CHEMICAL ENGINEERING TRANSACTIONS
VOL. 94, 2022
A publication of AIDIC
The Italian Association of Chemical Engineering
Online at www.cetjournal.it
Guest Editors: Petar S. Varbanov, Yee Van Fan, Jiří J. Klemeš, Sandro Nižetić

ISBN 978-88-95608-93-8; **ISSN** 2283-9216
DOI: 10.3303/CET2294157

Enhancing Sustainable Performance using Lean Quality Competitive Manufacturing Strategy: A Case Study in the Luggage Company

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Manufacturing companies must be more cautious in using their resources to create sustainable competitive advantages. A Lean Quality approach enables manufacturing companies to identify non-value-added activities and the severity of defects, thus sustaining their production process effectively and efficiently. The present research proposes a Lean Quality sustainable competitive manufacturing framework by combining the Sustainable Value Stream Mapping (SVSM), Quality, and Sustainability Index (SI) Assessment. This framework measures the contribution of the Lean Quality approach to achieving a better SI by considering the Defect Per Millon Opportunities (DPMO) indicator. The SVSM is applied to identify the non-value-added activities and the severity of the defect, and the Pairwise Comparison is applied to define the weight of performance indicators. The validation process is conducted using this framework to enhance the SI in an Indonesian luggage manufacturing company. The calculation of the DPMO value is 9,412, with a Sigma Level of 3.85. Based on the results of performance mapping for all sustainability indicators, the SI calculation results at the luggage company is 181.1 %. The company needs a continuous improvement program for the DPMO indicator, thus, reducing the value of change in all the other indicators related to the economic pillar. This research provides empirical evidence of the positive contribution of the Lean Quality approach to enhancing sustainable competitive manufacturing performance. The framework can assist the practitioners in implementing a Lean Quality approach and measuring its contribution to improving SI.

1. Introduction

The manufacturing sector is essential in supporting the successful implementation of the Sustainable Development Goals (SDGs) (Sari et al., 2021a). This sector plays a role in creating jobs, improving social welfare in the community, and reducing the environmental impact of the production process (Sari et al., 2021a). The manufacturing industry must be wise and responsible for determining and utilising production resources as production inputs, from the product design stage, process design, and production facility design to production operations and supply chain management supporting green production (Shah et al., 2021). To integrate all data, information, and processes across their entire extended value chain, progressive organisations require implementing a Sustainable Enterprise Resource Planning (S-ERP) system (Chofreh et al., 2016).
To create a sustainable competitive advantage, manufacturing companies need to be more careful in selecting production resources, production operational policies, and tactical and strategic policies to support the SDGs program. The focus of the SDGs program is Responsible Consumption and Production, which is the 12th point

Paper Received: 27 May 2022; Revised: 13 June 2022; Accepted: 24 June 2022
Please cite this article as: Marie I.A., Sari E., Dewayana T.S., Lestari F., Chofreh A.G., Goni F.A., Klemeš J.J., 2022, Enhancing Sustainable Performance using Lean Quality Competitive Manufacturing Strategy: A Case Study in the Luggage Company, Chemical Engineering Transactions, 94, 943-948 DOI:10.3303/CET2294157

of the 17 SDGs goals as one of the goals considered a priority for sustainable development (Moldavska and Welo, 2018).
The global market has begun to increase awareness of sustainable manufacturing, as indicated by the proliferation of companies adopting a sustainable manufacturing paradigm and showing positive impacts (Gbededo et al. 2018). Customers want to consume products from companies that can positively impact social, economic, and environmental aspects (Gbededo et al., 2018). An integrated sustainable product is a cost-effective product, produced in an eco-efficient system, eco-efficient in the usage phase, safe, and socially acceptable. To achieve the Responsible Consumption and Production target in the manufacturing industry, companies can use Competitive Manufacturing Strategies (CMS) (Garbie, 2016). Non-conventional CMS is essential in evaluating a company's manufacturing by optimising manufacturing complexity, leanness, agility, remanufacturing, and recycling (Garbie, 2016).
Lean techniques can contribute to sustainable development (Teixeira et al., 2021). Lean principles define a product or service value, among others in customer expectations, and then make the process flow according to the customer perfectly with continuous improvement to eliminate waste (Sundar et al., 2014). Seven types of waste are targeted in Lean Manufacturing: overproduction, inventory, over-processing, motion, waiting, defects, and transportation (Krajewski, 2019). The company's goal to reduce waste is to save on using resources and efforts to increase profits from an economic point of view. This is in line with the objectives of the sustainable manufacturing concept. The company's efforts to reduce waste also include non-value-added activities in the entire scope of the production process that cause waste to appear (Ishak et al., 2019).
With the waste problem caused by waste defects, the Six-Sigma approach is also a customer-focused continuous improvement strategy to minimise defects and variations toward achieving 3.4 Defects/M Opportunities (DPMO) in product design, production, and administrative processes (Valles et al., 2009). The case study results reveal that Define Measure Analyse Improve Control (DMAIC) based research can be effectively integrated into Sustainable Value Steam Mapping (SVSM) tools for sustainable manufacturing. Integrating the DMAIC approach in the application of sustainable manufacturing can identify and eliminate defective products so that companies can improve their improvement processes more sustainably (Jamil et al., 2020).
This study aims to determine the results of the integration of the Lean Quality method and the sustainable paradigm that can positively contribute to improving Sustainable Competitive Manufacturing Performance (SCMP). The case study is shown in a suitcase-producing manufacturing company. The utilisation of a Sustainable Lean Quality (SLQ) approach in luggage companies is expected to provide solutions for luggage companies to increase production efficiency and quality and assess sustainable manufacturing performance.

2. Research approaches

The research approach consists of three main sections: creating SVSM, calculating DPMO, and measuring the Sustainability Index (SI). The SVSM will monitor the variability in terms of processing time and resource use and assess sustainable manufacturing performance on economic, environmental, and social aspects. DPMO indicator measures Sigma level to assess process quality parameters related to waste due to defects. The calculation of the SI followed the formula developed by Sari et al. (2021b). This study integrates the Lean Quality method and the sustainable paradigm by strengthening the economic pillars by adding the DPMO indicator in the SVSM and SI calculations. DPMO is one of the process capability assessments to measure a sound production process, a metric used in the Six Sigma concept approach. Adding the DPMO indicator as a sustainability performance will strengthen the acquisition of economic pillar performance related to the achievement of quality performance, which is also a value needed by customers. Increasing value for customers will increase the company's sustainability capabilities.

3. Results and discussions

3.1 Luggage company

The utilisation of Sustainable, Lean, and Quality approaches in this study will be based on data from Luggage Company X, which carries out its production process activities with large amounts of plastic seeds. As stated in the sales contract, Luggage Company X has an export market with customers requiring the company to apply for international certification. The international certification is guided by the concept of sustainable development and quality management. Luggage Company strives to improve quality but still emphasises the efficiency of the production process.
The frame is the central part of luggage products that gets the customer's attention. The suitcase frame is made from polycarbonate plastic seeds and, in the production process, will leave waste in the form of pieces of plastic. Plastic waste is a waste that is difficult to decompose; its presence will harm the environment. The company

hopes to reduce waste as a form of responsibility related to the production process. Based on the Quality Control Outgoing inspection at the luggage company, defective products were found with a percentage of rework products of more than 0.01 %. The next problem is that waste overproduction is found due to luggage products produced without the delivery date and becoming warehouse stock within a period. With relatively high defects caused by production and overproduction, the company needs to identify further the causes and several other types of resources, such as the use of labour, production process activities, energy use, and the type of waste generated.

3.2 SVSM mapping at luggage company

This study uses SVSM, which helps companies better understand the production process flow by using sustainable aspects at all stages of the operational flow cycle. SVSM provides information on process flow and scores for each indicator using a traffic light system. The scoring system in SVSM is made with a traffic light system to indicate whether an indicator needs to be improved (Hartini et al., 2019). The red colour indicates that the indicator score is still below the target, requires corrective action recommendations, and the yellow indicates that the achieved indicator score still needs improvement. The green colour informs that the indicator score is following the target that must be maintained. The target score is determined based on the capacity level and company policy.

SVSM of production process flow starts from the process of the suitcase frame making department, the inner suitcase manufacturing department, and the suitcase assembly department. The SVSM indicators for the pillar economy are selected based on a Lean approach, namely cycle time, time, inventory, and DPMO (indicator to strengthen the adoption of the Six-Sigma approach related to sustainability initiatives). The environmental pillar indicators reflect factory requirements in the factory operational process, including material control, electricity efficiency/ energy loss, water consumption, and waste. Regarding the social pillar, selected indicators focused on employee welfare, including employee satisfaction level, health and work safety, and employee training. Table 1 summarises the selected SVSM indicators for the luggage company X.

Figure 1 shows that the suitcase frame-making department requires recommendations for corrective actions (DPMO, noise level, and safety level) and needs improvement because they have not reached the target (inventory and employee training). For the interior luggage manufacturing department, the DPMO indicator also requires recommendations for corrective action, and the water consumption and noise level indicators also need to be improved. For the luggage assembly department, the energy loss indicator requires recommendations for corrective action. At the same time, the material and water consumption indicators also need to be increased because they have not yet reached the target. The findings of these inadequate indicators are the focus of analysis and a priority for further improvement.

Table 1: The selected SVSM indicators for the luggage company

Authors	Economic			Environmental				Social			
	C1	C2	C3	E1	E2	E3	E4	S1	S2	S3	S4
Delgadillo et al. (2022)		o	o	o	o		o	o		o	o
Atoillah and Hartini (2021)	o		o	o					o	o	
Hartini et al. (2021)	o	o	o		o	o	o	o	o	o	o
Sari et al. (2021b)	o		o	o	o	o		o	o		o
Wen et al. (2021)					o						
Bhanot et al. (2020)			o	o	o	o	o		o	o	o
Dadashnejad and Valmohammadi (2019)		o									
Djatna and Prasetyo (2019)			o	o		o					
Gholami et al. (2019)									o		
Goyal et al. (2019)			o								
Hartini et al. (2019)	o	o						o	o	o	o
Zarte et al. (2019)				o	o		o	o	o	o	
Huang and Badurdeen (2017)				o	o		o		o	o	
Ocampo (2015)								o			

Cost : [C1] Time; [C2] Inventory; [C3] DPMO Conventional

Environmental: [E1] Material; [E2] Energy Loss; [E3] Water Consumption; [E4] Waste

Social: [S1] Satisfaction Level; [S2] Noise Level; [S3] Safety Level; [S4] Employee Training

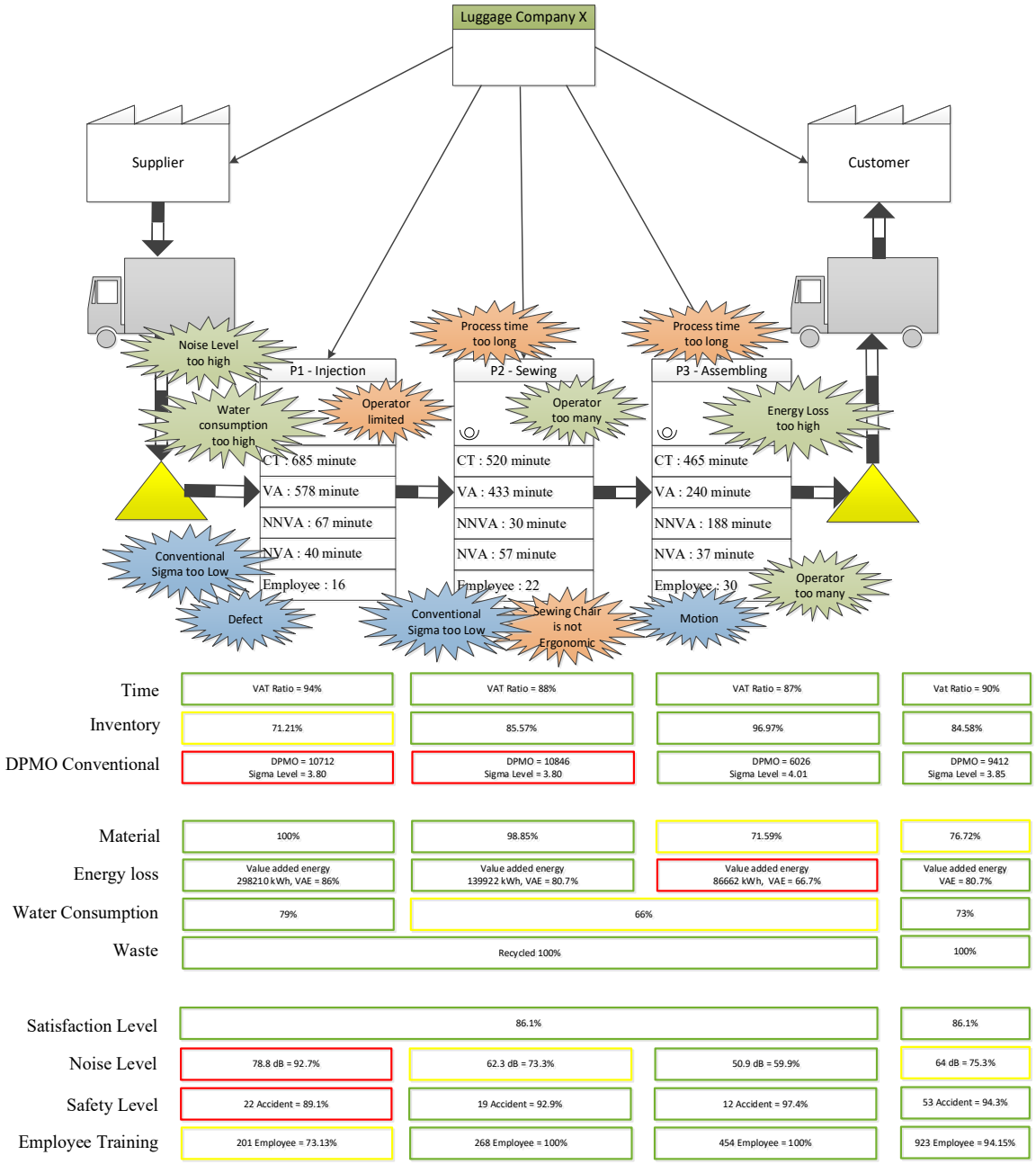

Figure 1: Current SVSM at company X

3.3 Sustainability index calculation at luggage company

Table 2 shows the results of the calculation of the SI at company X. Based on the results of SI calculations at PT X, 7 out of 11 indicators have a reasonably large gap between actual and target, with a change value of more than 10 %. DPMO has the highest value of change, i.e., 55.8 %. DPMO indicator is part of the pillar economy and will focus on improving using the Six Sigma approach. Improvements to increase this indicator enable enhancing the SI in the next period since it will affect the other indicator, i.e., time, inventory, material, energy loss, and water consumption. These results align with Delgadillo et al. (2022) that integrating the Lean Quality method and the sustainable paradigm by including the DPMO indicator with sigma level measurements can improve SCMP. The improvement program for noise level indicators, i.e., the use of earplugs and execution of a preventive maintenance program (Sari et al., 2021). Overall, the Manufacturing SI company X is 181.1 %. Luggage company X needs to make continuous improvement efforts by considering the results of the SVSM and the calculation of the SI, enabling the company to become a manufacturing company that continues to excel in global and sustainable competition.

Table 2: Sustainability index calculation at company X

Indicator		Performance Metric	Actual	Target	Value of Change (%)	SI (Factor)	Eigen Vector	Overall SI
Economy	Time	%	90.00	100	11.1	157 %	0.74	181.1 %
	Inventory	%	84.58	100	18.2			
	DPMO	%	3.85	6	55.8			
Environment	Material	%	76.72	100	30.3	297 %	0.17	
	Energy Loss	%	80.70	100	23.9			
	Water Consumption	%	73.00	100	37			
	Waste	%	100.00	100	-			
Social	Satisfaction Level	%	98.60	100	1.40	160 %	0.09	
	Noise Level	dB	64.00	85	32.8			
	Safety Level	%	94.30	100	6			
	Employee Training	%	94.00	100	6.4			

The Lean Quality mapping research results in collaboration with the sustainability concept show that utilising the SVSM and Six-Sigma approach can improve the performance of the company's SI. Furthermore, this research on luggage company X also supports previous studies' results that the integration of sustainability benefits corporate image, cost reduction, increased ability to innovate, financing, and increased productivity (Teixeira et al., 2021). The SVSM and sustainability analysis results on the luggage company X support the study results that the joint adoption of Lean and Green offers essential and positive outcomes for companies to improve triple-bottom-line performance (Cherrafi et al., 2021).

4. Conclusions

This study developed a comprehensive SVSM framework to measure the contribution of Lean Quality CMS for improving the manufacturing SI for luggage companies. The Lean Quality methodology enables the company to identify waste and defects (quantity and severity). The improvement program to be more sustainable can be defined. The overall manufacturing SI of luggage company X is 181.1 %. There are four indicators, namely DPMO, energy loss, noise level, and safety level, in the red zone. The correction actions need to be executed immediately to enhance the value of these indicators. From an academic perspective, the research would advance the SVSM framework by presenting the crucial indicators to measure the contribution of Lean and Quality CMS achieving the SDGs, especially SDG 12, Responsible Production, and Consumption. It provides empirical evidence of the positive contribution of a Lean Quality approach in improving SCMP. The framework can assist practitioners in implementing a Lean Quality approach and measuring its contribution to improving the SI. The limitation of this study is that there is no generic model for SLQ of luggage companies. For future studies, the authors will develop this model. This framework, methodology, and analysis can be customised for application in another manufacturing sector. The following study is encouraged to provide evidence of how Lean Quality and sustainability improve SCMP in the various manufacturing sector.

Acknowledgements

This research is supported by Internal Research Grant under the Universitas Trisakti (006/PL.01.11/FTI-STD/IX/2021). The authors highly acknowledge financial support from the project "Sustainable Process Integration Laboratory – SPIL funded by EU - CZ Operational Programme Research and Development, Education, Priority1: Strengthening capacity for quality research" (Grant No. CZ.02.1.01/0.0/0.0/15_003/000045).

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