International Journal of Business, Human and Social Sciences
ISSN: 2517-9411
Vol:9, No:11, 2015

MFCA: An Environmental Management Accounting Technique for Optimal Resource Efficiency in Production Processes

Omolola A. Tajelawi, Hari L. Garbharran

***Abstract*—**Revenue leakages are one of the major challenges manufacturers face in production processes, as most of the input materials that should emanate as products from the lines are lost as waste. Rather than generating income from material input which is meant to end-up as products, losses are further incurred as costs in order to manage waste generated. In addition, due to the lack of a clear view of the flow of resources on the lines from input to output stage, acquiring information on the true cost of waste generated have become a challenge. This has therefore given birth to the conceptualization and implementation of waste minimization strategies by several manufacturing industries. This paper reviews the principles and applications of three environmental management accounting tools namely Activity-based Costing (ABC), Life-Cycle Assessment (LCA) and Material Flow Cost Accounting (MFCA) in the manufacturing industry and their effectiveness in curbing revenue leakages. The paper unveils the strengths and limitations of each of the tools; beaming a searchlight on the tool that could allow for optimal resource utilization, transparency in production process as well as improved cost efficiency. Findings from this review reveal that MFCA may offer superior advantages with regards to the provision of more detailed information (both in physical and monetary terms) on the flow of material inputs throughout the production process compared to the other environmental accounting tools. This paper therefore makes a case for the adoption of MFCA as a viable technique for the identification and reduction of waste in production processes, and also for effective decision making by production managers, financial advisors and other relevant stakeholders.

***Keywords*—**MFCA, environmental management accounting, resource efficiency, waste reduction, revenue losses.

I. Introduction

MANUFACTURERS continuously seek opportunities to simultaneously generate financial benefits by reducing costs and adverse environmental impacts via material efficiency improvement [1]. It therefore becomes imperative that management tools strategically aligned to achieve this purpose are adopted. In a bid for more integrated approach to corporate economic and environmental approach, Environmental Management Accounting (EMA) tools such as Activity-Based Costing (ABC), Life-Cycle Assessment (LCA) and Material Flow Cost Accounting (MFCA) were developed.

O. A. Tajelawi is with the Department of Cost and Management Accounting, Faculty of Accounting and Informatics, Durban University of Technology, Durban, 4001, KwaZulu-Natal, South Africa (phone: +27 78 510 2696; e-mail: omolola.dele@ gmail.com).

H. L. Garbharran is with the Faculty of Accounting and Informatics, Durban University of Technology, Durban, 4001, KwaZulu-Natal, South Africa (phone: +27 82 267 3192; e-mail: garbharranhl@dut.ac.za).

II. Production Line Inefficiencies

One of the driving forces of waste is linked to the increase in production of goods [2]. Such increase when not efficiently managed has the potential to accommodate activities that choke the constant inflow of revenue on production lines. A financial leakage that gradually impacts the financial bottom line of organizations is usually the resultant effect. One of the major aims of manufacturing process is for material inputs to end up as products. Output that comes out as non-product is usually viewed as waste, and waste is costly to companies [3]. The quest to prevent production line losses prompted managers to seek cost efficient ways to prevent revenue losses [4].

Revenue leakage happens to be one of the major challenges manufacturers face in production processes, as most of the input materials that should emanate as products from the lines are lost as waste. Rather than generating income from material input which is meant to end-up as products, losses are further incurred as costs in order to manage waste generated. In addition, due to the lack of a clear view of the flow of resources on the lines from input to output stage, acquiring information on how resources are maximally utilized becomes a challenge.

III. Environmental Approach to Optimization

EMA is an accounting approach that gave rise to several accounting techniques, bridging the gap between environmental costs and costs associated with production, thereby providing the foundation that addresses the drawbacks associated with traditional accounting [5]. The EMA literature, have developed over the years. Due to the dynamic environment in which businesses operates, competition continuously increases and manufacturers constantly seek sustainable techniques that will reduce costs and improve efficiency [6]. Considering the notion that waste generation is regarded as a direct function of inefficient operations [2], most managers would be amazed if they knew the true cost of material wastes associated with their inefficient operations.

Fakoya [7] emphasized the ability of EMA in enabling managers to identify inefficiencies on the production lines in order to make waste-reduction decisions to enhance process and save costs that are lost as waste. Furthermore, EMA

generates and analyses financial and non-financial information to optimize corporate environmental and economic performance, thereby achieving sustainable business. It is evident from the above, that managers need access to waste information for strategic decisions on inefficient reductions. Jasch [3] however argues that decision makers rarely link environmental information to economic variables due to lack of cost information. This often leads to confusion because equations do not balance dimensionally. If one must use mixed units, one must clearly state the units for each quantity in an equation.

IV. The Need for a Waste Cost Information

The importance of cost factor cannot be over emphasized in manufacturing, considering that it is directly proportional to the financial performance and effectiveness of the company [8]. Besides, Drury [9] emphasize the need for accurate waste information in decision-making in order to distinguish between profitable and unprofitable activities. He argues that managers may be tempted to drop profitable products or continue the production of unprofitable products if the cost system does not capture accurately enough the consumption of resources reported product or service.

The responsibility therefore lies with the Management Accounting (MA) function to provide adequate and reliable waste information to improve resource efficiency in an organization, although accountants feel more comfortable dealing with readily quantifiable information and are rather reluctant towards environmental issues [2]. However, organizations must account for cost and benefits relating to environmental issues which include resource extraction and production consumption. Inaccurate information on material efficiency also incapacitates many companies to assess the cost of material loss from processes due to inefficient use [6]. Material efficiency was formerly regarded as normal practice until the industrial revolution [10].

The next section examines the review of the three EMA tools; ABC, LCA and MFCA mentioned previously.

V. Concept of ABC

As the name connotes, ABC is a cost accounting system that focus on the different activities performed in an organization [11]. This technique makes use of a multi-stage allocation process which consist of a multiple activity-based cost centres also known as cost pools. Overheads are assigned to the cost pools. The concept of ABC aims to prevent the cost distortion resulting from traditional costing where all indirect costs are combined into a single cost pool. In addition, ABC minimizes waste or non-value adding activities by providing a process view [11]. Illustrated in Fig. 1 is a representation of ABC. From the diagram, each cost activity is identified; categorized and overheads assigned to their respective cost centres, and also to the products. It can be noted that each activity cost is linked to the product, which gives a view of cost movement within the process. This is an effective way to monitor efficiency on production lines.

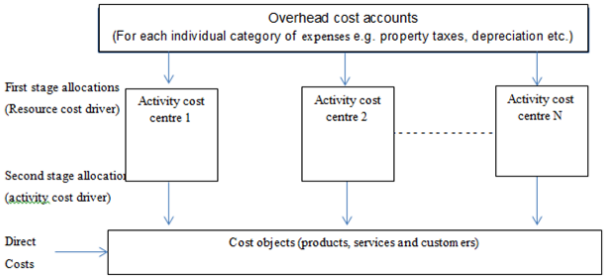

Fig. 1 Activity-Based Costing System

Drury [9] categorizes the ABC system into four steps:

- Identifying the activities
- Assigning costs to activity cost centres
- Selecting appropriate cost drivers for assigning the cost of activities to objects
- Assigning the cost of activities to products

Reference [9] argues that Activity Based Costing is motivated by a belief that traditional (general ledger) accounting information is all but useless to managers who are interested in evaluating the effectiveness of resource allocation decisions in their companies.

Other literatures addressed ABC as the costing method which focuses on attaching costs to products and services based on the activities conducted to produce, perform, distribute, or support those products and services [12]. Jasch [3] noted that ABC is the correct allocation of costs to processes and products, which reduces the amount of costs hidden in overhead cost categories. Hilsenrath et al. [13] supports with the view that ABC seeks to identify the best drivers of overhead costs for each product or process, and uses those drivers to allocate overhead costs to products.

A. Applications and Benefits of ABC

ABC has gained recognition and acceptance via the successful applications in both manufacturing and service industry. Cannavacciuolo et al. [14] applied ABC logic in an Orthopaedic Division of a University Hospital in Italy in identifying inefficiencies related to their diagnostic therapeutic pathways (DTP) and related reengineering interventions. Three benefits were derived from this application. ABC allowed the support cost containment process via highlighting the most cost consuming activities and resources. The ABC technique similarly allowed identifying the typology of reengineering interventions, distinguishing between incremental and radical ones through the comparison between the cost of a health and service and Diagnosis Related Groups (DRG) tariff. Lastly, ABC allowed the calculation of the cost absorbed by each activity of a DTP. Another successful application of ABC in a health care organization confirmed the use of ABC to get a better measurement of cost of health care [13]. The application of ABC model in a Slovenia paper manufacturing company to determine logistics costs also revealed the ability of the model to disclose more information on indirect logistics costs than the traditional approach adopted by the company. The information enabled better cost management and an effective measurement and assessment

logistics activities effects [15]. Tsai et al. [16] applied ABC in a Taiwan electrical industry to maximize company's profits and minimize environmental impact. These facts are an avenue to promote the effectiveness of ABC in providing accurate cost information that reveals points of revenue leakage in a company.

Mahal and Hossain [11] carried out reviews that examined the relationship between ABC and various recent issues. The issues highlighted benefits derived from the application of ABC. The technique has the ability to generate accounting information needed for Total Quality Management (TQM) to evaluate costs. Likewise, ABC can also help managers in supply chain management to improve the allocations of logistics costs to specific cost objects; including managerial implications and implementation techniques and a tool for pricing. The application of ABC using Activity-Based Management (ABM) approach in Strategic Cost Management can improve profits and operating performance. In addition, ABC has been applied to hospitals to improve efficiency, waste reduction, and better quality data for organizational analysis and pricing decisions. The author highlighted the potential of applying ABC in the academic institution for categorizing costs to different activities in the university and allocating these costs based on time spent on each activity. The authors concluded that ABC has positioned itself as a new generation concept trade and commerce, which measures more accurately than other volume based cost system. ABC is used as performance evaluation tool. It may then be deduced from the review that, ABC can measure efficiency via costs associated to the activities in each cost centre.

Most organizations that have adopted ABC have benefited from its adoption. Jasch [3] points out that ABC enhances the understanding of the business processes associated with each product, revealing where value is added and where value is destroyed. Adding that, the ABC approach has the ability to improve economic performance as a result of improved environmental protection.

B. Areas of Concern

Despite the successful application of ABC, certain concerns were raised that may inhibit its full application. Cannavacciuolo et al. [14] revealed a lack of an integrated information system which hindered the collection of some accounting data resulting in insufficient detailed information.

Jasch [3] argues that production lines and products, which used to be profitable, may suddenly perform poorly. Therefore, the responsible line managers will tend to refuse the change, if they don't have the means to improve the situation.

VI. Life-Cycle Assessment (LCA)

LCA is an analytical tool that evaluates the environmental impact caused by products or processes/services throughout their entire life cycle by calculating the impacts of using resources and releasing pollutant species into the environment, mainly based on cause-effect relationships [17].

A. Applications and Benefits of LCA

A number of studies have adopted the use of LCA to address environmental issues. Comandaru et al. [17] used LCA to account for the impacts of water consumption and discharge of wastewater flows to subsequent or downstream water uses. Cleary [18] adopted LCA to evaluate the potential net environmental impacts that could result from these means of reducing the residential waste associated with wine and spirit packaging. Ferreira et al. [19] used LCA to analyze the packaging waste management system in Belgium in order to evaluate the sustainability of the recycling scheme.

B. Areas of Concern

Sygulla et al. [20] argued that, although LCA aims at revealing the life cycle-related impacts of products and services on the natural environment, which is ecologically intended to support the reducing of environmental damages. Conversely, they do not make clear contributions to cost savings or corporate profits. In essence, the tool majorly measures the environmental implications of the life cycle of a product. Cleary [18] concluded that, although LCAs can be used to estimate the potential net environmental gains from package substitutions, they can be misleading if one's interpretation and extrapolation of the results lack an appropriate context.

VII. Material Flow Cost Accounting (MFCA)

MFCA is an EMA tool which has gained popularity for its ability to provide accurate waste information for internal decision making. The origin of Flow Cost Accounting (FCA) can be traced to Augsburg in Germany where it was developed by Bernd Wagner and colleagues at the Institute für Management und Umwelt (IMU). The modified version of FCA, now MFCA has been promoted and adopted in Japan since 2000 after the Japanese Ministry of Economy, Trade and Industry (METI) discovered the potential of its optimal use in manufacturing [1]. While the German version tends towards a facility wide management, the Japanese version focuses primarily on product lines or processes. Due to the ability of MFCA to quantify and provide a visual representation of material losses in a process; it became possible for management's decision to focus more on material losses over other losses such as energy, water, which attributed to its frequent use in the Japanese manufacturing and process industry as opposed to the number of use recorded in Germany [21].

Material flow cost accounting is one of the most fundamental and well-shaped tools of environmental management for quantifying the flows and stocks of materials in processes or production lines in both physical and monetary units [22]. MFCA was developed primarily to evaluate material flows within individual organizations, the purpose being to support eco-efficient decisions that enhance resource efficiency and simultaneously improve the economic and environmental performance of the entity [22]. MFCA is regarded as a cost collector by the German Federal

Environmental Ministry and Federal environmental Agency [3].

A. Working Principles of MFCA

The principle of MFCA builds on the core idea of eco-efficiency, while linking physical and monetary information in one accounting concept. The principal concept of MFCA is based on inputs (materials, energy, water and other inputs and outputs (primary products/byproducts, wastes, wastewaters, emission), determined within a quantity centre, with calculations carried out in respect of material, energy and system costs incurred for products and material losses . MFCA therefore relies on the physical input information within each quantity centre within the production process to produce a resultant cost effect.

Although MFCA was developed to integrate economic and environmental activities, its characteristics give it the ability to isolate a process in order to identify financial leakages and generate cost information thereof. The principles of MFCA have been applied both in isolation and in conjunction with other models and techniques such as Enterprise Resource Planning (ERP); Design of Experiment (DOE) etc.

According to [23], the principal concept of MFCA are any and all inputs (materials, energy, water and other inputs) and outputs (primary/ by-products, wastes, waste water, emissions) determined within a quantity centre, and calculation is carried out in respect of material, energy, and system costs incurred for products and material losses. Christ and Burritt [22] stated that MFCA is underpinned by the premise that all materials purchased by an organization must eventually leave as either product or waste (non-product). Since its inception in the nineties, MFCA has gradually gained popularity and acceptance by industries and researchers, especially in Germany where it originated. Moreover, the basic concept of MFCA was first introduced to Japan around the turn of the century, and both German and Japanese industries have laid the foundation for its development and diffusion [21].

Fakoya [7] highlighted that the essential focal point of MFCA is the recognition of waste as a non-marketable product. He further outlined that managers may need to analyze process output into marketable and non-marketable product to enhance waste reduction decisions in terms of value and physical, which, in turn, positively increases the organization's environmental performance. Fakoya further enlightened that the availability of precise waste data is a motivating factor for managers towards waste reduction rather than relying on conventional and cost accounting information. One of the salient features of MFCA is its ability to accurately capture waste cost information beyond that provided by conventional accounting systems [4]. Although MFCA has been subjected to research and has been applied in various pilot companies, no rapid adoption has been documented to date [21]. This study, therefore, aims to harness the benefits of MFCA technique for costing packaging waste and its relationship with respect to efficiency.

B. Applications of MFCA

MFCA has been applied in different manufacturing industries for achieving energy and resource efficiency. Viere et al. [24] discovered in a study conducted from the textile industries that MFCA gives a better understanding of cost drivers of material and energy usage, and provides new and precise information on inefficiency- related costs and product-specific costs' differences.

SWU Spinnweberei Uhingen Textil GmbH is a textile industry in Germany that adopted MFCA in two production sites to calculate the material and energy flow-based costs of short fibres [24]. MFCA was used to calculate material and energy flow-based costs of short fibers and then used to confront the sales revenue of its remnants. Cotton was passed from the warehouse through to the combing stage, passing through several steps; from the quantity-based and cost-based evaluation. Each production step was reported to consume energy and auxiliaries and generate waste that gave rise to disposal costs. MFCA also revealed that an inclusion of depreciation cost and labor cost will further increase the production costs [24].

Fakoya and van der Poll [4] conducted a study in the alcoholic beverage industry in which MFCA was integrated with the Enterprise Resource Planning (ERP) system to generate waste-cost information for decision making. The study concluded that integrating the ERP and MFCA systems help to speed up the availability of waste information both in quantity and costs for quicker waste management decision making. Fakoya [7] stressed that manufacturing and other industries, such as the brewery industry, are usually based on established standard costs to which actual costs are compared hereafter the resulting cost variance is analyzed and addressed.

Trappey et al. [25] reviewed two successful MFCA cases in electric power plants, i.e., Kansai Electric Power (KEP) and Tokyo Electric Power (TEP). The application of MFCA to KEP's new technology of power generation allowed KEP's outputs of negative products and waste is made transparent to the public. Also, TEP's application of MFCA to its nuclear power generation aided in the disclosure of both internal and external wastes, thereby making it transparent to the public. In addition, the output data provides information of the plant's power consumption, power transmissions and water pumps, and quantities of other wastes.

The study conducted by [25] at Innolux Corporation, an optoelectronic industry, via the adoption of MFCA in four factories located in China, revealed that the adoption of MFCA minimized negative environmental impacts and reduced its material costs. Hyršlová et al. [23] also carried out a study on a ceramic tiling plant in the Czech Republic using MFCA described stages from input (pulverization and homogenization of inputs) to output in the manufacturing process of interior ceramic tiles design. The stages where material losses mostly occur during manufacturing and where management should focus were highlighted. The different stages in the manufacturing process include grinding, drying, pressing, glazing, burning, sorting and packaging; the production process was monitored in m^2 and tons [23]. The

entire manufacturing process was segmented into three cost centres within the existing management accounting system which includes preparation of materials, preparation of glazes and manufacturing. Based on the MFCA calculation, the preparation of material quantity centre is proposed as the process to focus on as the process produces the majority of the material losses [23].

C. Benefits of MFCA

The success stories that have been recorded via the application of material flow cost accounting reveal its transparent and analytical abilities to positively influence management's decisions. The transparency exposes the material and monetary losses encountered on the lines, while the analysis is an eye-opener on inefficiencies in the process that leads to losses. Ultimately, MFCA provides optimization on the lines rather than at the output stage. Some other benefits of MFCA from different studies report that MFCA delivers both increased profits and material utilization, that is, it enables organizations to manufacture the same amount of finished products with less input [25]. Other advantages of applying the MFCA technique is to convert production losses to monetary terms to encourage managers to be aware of these losses and also reduce negative products as related by [26].

According to [3], the benefits of MFCA are:

- Cost-reduction and environmental impact reduction as a result of improved material and energy efficiency (i.e., reduced residual waste and reduced use of materials per product);
- Incentives to develop new products, technologies and procedures;
- Enhanced quality and consistency of corporate information systems, linking physical and monetary data;
- Improvement of organizational structures and procedures as a result of consistent referencing to the material flow system;
- Inter-departmental, material-flow-related communication and coordination instead of separation into divisions, departments, and cost centres with separate responsibilities;
- Increased motivation in staff and management regarding the comprehensive structuring of material flows;
- Focus on raising material and energy productivity instead of reducing the workforce.

VIII. Conclusion

An extensive review of the principles and applications of ABC, LCA, and MFCA has been presented. Also showcased, are the different ways the three techniques attempted to reduce cost of manufacturing waste via revenue leakage, and improve efficiency. MFCA has been found to provide better waste information to enable managers make informed waste management decisions thereby reducing revenue leakage and boosting efficiency on production lines. Although ABC proved to provide information lacking in the traditional cost accounting technique, it lacks continuity in the event of any changes made to the process. Furthermore, LCA is limited in terms of information flow. MFCA's loss concept gives the technique an edge over others, and manufacturers can adopt the tool to curb revenue leakage on production line.

References

[1] K. Kokubu, H. Kitada, and J. Mouritsen, "Material Flow Cost Accounting and Conventional Management Thinking: Introducing A New Environmental Management Accounting Tool Into Companies," in Interdisciplinary Perspectives on Accounting Conference, Cardiff, 2012.

[2] M. B. Fakoya, "Integrated Waste Management Decisions in South Africa: The Role of the Management Accounting Function," J Hum Ecol, vol. 43, pp. 249-255, 2013.

[3] C. Jasch, Environmental and Material Flow Cost Accounting. Vienna: Springer Science, 2009.

[4] M. B. Fakoya and H. M. van der Poll, "Integrating ERP and MFCA systems for improved waste-reduction decisions in a brewery in South Africa," Journal of Cleaner Production, vol. 40, pp. 136-140, 2// 2013.

[5] C. Herrmann, C. Schmidt, D. Kurle, S. Blume, and S. Thiede, "Sustainability in Manufacturing and Factories of the Future," nternational Journal of Precision Engineering and Manufacturing-Green Technology, vol. 1, pp. 283-292, 2014.

[6] K. Schliephake, G. Stevens, and S. Clay, "Making resources work more efficiently – the importance of supply chain partnerships," Journal of Cleaner Production, vol. 17, pp. 1257-1263, 9// 2009.

[7] M. B. Fakoya, "An adjusted material flow cost accounting framework for process waste-reduction decisions in the South African Brewery industry," PhD Commerce Online, University of South Africa, 2014.

[8] J. S. Dai, S. Balabani, and L. Seneviratne, "Product cost estimation: technique classification and methodology eview," Journal of manufacturing science and engineering, vol. 128, p. 563, 2006.

[9] C. Drury, Management and Cost Accounting, 7th ed. Hampshire, United Kingdom: Pat Bond, 2011.

[10] J. M. Allwood, M. F. Ashby, T. G. Gutowski, and E. Worrell, "Material efficiency: a white paper," Resources, Conservation and Recycling, vol. 55, pp. 362-381, 2011.

[11] . Mahal and M. A. Hossain, "Activity-Based Costing ABC)–An Effective Tool for Better Management," Research Journal of Finance and Accounting, vol. 6, pp. 66-73, 2015.

[12] J. T. Barfield, C. A. Raiborn, and M. R. Kinney, Cost Accounting: Traditions and Innovations, 5th ed. United States of America: Thomson Learning, 2003.

[13] P. Hilsenrath, C. Eakin, and K. Fischer, "Price-Transparency and Cost Accounting Challenges for Health Care Organizations in the Consumer-Driven Era," INQUIRY: The Journal of Health Care Organization, Provision, and Financing, vol. 52, p. 0046958015574981, 2015.

[14] L. Cannavacciuolo, M. Illario, A. Ippolito, and C. Ponsiglione, "An activity-based costing approach for detecting inefficiencies of healthcare processes," Business Process Management Journal, vol. 21, pp. 55-79, 2015.

[15] J. Krajnc, K. Logožar, and B. Korošec, "Activity-based management of logistic costs in a manufacturing company: a case of increased visibility of logistics costs in a Slovenian paper manufacturing company," PROMET-Traffic&Transportation, vol. 24, pp. 15-24, 2012.

[16] W.-H. Tsai, T.-S. Tsaur, Y.-W. Chou, J.-Y. Liu, J.-L. Hsu, and C.-L. Hsieh, "Integrating the activity-based costing system and life-cycle assessment into green decision-making," International Journal of Production Research, vol. 53, pp. 451-465, 2015.

[17] M. Comandaru, G. Bârjoveanu, N. Peiu, S.-A. Ene, and C. Teodosiu, "Life cycle assessment of wine: focus on water use mpact assessment," Environmental Engineering and Management Journal, vol. 11, pp. 533-543, 2012.

[18] J. Cleary, "Life cycle assessments of wine and spirit packaging at the product and the municipal scale: a Toronto, Canada case study," Journal of Cleaner Production, vol. 44, pp. 143-151, 4// 2013.

[19] S. Ferreira, M. Cabral, S. De Jaeger, N. F. Da Cruz, P. Simões, and R. Marques, "Life cycle assessment and valuation of the packaging waste recycling system in Belgium," Journal of Material Cycles and Waste Management, pp. 1-11, 2015.

[20] R. Sygulla, A. Bierer, and U. Götze, "Material Flow Cost Accounting–Proposals for Improving the Evaluation of Monetary Effects of Resource Saving Process Designs," in Beitrag zur 44th CIRP international conference on manufacturing systems, 2011.

[21] S. Schaltegger and D. Zvezdov, "Expanding material flow cost accounting. Framework, review and potentials," Journal of Cleaner Production, 2014.
[22] K. L. Christ and R. L. Burritt, "Material flow cost accounting: a review and agenda for future research," Journal of Cleaner Production, 2014.
[23] J. Hyršlová, J. Palásek, and M. Vágner, "Material flow cost accounting (Mfca)–tool for the optimization of corporate production processes," Business, Management and Education, pp. 5-18, 2011.
[24] T. Viere, M. Stock, and A. Genest, "How to achieve energy and resource efficiency: Material and energy flow modeling and costing for a small and medium-sized company," in Energy Related Balancing and Evaluation in Production Engineering-Methods and Examples, Technical University of Chemnitz, Auerbach, 2013, pp. 451-467.
[25] A.J. Trappey, M. F. Yeh, S. C.-Y. Wu, and A. Y. Kuo, "ISO14051-based Material Flow Cost Accounting system ramework for collaborative green manufacturing," in Computer Supported Cooperative Work in Design CSCWD), 2013 IEEE 17th International Conference on, 2013, pp. 639-644.
[26] C.Kasemset, S. Sasiopars, and S. Suwiphat, "The Application of MFCA Analysis in Process Improvement: A Case Study of Plastics Packaging Factory in Thailand," in Proceedings of the Institute of Industrial Engineers Asian Conference 2013, 2013, pp. 353-361.