

A Case Study of Sustainable Manufacturing Practices

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Abstract—Sustainable manufacturing practices aims at minimizing the impacts of manufacturing operations on the environment while optimizing the production efficiency of firms. Today, products are no longer judged by the price but the sustainable initiatives implemented by firms. Efforts to reduce the environmental impacts of manufacturing operations have traditionally been viewed as an obstacle to profitability and efficiency. However, studies have shown that the implementation of sustainable manufacturing practices is beneficial to firms. This research reports a case study on the sustainable manufacturing practices of a selected company in Kedah, Malaysia. Data were collected using a semi-structured interview from key personnel in the company that directly involved in the implementation of the practices. The interview was recorded and transcribed and the result revealed that responsive product strategy, lean practices, supply chain restructuring and sustainable material and design are the sustainable manufacturing practices implemented by the case company while on-time delivery, recycle carbon fibre and trend to green material are the benefits of sustainable manufacturing practices.

Index Terms—sustainable manufacturing, aerospace industry, lean manufacturing

I. INTRODUCTION

Organisations in all sectors are feeling increased pressure from regulators, customers and other stakeholders to adopt sustainable manufacturing practices. In the case of manufacturing sectors, retailers and consumers are no longer just care about product quality and price. Today, products are judged by the methods used to manufacture and transport them. Manufacturers are feeling pressure in the form of increased environmental and social legislation. Industry Week reports a 300 percent increase in climate change regulations between 2002 and 2007, affecting all manufacturers that are part of a corporate supply chain in all geographic regions [1].

Efforts to reduce the environmental impacts of manufacturing operations have traditionally been viewed as an obstacle to profitability and efficiency. However, many manufacturers are discovering that effort to reduce environmental and the impact results in reduced operating costs and improved employee workplace satisfaction. Through making sustainable improvements to

manufacturing operations, companies are realizing operational expense savings as well as improved marketability of their product. This paper describes sustainable manufacturing practices that have been implemented by a manufacturing company. It is particularly important since increased research, information and technology transfer is needed if sustainable manufacturing is to become adopted quickly and in a widespread manner in the future.

II. LITERATURE REVIEW

There are large number of definition of sustainability by different groups as per their suitability and needs [2]. Sustainability is the philosophy of “meeting the needs of the present without compromising the ability of future generations to meet their own needs” [3]. Sustainability is now a prime concept in the developing thinking at all discipline. Over the last decades, sustainability has got the whole world’s attention when activities induced by human created adverse effects on the earth’s environment. Stakeholders including consumers, investors, employees, retailers, non-profit organisations, and NGOs increasingly expect companies to implement sustainable manufacturing practices.

Achieving sustainable manufacturing or in an older perspective, green manufacturing, has become the main part in many companies vision. The economical and environmental benefits obtained as a result of having sustainable processes and products, have put this issue in the centre of attention during recent years. There have been many strategies to achieve this goal and many efforts have been done to increase the sustainability of the products and processes.

Sustainable manufacturing can be categorised into four; Responsive Product Strategy (RPS), Lean Practices (LP), Supply Chain Restructuring (SCR), and Sustainable Material and Design as shown in Table I.

There are a number of critical factors leading to sustainable manufacturing practices. The factors affecting sustainable manufacturing practices can be divided into three main dimensions; management, internal and external factor as shown in Fig. 1. For the first dimension, management’s attitude towards the sustainable manufacturing practices is one of the key drivers. Various researchers have studied the social orientation and

perception of social corporate sustainability and relating concepts from the management perspective [4]; [5] and [6]. Leaders of those companies which have a well articulated set of guiding principles and strong sense of shared value are at higher motivation level and more eager to make changes.

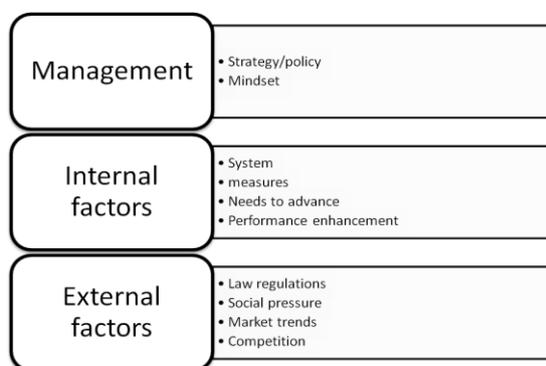


Figure 1. Key factors influencing the adoption of sustainable manufacturing.

To adopt sustainable manufacturing practices, it requires a supportive environment. The drivers of the sustainable practices are the context in which the firm finds itself and its overall direction [7]. The internal components in such a supportive environment include relevant supportive policies, resources and internal infrastructure, as well as an established performance evaluation system within the corporation. In an organisation that adopts and implement sustainable manufacturing practices, the organisational policy should favour its implementation.

External factors to implementation of sustainability manufacturing are discussed by [8], [9] and [10]. External factors such as local laws and regulations, market trends (industry specific) as well as social pressures are leading to the operationalization of sustainability practices. Like manufacturing companies need to develop sustainable products to meet the market needs. The sustainable product involves both cost and market factors that reflect the common perception on the firms.

III. RESEARCH METHOD

In this study, the authors used qualitative data collection method. According to [11], qualitative data gives the researcher depth of understanding in terms of inner working of human organisations. A manufacturing company was chosen for in-depth interviews. This company was selected based on the willingness to participate and experience in sustainable manufacturing implementation. The authors prepared the data collection by first contacting the company to be studied to gain their cooperation, explained the purpose of the study, and recorded the key contact information. A semi-structured interview guide was developed upon a common case study protocol inferred from the review of literature done prior to the case study. The interview protocol was developed to probe the sustainable manufacturing implementation in the case company. The interview was done in the form of a “one to one” discussion that lasted approximately two

hours. The interview was recorded and transcribed. The respondent involved is the key personnel in the company that directly involved in implementation of sustainable manufacturing. He was questioned with regard to his actual experiences.

IV. FINDINGS AND DISCUSSION

A. Company Background

Company XY which is located at Kedah, Malaysia manufactures composite material components and sub-assemblies for aircraft applications. The company was established in February 1998 with collaboration of Boeing, Hexcel and local company. The composites produced by Company XY consists of fabricated parts for secondary structural assemblies on commercial aircraft, including assemblies of wing fairings, fixed or movable surfaces, inspection-access doors and similar parts for the worldwide market.

B. Sustainable Manufacturing Practices in Company XY

From the interview, the authors identify that sustainable manufacturing practice being used in Company XY can be divided into the following categories:

1) Quality improvement tools

The purposes of quality improvement tools are to reduce the defect and increase the customer satisfaction. The quality effort in Company XY is continuously pursue through empowerment and quality improvement by complying the procedures and processes in accordance with BS EN9100:2003, AS 9100 Rev B, BS EN ISO9001: 2000 & Napcap for composites and NDT, deliver quality products on time, and competitively priced. The company also focuses on Six Sigma, Kaizen, Design of Experiment, Lean Practices and relentless company-wide pursuit of continuous improvement combine to yield aerospace products of unrivalled quality and value.

2) Improve effectiveness of Environmental, Health and Safety Policy

Company XY is committed to maintaining the highest standard of Environment, Health and Safety (EHS) Policy. The accreditation of OHSAS 18001 and ISO 14001 serve as a testimony to their commitment in ensuring products is in accordance with internationally recognised standards of EHS and Quality. The company has emphasizes great priority on EHS and take proactive steps toward the conversion and preservation of environment. In 2006, the company were awarded Environmentally Best Kept Industry by the Kedah State.

As for July 2009, they have accumulated 7.3 millions man-hours without lost time injury. This achievement would not have been possible without active employees’ involvement and management commitment in promoting EHS awareness and complying with all EHS procedures and regulations on their safety programs such as Safety Observation Card, and near misses reporting to inspire the proactive approach towards mitigating EHS incidents. Such programs are also extended and applicable to the company’s suppliers and third party workers to ensure a

synergised approach of EHS and to inculcate EHS to personal behaviour level. All these efforts have been recognised nationally as Company XY have been awarded with Silver Awards from National Council of Occupational Safety & Health in 2007.

Company XY's commitment in EHS is solidly reinforced in EHS policy statement which to provide a safe, health work environment and free from recognised industrial hazards. They are committed to identify and control environmental, health, safety risk and comply with the relevant EHS laws and regulations and other legal requirements. As a condition of employment, every employee is expected to implement this policy, take responsibility and keep unformed about EHS risks and standards, operate a safe and environmentally sound facility and advice management promptly of any adverse situation which come to their attention. With the commitment and cooperation of each member of the work force, they will continue to provide a safe and healthy workplace for the future.

3) *Development of Bill of Material (BOM)*

According to the respondent, the development of BOM also contributes in Company XY's sustainable manufacturing implementation. BOM is a list of the arts or components that are required to build a product. At its most complex, a BOM is a multi-level document that provides build data for multiple subassemblies and includes each item such as part number, approved manufacture list, mechanical characteristics, part specification and a whole range if component descriptors.

BOM errors typically fall within three categories: completeness, consistency and correctness. To develop the BOM, the company need to do and tell the proper and correct ingredients. If there are errors, the BOM requires immediate change and decision. The reason is to control the cost of BOM and reduce wastes.

4) *Lean manufacturing*

Lean manufacturing is a management approach to manufacturing that strives in making organisations more competitive in the market by increasing efficiency, decreasing costs through elimination of non-value adding steps, and inefficiencies in the processes [12], as well as reducing cycle times [13].

Since Company XY faced some problems of resources and supply chain, adoption of lean manufacturing is a good choice for the company to improve this situation. It is because lean is achieved through a set of mutually reinforcing practices, including total quality management, continuous improvement, supplier management, integrative information system, and effective human resource management. Lean manufacturing results in waste elimination that lead to improved output and quality levels, by using fewer resources such as raw materials and employee effort.

5) *Composite materials*

The composites produced by Company XY consist of material components and sub-assemblies for aircraft applications. To make a composite structure, the composite material, in tape or fabric form, is laid out and

put in a mould under heat and pressure. The resin matrix material flows and when the heat is removed, it solidifies. The material can be formed into various shapes. In some cases, the fibres are wound tightly to increase strength. One useful feature of composites is that they can be layered with the fibres in each layer running in different direction. This allows materials engineers to design structure that behave in certain ways. The greatest value of composite materials is that they can be both lightweight and strong. The heavier an aircraft weighs, the more fuel it burns. Therefore reducing weight is important in Company XY.

TABLE I. SUSTAINABLE MANUFACTURING PRACTICES

Sustainable manufacturing practices	Details	Authors
Responsive Product Strategy	<ul style="list-style-type: none"> Focus on offering products with competitive elements in terms of innovativeness, flexibility and frequent offerings. 	[14] & [15]
Lean Practices	<ul style="list-style-type: none"> To empower the workforce with enhanced sets of skills and expertise while continuously streamlining the entire business process from sourcing to delivery by minimising wastes and increasing quality and productivity. Major LP tools and practices: cellular manufacturing, continuous improvement programs, cross-functional workforce, lot size reduction, preventive maintenance, kanban and quick changeover technique. 	[16] & [17]
Supply Chain Restructuring	<ul style="list-style-type: none"> Increasing availability of outsourcing, large numbers of suppliers with manufacturing and service capabilities, and globalisation. Improvements in business routines, strategic policy shift to implement group purchasing, reverse e-auction, time-based logistics, different supply chain relationship, and employee redeployment. 	[1] & [18]
Sustainable Material and Design	<ul style="list-style-type: none"> Sustainable material – do not harm either the environment or potential customer. Sustainable design – efficient, user friendly, durable and easily recycled. 	

6) *Energy saving*

Company XY realised the energy savings through lean manufacturing results efficiencies such as decreased space utilisation, decreased transportation, and less product rework. High level results achieved at Boeing's machine fabrication manufacturing business unit (MBU) indicate that, as a result of Lean, overall space utilised by MBU has decreased from 650,000 to 450,000 square feet, and 8,000 square feet worth of temperature controlled atmosphere has been eliminated. This yields cross-the-board energy

savings on a per product basis associated with all aspects of building space energy utilisation, for example heating, cooling and lighting. With respect to transportation, Boeing's value chain analysis has produced substantial reductions in the amount of transportation utilised in its manufacturing and assembly activities. Within its factory, Company XY utilises cellular manufacturing strategy to substantially decreased internal product travel. The company's Lean initiatives have likewise substantially reduced the amount of rework and associated energy requirements conducted in its manufacturing and assembly operations.

7) *Water consumption*

According to the respondent, water is very important to the manufacturing process. Company XY is very concerned with both the amount of water consumed and quality of water released. To reduce the amount of water in the manufacturing process, the process is assessed to determine whether less water can be used by increasing efficiency of application, or whether more water can be reused and recycled. In the manufacturing process, frequently water usage could emit wastewater containing chemicals. Depending on its composition, the wastewater may be subject to local health regulations and requires expensive treatment and remediation. Company XY reduce the costs and risks related to water and wastewater by minimising the overall use of water in their manufacturing process, using recycled water rather than potable sources, minimising contaminants in wastewater, and investigating the feasibility of capturing recycle and reuse water onsite.

C. *Benefits of Sustainable Manufacturing Practices in Company XY*

1) *On time delivery*

One of the best criteria of Company XY is on time delivery. The sustainable manufacturing help in effective production process flow which makes the product on time delivery to the customers. Once an order is delivered on time, the customer will be satisfied and loyal to the company. Hence lead to profit and competitive gain to Company XY.

2) *Recycled carbon fibre*

The introduction of the largely composite Boeing 787 Dreamliner presents new opportunities in composite recycling. For the past several years, Boeing has been working with a number of third party technology firms on the recycling of an aerospace grade composites. Boeing began these efforts in 2004 with the first tests using scrap carbon fibre reinforced plastic (CFRP) composite from retired F-18A airplanes. More recent tests have used 777 and 787 composite manufacturing scrap. Recycling carbon fibre can be done approximately 70 percent of the cost and using less than 5 percent of the electricity required to make new carbon fibre.

3) *Trend to green 'material'*

Starting from 2010, Boeing Company has initiatives to implement the Green Aviation Program. This program consisted of advanced wing designs, composites for

efficient structure, structural analysis method, efficient low emission engines, fly by wire and quiet engine nacelle. As a joint venture for Boeing Company, Company XY has strived forwards focus in this program to achieve the strategic success in Boeing Company. The company is more focused in advanced wing design that includes computational fluid dynamics (CFD) and wind tunnel validation, and also further develops composite materials for efficient structure. As a result, the company considered to move to sustainable material development in the future.

V. CONCLUSION

The pressures in the form of increased environmental and social legislation have driven the implementation of sustainable manufacturing practices among the manufacturers. Sustainable manufacturing practices is traditionally seen by companies as a burden and thereby reduces the profitability and efficiency opportunities of the companies, however, reduction of operation costs and improved employee satisfaction are the benefits of the companies when the initiative is successfully implemented. This study through the data collected by using a semi-structured interview from the selected case company has been able to highlight that responsive product strategy, lean practices, supply chain restructuring and sustainable material and design are the prominent sustainable manufacturing practices implemented by company XY. The review of literature in this study also highlighted that the critical factors to successful implementation of sustainable manufacturing practices are classified into the management, internal and external factors.

This research has been able to successfully achieve its aims by shedding more light into the implementation of sustainable environmental manufacturing practices, the critical success factors and the benefits of the initiative. However, the study is limited to only one company which have a tendency to affect the generalization of its results. Therefore, future researchers are expected to use this study as a basis to expand the study on sustainable manufacturing practices by collecting data from a larger sample size across firms of various industrial sectors, Furthermore, future researchers on this similar study are advised to conduct a comparative study to ascertain the significant difference among companies in implementing sustainable manufacturing practices.

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REFERENCES

- [1] T. L. Friedman, *The World Is Flat—A Brief History of the Twenty-first Century*, 1st ed. Farrar, Strauss & Giroux, April 2005.
- [2] C. A. Langston and G. K. C. Ding, *Sustainable Practices in the Built Environment*, 2nd ed. Oxford: Butterworth-Heinemann, 2004.

- [3] "World commission on environment and development (WCED)," *Our Common Future*, Oxford and New York: Oxford University Press, NY, 1987.
- [4] D. Clifford and R. Cavanaugh, *The Winning Performance: How American's High Growth Companies Succeed*, New York: Bantam Books, 1985.
- [5] J. W. Marz, T. L. Powers, and T. Queisser, "Corporate and individual influences on managers' social orientation," *Journal of Business Ethics*, vol. 46, no. 1, pp. 1-11, 2003.
- [6] A. M. Quazi and D. O'Brien, "An empirical test of a cross national model of corporate social responsibility," *Journal of Business Ethics*, vol. 25, no. 1, pp. 33-51, 2000.
- [7] R. B. Hutton, D. B. Cox, M. L. Clouse, J. Gaebauer, and B. D. Banks, "The role of sustainable development in risk assessment and management for multinational corporations," *The Multinational Business Review*, vol. 15, no. 1, pp. 89-111, 2007.
- [8] P. Bansal and K. Roth, "Why companies go green: A model of ecological responsiveness," *Academy of Management Journal*, vol. 43, no. 4, pp. 717-736, 2000.
- [9] J. B. Skjaerth and T. Skodvin, "Climate change and the oil industry: Common problems, different strategies," *Global Environmental Politics*, vol. 1, no. 4, pp. 43-63, 2001.
- [10] M. I. Winn, "Corporate leadership and policies for the natural environment, sustaining the natural environment: Empirical studies on the interface between nature and organizations," 1995.
- [11] R. Hessler, *Social Research Method*, 1992.
- [12] J. Motwani, "A business process change framework for examining lean manufacturing: A case study," *Industrial Management & Data Systems*, vol. 103, no. 5, pp. 339-346, 2003.
- [13] A. S. Sohal and A. Egglestone, "Lean production: Experience among Australian organizations," *International Journal of Operations & Production Management*, vol. 14, no. 11, pp. 35-51, 1994.
- [14] M. Christopher and D. Towill, "An integrated model for the design of agile supply chains," *International Journal of Physical Distribution and Logistics Management*, vol. 31, no. 4, pp. 235-246, 2001.
- [15] N. Slack and M. Lewis, *Operations Strategy*, 2nd ed. Edinburgh Gate, Harlow, England, 2001.
- [16] J. Womack and D. T. Jones, *Lean Thinking: Banish Waste and Create Wealth for Your Corporation*, 2nd ed. New York: Simon and Schuster, 2003.
- [17] M. Holweg, "The genealogy of lean production," *Journal of Operations Management*, vol. 25, pp. 420-437, 2007.
- [18] D. Lei and M. A. Hitt, "Strategic restructuring and outsourcing: The effect of mergers and acquisitions and LBOs on building firm skills and capabilities," *Journal of Management*, vol. 21, no. 5, pp. 835-859, 1995.



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