. The results of this study led to suggestions for process improvement and cost reduction. Wang et al. [2] in research in Chinese industries, highlighted the economic and environmental benefits of MFCA, showing that this method can provide significant economic benefits for companies and environmental benefits for the entire society.

Kokubo and Kitada [3] in 2015, while emphasizing the advantages of MFCA as a tool for environmental and financial management, stressed the need to use this method in conjunction with other efficiency improvement methods. They also offered theoretical solutions to address potential conflicts between MFCA and existing management perspectives. In 2012, MFCA was implemented for the first time in the amine unit of the Tabriz Refinery Company (TZORC) [1], and the results were presented in a report that included the identification of waste and associated costs. Nitto Denko Corporation, a manufacturer of adhesive tape, by implementing MFCA from 2001 to 2010, managed to reduce its negative output from 32% to 10% [4]. Sekisui Chemical Company in Japan also reduced its waste by 11% using MFCA in 2007

Please Cite This Article Using:

Firouzi, M., Aghajani, H., Mohammadzadeh, P., Fatehifar, E., "Implementation of Material Flow Cost Accounting System to Optimize and Increase Financial Efficiency in a Chlor-alkali Production Complex: Electrolyzer Department", Journal of Farayandno – Vol. 19 – No. 86, pp. 5-20, In Persian, (2024).



[4]. Tomo Corporation, as a chemical company producing highly pure products and consuming large quantities of chemical solutions, used MFCA to reduce the consumption of chemicals and wastewater production.

Other studies have shown that MFCA can be effective in reducing various costs. In one process, the cost of material waste was 13.8% of the total costs, and in another process, it was 1.87% of the total costs [5]. In these studies, methods for reducing energy costs, personnel costs, and the amount of wastewater produced were presented.

In a case study, using collected and measured mass, financial, and process data, a mass and energy balance was performed using the MFCA method over a six-month period. Using the results obtained, losses and their causes were identified, and improvement solutions were extracted to reduce waste and increase productivity. Re-evaluation showed that the sum of these solutions had a significant impact on improving productivity. This study used a combination of scientific findings in the fields of economics, accounting, and management to achieve the best possible result for high productivity by increasing effectiveness and efficiency. The results of this research and similar studies can contribute to improving the economic, scientific, cultural, and social conditions of society and increasing the general welfare of the people. In short, MFCA is a powerful tool for improving productivity and reducing waste in various industries, and the results of the studies conducted demonstrate its positive impact on reducing costs and increasing profitability. This method, by providing practical and implementable solutions, can contribute to improving company performance and enhancing environmental sustainability.

3. METHODOLOGY

MFCA measures material and inventory flow using monetary units. Costs are categorized into material, system, and waste management costs. Lost costs in negative products (waste) are evaluated by calculating their quantity, identifying their source, and converting them to monetary value. Raw material, labor, depreciation, and other costs are also calculated as waste costs within the production cost. MFCA combines mass balance with system cost estimation. Mass balance lists materials inputs and outputs. MFCA measures the total output flow (product and waste) in physical units, identifying inefficiencies in both physical and monetary units and precisely specifying waste costs [6]. For manufactured products, MFCA considers material (MC), energy (EC), system (SC), and waste management costs.

3.1. Wastemanagement

The linear economy (extract, produce, consume, discard) is environmentally unsustainable. The circular economy improves resource reuse, but often neglects productivity. True efficiency maximizes output with minimal input. Material Flow Cost Accounting (MFCA) helps achieve this by tracking material flows and costs, leading to waste reduction, improved efficiency, and enhanced profitability while prioritizing environmental sustainability. Waste reduction, not just recycling, is key.

4. RESULTS AND DISCUSSION

4.1. Process and Determination of QC

Saltwater gets prepped and then fed into the anode of an electrolyzer. Electrolysis happens, splitting it into sodium ions and chlorine gas. The chlorine gas gets separated from the leftover brine in a degasser. Meanwhile, demineralized water goes into the nickel cathode. This produces hydroxide ions and hydrogen. The sodium from the anode reacts with the hydroxide from the cathode, and is produced sodium hydroxide. The hydrogen and caustic soda are separated in another degasser. The whole system is treated as a quality control center, and a Material Flow Cost Accounting (MFCA) analysis is run on it for a year period. Figure 1 shows the QC and material flow diagram.

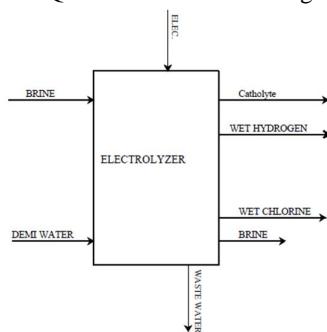


Figure 1. Material flow diagram and quantitative center for electrolyzer unit in chlor-alkali complex

4.2. Mass Balance

Mass flow rates were calculated using the unit's control system and actual data. The only waste product, unsaturated brine, is recycled. Waste management costs are included in the QC center's overhead. Table 1 detail material consumption, positive and negative product distribution, mass losses, and a mass balance summary.

Table 1. Total mass balance of the unit

Input/Output/Waste	Mass (Kg)	Percentage
Total Input (ton/year)	159667362	100
Total Production (ton/year)	44855734	28

4.3. Valuation and Identification of Waste

Raw material consumption determines cost allocation, calculated per product content. System and service costs were calculated from unit data. About 28% of output is positive product, but only 29% of total costs are allocated to it (Figures 2a and 2b). A significant portion of costs is assigned to negative products.

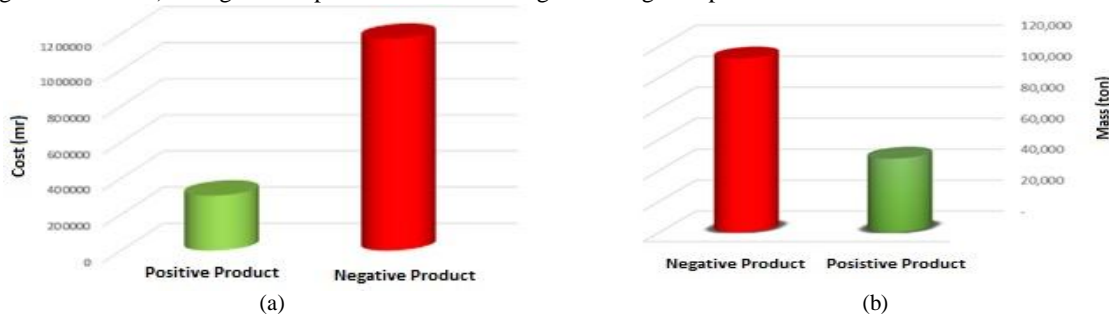


Figure 2. The ratio of positive products and negative products based on cost (a) and mass (b)

4.4. Suggestions for Improvement

- Optimization of the effective parameters in the membrane and electrolyzer cell
- Registering unit data systematically and storing them centrally on the server
- Production program modifications
- Continuous monitoring and control

MFCA analysis predicts the financial and mass balance impacts of implemented improvements (Figure 3). A 3% reduction in waste mass leads to a 4% decrease in financial losses (42,149 million Rials over six months), resulting in increased product output.

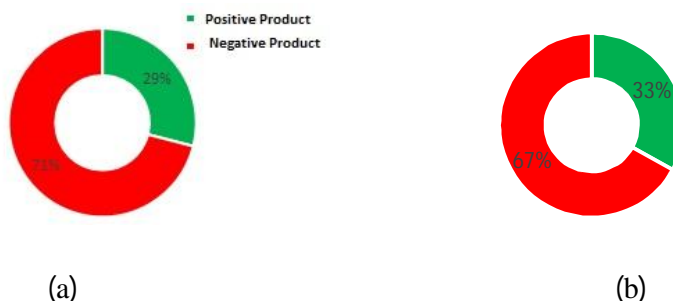


Figure 3. Cost analysis of positive and negative product produced before implementing improvement solutions (a) and forecast after implementing solutions (b) based on the MFCA method

5. CONCLUSION

This study uses Material Flow Cost Accounting (MFCA) to analyze an electrolyzer, identifying 72% of products by weight and 71% of costs as negative (waste). MFCA-based solutions are proposed to reduce negative products and increase positive output, minimizing energy waste and environmental impact. Implementing these solutions predicts a 3% reduction in waste mass, a 4% decrease in waste costs (42,149 million Rials annually), and a 3% increase in positive product output. This demonstrates MFCA's effectiveness in optimizing industrial processes.

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