

Available online at [www.sciencedirect.com](http://www.sciencedirect.com)**ScienceDirect**

Procedia CIRP 26 (2015) 99 – 102

[www.elsevier.com/locate/procedia](http://www.elsevier.com/locate/procedia)

12th Global Conference on Sustainable Manufacturing

## KEY DETERMINANTS OF SUSTAINABLE PRODUCT DESIGN AND MANUFACTURING

Sumit Gupta\*

G. S. Dangayach

Amit Kumar Singh

*Department of Mechanical Engineering, Malaviya National Institute of Technology, Jaipur-302017 India*\* Corresponding author. Tel.: +91-9560022023; E-mail address: [sumit.nitjp@gmail.com](mailto:sumit.nitjp@gmail.com)

### Abstract

In the present era, there is an urgent need to make all industrial products sustainable for reduce environmental impact in the Production and consumption. Sustainable manufacturing is becoming crucial for businesses more than ever before. In this context, The key determinants of sustainable Product Design and manufacturing (SPDM) has been examined in the form of Environmental, Economical and Social factors in the Indian manufacturing organisations which provides the basis of SPDM for Indian manufacturing firms. This paper identified the various types of key determinants of Sustainable Product Design and Manufacturing (SPDM) by the survey methodology. A survey is conducted to confirm the key determinants in Indian manufacturing organisations. From this study it is proposed that the more emphasis should be given on Product life cycle, 6R (reuse, recover, recycle, redesign, reduce and remanufacture) and Housing and service infrastructure for this the new tools and techniques will be develop for creating a sustainable product. In this regards, it is suggested that proposed key Determinants play a vital role in product design and manufacturing and gives the better approach for sustainability.

© 2015 The Authors. Published by Elsevier B.V. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

Peer-review under responsibility of Assembly Technology and Factory Management/Technische Universität Berlin.

*Keywords:* Sustainable manufacturing, sustainable product design, environmental factors, economical factors, social factors and LCA

### 1. Introduction

Worldwide competition in today's global economies has brought significance challenges to many companies that want to meet continuously changing specific requirements of present and potential customers. Some of the critical issues that manufacturing companies should consider to remain competitive in the market are maintaining high quality products, lowering cost and prices, decreasing product cycle time and protecting environment. It is well known that the requirements for manufacturing operations towards environmental sustainability have become more and more stringent every year. It is also well known that manufacturers around the world have taken very different approaches to meet these requirements, resulting in very different practices

in various countries. Sustainable manufacturing promotes minimizing or eliminating production and processing wastes through eco-efficient practices, and encourages adopting new environmental technologies.

Sustainability or sustainable development is a much-discussed and significant topic of today in the light of increasing environmental degradation (global warming, depletion of the ozone layer etc.) and violation of human rights [1]. The more emphasis is given to increase awareness towards environmental management. Sustainable development is defined as the development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs [2].

Sustainability has three dimensions: economic, social and environmental, also known as the triple bottom line (TBL) or 3BL, as shown in Figure 1.

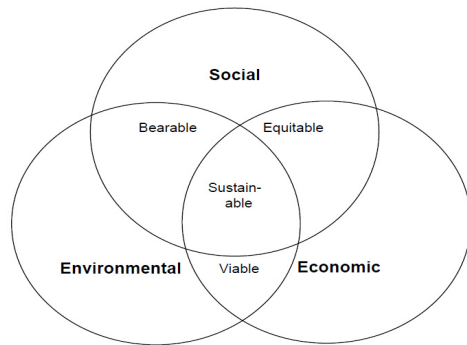


Figure-1: Dimensions of sustainability: Triple Bottom Line [3]

While economic viability is necessary for an organization to survive, it is not sufficient to sustain the organization in the long run if it causes irreversible damages to the ecosystem by emitting greenhouse gases (GHG) and toxic wastes and depleting non-renewable resources or it fails to ensure safety, security, dignity, healthcare, minimum wage, indiscrimination and better working conditions for its employees, the community and the society in general. Therefore, it has become imperative for any organization to behave in a socially and environmentally responsible manner while trying to achieve its economic goals.

Sustainable product design and manufacturing play a vital role for industrial growth and quality product to the customers. Sustainability becomes a major issue for product design and manufacturing in the present scenario. It is also taking a part in to modern economic growth. The sustainable products can be made by researchers and practitioners by developing methodologies and tools. In the sustainable product design and manufacturing, it is examine the economic and environmental impacts of the total life-cycle of a product. It is generally accepted that sustainable development includes three factors which includes economy, environment and social [4]. Sustainable product design and manufacturing has become an obligation to environment and society itself, enforced primarily by government regulations and customer perspective on environmental issues. Sustainable product design and manufacturing includes design, material selection, manufacturing process and delivery of product to customer and end of life of product [5].

The literature review reveals that most research works have been done from the outside of India in the different countries and included weather sustainable manufacturing or sustainable design and development. In this study, we classified the deferent issues in the three factors economical, environmental and social factors [6]. After that we examined the key determinates of SPDM in Indian manufacturing organizations on the basis of these three factors.

This research assesses the sustainability in product design and manufacturing in India context. The research is focuses on to various key determinates of sustainable manufacturing and product design, which affect the sustainable performance and manufacturing competitive advantage. Research aim to identify the major key aspects of product design sustainability that can provide a basis for Indian manufacturing companies.

## 2. Literature review:

The literature related to sustainability is relatively well developed. Numerous articles dealing with the theory and practices of sustainable product design and manufacturing have been published over the years, but the topic is still under development. The literature collected for sustainable product design and manufacturing based on the information about the important journals in this field. The concept of sustainability emerged from a series of meetings and reports in the 1970s and 1980s, and was largely motivated by environmental incidents and disasters as well as fears about chemical contamination and resource depletion. Our focus is on determinates indicators sustainability in design and manufacturing of product. The concept of sustainable Product design and manufacturing is enormously use by the manufacturing organisation for the competitive advantage. Sustainable product design development is to find the solution for the problems that cause diverse social and environmental impact [7].

According to [7–8], sustainable design success is depends on consideration of the environmental issues at the very beginning of the product development process, the effective application of tools and environmental design principles, rules and standards and the availability of the information required in cross functional teamwork. A way to foster these aspects is to provide a reference sustainable design process and data models.

Sustainable manufacturing assumes three dimensions for sustainability (i.e., economic, environmental, and social). The great number of indicators is in product manufacturing [9]. Literatures show many indicators in an expandable indicator repository with dimensions of sustainability: environmental sustainability, economic sustainability, social sustainability [10].

According to [11] categorise the indicators of sustainable manufacturing in the different dimensions and major indicator sets have been developed to analyze and score sustainability of manufacturing processes in USA. Sustainable manufacturing indicators are representing the sustainability index for the manufacturing.

[12] Focusing on the views of Spanish companies' on objectives, enablers and potential barriers or challenges related to sustainable development and manufacturing. They critically analyzed the enablers and barriers of sustainable development in manufacturing.

According to [13] the major current drivers for implementing product life cycle oriented environmental strategies and also barriers. He said manufacturing companies as well as policy makers to consider for a successful implementation of strategic environmental goals in manufacturing industry.

[14] Investigate the driving factors and the barriers to implement sustainable manufacturing initiatives in automotive companies. They said that drivers which are motivating companies to sustainable manufacturing initiatives were regarded to be more important and they suggested the different key factors for sustainable manufacturing [15].

Form the literature it is shown that there is some need to identify the key determinants of sustainable product design and manufacturing in Indian context. This is a gap of this research and we try to fill this gap with the investigation in the Indian context. The methodology adopted for this study is descriptive study. Next section tells about the methodology use for this study.

### 3. Methodology:

#### 3.1 Research goal

In this study we investigated the determinants of sustainable Product design and manufacturing. This study was very important in Indian context because most of the Indian manufacturing industry are trying to adopt sustainability concept therefore this study play a vital role for the adoption of the sustainability in India.

#### 3.2 Sample and Data collection:

For this study there were three types of industry automotive, electrical & electronics and plastic & rubber product manufacturing organizations included for the study and the survey questionnaire have been send to 104 organization for the response. The questionnaire was divided into two main sections. The first section was intended to obtain some basic information of respondent such as number of employee, year in business, ownership status, types of product manufactured, certifications have been received. In the second section, respondent were asked to rate their level of agreement on the factors for sustainable Product design and manufacturing. A five point Likert-type scale was used to collect the responses.

#### 3.3 Tests for Reliability and Validity:

A reliability test was performed to examine the research findings have the ability to provide consistent results. The Cronbach's alpha was calculated to measure the internal consistency of the research instrument. A commonly used value for reliability in the literature is 0.70 [16]. The coefficients alpha for Economical aspect, Environmental and Social factors of sustainability are 0.83, 0.89, and 0.78, respectively. A total of 45 questionnaires were sent to a pilot study and 36 responses were received. Through the pilot study, the instrument was improved and validated.

#### 3.4 Analysis and Results

The questionnaire used in this research was gleaned and compiled from various instrument. The responses were analyzed and the most determinants of sustainability of design

and manufacturing were identified. The determinants for sustainable Product design and manufacturing were identified on the basis of three factors of sustainability economical, environmental and social [17]. The determinants identified were very useful to adopt sustainable development in Indian manufacturing.

For this study the respondents were asked to respond the determinants of SPDM in economical aspect of sustainability the mean value for the determinants are shown in the table-1. From this table it is clearly examine the product life cycle is the most driving factor for SPDM. Product life cycle finds the life of the product therefore it is very much important that Indian manufacturing organization need to focus on the new tools and techniques for assessment of product life cycle.

Apart from this product innovativeness, carbon trading, profitability, return on investment, GSM and Product life span has to be put more emphasis by the industries.

Table: 1 Economical aspect for SPDM

S. No.	DETRMINANTS	MEAN
1	Product life cycle	4.73
2	Product innovativeness	4.58
3	Carbon trading	4.20
4	Profitability	3.92
5	Return on Investment	3.68
6	Green supply chain management	3.62
7.	Product life span	3.48

In the environmental factor in table -2, it is clearly shown that 6R (reuse, recover, recycle, redesign, reduce and remanufacture) [18] high mean and it is play an important role for SPDM. On the other hand Biodegradable material, waste minimization, Carbon foot print, Energy conservation and CDM mechanism has its own importance for SPDM.

Table: 2 Environmental aspects for SPDM

S. No.	DETRMINANTS	MEAN
1	6R' concept	4.87
2	Biodegradable material	4.56
3	Waste minimization	3.96
4	Carbon foot print	3.73
5	Energy conservation	3.25
6	Clean development mechanism Practices	3.21

In the Social factor in table -3, it is clearly shown Housing and service infrastructure has high mean and it is play an important role for SPDM. On the other hand Health and education, Job opportunity, Social capital and Legislation and enforcement have its own importance for SPDM.

Table: 3 Social aspects for SPDM

S. No.	DETRMINANTS	MEAN
1	Housing and service infrastructure	4.47
2	Health and education	4.18
3	Job opportunity	3.98
4	Social capital	3.83
5	Legislation and enforcement	3.64

#### 4. Conclusions

Sustainable product design and manufacturing is an important concern for every organisation and has its own importance for the sustainable development. This paper shows the key determinants of SPDM in term of economical, environmental and social factors. From the survey in the Indian manufacturing industry it is clear that for the sustainability in the design and manufacturing of a product the organisation should have focuses on the key factors which are identified.

From the results it is to be conclude that key Determinants for on the basis of three factors of sustainability for SPDM were Product life cycle, 6R (reuse, recover, recycle, redesign, reduce and remanufacture) and Housing and service infrastructure and on the basis of these key determinants, the organisation should decide the path of sustainable product design and manufacturing. Thought other determinants which were identified played their own importance for SPDM. this study provides the clear picture determinants of sustainable product design and manufacturing. This study is limited for the automotive, electrical and electronic and plastic product manufacturing organisation in the Indian context. The further study may be carrying out for different organisations.

#### References

- [1] Gladwin, T.N., Kennelly J.J. and Krause T-S. (1995), "Shifting Paradigms for Sustainable Development: Implications for Management Theory and Research", the Academy of Management Review, Vol. 20, No. 4, pp. 874-907
- [2] World Commission on Environment and Development (1987), Our Common Future, Oxford University Press, Oxford, England.
- [3] Clark, G., Kosoris, J., Hong, L. N., & Crul, M. (2009). Design for Sustainability: Current Trends in Sustainable Product Design and Development. *Sustainability*, 1(3), 409–424.
- [4] Copper, T (2000) Product development implications of sustainable consumption. *The design journal*, 3(3), 46-57.
- [5] Fadzlin, A., Zubir, M., & Habidin, N. F. (2012) The Development of Sustainable Manufacturing Practices and Sustainable Performance in Malaysian Automotive Industry, *Journal of Economics and Sustainable Development* 3(7), 130–139.
- [6] Kara, S., Honke, I., & Kaebnick, H. (2005) Integrated Framework for Implementing Sustainable Product, *Proceedings of IEEE conference*. 684–691.
- [7] Maxwell, D., (2004) development sustainable product and services in industry. PhD thesis. London: Imperial College.
- [8] Johansson G., (2002) Success factors for integration of ecodesign in product development a review of state-of-the-art, *Environmental Management and Health* 13 (1) 98–107.
- [9] Lofthouse V., (2006) Ecodesign tools for designers: defining the requirements, *Journal of Cleaner Production* 14 (15–16) .
- [10] Fan, C., Carrell, J. D., & Zhang, H. (2010) An Investigation of Indicators for Measuring Sustainable Manufacturing.
- [11] Chang, Y. C. C. (2013). The Determinants of Green Product Development Performance: Green Dynamic Capabilities, Green Transformational Leadership and Green Creativity, *Journal of Business Ethics*, 116 107–119.
- [12] Jung, C. B., Carrell, J., Sarkar, P., & Feng, S. C. (2012). Categorization of indicators for sustainable manufacturing, *Ecological Indicators*, 24, 148–157.
- [13] Kenneth, W., Jr, G., & Zelbst, P. J. (2012). Green supply chain management practices: impact on performance, *Supply Chain Management: An International Journal*, 17 (3) 290–305.
- [14] Bey, N., Hauschild, M. Z., & Mcaloone, T. C. (2013). CIRP Annals - Manufacturing Technology Drivers and barriers for implementation of environmental strategies in manufacturing companies. *CIRP Annals - Manufacturing Technology*, 62(1), 43–46.
- [15] Amrina, E. (2012). Drivers and Barriers to Sustainable Manufacturing Initiatives in Malaysian Automotive Companies, *Proceedings of the Asia Pacific Industrial Engineering & Management Systems Conference*, 629–634.
- [16] Nunnally, J.C. (1978) *Psychometric theory*, McGraw- Hill, New York.
- [17] Kaebnick, H., Kara, S., & Sun, M. (2003). Sustainable product development and manufacturing by considering environmental requirements, *Robotics and Computer Integrated Manufacturing* 19, 461–468.
- [18] Jawahir, I.S., Dillon, O.W., Jayal, A., Badurdeenand, F., Rouch. K.E., (2010) Developing Next Generation Products and Processes using Innovative Sustainable Manufacturing Principle, *Proceedings of 4th Int. Conf. on Sustainable Energy and Environmental Protection*.