A Review on Current Trend of Sustainable Manufacturing in Malaysia

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Abstract
In today manufacturing world, we already faced the critical factors for industrial growth; a rising consumption of natural resources, increase of population, pollutions and environmental impacts, a rapid development of global communication network and unstoppable globalization activities. Sustainable manufacturing system involve all the value in the product cost and life cycle , process and closed loop system as to harmonize the impact of the manufacturing to the environment and organism. In this paper, the current trend of sustainable manufacturing in Malaysia is reviewed. Related topics about the development on sustainable manufacturing and initiative research in four organizations in Malaysia are highlighted. Undoubtedly, the design for sustainable manufacturing will help to integrate economic, social and environmental sustainability. The basic principles for sustainable manufacturing systems are the recyclability, renewability, and energy efficient for the overall components in the systems.

Keywords: Design; Ecological; Environmental; Green use, Sustainable manufacturing; Recyclable; Renewable

1.0 Introduction

The rise of issues such as environmental pollution, energy, material, and global warming, along with ecological technology and policy lead to the sustainable manufacturing (SM). In Malaysia, around 23, 000 tonnes of waste is delivered every day. This amount is projected to increase to more than 30 000 tonnes towards the year of 2020 (Global Environment Centre, 2015). In spite of the massive amount and complexity of waste produced, the standards management of waste in Malaysia is still poor. These include the invalid and poor documentation of waste generation rates and its composition, ineffective storage and collection systems, disposal of public wastes with toxic and hazardous waste, indiscriminate disposal and inefficient utilization of disposal site space.

Due to the increasing expenses of energy, industrial contamination, deficiencies of strategic raw materials and natural resources, and ecological changes (Zohreh and Napsiah, 2013). Sustainable has become one of the most emphasize areas for current researchers and organizations. From 1992, a commitment for sustainable development is agreed by all governments of the world in the United Nations Conference on Environment and Development or Agenda 21 “Earth Summit”, Brazil. Through this agenda, everyone has roles to achieve sustainable development and involved in process decision on environmental system (MPC, 2015). Sustainable development means inculcating the process of maintaining human needs while preserving the environment for future generations (WCED, 1987). In other words, it refers to the efficient activities to use the available resources so that they

will be available for many years to come. A technical definition of sustainable manufacturing is a systems approach for the creation and delivery (supply chain) of innovative products and services that reduces natural resources (raw materials, energy, water, and earth); reduces toxic elements; and yields less waste that in effect reduces greenhouse gases. According to Nordin et al. (2014) sustainable manufacturing be categorized into four; Responsive Product Strategy (RPS), Lean Practices (LP), Supply Chain Restructuring (SCR), and Sustainable Material and Design (Norani *et al.* 2014).In general, the view of sustainable manufacturing is related to reducing the consumption of resources, minimize negative environmental impact, recyclable products, reliable, safe, economic and high value adding in manufacturing system.

2.0 Development of Sustainability Manufacturing Practices

In the past, Sustainability Manufacturing (SM) is defined in three dimensions, environmental, socials and economical or three pillars of sustainability, profit, planet and people (Elkington, 1994). In current literatures the development of sustainability and SM concepts has given rise to a series of Sustainability Manufacturing Practices (SMP). The general concept of the real definition of SMP is begin from production methods or technologies that focus on economic development and environmental protection to environmental friendly and eco-innovation (Norsiah *et al.* 2015). The application of technology for treatment of pollution at the "end of the pipe" focus on product life cycles and integrated environmental strategies and create closed-loop, circular production systems in which discarded products are used as new resources for production (OECD, 2010).

3.0 Trends in Sustainable Manufacturing

The natural resources are depleting and regenerative capacity of the environment is able to compensate human activities are no longer suitable. Sustainable manufacturing now influence all the organizational aspects of the human life; political, economic, social, and environmental. About twenty years ago, sustainable concepts has been applied in the manufacturing field, engineering design and green environmental management system (Varinder *et al.* 2014). From a review, the advantages of sustainable manufacturing are; 1) Reduce the usage of material and energy resources and harmful environmental impact 2) Improve the energy efficiency by energy management systems and resource efficiency 3) Reusing and recovering energy implemented in production systems 4) Using renewable resources 5) Lowest quantity of wastes 6) Afford operational safety 7) Offer improved personal health while maintaining or improving the product and process quality (Negin Ashrafi, 2014). Sustainability addresses the entire system of integrated components, energy and transportation required to assemble the final product and deliver to the customers (O'Sullivan, 2011). Here are some of the current trends in sustainable manufacturing; 1) Integration of product-process-machine approaches 2) Reduce the materials and energy resources 3) Improve the energy-efficiency by energy management

systems 4) Reuse and recover the energy used in the production systems and 5) Using renewable resources.

In general, the development of sustainable manufacturing can be categorize into three level, product, process and system (Jayal AD, 2010). For the product design life cycle level, the concept of 3R (reduce, reuse and recycle) has been transformed into 6R (reduce, reuse, recycle, recover, redesign and remanufacture) (Sumit Gupta *et. al*, 2015). A product life cycle is change from single level life cycle to multiple level of life cycles. In term of process, technological solution and proper infrastructures need to develop or innovate in order to cater the entire supply chain and production. Thoroughly speaking, sustainable is best described in the context of a closed system. Refers to Dornfeld. et al. (2013) sustainable manufacturing is a philosophy that cannot be considered independent of broader environmental and socioeconomic systems, such as that displayed in Figure 1. Since the evolution of sustainable manufacturing is in place, the orientation of sustainable practices are divided into two categories; internal sustainable manufacturing practices and external sustainable manufacturing practices. Internal sustainable practices are focusing on the practices within the firm, and external sustainable practices are refer to inter organizational practices within the system.

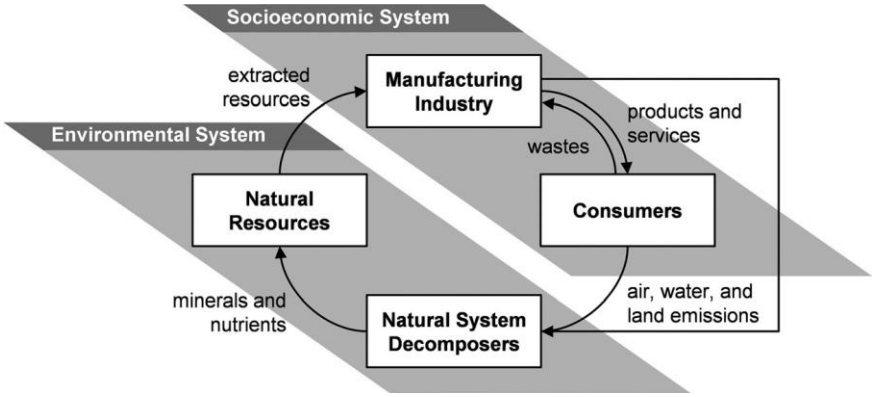

Figure 1. The role of the manufacturing industry in a sustainable system Dornfeld. Et.al, (2013)

According to Bocken *et.al*, (2014), the development of sustainable business model (SBM) incorporate a triple bottom line approach and consider a wide range of stakeholder interests, including environment and society are referring to the eight archetypes as follow; 1) maximize material and energy efficiency 2) create value from 'waste' 3)substitute with renewables and natural processes 4) deliver functionality, rather than ownership 5) adopt a stewardship role 6) encourage sufficiency 7) re-purpose the business for society/environment and 8) develop scale-up solutions.

Sustainable development is one-sided so that we as a whole can have a desirable future that includes a cleaner environment, a sustained level of economic growth without excessive waste and pollution, and the protection of natural assets and biodiversity. According to Malaysia

Productivity Corporation (MPC) 2010 initiative research, four organizations in Malaysia that participated in the sustainable development and green practices. The companies are Panasonic Malaysia, GE Malaysia, GreenTech Malaysia (PTM) and Toyota Malaysia. Momentarily, the initiative research of sustainable development in Malaysia has enhanced the awareness and knowledge about the sustainable practices that reduce the impact of manufacturing operations on the environment. Manufacturing activities are energy demanding and responsible for creating pollutants. Thus, the government of Malaysia has directed its highlight that green economy and green tourism in the 10th Malaysia Plan (2011-2015).

4.0 Designs for Sustainable Manufacturing

Designing a sustainable manufacturing system includes the consideration about the environmental influence in each level of the design processes and methods. Sustainable design success is depends on the effective application of tools and environmental design principles, rules and standards and the availability of the information required in cross functional teamwork (Sumit Gupta *et. al*, 2015).. The full life cycle assessment (LCA) of the product is an important tool to assist in ensuring proper sustainability through assessing the environmental impacts of product designs (Danni Chang *et. al,* 2014). Life cycle assessment covers the four components of design which are the concept of the design, part to be design, process design and closed loop decisions making. There are four principles related to the design for sustainable manufacturing; 1) recyclability 2) renewable 3) green use and 4) efficient. The product's end of life should be consider at the first stage of the design process. What happens to the product after its lifetime over, it can be dismantled, disassembled, recovered, redesigned, remanufactured or manipulated so that it will take a new form and reuse for the next cycle. This principle intended to recycle and reuse all the valuable products so that proper waste management is in place. Other technique to ensure the recyclability of the product is the product should be made from recycled materials, compostable organic materials or minerals which are consistently reuse in a closed loop. In certain country, high energy consumption will lead to unsustainable in the long run due to its environmental impact and the limited resources (Xie Nai-ming *et. al*, 2015). Electricity generation using renewable energy generation technologies is one of the most practical alternatives for network planners in order to achieve national and international Greenhouse Gas (GHG) emission reduction targets (Abdullah *et. al,* 2015). Therefore, it is essential to design a process with reflecting the sources of energy in both manufacturing and end user. Hybrid energy system for vehicles, smart building, smart house and smart factory are among the important concept of designs which aim to use the renewable energy as its main source of energy.

Green design for environment is totally about to save the environment and reduce the cost of the product (Paula *et. al,* 2014). The philosophy of the green technology is that, the impact of the product to

the environment should be zero, and with the help of technology and innovations; any release to the environment can give benefits to the life beings. The Technical Committee 207 of the International Standardization Organization (ISO) has published numerous guidelines and standards for product and production integrated environmental management systems. The new version of ISO140001 is significant step for the critical environmental standard which deals with all environmental issues; water, air, climate change or others in a 'holistic' manner. Other key controls which began from EU, such as Registration, Evaluation, Authorization and Restriction of Chemical Substances (REACH) Regulation, Restriction of Hazardous Substances (RoHS) Directive, and WEEE Directive effectively driven the adoption of green innovation in the manufacturing industries. Efficient procedures, methods or frameworks, resources management, coordination and decision making will lead to a thorough positive effect on the three pillars of sustainability; environmental, economic and social. In reality, efficient brings a lot of benefits to the organization. In fact, efficiency implies the fraction of the useful work performed by a machine or in a process to the total energy expended or heat taken in. With higher rate of efficiency, the better the process to be. Sustainable manufacturing design includes energy saving, reliable and producing less waste. When possible, a best environmental product should be processed with fewer energy and can operate with optimal levels of power. Figure 2 below summarize the principles for design a sustainable manufacturing system.

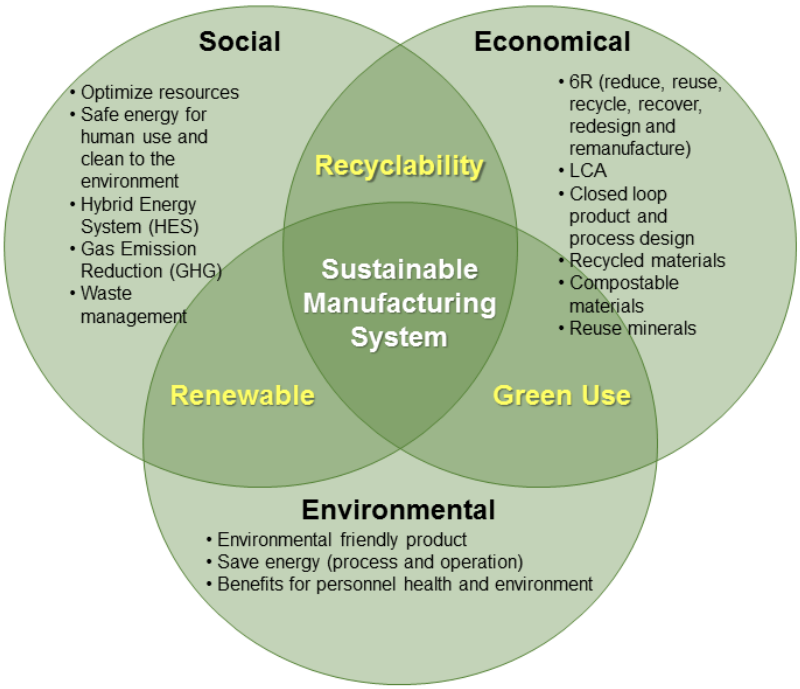

Figure 2: The basic principles of the design for sustainable manufacturing system

Sustainable manufacturing is a continuous processes. It requires understanding of the relationships between the human activities and natural environment. Thus, to create sustainable value through sustainable manufacturing will require transformational and innovative reforms in education with an overall paradigm shift to provide the future generation of engineers, scientists and managers the necessary technical knowledge, skills and capabilities (Jawahir *et. al,* 2013).

5.0 Conclusions

The adoption of sustainable manufacturing is very important as it will integrate the economic sustainability, social sustainability and the environmental sustainability. Products are the cause of all ecological problems. It is the unintentional side effects of the manufacture, and consumers which use and disposal the products. The implementation of sustainable manufacturing should be practice in all levels of the organization; management, internal and all external factors. Achieving sustainability in manufacturing requires a holistic view spanning not just the product, and the manufacturing processes involved in its fabrication, but also the entire supply chain, including the manufacturing systems across multiple product life-cycles. Major pollutions, deforestation, global warming, and species loss are all the events that caused by humans activities and production. Appropriate advancement on technology, innovation, particular training module and sustainable worldview in educational frame work perhaps will improve the knowledge gap about the sustainability manufacturing and alter the quality of life and wellbeing for the next generation.

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