SSRG International Journal of Economics and Management Studies
ISSN: 2393 – 9125 / https://doi.org/10.14445/23939125/IJEMS-V7I3P121

Volume 7 Issue 3, 153-158, March, 2020


*Original Article*

# MFCA Application Aiming to Analyze the Cost of The Steel Production Process in Thai Nguyen Iron and Steel Corporation

Nguyen Thi Kim Huyen

*Faculty of Industrial Economy, Thai Nguyen University of Technology, Thai Nguyen University*
*No. 666, 3/2 Street, Tich Luong ward, Thai Nguyen city, Thai Nguyen province, Vietnam*

Received Date: 28 February 2020
Revised Date: 29 March 2020
Accepted Date: 31 March 2020

***Abstract*** *- This study used the Material Flow Cost Accounting (MFCA) method to focus on identifying the wastes in steel production at Thai Nguyen Iron and Steel Joint Stock Corporation (TISCO) by approaching the Material Balance equation. Research analyzed the input cost (including cost materials, energy cost, and system cost) in steel manufacturing prosses in TISCO and found that from 56.58% - 96.94% total cost has been allocated as the cost of positive, 3.06% - 43.42% in the negative product. The results of the MFCA analysis provided initial calculations that not only evaluated material losses in the company in monetary terms, but also helped TISCO executives can see one of the parts of the difference between conventional accounting and material flow cost accounting. Since then, TISCO has the cornerstone to search, to apply measures to use the most cost-efficient and reduce emissions to the external environment, thus correctly and fully calculating the price of positive products.*

***Keywords*** *- Material Flow Cost Accounting, MFCA, TISCO, steel manufacturing prosses, positive product, negative product.*

## I. INTRODUCTION

Material Flow Cost Accounting (MFCA) "is a method that traces physical flows and stocks of materials in process, and then calculates their cost by multiplying material quantifies by unit price. MFCA highlights the cost generated by and/or associated with material losses (along with products costs) as accurately as possible" [8], has been developed firstly in Germany, after that has been extended to Japan. Up to now, MFCA has gained a lot of attention from businesses and countries because of the efficiency which has brought to companies in Germany and Japan.

After examining the steel production process in Thai Nguyen Iron and Steel Corporation (afterward TISCO), a company which has specialized in constructing steel products, I - the author - find that the company still has much potential for applying MFCA to determine the wasted materials in each step of the production process and to measure the precise, sufficient costs for specified products. Based on applying MFCA, TISCO can improve the quality of collecting production expenses, measure costs, efficiently use materials and energy, and reduce emissions into the environment. TISCO can target the sustainable development, generate cleaner production, and protect the environment.

The purpose of this study is to find the chance to apply MFCA in the cost analysis of the steel production process in TISCO. Based on the MFCA application, the shortcoming of allocation of costs into product costs and the wasted materials in each step of the production process is investigated.

## II. LITERATURE REVIEW

MFCA is one of the major tools in environmental management accounting [9]. It focuses on identifying and differentiating between the costs associated with "products" and "material losses" [1]. The four basic principles of MFCA include: (i) Understand material flow and energy use; (ii) Link physical and monetary data; (iii) Ensure accuracy, completeness, and comparability of physical data and; (iv) Estimating and assigning costs to material losses.

Chompoonoot Kasemset et al. in their research: "Application of MFCA and ECRS in Waste Reduction: A Case Study of Electronic Parts Factory", authors applied Material Flow Cost Accounting (MFCA) and ECRS (Eliminate – Combine – Rearrange - Simplify or propose) techniques to reduce material waste in the production of one electronic parts factory in Thailand. The results from MFCA analysis for the improvement showed that the total input cost was decreased from 22,444.46 to 22,300.92 THB, and the negative product cost of MC was decreased from 2,557.10 to 2,437.21 THB. In addition, this solution can help in material reduction as 465.50 g. and gained more product as 2,000 pieces per production lot. Moreover, the total benefit for this product was approximate as 23,611.24 THB per month [2].

The other research of Jedsada Tipmontian et al. is "Application of Material Flow Cost Accounting and System Dynamics Approach for Waste Reduction and Sustainable Food Manufacturing Development in Thailand", in this study, the authors were carried out at a food factory in Saraburi Province, Thailand. MFCA was applied to analyze the cost of losses that occurred at each step of the sausage production process and found that the sawdust smoking process was the highest significant loss, so that it was replaced by the liquid smoking system. The result of this study helps the company reduce waste and saves cost more than 150,000 US dollars per year [5].

Besides, MFCA was introduced to many industries such as electronic industries, food industries, fruit industries, and others in Japan in 2011 by the ministry of economy, trade, and industry of Japan to contribute to improving both environmental and economic impacts using advanced environmental management accounting approach [2].

MFCA has been introduced to many International documents, including: Environmental Management Accounting: Procedures and Principles of United Nations Division for Sustainable Development [11]; International Guidance Document: Environmental Management Accounting of International Federation of Accountants [3]; And Environmental Management Accounting: MFCA Case Examples of Japanese Ministry of Economy, Trade, and Industry [6].

In 2008, the International Standardization Organization (ISO), decided to develop a guideline on material flow costs accounting. And to 2011, ISO 14051 was issued. In MFCA, the flows and stocks of materials within an organization are traced and quantified in physical units, and then assigned an associated cost. Under ISO 14051:2011, MFCA includes four types of costs that are quantified: material costs, system costs, energy costs, and waste management costs, they are defined as follows:

**Material cost (MC):** Cost for a substance that goes through a central quantity (measurement unit of input and output for MFCA analysis). Typically, the purchase cost is used as material cost.

**Energy cost (EC):** Cost for energy sources such as electricity, fuels, steam, heat, compressed air.

**System cost (SC):** Cost incurred in the course of in-house handling of the material flows, excluding material cost, energy cost, and waste management cost.

**Waste management cost (WMC):** Cost for handling material losses [1].

In Viet Nam, MFCA is not a newly minted concept. It has been known for more than 10 years. Two organizations that have in-depth consulting services that relate to MFCA in Viet Nam include: Institute of Management and Technology promotion (IMT) and the Small and Medium Enterprises Development Support Center 2 (SMEDEC 2).

Up to now, MFCA has been applied in some companies in the manufacturing sector, such as: an optical cable company, a tobacco company, a candy company, a plastics company, and a sugar company [4].

MFCA help to enhance both environmental and economic performance through improved material and energy use based on: Increasing transparency regarding material, energy flows, and the respective costs; Supporting organizational decisions in areas such as process engineering, production planning, quality control, product design, and supply chain management; Improving coordination and communication on material and energy use within organizations. So, the expansion of MFCA applications in Vietnamese industries is essential.

## III. CAES STUDY

Thai Nguyen Iron and Steel Joint Stock Corporation (TISCO), was selected to be the case study. This is a large enterprise that specializes in manufacturing construction steel in Thai Nguyen, Vietnam. TISCO is using Electric Arc Furnace technology to produce steel. Manufacturing processes undergo closed chain from raw iron ore, through sintering (or agglomeration), iron making, steel making, and finally rolled steel (more detail in Fig. 1). In this study, the author used MFCA to analyze costs in the steel manufacturing process of TISCO. Accordingly, the Cost for Production will be considered four types: Material costs (MC); Energy costs (EC); System costs (SC), Waste management costs (WMC) that are in four stages of the steel production process in TISCO. And the data for the study has been collected from the TISCO's Final Accounts in 2019 Q3.

## IV. RESEARCH RESULTS

### *A. Cost accounting in the Steel manufacturing process in TISCO: Current Situation*

In TISCO, steel manufacturing costs include: direct materials cost (with main materials, subsidiary materials, fuel, energy), direct labors cost (with salary and insurance), and factory overhead expenses. Accountants base on manufacturing costs that are incurred during the production process to calculate the price of the finishing product.

In the steel production process, all costs would only be allocated to the positive product as a cost unit. The material costs are not divided between positive products and negative products. In fact, after each production process, the amount of actual material is not fully transformed into the positive product (in the first process, there are only 63,326.977 tons of main materials and 11,401.442 tons of subsidiary materials that are transferred into the sintered ore output (the sintered ore is the positive product in the first process), and then, there are only 55,912.472 tons of main materials and 10,066.528 tons of subsidiary materials that are transferred into sintered ore. In the second process, sintered ore is put into the production of liquid iron. In this step, there are 12,344.391 tons of main materials and 1,071.199 tons of subsidiary

materials which are been added. At the end of the second process, there are only 37,954.201 tons of main materials and 6,193.129 tons of subsidiary materials that are transferred into liquid iron (liquid iron is the positive product in this process). In the third and the fourth process, materials are not transferred entirely into finished products, too (in two processes, billet and steel are positive products) (More Fig. 2). In addition, system costs and energy costs generated in the steel manufacturing process that are not also divided between them on the basis of suitable key indicators. In fact, conventional cost accounting in the steel manufacturing process in TISCO concentrates on monetary value flows and interprets them as costs of products. It focuses on the accuracy of cost figures for each product after the process, and pays attention to the consistency between the sum of product costs and periodical manufacturing costs, based on bookkeeping (Although, there are material losses in the production process, the accountant has not shown this cost fully) (More Table I).

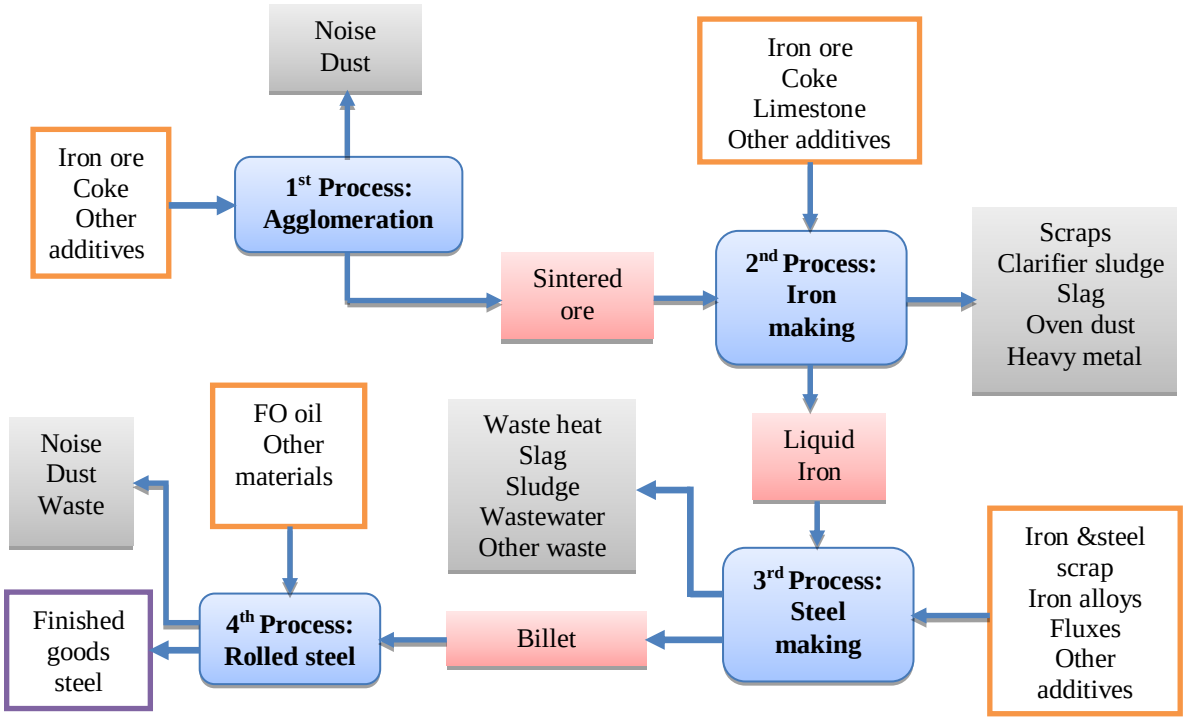


**Fig. 1 The Steel Manufacturing Processes in TISCO**

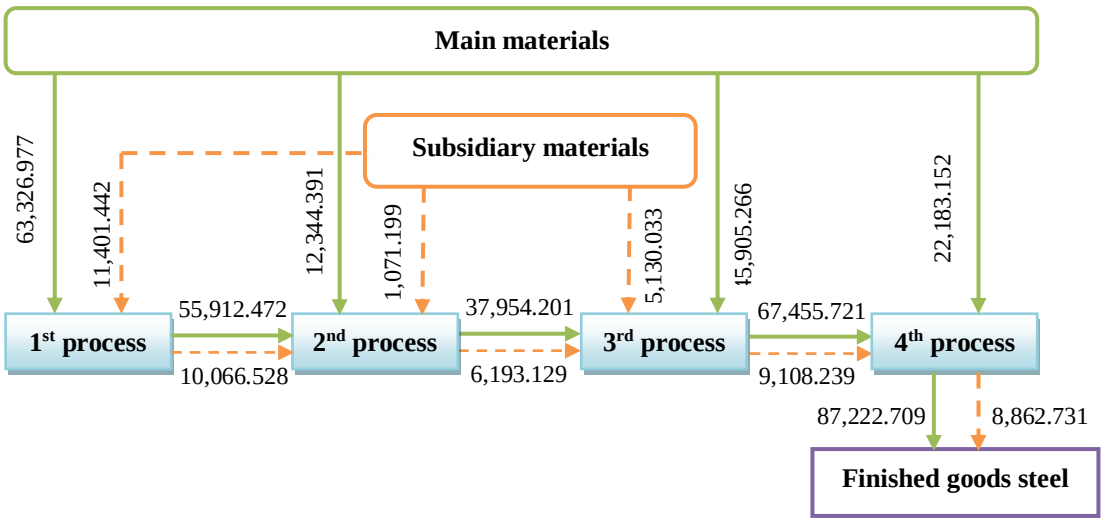


**Fig. 2 Material Flow in the Steel Manufacturing Process in TISCO (Unit: Tons)**

*(Source: Compiled by the author)*

Although, TISCO knows what the main input materials of the liquid iron manufacturing process are, and how many quantities of this product are produced from these inputs. But, it does not know how much material losses are generated in this process and does not. Typically, the figures for waste are only known for relative data.

Therefore, identifying the real losses of the production process is an important and very useful.

**Table 1. Material Flow Cost Accounting in the Liquid Iron Manufacturing Process (Unit: VND)**

| | 1st process | | 2nd process | |
|---|---|---|---|---|
| | **Input** | **Output** | **Input** | **Output** |
| MC | 50,293,678,731 | 50,293,678,731 | 85,425,961,718 | 83,967,185,453 |
| EC | 18,033,813,236 | 18,033,813,236 | 175,680,467,029 | 175,680,467,029 |
| SC | 0 | 0 | 21,133,382,746 | 21,133,382,746 |
| Waste (MC) | | 0 | | 1,458,776,266 |
| **Total** | **68,327,491,967** | **68,327,491,967** | **282,239,811,494** | **282,239,811,494** |
| | **3rd process** | | **4th process** | |
| | **Input** | **Output** | **Input** | **Output** |
| MC | 700,608,353,919 | 698,042,453,919 | 1,051,480,488,404 | 1,036,715,303,577 |
| EC | 61,315,090,109 | 61,315,090,109 | 30,645,885,147 | 30,645,885,147 |
| SC | 30,136,377,269 | 30,136,377,269 | 32,247,004,192 | 32,247,004,192 |
| Waste (MC) | | 2,565,900,000 | | 14,765,184,827 |
| **Total** | **792,059,821,297** | **792,059,821,297** | **1,114,373,377,743** | **1,114,373,377,743** |

*(Source: According to the author's calculations)*

### *B. Cost accounting in the Steel manufacturing process in TISCO: MFCA analysis*

MFCA is based on the concept of mass balance. It means MFCA traces all input materials that flow through production processes and measures products and material loss (waste) in physical units using the following equation (1):

Input = Products + Material loss (waste) (1) [1]

According to equation (1), MFCA analysis shows the balance of materials in the steel production process in TISCO as follows (more detail in Fig.3).

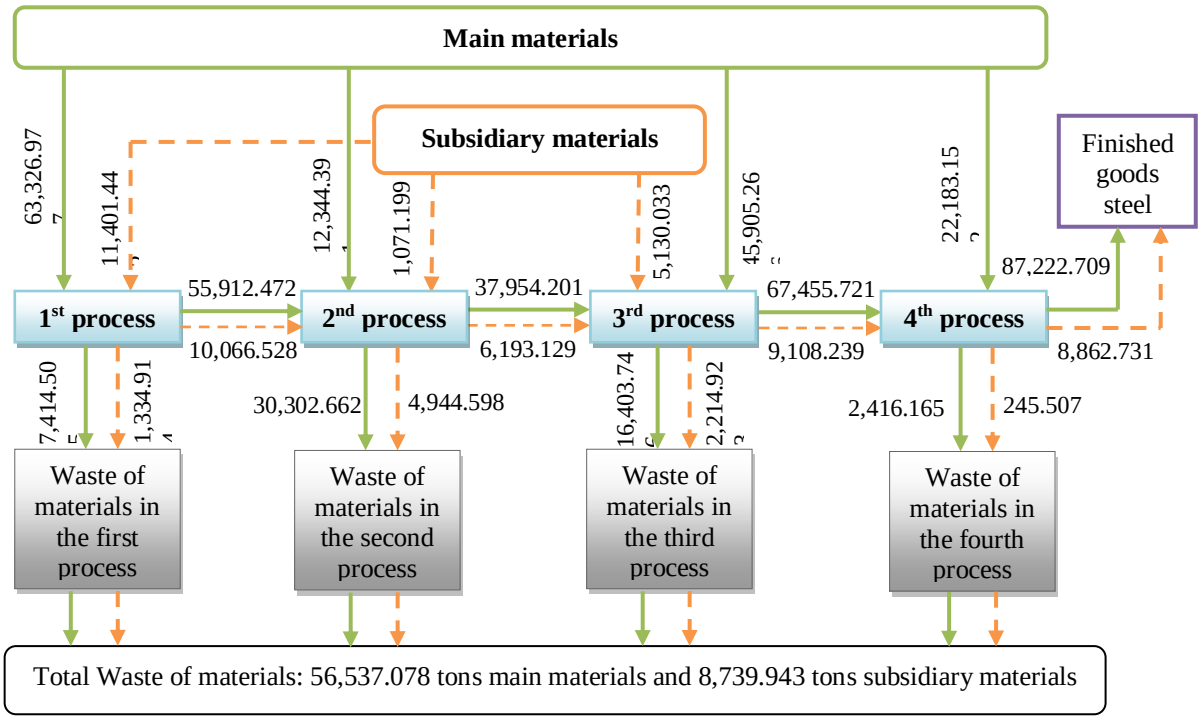


**Fig. 3 MFCA Analysis Results - The Mass Balance Of Each Process (Unit: Tons)**

*(Source: According to the author's calculations)*

MFCA analysis results in Fig.3 show that all processes along the production line generated waste with no storing materials at each process. Based on the equation to proposed in studying of Chompoonoot Kasemset et al.

(2016), the author performed an MFCA analysis at each stage of the steel production process. So, the results from MFCA analysis are presented in Table II and Table III.

All production costs in the steel production process in TISCO can be divided into two parts: the positive and negative ones (see more details in Table II). The results of MFCA analysis in Table III show that in the first stage of the production process, the total production costs of the positive part equal to 60,327,511,980 VND, in which MC is 44,405,149,653 VND (73.61%) and SC is 15,922,362,328 VND (26.39%). In the second stage, the total costs of the positive part are 158,592,177,730 VND, where MC, SC, and EC are 38,216,104,188 VND (24.1%), 108,417,819,654 VND (68.36%), and 11,958,253,889 VND (7.54%), respectively. Interestingly, the positive part' costs in the second stage only account for about 60% of the total production costs, which are the lowest in all stages to produce steel in TISCO. In the third stage, of the total 541,731,605,752 VND production costs of positive products, 68.65%, 25.12%, and 6.23% belong to MC, SC, and EC, respectively. The production costs of the positive part in the last stage are the highest and account for 96.94% of the total production costs of this period. MC, EC, and SC account for 73.15% (614,473,058,621 VND), 19.24% (161,625,811,692 VND), and 7.62% (63,976,008,283 VND), respectively.

**Table 1. Percentage used cost allocation from mass balance and MC of each process**

| Process | Unit | Positive material cost | Negative material cost |
|---|---|---|---|
| The first | Ton | 65,979 | 8,749.419 |
| | % | 88.29% | 11.71% |
| | VND | 44,405,149,653 | 5,888,529,078 |
| The second | Ton | 44,925.163 | 34,469.427 |
| | % | 56.58% | 43.42% |
| | VND | 38,216,104,188 | 26,743,770,969 |
| The third | Ton | 76,937.390 | 19,023.072 |
| | % | 80.18% | 19.82% |
| | VND | 371,896,469,963 | 91,952,864,533 |
| The fourth | Ton | 96,085.440 | 3,035.102 |
| | % | 96.94% | 3.06% |
| | VND | 614,473,058,621 | 19,409,688,613 |

*(Source: According to the author's calculations)*

**Table 2. MFCA Analysis (Unit: VND)**

| Cost item | | 1st process | 2nd process | 3rd process | 4th process |
|---|---|---|---|---|---|
| **New input cost** | Total | 68,327,491,967 | 217,368,575,279 | 517,084,697,687 | 324,879,166,609 |
| | MC | 50,293,678,731 | 20,554,725,504 | 425,633,230,309 | 261,986,277,270 |
| | SC | 18,033,813,236 | 175,680,467,029 | 61,315,090,109 | 30,645,885,147 |
| | EC | 0 | 21,133,382,746 | 30,136,377,269 | 32,247,004,192 |
| **Total cost handed over from previous process** | Total | 0 | 60,327,511,980 | 158,592,177,730 | 541,731,605,752 |
| | MC | 0 | 44,405,149,653 | 38,216,104,188 | 371,896,469,963 |
| | SC | 0 | 15,922,362,328 | 108,417,819,654 | 136,085,287,362 |
| | EC | 0 | 0 | 11,958,253,889 | 33,749,848,426 |
| **Total cost of the process** | Total | 68,327,491,967 | 277,696,087,260 | 675,676,875,417 | 866,610,772,361 |
| | MC | 50,293,678,731 | 64,959,875,156 | 463,849,334,497 | 633,882,747,233 |
| | SC | 18,033,813,236 | 191,602,829,357 | 169,732,909,763 | 166,731,172,509 |
| | EC | 0 | 21,133,382,746 | 42,094,631,158 | 65,996,852,618 |
| **Positive product cost** | Total | 60,327,511,980 | 158,592,177,730 | 541,731,605,752 | 840,074,878,596 |
| | MC | 44,405,149,653 | 38,216,104,188 | 371,896,469,963 | 614,473,058,621 |
| | SC | 15,922,362,328 | 108,417,819,654 | 136,085,287,362 | 161,625,811,692 |
| | EC | 0 | 11,958,253,889 | 33,749,848,426 | 63,976,008,283 |
| **Negative product cost** | Total | 7,999,979,987 | 119,103,909,529 | 133,945,269,666 | 26,535,893,765 |
| | MC | 5,888,529,078 | 26,743,770,969 | 91,952,864,533 | 19,409,688,613 |
| | SC | 2,111,450,908 | 83,185,009,703 | 33,647,622,401 | 5,105,360,817 |
| | EC | 0 | 9,139,097,312 | 8,292,295,731 | 1,773,413,653 |
| | WMC | 0 | 36,031,545 | 52,487,000 | 247,430,682 |

*(Source: According to the author's calculations)*

## V. CONCLUSION

The findings of the MFCA analysis provide some evidence of the disparity in product costs measured by traditional accounting and MFCA. Moreover, based on the findings of MFCA, the shortcomings in the conventional accounting of commodity costs and prices can be found. That is, a part of the material costs of the negative products is accounted for in the costs of the positive products. The fact that MFCA focuses on the actual allocation of the product costs into positive and negative products where the negative parts are considered economic losses. That helps TISCO managers identify and apply new solutions to save and to increase the performance in using inputs, minimize emission in the environment, and measure the accuracy and completing prices of positive products.

## ACKNOWLEDGMENT

This article was supported by Thai Nguyen University of Technology - TNU.

## REFERENCES

[1] Asean Productivity Organization, Manual on Material Flow Cost Accounting: ISO 14051, Hirakawa Kogyosha Co., Ltd., Japan, (2014).

[2] Chompoonoot Kasemset, Chavis Boonmee and Penpatchara Khuntaporn, Application of MFCA and ECRS in Waste Reduction: A Case Study of Electronic Parts Factory, Proceedings of the 2016 International Conference on Industrial Engineering and Operations Management Kuala Lumpur, Malaysia, March 8(10) (2016) 1844-1853.

[3] IFAC, International Guidance Document: Environmental Management Accounting, International Federation of Accountants, (2005).

[4] IMT, MFCA cases in Vietnam, APEC MFCA workshop in Malaysia – MFCA as a Key Environmental Performance Tool through Energy and Material Efficiencies, (2015).

[5] Jedsada Tipmontian, Ketinun Kittipongpittaya và Rajmohan Murugesan, Application of Material Flow Cost Accounting and system dynamics approach for waste reduction and sustainable food manufacturing development in Thailand, Proceedings of the 2016 International Conference on Industrial Engineering and Operations Management Kuala Lumpur, Malaysia, 8(10) (2016).

[6] JMETI, Environmental Management Accounting: MFCA Case Examples, Japanese Ministry of Economy, Trade, and Industry, (2010).

[7] Nguyen Thi Kim Huyen, Duong Huong Lam, Application of Material Flow Cost Accounting for the manufacturing process of liquid iron in Thai Nguyen Iron And Steel Joint Stock Corporation, ICECH2017 - International Conference on Emerging Challenges: Strategic Integration, Ha Noi, Vietnam, (2017) 170-176.

[8] Katsuhiko Kokubu, Hirotsugu Kitada, Conflicts and solutions between Material Flow Cost Accounting and conventional management thinking, A Paper Presented at the 6th Asia-Pacific Interdisciplinary Perspectives on Accounting Research (APIRA), Conference at University of Sydney on 12(13) (2010).

[9] Katsuhiko Kokubu and Hiroshi Tachikawa, Material Flow Cost Accounting: Significance and Practical Approach, Handbook of Sustainable Engineering (Springer, Dordrecht), (2013) 351-369.

[10] Thai Nguyen Iron and Steel Corporation, Final Accounts in Q3 (2019).

[11] USD, Environmental Management Accounting: Procedures and Principles, United Nations Division for Sustainable Development, New York, (2001).