A REVIEW ON OPTIMISTIC IMPACT OF CLEANER PRODUCTION ON MANUFACTURING SUSTAINABILITY

Yusup, M.Z.[2], Wan Mahmood, W.H.[1], Salleh, M.R.[1], and Tukimin, R.[1]

[1]Sustainable and Responsive Manufacturing Group,
Faculty of Manufacturing Engineering,
Universiti Teknikal Malaysia Melaka, 76100 Durian Tunggal, Melaka, Malaysia

[2]Kolej Kemahiran Tinggi MARA Kuantan,
KM8, Jalan Gambang, 25150 Kuantan, Pahang, Malaysia

Email: dzaki_78@yahoo.com

ABSTRACT: As a continuous application of an integrated environmental strategy, Cleaner Production (CP) is seen to have a substantial impact in establishing a sustainable manufacturing system. Thus, this paper explores and discusses intensively the impacts and benefits gains from the CP implementation that influences the sustainability development. The findings show that CP have optimistic impact on manufacturing competency, environment and economics performance which considered most significant influence on sustainability. Besides, economic performance was identified as an ultimate goal in manufacturing sustainability that can be enhanced significantly by competency and environmental performance. This paper provides the correct translational process of CP in order to achieve high level of sustainable manufacturing practice included the specific characteristics of performances. It can be referred as a guideline for manufacturing firms to define and measure performance based on CP implementation.

KEYWORDS: *Cleaner production, Manufacturing sustainability, Performance measures, Review analysis.*

1.0 INTRODUCTION

Cleaner Production (CP) was known as a preferred strategy in achieving an efficient use of natural resources and pollution prevention. From the perspective of thinking, CP can be well-defined as the use of key concepts in the overall prevention, eco-efficiency, environmental strategies, full life cycle and etc. [1]. As an integrated management strategies and preventive environmental approach, implementation of CP has successfully providing the promising benefits with a wide range of implication to the manufacturing firms, employees and environment [2]. Proper CP practices by manufacturing firms will produce the economic and environmental benefits, and basis for the realization of circular economy [3, 4]. CP can be expanded and applied as an idea for process improvement and can be integrated in any processes for better environmental performances [5].

Today, most manufacturing firms have made a significant effort in the implementation of CP. Nevertheless, different types of efforts on CP will provide different implication. Result from the implementation of CP can served as the basis for improving the performance or efficiency [6]. The increasingly cost of environmental, operations, market, regulatory, voluntary initiatives and international standards was an important measures for the implementation of CP. However, some manufacturing firms are still reluctant to take more aggressive and proactive actions towards CP due to perceived lack of evidence that the impact of CP exceed the costs required in implementing this strategy [7].

As a set of management and analytic processes that allows the management to improve their environmental performance, this paper brings form an exploratory discussion based on the literature that focuses on the impact from CP implementation. This was intended to provide an overview on the impact and benefit offered from the implementation of CP practice. The organizations of the paper are as follows. Section 2 explained about the methodology. Section 3 provides the literature reviews on the impact and benefits of CP on manufacturing sustainability and conclusion in Section 4. Some suggestions for future works were described at the end of the paper.

II. METHODOLOGY

This study begins with the selection of review topic, searching and analyzing the literatures. Focus area, analytical methods, framework, findings, factors and limitations from the implementation of CP strategies in various industries was the main focus in this systematic qualitative literature reviews. Its primary used to provide a comprehensive background and highlight the importance information required [8]. Basic body of literature that focus on the implementation of CP was used to summarize the existing research by identifying the related issues [9]. Selected publications of the existing research in the review process are from 1999 – 2013.

This study was based on two main focuses. The first parts were focus on identifying the key elements that provide the major impact on the implementation of CP. Literatures shows that CP practice was the key element in manufacturing sustainability [2, 3, 10]. Thus, rigorous method to synthesize on existing research to the related topic was performed to ensure each criteria that being discuss was accurate and unbiased [11].

In the second part, each criterion has been explored in details. Several positive impacts from the implementation of CP are identified. The information was then serve as a body of knowledge in assessing and identifying the benefit obtained from the implementation of CP on each key elements identified in the early stage [12]. Next, each benefit identified was grouped based on related key elements and comprehensively explored and discussed. Revision on the classification categories was carried out if the elements are not clearly classified based on the major contribution and influence of CP on sustainable manufacturing. A sequential step in this study was illustrated in Figure 1.

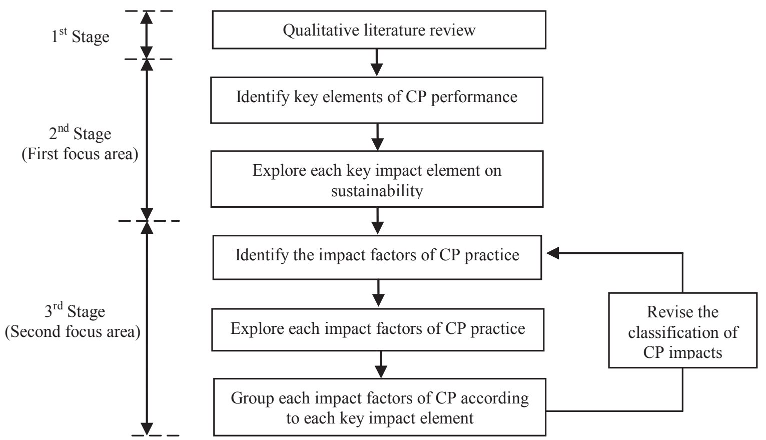

Fig. 1. Methodology of the study.

III. IMPACT OF CLEANER PRODUCTION

Implementation of CP has successfully providing the promising effects to the manufacturing firms. The appropriate implementation of CP will influences the economic, environmental and manufacturing competency and provide as a basis practice of the circular economy [3, 4]. Through the proactive action, manufacturing firms could create additional business opportunities to establish the new way to manufacture the product for the sustainable development [13]. In new sustainable manufacturing paradigm, CP can be fairly implement at the beginning stage of product development [14]. Literature shows that the implementation of CP can offer three main impacts on the sustainability development as follows:

- Impact on competency performance
- Impact on environmental performance
- Impact on economy performance

These performance elements were the basis in providing a sustainable manufacturing system where the performance level identified influence by the successful implementation of CP. The relationships between CP practices with the three performance elements identified are illustrated in Figure 2.

The implementation of CP through the meticulous strategy provides a direct impact on the level of environmental and competency performance, thus contribute to the improvement in economic performance as illustrated in Figure 2. Factors that mostly influence the competency performance are from the strict enforcement of laws and the increasing global awareness on environmental. This has urged manufacturing firms to take a proactive action to address any issues arising from their operations activities. Proper translational process towards CP primarily through successful innovation process will enhance this performance level, particularly through the development of environmentally friendly products. This further motivated the manufacturing firm to provide the best facilities and production system to meet the critical elements in product development and production stage [15]. Integration of employees in this process will urge them to increase their knowledge and skills in ensuring the innovation processes are fully achieved. This will provide a better product design, better process optimization, better monitoring, better training and management in achieving sustainable manufacturing practices [16, 17].

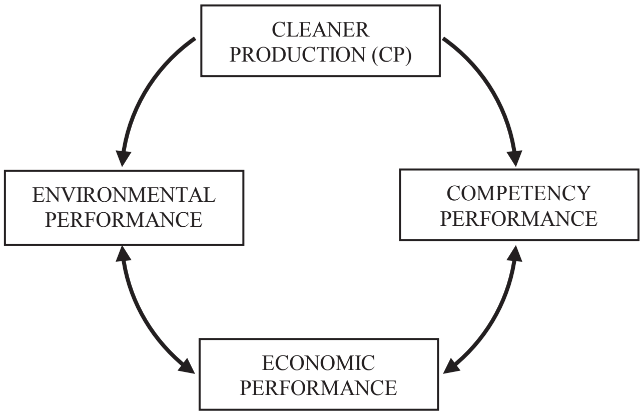

Fig. 2. The impact of CP on sustainability performance.

Meanwhile, the increasing of environmental performance was mainly affected from the worthy practice in managing the environmental issues. Integration of each environmental requirements and laws in every stage of product development and production will lead to a new paradigm of sustainable manufacturing [14]. Efficient use of recycled materials in material composition of products and selection of appropriate manufacturing system will reduce the consumption of natural resources and energy. This will ensure waste and pollution generated from the manufacturing activities will be minimized. Attain the higher level of energy and resource management will improve the environmental performance continuously from a proper establishment of manufacturing process standard [13].

High performance in both environmental and competency elements will directly influence the level of economics performance. Reduction of material use in production and careful planning in the selection of efficient technology and equipment will reduce the total investment cost. Reduction in raw material, energy costs and waste disposal costs will provide a beneficial economic impact to the manufacturing firm [18]. Trade-off between sustainability cost and technology of proper CP practice will benefit to the economic growth [19]. Manufacturing firms with good financial performance will have ability to provide additional budget and make additional investments in equipment, technology and provide more training to enhance the skills of their employees with new approach in dealing with environmental legislation requirement. The worthy level of economic will become the main input in improving the environmental and competency performance of the manufacturing firm.

The next section will intensively explore and discuss in more details on each performance elements stated that could be derived from the implementation of CP. The discussion will reveal how CP can provide beneficial impact while providing a sustainable manufacturing practice to the manufacturing firms.

A. Environmental Performances

Sustainable manufacturing in the economic, social and environmental have an important role in modern manufacturing model where environmental performance become the precedence in the manufacturing sustainable paradigm [13, 19, 20, 21, 22, 23]. Manufacturing firms are more competitive when they have high capacity of innovation and able to continually demonstrate the culture of continuous improvement. This will bring a better environmental sustainability performance effect, thereby enhance the performance of the environmental management system [24].

Through the development of strategies, policies, objectives and targets, outcome measure of responsibility for the environmental issues of an entity can be implemented [25]. Adoption of environment friendly as a rational decision making strategy, environmental awareness is seen increasingly as an important issue in business at present [26]. Thrane et al. [27] stated that a significant environmental improvement can be obtained through this strategy. Simple solution requires only a small investment, especially through the efficient use of resources. Sustainable implementation of CP needs a good support from environmental management systems, that allows the manufacturing firms to obtain a significant environmental performances [1, 28],. For the example, Hicks and Dietmar [3] in their analysis on the environmental oriented cost management (EoCM) found that CP potentially have a significant contribution for sustainable development. Their study revealed that CP has successfully reduce water consumption at average of 15.5 %, waste gas at average at 21.2 % and solid waste at average of 25 % in electroplating, dyeing, chemicals and pharmaceuticals industry. This implies that CP can offer a method to improve the operational efficiency thus increase the environmental performances.

Recyclability was the key component in waste reduction approach. The increasing use of recycle materials and components in products composition should be considered by manufacturing firms. The increased of recycle material consumptions relief in reducing the usage of new resources [19]. Through recyclability, manufacturing firms able to change the material (waste) into new product in order to prevent waste of potentially useful material or reduce the usage of raw material and natural resources. Paper, metal, plastic, textile, electronics components and so on are some of the material that can be process and transformed into new components. For the example, used of office paper that can be process over again and transformed into new office paper. Recyclability was proven to influence the sustainability of environmental performance where the recycle material will be reuse in future production manufacturing [20, 29, 30, 31, 32, 33, 34]. As a complex system engineering, CP has inspired manufacturing firms to implement recycling process and realization of this objectives. The waste (useful material) from the production of products or processes will permit the manufacturing firms to reduce the cost of material and resources.

Nosrat et al. [35] found that the use of recycle glass in glass and large scale solar photovoltaic manufacturing can lower the consumption of raw material. This has reduced the release of carbon dioxide (CO2) that created form the reaction of the raw material processes. The lower temperature of the recycle glass has increase the life of furnace up to 30%, while the reduction of the energy in melting stage lead to the cost reduction that associated with the emission of nitrogen monoxide (NOx) and sulphur dioxide (SO2). Gombault and Versteege [36] found that internal recycling has increased by 5% in plastic and rubber processing from the implementation of CP.

Improvement from CP practices has increase the reuse of waste at 46% and lead to lower the disposal cost, reduction of water usage, raw material and energy in small and medium size business sector [37]. In concrete production, the dynamic recycling of water and air found effectively reduce the energy consumption and create the production more clean and environment friendly [33]. These shows that the increasing rate of recyclability practice can minimize the environment impact thus allow the manufacturing firm to transform their pattern of manufacturing in the new modern manufacturing organization especially at the operational level [7, 19]. The maximum reuse of components and recycle material was identified as one of the characteristics and elements of sustainable production system [29, 30]. Recycling process was recognized can bring a radical improvement to the manufacturing firms, thus increase the level of environmental performance [27].

Literature shows that CP could be implemented in a variety of situations and approaches. Nosrat et al. [35] found that manufacturers of glass and large scale solar photovoltaic manage to reduce the energy required during the melting stage in their process. This was resulted from the efficient use of equipment in their process [38]. Dobes [39] found that good practice of CP strategies can bring significant impact on energy consumption and overall costs saving. At the printed circuit board manufacturer, CP practices such as the accumulation of cold water in sprinkler tank, replacement of steam humidifiers, improvement on photovoltaic power panel, speed control of heating, ventilating and air conditioning (HVAC) unit, replacement fluorescent tubes in workshop and switching off production equipment during non-operating hours has led to the reduction of energy. As a result, they manage to reduce 10% of the total energy and 14% savings on the overall energy bills. Meanwhile, at the manufacturer and supplier of refractory products, CP implementation actions such as replacement of pressure regulators on the compressors, reducing the pressure in reservoir from 8.5 bar to 7 bar, replace defective safety valves, reduce use of compressed air for clothing or trolley, clean and repair each leak detected and blocking of individual branches of the dust separator when the mixer was not running bring the reduction of 9% of the total energy costs.

In addition, the implementation of dynamic recycling of water and air used in concrete production proves that the effective implementation of CP can effectively reduce the energy consumption and make the production clean and environmentally friendly [33]. The efficient use of technologies in small to medium size business has reduce the usage of the energy by 23% [37]. Huang et al. [10] found that the energy consumption was reduced by 22.33% in medium scale ceramic tiles manufacturers when they focus on the energy conservation in their process. Foreign direct investment (FDI) of manufacturing sector shows that the export of products and manufacturer FDI to energy consumption correlated above 70%, manufacturer output and energy consumption correlated up to 95.46 % and manufacturer FDI and energy consumption correlated at 80% [40]. This proves that the application of CP was the most important procedure to effective manage the manufacturing costs, thus promote the energy conservation and reduction. Application of CP in key procedure and process management will effectively reduce the energy consumption and improve the level of environmental management performance. Energy consumption was one of the key sustainability issues. Prompt attentions are needed to respond at this situation. Literatures have verified that CP strategies can offer the best practices to obtain the greatest reduction of energy consumption.

Reduction of the pollutants emission of substances in production could reduce the impact on the environment throughout its life cycle [41].

Literature shows that the selection of CP strategy can be beneficial in addressing this issue where the controlling and monitoring of the pollution emission of substances and whole process was the essence of CP in order to achieve economic, social and environmental benefits. This can be implemented in a comprehensive manner by using the environmental technologies such as pollution control technologies, prevention technologies and management system [42]. For example, the implementation of CP strategy such as recyclability in glass industry and large scale production of solar photovoltaic manage to reduce the emission rate of carbon dioxide (CO2), nitrogen monoxide (NOx) and sulphur dioxide (SO2) that generated from the chemical reaction during the processing of raw materials [35]. Ability to implement this approach indirectly reduces the costs associated with emission pollution management and leads to the efficiency of improvements [10, 43].

Gombault and Versteege [36] found that the manufacturing firm faced the issue of general solid waste by 26%, rubber plastic waste (23%) and 5% of hazardous waste in plastic and rubber processing area. Based on CP strategies, several preventive techniques could be implemented such as internal reuse of material, change of raw material, adoption of process and good housekeeping to address this issue. Hicks and Dietmar [3] indicate that the implementation of CP permit manufacturing firms to reduce waste gases by an average of 21.2% and average of 25% of solid waste in electroplating, dyeing, chemical and pharmaceuticals in their study in Zhejiang Province, China. This not only reduces amount of waste generated, but also contribute to the total saving approximately 5 % of the total production cost. This proves that implementation of CP not only relief in reducing the waste produced, but also provide economic benefits and hence improve the environmental performance. In other areas, Kist et al. [44] found major issue with waste water management that lead to major environmental problems in the poultry slaughterhouse . Environmental problems such as the production of unpleasant odours, heat and noise emissions, contamination of receiving body, reduction and loss of local fauna and increase in waste water treatment cost are caused by poor waste water management practices. Through CP measures, the negative impact have been minimized through dry removal of residues from trucks, floor and equipment, standardized the cleaning procedures, use automated water management, enlargement of bleeding trough and tunnel to maximize amount of blood collected and adoption of environmental management policy. This will allows water consumption to be reduced by 13%, and indirectly reduce waste of water.

These example shows that CP can bring an optimistic impact in reducing the amount of waste produced. The prevention strategies can reduce the effects of processing and production of products to the environment [42]. Waste minimization, reprocessing of waste and materials recovery was also part of the sustainability elements in sustainable manufacturing systems [20, 45, 46, 47]. The right implementation of CP was the basis for the realization of circular economy, maintain the momentum for improvement and contribute to the selection of new manufacturing system practices [27, 48].

B. Competency Performances

Literature indicates that adequate quality, knowledge and qualification were essential to achieve maximum impact of CP. These constraints are seen as motivated factors to increase the level of competency where education, training and experience contribute significantly through the effective integration between employee and employer in CP implementation process. CP has allowed manufacturing firm to improve the efficiency of operational at optimal conditions. Commitment to improve and modify the process that focus on the reduction of raw material consumption, waste reduction, usage of renewable energy and materials through cleaner technologies require a high level of competency [49]. This will allows manufacturing firms quickly response to the market changes and act as a pioneer in exploring new opportunities due to changes in market conditions [50].

Application of technology has increased the operations capabilities. It has enable the manufacturing firms to focus on process innovation and permits comprehensive control of resources and pollution emission [4, 6]. Through the radical changes in technology and innovation, manufacturing firm can achieve a high level of competency performance [27]. Ability to monitor the equipment's (software and hardware) has urged manufacturing firm to be more competent with new production techniques in CP. Thereby the highest competency level in relevant field will increase their competitiveness in global markets [36, 39, 41].

Implementation of CP also improved safety practice by providing a safe system of work. Elements found in CP such as monitoring and evaluation has effectively reduce the accident rate through high level of environment and labour safety [4]. In manufacturing sustainability, to manage the production growth, both ecological safety and economic return should be consider and been given priority [19]. Tseng et al. [43] stated that CP can provide an efficient use of resource and minimizes waste and pollution as well as reduce risks to human health and safety.

CP not only improve the competitiveness of products, but also offer better ecological safety and human health [10]. The need to comply with laws and regulation of labour, environmental and safety and health prompted the manufacturing firms to enhance their efficiency in dealing with issues related to the safety practices [21]. Ability to have good safety management practices not only provide safe working environment, but also improve the competency level of employee during performing their work. They will be more focused on the task being performed and thus contribute in increasing the productivity.

For example, good housekeeping practices that derived from the implementation of CP can provide clean working environment and eco-friendly [49, 51]. Thrane et al. [27] stated that good housekeeping practice was one of the effective CP solutions other than process optimization and reuse of materials and resources. Commitment, involvement and employee competencies were an important factor for housekeeping practices and maintain the momentum of improvement. In small and medium enterprise, [36] found that a good housekeeping practice has risen up to 71% from the implementation of CP in plastics and rubber processing area. While [37] found that the level of noise pollution has been reduced by 14% in the small and medium manufacturer in Australia.

Increase the level of technical skills and management capacity of the environment was crucial in achieving a significant CP results [52]. Manufacturing firms are often complaint about penalties as well as payments required to manage the environmental issues, simultaneously they are missing the fact of significant savings come from the preventive approach [5]. The use of design for environment (DfE) has help in identifying the efficient use of chemicals in the process [49]. Reducing of CO2 emissions caused by the chemical reaction of raw materials, and reduction of dust pollution was an example of the effective implementation impact from the environmental management assessment activities [33, 35].

CP was a significant input to the implementation of environmental management systems such as ISO 14001 [3, 6, 7, 27, 42, 53],. This will enable the manufacturing firms to comply with the laws and regulations relating to the environment and thus can avoided them from any fine or penalty due to non-compliance with the environmental rules and regulation [36, 39, 48]. Adoption of ISO 14001 environmental management system may have a longer impact as it is resulted from the reforms of manufacturing firm in their daily operations [6]. This suggest that competencies in performing each of elements found in environmental management system was essential to ensure the manufacturing firm always comply with all related laws and regulations.

Literature shows that the pollution reduction element, pollution control element and pollution prevention elements are extensively used in evaluating the effectiveness of CP and environmental performance level [1, 5, 36, 38, 42, 46, 54]. Environmental behavior of manufacturing firm can be characterized by pollution prevention and anticipation to environmental requirement [55]. Through high level of competencies and proactive plan in preventing the pollution, CP model has effectively remove the dust pollution in crunching grinding plant [33]. Huang et al. [10] found that the pollution emission of SO2 has decreased by 8% using CP strategy in medium scale ceramic tiles manufacturer. Pollution control technologies, pollution prevention technologies and management system are three general categories of environmental technologies that should be given an attention in increasing their proactive action for pollution prevention, thus increase their competency performance [42]. Pollution prevention has proven to be a valuable concept that leads to increase the efficiency of waste reduction and emission control [43]. Thus increase the level of environmental management performances.

Effective priority process was required for manufacturing firm to build the key competitive advantage in market [41]. Development of cleaner products and processes through optimization of technological change and innovation can provide the momentum for improvement [27]. Jia et al. [28] stated that CP requires a new way of thinking in the design processes. Through innovation, new solutions to meet the need of existing market requirements can improve the sustainability of the manufacturing firm. This can be achieved through more valuable product, processes, services, technology or ideas to meet the needs of the market and society. Evaluation should be done from product design and processes throughout the product lifecycle [42]. This shows that CP is a process of diffusion of innovation where a sustainable product development should be integrated with the product development process [56].

Dieleman [54] found that the innovation perspectives in the implementation of CP can be divided into four main perspectives. First, CP can be seen as a learning and changes process in manufacturing firm. Second, CP was seen as a framework to control the pollution emission. Third, CP as an innovations diffusion processes. Finally, in fourth perspective CP was seen as a process to build new socio technical network. More radical technological innovation and the exchange of knowledge in the implementation of CP can mostly be seen in large integrated manufacturers [57]. However, this does not mean that CP cannot be implemented by smaller manufacturers. Increase technical collaboration, information sharing and capacity building can be used as the main approach to implement CP in small and medium industries [38]. Minimize the cost of pollutants and improve resource productivity to avoid pollution in the first place are two broad categories of innovation that can be considered during the implementation of CP [7].

Reputations, pressure groups, competitive advantages, response to stakeholder and customer demands are a part of the driving force for innovation. In order to achieve this, manufacturing firm should have a great competency level in the area of strategic purchasing, supply management strategies, external orientation and transparency, cooperation between department, learning and adapting, leadership, autonomy and possibility for experimenting and results driven [58].

C. Economic Performances

The development and the awareness of CP implementation nowadays by most manufacturing firms indicate that this element has a significant impact in transforming their economic growth towards sustainable development [4]. It suggests that the third impact that can be influenced from the implementation of CP was economic performance. This further enable manufacturing firm to assess the areas associated with the assets, liabilities and their overall market strength to ensure remains on track financially. Many manufacturing firms will benefit economically, particularly in their manufacturing operations management system [3]. Constant implementation of CP will make the manufacturing firm viable economically and financially through the elements found in CP such as pollution reduction, reuse or recycling of materials that allow better control of their financial resources [49]. This will allow the overall production cost to be reduced or minimized as well as helping them to enhance their economic and financial performance [3, 6, 27, 28, 35, 37, 39, 41, 55].

For example, Hicks and Dietmar [3] found that the implementation of CP in electroplating, dyeing, chemicals and pharmaceuticals sector manage to achieve the total savings of 5% in their total production cost. CP will allows manufacturing firms to reduce the material cost, energy costs and depreciation cost and led to an increase in profit from the sale of products [28]. Andrews et al. [37] found that CP implementation helps to improve financial benefits by 15% in small and medium manufacturers in Victoria, Australia. This verifies that the proper implementation of CP will improve the economic performance, but the success rate may be different in different sectors and industries.

A natural resource was the materials and components that can be obtained from the environment such as water, air, energy and minerals. Most manufacturing firms use large number of natural resources in the manufacturing processes, particularly those involve in the processing of raw materials. Literature shows that the total consumption of natural resources not only affects environmental performance, but high usage of natural resources will also increase the operation and maintenance cost. The excessive or uncontrolled use of natural resources will result in wastage and affect operating cost [32]. Today, awareness of the negative impact on the overall cost and environmental due do inefficient use of natural resources has prompted manufacturing firms to look for more efficient practice. Elements found in CP was seen can address with this issue [59]. As an integrated preventive environmental strategy involve processes, products and services, CP has emphasizes on the efficient use of natural resources that contribute to overall operation cost [43]. Telukdarie and Haung [60] stated that the proper implementation of CP will result a significant reduction demands for natural resources and led to a reduction of operation cost.

Hicks and Dietmar [3] found that the manufacturer in ceramic tile manufacturing activities manage to reduce the water consumption by 15.5 % when they promoting CP in their practices. By using environmental oriented cost management (EoCM), they can systematically reduce the cost of non-product output (NPO) such raw materials, water and energy used in the production process. This contributes to a total saving approximately about 5 % of the total production cost. Feasibility studies on the implementation of CP by [10] found that resource comprehensive utilization was significantly improve through the implementation of CP strategies. As a result, water consumption in medium scale ceramic tiles manufacturer has been reduced by 4.3%. By increase the water reuse rate to 93%, they managed to decrease fresh water consumption by 22.33%. The total consumption of raw material also reduces by 1.14 % through the implementation of CP program.

The above examples have explained how CP can be used to provide the way for efficient use of natural resources. This will allows a reduction in operating costs and consequently increases the economic performance. This proved that CP able to help manufacturing firms to control their operation where operating cost more effectively and produce a significant sustainable manufacturing system [60]. Only sustainable production will be able to survive in the long term due to the rising cost of natural resources [48].

IV. CONCLUSIONS AND FUTURE WORK

This paper has disclosed that CP has provided the opportunities to the manufacturing firms to improve their environmental management performance and saving in operation and products cost. Requirement in environmental protection and the increasing demand for natural resources was known as the main driving force for the implementation of CP. Awareness of global activities was essential to ensure the success of the business for a long term. CP can be accomplished through various area of translational process in order to obtain the optimum impact hence lead for better sustainable manufacturing practice. Different sectors will produce a different effect of the CP implementation. To ensure the implementation of CP has a beneficial effect, the exact determination of the translational process should be appropriate to the type of operational activities.

From literature, it shows that the implementation of CP can provide a numerous beneficial impact such as increase recyclability, using less energy consumption, reduce the pollution emission of substances, produce less amount of waste, nominal use of natural resources, nominal use of packaging material, decrease raw material usage, better safety practice, avoid penalties due to violation of environmental law, proactive in preventing pollution and bring blaze intention force for the innovation. All the beneficial impacts will increase the level of environmental, economic and competency performances which was the key elements in sustainable manufacturing practices.

Further works might reveal more benefits that can be derived from the implementation of CP and influence the level of sustainable manufacturing practice. The dominant factors such as types of business, adoption of proper translational process and obstacles encountered can provide better information that can be used by manufacturing firms in determining the appropriate strategies that should be used for optimum results. Using this information, a field study should be carried out accurately and comprehensively to achieve a better result at high level of performance.

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