

## Review Paper on Sustainability in Manufacturing System

Afsaneh Nouri Houshyar<sup>1</sup>, Azadeh Noori Hoshyar<sup>2</sup>, Riza bin Sulaiman<sup>3</sup>

<sup>1</sup>Faculty of Information Technology, University Kebangsaan Malaysia

<sup>2</sup>Faculty of Engineering and Information Technology, University Technology Sydney

<sup>3</sup>Institute of visual Informatics, University Kebangsaan Malaysia

Received: March 12 2013

Accepted: February 19 2014

### ABSTRACT

Considering the impact of global warming, terrorism, earthquakes, hurricanes, and carbon footprint awareness reveal that having a successful business is not sufficient. Indeed concentrating on the environmental issue and try to safeguard the environment is crucial, therefore, sustainability become an attractive concepts in industry and manufacturing system during these years. In recent years, the concept of sustainability has gradually evolved and has begun receiving international attention. Environmentally friendly product and totally sustainable supply chain and manufacturing system help organization to reduce use of material and enhance the business competitiveness. In the other words, sustainability is a weapon which employed in order to help organizations perform well, not only environmentally, but also, socially and economically. This paper has taken the broad look at the sustainability in manufacturing system, supply chain, also tries to show the importance of sustainability among the researchers, in addition, this paper makes effort to have a brief review on literature of sustainability in manufacturing system.

**KEYWORD:** sustainability, manufacturing system, supply chain management.

### 1. INTRODUCTION

In recent years researcher have started to seriously focusing on sustainable manufacturing [1]. Nowadays the term of sustainable manufacturing becomes more highlighter in academic area. Since sustainable manufacturing consider the environmental, social and economic factors, therefore, a lot of researchers have focused on these issues during these years. Moreover, due to the diminishing non-renewable resources, stricter regulations related to environment and occupational safety/health, increasing consumer preferences for environmentally friendly products, etc. the issue of sustainability, in industrial, activities become so crucial. Furthermore, having 'environmentally friendly' or 'green' product become the main claims of society in these decades. Hence in order to have a sustainable manufacturing system it is necessary to considering the relevant levels which are product, process, and system. In product level Concentrating on traditional 3R concepts is necessary. The 3R concept is contained the green technologies which are reduce, reuse, recycle. In recent years it evolved and formed the 6R concept. This new concept involves reduce, reuse, recover, redesign, remanufacture, recycle technologies [2]. Process planning for reducing energy and resource consumptions, toxic waste and occupational hazards are the factors which must be considered in the process level in order to have a sustainable manufacturing system[3]. Last level which is important for having a sustainable manufacturing is system. The entire supply chain which the manufacturing system is part of that, must become in to the account such as life cycle stages, pre-manufacturing, manufacturing, use and post use, over multiple life cycle [4] . These levels will be described by details in following section.

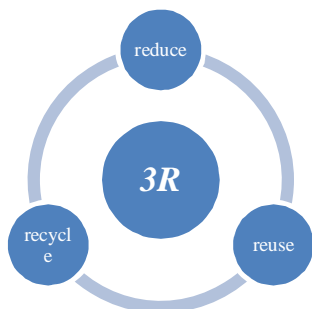


Fig1.Traditional3R concept towards sustainability

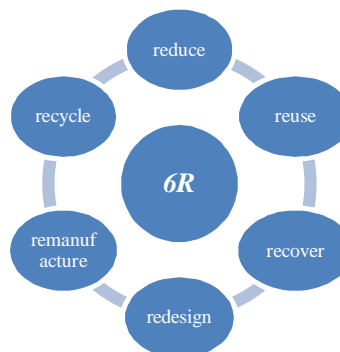


Fig2. New 6R concept toward sustainability

Regard to Gunasekaran and Spalanzani [1] explanation, moving the companies to have the sustainable supply chain and manufacturing system is one of the key challenges in 21 century and also in order to be survived in world competitive market, it is crucial to respond the customer awareness which is environmentally friendly product and

services. Hence, the contribution of this paper is providing an attempt to concentrate on above issue and have brief overview toward sustainability.

The organization of this paper is as follows: The paper begins with a section on understanding sustainable manufacturing. Research methodology is illustrated in section 3. Importance of Sustainability among researcher will be followed by section 3. In section 5 the Review on sustainability literature will be explained. Finally conclusion comes in section 6.

## 2. SUSTAINABLE MANUFACTURING

Based on definition which presented by US Department of Commerce, sustainable manufacturing is “the creation of manufactured products that use process to minimize negative environmental impacts, conserve energy and natural resources, and also are safe for employees, communities, and consumers and are economically sound[5]. Sustainability let organization to reduce risk, avoid waste generation, increase material and energy efficiency, innovate by creating new and environmentally friendly products or services[1]. Dyllick and Hockerts [6] defined three dimensions for sustainability which are business case (economic), the natural case (environmental), and the societal case (social). Furthermore, safeguarding natural resources against exploitation, in the name of productivity and competitiveness, by manufacturing and service organizations are considered as the main factors in sustainability issue [1]. Manufacturing system is the main element in the manufacturing supply chain, therefore, in order to have the sustainable manufacturing supply chain it is crucial to concentrate on the main core of that chain which is manufacturing system and must attempt to implement 6R methodology which completely explain in following table [7].

<i>6R methodology</i>	<i>Explanation</i>
<b>Reduce</b>	<ul style="list-style-type: none"> <li>• Reduced use of resources in pre-manufacturing</li> <li>• Reduced use of energy and material in manufacturing</li> <li>• Reduce the waste during the use stage</li> </ul>
<b>Reuse</b>	<ul style="list-style-type: none"> <li>• Reuse of the product or its component in order to use as the raw material for producing the new product</li> </ul>
<b>Recover</b>	<ul style="list-style-type: none"> <li>• Collecting, disassembling, sorting and cleaning at the end of usage stage of product</li> </ul>
<b>Redesign</b>	<ul style="list-style-type: none"> <li>• Simplifying future post-use processes</li> </ul>
<b>Remanufacture</b>	<ul style="list-style-type: none"> <li>• Re-processing of already used product</li> </ul>
<b>Recycle</b>	<ul style="list-style-type: none"> <li>• Converting the waste material or product to new material and product</li> </ul>

Table1. 6R methodology in sustainability

## 3. RESEARCH METHODOLOGY

An in-depth literature review is done by reviewing and analyzing articles from several sources. This study used library search for getting knowledge about different aspects of sustainability and related issues. Search was done using academic databases provided by University Putra Malaysia library, Google and Google scholar. The purpose of this review is to understand the background of relevant issues and also obtain the state of research.

## 4. IMPORTANCE OF SUSTAINABILITY AMONG RESEARCHER

As Barber [8] explains, increment the rate of resources consumption and industrial growth which leads to many problems such as :environmental pollution, lack of natural resources in future and so on. Because of these issues, most of researcher were interested to concentrate on environmental, social issues and totally sustainability between 1970 and 1990. During that period, the attitude towards the sustainability had changed from fancy strategy to real strategy that helps organization to be survived in competitive markets.

Regarding Seuring and Muller [9] research, the following figure is revealed. Following figure shows distribution of published paper in the area of sustainable manufacturing and supply chain. Figure indicates, almost the trend of published papers has been increased from 1994 till 2007. This trend expresses the wide acceptance of the topic among researcher in academic area.

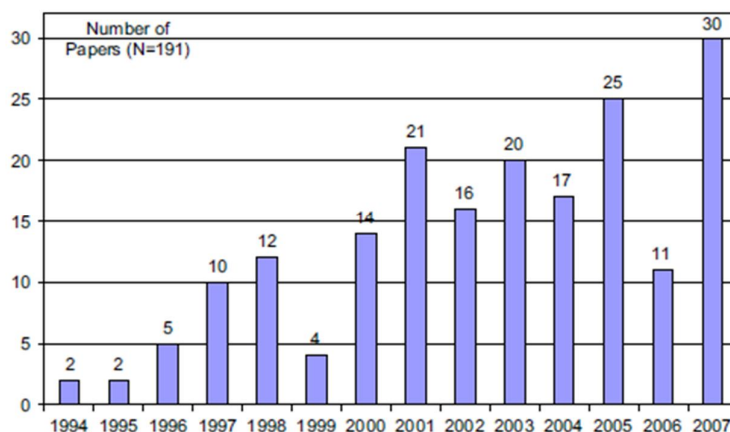


Fig3. Distribution of publications for sustainability papers

In addition, based on the recent research of Gunasekaran and Spalanzani in 2011 [1] the number of papers which were published in the journals of sustainability have been increased from 2003 till 2011.

At the end of this part it can be concluded that in recent years, the concepts of sustainability has gradually evolved and has begun receiving international attention. Environmentally friendly product and totally sustainable supply chain and manufacturing system help organization to reduce use of material and enhance the business competitiveness.

## 5. REVIEW ON SUSTAINABILITY LITERATURE

As explained in previous section the concepts of sustainability has gradually evolved and has begun receiving international attention to itself, therefore, The purpose of this section is to indicate and review the background of the relevant issues.

The recent paper of Kleindorfer et al. [10] review different papers on the area of sustainable operation management and released that this issue is between the first 50 issue in the production and operation management area. Their research had an overall insight to the development and status of these issues. In addition, the main effort of Seuring and Muller paper [9] is to outline the literature review in the field of sustainability and supply chain management. Pagell and Wu[11] propos a model for sustainable supply chain management, it incorporate with design, innovation capability, managerial orientation toward sustainability, re-conceptualizing participant in supply chain. This model is proposed by focusing on economical and environmental issues. Baldwin et al. [12] explain the useful tools such as benchmarking, total cost, life cycle cost, eco-portfolio analysis and product summary matrix, design for environment, cleaner production indicators, process audit .These tools are employed in order to have sustainability in manufacturing system and supply chain. Markley and Davis [13] consider the effects of sustainable supply chain on 3 main elements of firm which are people, planer and profit. Mahler [14] believes that although the sustainability is a strategy in order to reach social goal, it is employed for competitive advantages. Ansett [15] illustrates that for having more sustainability in a system in long period of time, it is crucial for companies to highlight the importance of social responsibility. Carter and Rogers [16] focus on some concepts such as organizational culture, transparency and risk management in order to build the sustainable supply chain. Zhu et al. [17] consider the Chinese manufacturing firm as their case study and study the relationship between the adoption of green supply chain and organizational learning and operational learning.

Regard to global development and competition, typically supply chain are interested to outsource their activities, following of this companies have introduced evaluation schemes which integrate environmental and social criteria. [18,19,20]. Therefore, the environmental issues and designing, producing an environmentally friendly product is one of the main considerations in sustainability concept. AsBurgos and Lorente in 2001[21] express, environmental performance is one of the main operation's goal of products or services producing. Moreover, Clark [22] explains that in order to reduce the negative environmental effects which are associated with product design and manufacturing system, most focus must be on process-oriented strategies. Baumann et al. [23] concentrate on development of green products in their research as it leads to safeguard the environment. Abukhader and Jo'nson [24 ] review the environmental issues in supply chain by concentrating on logistic part . In addition, Ayres [25] expresses that, it is necessary for the companies to find a way to convert waste of their industry to raw material of another industry. Madu et al. [26 ] do their research on product life-cycle in sustainable manufacturing field by considering different issues such as recycling, environmentally supportive equipment design and material selection, manufacturing processes , product design, effective waste collection systems, disassembly and reclamation of scraps, disposal of hazardous waste and components. Also, Maxwell and Vorst [27] propose and developed the method for industry and practitioners in order to have sustainable product and service. In this model they try to make balance between environmental protection, social quality and economic prosperity while still the traditional requirements of product such as quality, market, technical and cost issues have been considered.

This part provides an attempt to summarize some of the researches which had been done on the area of sustainability and related issues. To sum up, based on the finding of researchers which few of them illustrated here, it can be revealed that sustainability is a weapon which employed in order to help organizations to perform well, not only environmentally, but also, socially and economically and in addition Houe and Grabot [28] believe that based on the increasing of customers awareness about the sustainability and environmental issues, it is crucial for the companies to consider these competitive concepts in order to be survived in global market.

## 6. CONCLUSION

Since In recent years, the concepts of sustainability has gradually evolved and has begun receiving international attention, In addition, companies are under pressure to have environmental friendly manufacturing and service sectors, hence, this paper provides an attempt to have a brief overview towards the sustainability and related issues. Sustainability in manufacturing is considered as an operation strategy similar to agile manufacturing, lean production and business process reengineering. This concept helps organization to have economically improvement but not only this, but also, environmentally and sociality. In the other words, environmentally friendly product and totally sustainable supply chain and manufacturing system helps organization to reduce use of material and enhance the business competitiveness. Although there are lots of researches which have been done on the area of sustainability, there are few works on sustainability of supply management, product and process design and operation, therefore, these issues need more investigation in future research.

## Acknowledgment

The authors declare that they have no conflicts of interest in the research.

## REFERENCES

- [1] A. Gunasekaran , A. Spalanzani, Sustainability of manufacturing and services: Investigations for research and applications, *International Journal of Production Economics*, 2011.
- [2] Joshi, K. Venkatachalam, A. Jawahir, I.S. A new Methodology for transforming 3R Concept into 6R Concept for improved Product Sustainability. *Proceeding of the IV Global Conference on Sustainable product Development and Life Cycle Engineering*. 2006.
- [3] Jawahir. I.S, Dillon J.R. o.w, Sustainable Manufacturing Process :New Challenges for Developing Predictive Models and Optimization Techniques, *Proceeding of the 1<sup>st</sup> International Conference on Sustainable Manufacturing* , 2007.
- [4] Badurdeen, F., Goldsby, T.J., Iyengar, D., Metta, H., Gupta, S., Jawahir, I.S, Extending Total Life –Cycle Thinking to Sustainable Supply Chain Design, *International Journal of Product Lifecycle Management*, 2010, 49-67.
- [5] International Trade Administration . How Does Commerce Define Sustainable Manufacturing? US Department of Commerce. Available : [http://www.trade.gov/competitiveness/sustainablemanufacturing/how\\_doc\\_defines\\_SM.asp](http://www.trade.gov/competitiveness/sustainablemanufacturing/how_doc_defines_SM.asp). 2007.
- [6] Dyllick, T., Hockerts, K. Beyond the business case for corporate sustainability. *Journal of Business Strategy and the Environment* 2002; 11(2):130–41.
- [7] U.S. Environmental Protection Agency. Municipal Solid Waste (MSW) Reduce, Reuse, Recycle. Available: <http://www.epa.gov/msw/reduce.htm>. 2008.
- [8] Barber, J., Mapping the movement to achieve sustainable production and consumption in North America. *Journal of Cleaner Production* 2007. 15, 490–512.
- [9] Seuring, S. Muller, Martin. From a literature review to a conceptual framework for sustainable supply chain management. *Journal of Cleaner Production* 2008. 16: 1699–1710
- [10] Kleindorfer, P.R., Singhal, K., Van Wassenhove, L.N. Sustainable operations management. *Production and Operations Management* 2005; 14(4):482–92 [review, sustainable].
- [11] Pagell, M., Wu, Z., Building a more complete theory of sustainable supply chain management using case studies of 10 exemplars. *Journal of Supply Chain Management*. 2009. 45 (2), 37–55.
- [12] Baldwin, J.S., Allen, P.M., Winder, B., Ridgway, K., Modelling manufacturing evolution: thoughts on sustainable industrial development. *Journal of Cleaner Production* 2005. 13, 887–902.
- [13] Markley, M.J., Davis, L., Exploring future competitive advantage through sustainable supply chains. *International Journal of Physical Distribution & Logistics Management*. 2007 37 (9), 763–774.
- [14] Mahler, D., The sustainable supply chain. *Supply Chain Management Review*. 2007. 11 (8), 59.

- [15] Ansett, A., Mind the gap: a journey to sustainable supply chains. *Employ Response Rights Journal*. 2007. 19, 295–303.
- [16] Carter, C.R., Rogers, D.S., A framework of sustainable supply chain management: moving toward new theory. *International Journal of Physical Distribution & Logistics Management*. 2008. 38 (5), 360–387.
- [17] Zhu, Q., Sarkis, J., Cordeiro, J.J., Lai, K.-H., Firm-level correlates of emergent green supply chain management practices in the Chinese context. *Omega*. 2008b. 36, 577–591.
- [18] Trowbridge P. A case study of green supply-chain management at advanced micro devices. *Greener Management International* 2001;Issue 35:121–35 [case, environment].
- [19] Beske P, Koplin J, Seuring S. The use of environmental and social standards by German first-tier suppliers of the Volkswagen AG. *Corporate Social Responsibility & Environmental Management* 2008;15(2):63–75
- [20] Koplin J, Seuring S, Mesterharm M. Incorporating sustainability into supply management in the automotive industry: the case of the Volkswagen AG. *Journal of Cleaner Production* 2007;15(11–12):1053–62 [case, sustainable].
- [21] de Burgos Jiménez J, Céspedes Lorente JJ. Environmental performance as an operations objective. *International Journal of Operations & Production Management* 2001;21(12):1553–72 [review, environment].
- [22] Clark, G., Evolution of the global sustainable consumption and production policy and the United Nations Environment Programme's (UNEP) supporting activities. *Journal of Cleaner Production*. 2007.15, 492–498.
- [23] Baumann H, Boons F, Bragd A. Mapping the green product development field: engineering, policy and business perspectives. *Journal of Cleaner Production* 2002;10(5):409–25 [review, environment].
- [24] Abukhader SM, Johnson G. Logistics and the environment: is it an established subject? *International Journal of Logistics: Research and Applications* 2004; 7(2):137–49 [review, environment].
- [25] Ayres, R., Industrial metabolism and global change. *International Social Sciences Journal*. 1989.121, 23–42.
- [26] Madu, C.N., Kuei, C., Madu, I.E., A hierarchic metric approach for integration of green issues in manufacturing: a paper recycling application. *Journal of Environmental Management*. 2002. 64, 261–272.
- [27] Maxwell, D., van der Vorst, R. Developing sustainable products and services. *Journal of Cleaner Production* . 2003.11, 883–895.
- [28] Houe, R., Grabot, B. Assessing the compliance of a product with an eco-label: from standards to constraints. *International Journal of Production Economics*. 2009 121, 21–38.