DMAIC-BASED SUSTAINABLE VALUE STREAM MAPPING METHODOLOGY FOR SUSTAINABLE MANUFACTURING IMPROVEMENT

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ABSTRACT

After the seminal report of "Our Common Future" as a normative reference, sustainability has significantly and unprecedentedly evolved over the years, unanimously accepting that being sustainable is more beneficial. The research was accordingly built upon the discussion concerning sustainable value stream mapping (Sus-VSM) which recently emerged with the purpose of advancing sustainable manufacturing systems. Research on this sustainable-oriented lean tool is considered to be limited. It involves constant implementation plans for continuous improvement at value-stream level. Therefore, due to the lack of a continuous improvement process, subsequent developmental maps of this value stream can be established to continue the cycle which has been highlighted as a notable shortfall in this context. To fill the gap, this research study presents the application of a unified improvement approach known as 'Lean Six Sigma' through the development of the DMAIC methodology (Define, Measure, Analysis, Improve and Control) on sustainable value stream mapping. The methodology is outlined in detail by providing well-defined processes for each phase in the DMAIC-based approach, while at the same time considering sustainability elements in each step. The methodology begins by defining the research objectives and identifying relevant sustainable metrics as well as establishing the Sus-VSM appropriately for the Measure phase. A comprehensive analysis of waste and improvement activity identification was carried out by utilizing the Six Sigma tools thus deriving the future state of Sus-VSM in the Improve phase. Continuous improvement activity by performance monitoring and institutionalization was carried out in the final phase. The developed methodology was practically validated with an industrial case study in order to support this narrow body of knowledge. The research findings is revealed that the DMAIC-based approach can be effectively applied to systematize sustainable value stream mapping in sustainable manufacturing by contemplating environmental, economic and social sustainability elements. Additionally, the improvement activities conducted have resulted significant waste reduction of 28% and 21% for the environmental metric in terms of chemical and energy consumption respectively, 17.3% of cycle time reduction for the economic metric, and 44.4% for the social metric. The study also provides a guiding reference for operation managers who wish to undertake similar improvement projects and make their manufacturing operations more sustainable.

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ABSTRAK

Selepas laporan berpengaruh “Masa Hadapan Kita Yang Sama” dijadikan rujukan normatif, kemapanan telah berkembang dengan ketara dan tidak pernah berlaku sebelumnya, disepakati bahawa berkemapanan adalah lebih bermanfaat. Penyelidikan ini dibangunkan berdasarkan perbincangan mengenai pemetaan aliran nilai mapan (*sustainable value stream mapping* atau Sus-VSM) yang baru-baru ini diberi perhatian bermatlamat memajukan sistem pembuatan mapan. Penyelidikan ke atas kaedah *lean* berorientasikan kemapanan masih terhad. Ia melibatkan pelan pelaksanaan untuk penambahbaikan berterusan di peringkat aliran nilai. Justeru itu, disebabkan oleh kekurangan proses penambahbaikan berterusan, pembangunan peta aliran nilai seterusnya boleh dibangunkan bagi meneruskan kitaran tersebut, sebagaimana yang telah disorotkan sebagai kelemahan ketara dalam konteks ini. Bagi mengisi jurang ini, penyelidikan ini mencadangkan penggunaan pendekatan penambahbaikan bersepadu yang dikenali sebagai ‘*Lean Six Sigma’* menerusi pembangunan kaedah DMAIC (Takrif, Ukur, Analisis, Tambah baik dan Kawal) ke atas pemetaan aliran nilai mapan. Kaedah ini digariskan secara terperinci dengan menyediakan proses-proses yang ditakrif dengan jelas bagi setiap fasa di dalam pendekatan berasaskan DMAIC disamping mengambilkira elemen-elemen kemapanan pada setiap langkah proses-proses terbabit. Metodologi dimulakan dengan mentakrifkan objektif penyelidikan dan mengenalpasti kemapanan metrik yang relevan disamping membangunkan Sus-VSM yang bersesuaian untuk fasa Ukur. Analisis menyeluruh ke atas pengenalpastian sisa buangan dan aktiviti penambahbaikan telah dilaksanakan dengan menggunakan kaedah Six Sigma, dengan yang demikian mendorong keadaan masa hadapan Sus-VSM dalam fasa Tambahbaik. Aktiviti penambahbaikan berterusan menerusi pemantauan prestasi dan penginstitusian dilaksanakan pada fasa akhir. Kaedah yang telah dibangunkan disahkan secara praktikal dengan kajian kes industri bagi menyokong pengetahuan yang terhad ini. Dapatan kajian mendapati bahawa pendekatan berasaskan DMAIC ini boleh diaplikasi secara berkesan kepada pemetaan aliran nilai mapan bersistem dalam pembuatan mapan dengan mengambilkira elemen-elemen kemapanan alam sekitar, ekonomi dan sosial. Tambahan pula, aktiviti-aktiviti penambahbaikan yang dilaksanakan telah menghasilkan pengurangan yang ketara ke atas sisa buangan masing-masing sebanyak 28% dan 21% untuk metrik alam sekitar dari segi penggunaan bahan kimia dan tenaga elektrik, 17.3% pengurangan dalam kitar masa untuk metrik ekonomi dan 44.4% untuk metrik sosial. Kajian ini turut menyediakan garis panduan untuk pengurus operasi yang berhasrat untuk menjalankan projek-projek penambahbaikan yang serupa dan menjadikan operasi pembuatan mereka lebih mapan.

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LIST OF ABBREVIATIONS

3R	-	Reduce , Reuse , Recycle
6R	-	Reduce , Reuse , Recycle , Recover , Redesign , Remanufacture
CI	-	Continuous Improvement
DMAIC	-	Define, Measure, Analyse, Improve and Control
DMAIRC	-	Define, Measure, Analyse, Improve , Review and Control
DOSH	-	The Department of Occupational Safety and Health Malaysia
E – VSM	-	Environmental Value Stream Mapping
EHPS	-	Electrical systems (E), Hazardous chemicals/materials used (H), Pressurized systems (P), and High-Speed components (S)
EHS	-	Environmentally Hazardous Substance
EN-Plating	-	Electro less Nickel Plating
EM		Environmental Manufacturing
EPA	-	Environmental Protection Agency
GWP	-	Global Warming Potential
HDD	-	Hard Disc Drive
IDM	-	Indirect Material Cost
JIT	-	Just In Time
LCA	-	Life Cycle Analysis
LM	-	Lean Manufacturing
LSS	-	Lean Six Sigma
MSD	-	Musculoskeletal Disorder
MTO	-	Metal Turn Over
NIHL	-	Noise Induced Hearing Loss
OWAS	-	Ovako Working Posture Analysing System
PDCA	-	Plan Do Check Act
PLI	-	Physical Load Index
REBA	-	Rapid Entire Body Assessment
RNLE	-	Revised NIOSH Lifting equation
RULA	-	Rapid Upper Limb Assessment

SM	-	Sustainable Manufacturing
SMP	-	Sustainable Manufacturing Practices
SPC	-	Statistical Process Control
STVSM	-	Sustainable Transportation Value Stream Mapping
Sus- VSM	-	Sustainable Value Steam Mapping
TBL	-	Triple Bottom Line
TPM	-	Total Productive Maintenance
TTM	-	Time to Market
VSM	-	Value Stream Mapping
WCED	-	World Commission on Environment and Development
VAR	-	Value Added Ratio

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CHAPTER 1

INTRODUCTION

1.1 Research Background

Sustainability has become a significant and critical criterion for any product and process design in general and for companies in particular as it provides them with competitive edge and a cost effective roadmap for their manufacturing processes performance. The current global society is also increasingly demanding for sustainability not only on the environmental dimension, but also on the economic and social aspects. A proper definition of sustainability takes into consideration the triple bottom lines (TBLs) namely the environmental, societal and economic dimensions throughout a product's full life cycle i.e. from raw materials extraction, production, usage and eventually disposal and recycling. Figure 1.1 illustrates the interconnections between the environmental, economic and social dimensions according to WCED (1987).

The relationship between the TBLs plays a crucial role in ensuring optimum sustainability achievements. A further definition of sustainability is given by Barrett and Sexton (2000) who highlighted that sustainability can be improved by minimizing environmental and social impacts while at the same time maximizing the economic benefits. However, one question remains: How well has the methodology been developed and structured towards sustainable manufacturing? To address this question, this research is carried out to examine the integration between sustainability and Lean Six Sigma (LSS) with development of comprehensive and systematic approach methodology. The sustainability elements are defined specifically in the selected case study of Electro less Nickel plating process by considering all the TBLs.

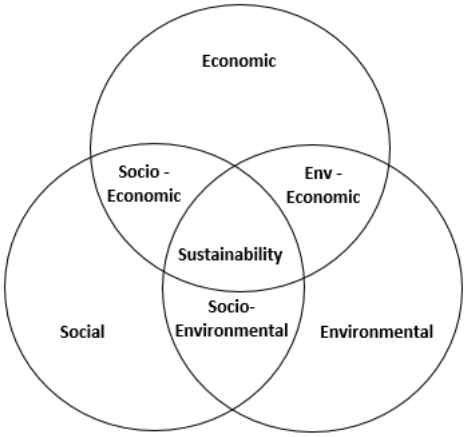

Figure 1.1 Three Pillar Concepts (WCED, 1987)

Shah et al. (2008) concluded that lean six sigma (LSS) is the powerful integration for continuous improvement after surveying 2511 companies involved in LSS application projects. Powell et al. (2017) had adopted VSM into the DMAIC approach and focused on the environmental sustainability assessment in the food industry. Similarly, Nagi and Altarazi (2017) used conventional VSM and the DMAIC approach to study the economic impact in the carpeting process. LSS can be applied in many industrial or organizational sectors, but somehow many researchers tend to integrate the LSS subsequently during the improvement activity. The LSS was applied together with VSM and DMAIC in the studies by Powell et al. (2017), Bendell (2006), Engelund et al. (2009), Miguélez et al. (2014) and Thomas et al. (2008), but they integrated both systems separately starting with VSM to identify waste followed by DMAIC as the problem solving tool.

Therefore, with the sequence of the integration method approached by previous researchers , this study aim to narrow down the system approach gap whereby the LSS research methodology is presented as one system and the Sus-VSM is utilized into the DMAIC system from the very beginning of the project. The methodology developed through the case study contributes to the body of knowledge as a comprehensive guidance for researchers and practitioners.

Garza-Reyes et al. (2014) introduced the review phase of the DMAIRC approach for the improvement activity on the conventional VSM, focusing on the

reduction of costs and lead time. Faulkner and Badurdeen (2014) developed the sustainable value stream mapping (Sus-VSM) to evaluate TBL performance in manufacturing using general metrics without integrating the Lean Six Sigma approach. Sus-VSM is applicable for a variety of industries and organizations as proven by Brown et al. (2014) through their case study that involved many sectors and fields.

Specifically, lean Sus-VSM was merged into sustainability manufacturing focusing particularly on TBL and LCA. The extended application of value stream mapping has more recently been clarified to fulfill the TBLs requirements in the manufacturing systems. Thus, there is a lack of literature on this sustainable-oriented lean tool, whereby the research attention had mainly on the economic issues, largely neglecting the environmental and societal aspects. Furthermore, the abovementioned innovative studies clearly indicated that extended VSMs have better capabilities in visualizing the TBLs for the assessment and improvement of sustainability performance. However , a systematic approach is observed to be lacking for the development of a more comprehensive methodology even though it has been integrated into the research methodology.

1.2 Statement of Problems

With sustainability as a constant standard reference, manufacturing systems have undergone numerous revolutions from its initial substitution-based ‘traditional manufacturing’; the revolution began with the waste reducing ‘lean manufacturing’ followed by the environmentally-driven ‘green manufacturing’ which introduced the highly popular 3R concept (reduce, reuse, recycle) in the 1990s, to the present-day ‘sustainable manufacturing’ which offers better stakeholder value as compared to the previous two practices through the introduction of the 6R concept i.e. reduce, reuse, recycle, recover, redesign, and remanufacture (Jawahir et al.,2006; Faulkner & Badurdeen, 2014).

Sustainability-driven innovations via these practices have been widely acknowledged. Innovation is identified to be highly crucial in developing sustainable manufacturing systems (Brown et al., 2014), which in turn requires "the creation of manufactured products which use processes that minimize negative environmental impacts, conserve energy and natural resources, are safe for employees, communities, and consumers and are economically sound" (US DOC, 2012). Such revolution necessitates a profound knowledge of the workings of waste systems that not only incorporate time-based wastes (muda), but also those that are attributed to the environment and society. Due to this, a methodology was proposed by Faulkner and Badurdeen (2014) which incorporates the value stream mapping (VSM) technique from lean manufacturing with added metrics to gage the sustainability of the environmental and societal impacts, thus known as Sus-VSM.

Based on relevant literature, several studies have examined the integration of additional metrics to extend the VSM, with the majority focusing on energy-related metrics (Torres & Gati, 2009; Kuriger & Chen, 2010; Dadashzadeh & Wharton, 2012). Others that had focused on 'sustainable' VSM are Fearne and Norton (2009) and Paju et al. (2010) which had mainly focused on environmental performance. Lai et al. (2008) employed VSM in proposing a framework that integrates the analyses of life-cycle environmental input, total cost, and energy consumption. Wills (2009) incorporated the environmental dimension into VSM and expanded the concept to become what is now known as the environmental value stream mapping (E-VSM). The E-VSM was further extended by Torres and Gati (2009) by incorporating the lean and environmental toolkit of the U.S. Environmental Protection Agency (EPA), and this approach was validated using a Brazilian case study specifically aimed at the sugar and alcohol manufacturing industry. Another extension of VSM called sustainable transportation values stream mapping (STVSM) was developed by Garza-Reyes et al. (2016) to improve the transport operations of a leading logistics firm based in Monterrey, Mexico.

From here, it is apparent that the VSM used in analysing TBLs and sustainable manufacturing has not been defined and structured properly (Duflou et

al., 2012). In general, research on this sustainable-oriented lean tool is still considered limited (Powell et al., 2017; Hartini et al., 2018).

Apart from the above-mentioned shortcomings of the Sus-VSM, another one of its glaring weaknesses is the lack of lean practices and tools that would otherwise contribute to the utilization of cutting-edge statistical/mathematical tools, the ability to gather and utilize statistical data as a means for process control and monitoring, as well as the ability to identify lingering issues following the elimination of waste. As one of the lean tools identified to enhance sustainability performance (Brown et al., 2014; Faulkner & Badurdeen, 2014), Sus-VSM ought to be treated as the enabler of a continuous improvement process whereby following the creation of a current-state map and the accomplishment of a future-state map, ensuing future-state maps can be established to continue the cycle. Nevertheless, Prashar (2017), Powell et al. (2017) and Garza-Reyes et al. (2018) had provided empirical evidence that such application would be more effective and efficient with the use of a systematic approach that incorporates logically and well-defined sequenced transitional stages. Hence, improvised tools that could help reduce or eliminate the said shortcomings are needed.

Such tools will be derived from Six Sigma considering the highly compatible integration between Lean and Six Sigma (LSS) as proven by numerous studies, which are presented in the theoretical framework of this research project. Six Sigma entails a project-based approach aimed at improving processes and quality of product (Gitlow et al., 2006; Ray & Das, 2010) . Gitlow et al. (2006) and Sin et al. (2015) carried it out using the DMAIC methodology, the acronym that incorporated the define, measure, analyze, improve, and control phases. The DMAIC users are provided with a decision-making and implementation platform that is based on actual and scientifically-proven facts. This is an effective alternative in achieving the maximum potential of a process improvement project (Garza-Reyes, 2015).

In overall, structured and systematic approach methodology are required to improvise the tools with the integration of Lean six sigma towards optimum sustainable manufacturing by considering the TBLs.

1.3 Research Questions

The research questions of this research are as follows:

a) What is the methodology to accommodate the Sus-VSM tool in the systematic LSS approach while simultaneously considering the overall sustainability elements for the TBLs?

b) Is it practicable to utilize Sus-VSM towards the sustainable manufacturing in determining and reducing the negative impacts of environment, economic and social aspects?

1.4 Research Objectives

The objectives of this research study are as follows:

(a) To establish and develop an effective methodology for continuous improvement activity through the integration of LSS, Sus-VSM and DMAIC-based approach.

(b) To demonstrate the practicability of the Sus-VSM in an actual industrial manufacturing case study, taking into consideration the environmental, economic and social elements.

1.5 Research Scopes

The scopes of this research are as follows:

a) The three pillars of sustainability consist of the environmental (chemical, water, and energy consumption), social (noise level and ergonomics) and economic (indirect material cost and cycle time) elements were considered in the proposed methodology.

b) The methodology developed was based on the integration of Lean Six Sigma and the improvisation of VSM to cover all the sustainability elements i.e. environment, economy and society.

c) An industrial case study was conducted in the substrate manufacturing industry specifically in the boundary of Electro less Nickel plating.

1.6 Significance of Research

The proposed methodology in this research project allows for a systematic, repetitive, and continuously improved cycle for the Sus-VSM together with the provision of uniquely characterized sequencing. Therefore, this project aims to contribute in filling the gap in literature concerning the use of Sus-VSM for meeting the triple bottom line requirements in sustainable manufacturing systems and to support the LSS body of knowledge by proposing a DMAIC-based approach for the systematic studies on Sus-VSM.

Effective demonstrations of Sus-VSM development in this case study significantly contribute towards sustainable manufacturing. The study also aims to be a reference for industrial practitioners and academicians for improvement project implementation and further research innovation studies. Torres and Gati (2009) in their research of E-VSM emphasized the need for a structured methodology as a sustainable management tool that can be applied and propagated to other industrial areas.

This study combines not only exclusive interviews with the management teams of the selected company, but also observations on their employees and SOP

document analysis making the research process a triangulation that can answer research questions more comprehensively. Furthermore, this study provides empirical evidence on how the integration of Lean Manufacturing, Six Sigma and sustainability approaches in methodological waste reduction can be successfully implemented. All the above increases the value of this research and even attract the attention of other scholars, academicians and industrial practitioners.

1.7 Thesis Structure

This thesis consists of six chapters. Each chapter is briefly described as follows:

Chapter 1 presents the background of the research consist of studies related to the sustainable manufacturing and integration of LSS, statement of problems, research questions, research objectives, research scopes, summary of research methodology, and the significance of the research to the body of knowledge and to the industry.

Chapter 2 discusses a detailed literature review concerning the sustainability and sustainable manufacturing concepts and their definitions, key successful factor to achieve sustainable manufacturing, equipped with the benefits of the sustainable manufacturing and industrial in practice. Other than that, this chapter also revealed the Lean Manufacturing (LM) tools and methodology as well as implementation of lean manufacturing in various industries. Besides that, Six Sigma concepts, tools and methodology highlighting the DMAIC-based approach been explained in this chapter. The integration of Lean Manufacturing and Six Sigma towards sustainable manufacturing been discussed thoroughly and also emphasizes on the VSM and Six Sigma applicability in sustainable manufacturing. Comparative analysis for previous researches in LSS been tabulated in details to support the significance of this research study. Sus-VSM metrics applied in previous studies considering the environmental, economic and social aspects been extensively reviewed in term of definition and application in industrial at the end of the chapter.

Chapter 3 explains the development of the methodology for structuring the framework by integrating the LSS in the research study. Proposed methodological framework been discussed in details and illustrates for easy understanding. The methodological steps describe the determination of the sustainability elements, defining the area scopes and process specification, and ultimately the application of those detailed parameters in the case study been revealed step by step in this chapter. Methodological framework been elaborated in details for each step.

Chapter 4 describes the application of the developed methodology for the LSS specifically in Sus-VSM towards sustainable manufacturing. This chapter presents a case study of EN-Plating process conducted to validate the proposed methodology. This chapter begins with the implementation of the DMAIC-based approach presented phase by phase with the integration of the LM and VSM tools, the latter of which was selected to define waste reduction opportunities for continuous improvement cycles. The current state Sus-VSM is analysed and the wastes identified. Hence, from the data collected, the future state is presented in this chapter as validation of the improvement activity carried out in the case study. Finally, an overall view of the research conducted is presented.

Chapter 5 discussed in details of the finding and results obtained from application of methodological framework developed. Through this chapter, Sus-VSM improvement summary been discussed proving the significance and the importance of the study. Institutionalizing and critical appraisals of the study been contemplated

Chapter 6 summarizes and concludes the research outcomes of the thesis. This chapter summarizes the research objectives achieved through the research study. Concluding remarks and future research opportunities are also discussed at the end of this chapter.

REFERENCES

Abdulmalek, F. A. and Rajgopal, J. (2007) Analyzing the benefits of lean manufacturing and value stream mapping via simulation: A process sector case study. *International Journal of Production Economics*, 107(1), 223–236.

Abdul-Rashid, S. H., Sakundarini, N., Raja Ghazilla, R. A. and Thurasamy, R. (2017). The impact of sustainable manufacturing practices on sustainability performance. *International Journal of Operations & Production Management*, 37(2), 182–204

Abu, F., Gholami, H., Mat Saman, M. Z., Zakuan, N. and Streimikiene, D. (2019). The implementation of lean manufacturing in the furniture industry: A review and analysis on the motives, barriers, challenges, and the applications', *Journal of Cleaner Production*.

Acero, R., Torralba, M., Pérez-Moya, R., & Pozo, J. A. (2019). Value Stream Analysis in Military Logistics: The Improvement in Order Processing Procedure. Applied Sciences, 10(1), 106.

Agus, A. 2011. "The Structural Influence of Supply Chain Management on Product Quality and Business Performance." International Journal of Trade, Economics and Finance 2 (4): 269–275.

Aja, O. C., Al-Kayiem, H. H., Zewge, M. G. and Joo, M. S. (2016) .Overview of Hazardous Waste Management Status in Malaysia. *Management of Hazardous Wastes*.

Alvair Silveira, T. J. and Ana Maria, G. (2009) Environmental Value Stream Mapping (EVSM) as Sustainability Management Tool. 1689–1698.

Andreadis, E., Garza-Reyes, J. A. and Kumar, V. (2017). Towards a conceptual framework for value stream mapping (VSM) implementation: an investigation of managerial factors. *International Journal of Production Research*, 55(23), 7073–7095.

Arturo Garza-Reyes, J., Flint, A., Kumar, V., Antony, J. and Soriano-Meier, H. (2014). A DMAIRC approach to lead time reduction in an aerospace engine assembly process. *Journal of Manufacturing Technology Management*, 25(1), 27–48.

Asif, M., Searcy, C., Zutshi, A. and Fisscher, O. A. M. (2013). An integrated management systems approach to corporate social responsibility. *Journal of Cleaner Production*, 56, 7–17.

Assarlind, M., Gremyr, I. and Bäckman, K. (2013). Multi-faceted views on a Lean Six Sigma application. *International Journal of Quality and Reliability Management*, 30(4), 387–402.

Azapagic, A., Stamford, L., Youds, L. and Barteczko-Hibbert, C. (2016). Towards Sustainable Production and Consumption: A Novel Decision-Support Framework Integrating Economic, Environmental and Social Sustainability (DESIRES). *Computers & Chemical Engineering*, 91, 93–103.

Banuelas, R. and Antony, J. (2004), "Six Sigma or design for Six Sigma", TQM Magazine, Vol. 16 No. 4, pp. 250-63.

Barrett, P. S. and Sexton, M. G. (2000) Sustainable Construction: A Framework and International Agenda for Change. *CIB Publication* 260, (1), 1–2.

Bhasin, S. (2012).Performance of Lean in Large Organisations. *Journal ofManufacturing Systems* 31 (3): 349–357.

Basu, R. (2004). Six-Sigma to operational excellence: role of tools and techniques. *International Journal of Six Sigma and Competitive Advantage*, 1(1), 44.

Belekoukias, I., Garza-Reyes, J. A. and Kumar, V. (2014) The impact of lean methods and tools on the operational performance of manufacturing organisations. *International Journal of Production Research*, 52(18), 5346–5366.

Bendell, T. and Bendell, T. (2006) Organisations A review and comparison of six sigma and the lean organisations, 18(3),255-262

Bezerra, C.I.M., Adriano, A.B.A., Placido, L.S. and Goncalves, M.G.S. (2010) MiniDMAIC:an approach to causal analysis and resolution in software development projects*: QualityManagement and Six Sigma*, August.

Boon Sin, A., Zailani, S., Iranmanesh, M. and Ramayah, T. (2015). Structural equation modelling on knowledge creation in Six Sigma DMAIC project and its impact on organizational performance. *International Journal of Production Economics*, 168, 105–117.

Bortolotti, T., P. Danese, and P. Romano. (2013). Assessing the Impact of Just-in-time on Operational Performance at Varying Degrees of Repetitiveness. *International Journal of Production Research* 51 (4): 1117–1130

Braglia, M., Carmignani, G. and Zammori, F. (2006). A new value stream mapping approach for complex production systems. *International Journal of Production Research*, 44(18–19), 3929–3952.

Braunscheidel, M. J., Hamister, J. W., Suresh, N. C. and Star, H. (2011). An institutional theory perspective on Six Sigma adoption. *International Journal of Operations and Production Management*, 31 (4), 423–451.

Brown, A., Amundson, J. and Badurdeen, F. (2014). Sustainable value stream mapping (Sus-VSM) in different manufacturing system configurations: Application case studies. *Journal of Cleaner Production*, 85, 164–179.

Brown, B. J., Hanson, M. E., Liverman, D. M. and Merideth, R. W. (1987). Global sustainability: Toward definition. *Environmental Management*, 11(6), 713–719.

Brue, G. and Howes, R. (2006) *Six Sigma: The Mcgraw-Hill 36 Hour Course*. New York: McGraw- Hill.

Brundtland, G. H. (1987). Our Common Future. *Oxford paperbacks*, 400.

Chen, J. C., Li, Y. and Shady, B. D. (2010). From value stream mapping toward a lean/sigma continuous improvement process: An industrial case study. *International Journal of Production Research*, 48(4), 1069–1086.

Cherrafi, A., Elfezazi, S., Chiarini, A., Mokhlis, A. and Benhida, K. (2016). The integration of lean manufacturing, Six Sigma and sustainability: A literature review and future research directions for developing a specific model. *Journal of Cleaner Production*, 139, 828–846.

Chiarini, A. and Vagnoni, E. (2015) .World-class manufacturing by Fiat. Comparison with Toyota Production System from a Strategic Management, Management Accounting, Operations Management and Performance Measurement dimension. *International Journal of Production Research*, 53(2), 590–606.

Choobineh, A, Lahmi, Mohammadali, Shahnavaz, Houshany, Jazani, Reza K., and Hosseini, Mustafa (2004). Musculoskeletal symptoms as related to Ergonomic factors in Iranian hand-woven carpet industry and general guidelines for workstation design. *International journal of Occupational Safety and Ergonomics (JOSE)*, Vol. 10, No. 2, pp. 157 – 168.

Chong, Y. T., Teo, K. M. and Tang, L. C. (2016). A lifecycle-based sustainability indicator framework for waste-to-energy systems and a proposed metric of sustainability. *Renewable and Sustainable Energy Reviews*, 56, 797–809.

Chiasson, M., D. Imbeau, K. Aubry and A. Delisle, (2012). Comparing the results of eight methods used to evaluate risk factors associated with musculoskeletal disorders. *Int. J. Indust. Ergonom.,* 42: 478-488

Clute, J. (2008).Sustainable Manufacturing Practices and Business Strategies: Ford Motor Company. *International Conference on Sustainable Manufacturing, Rochester Institute of Technology Rochester*, September 23–24, 2008, NY, USA.

Conti, T., Kondo, Y. and Watson, G. H. (2003). Quality into the 21st Century and Competitiveness, Quality.

Corlett, E. N. (2003). Rapid Upper Limb Assessment (RULA). *Occupational Ergonomics: Principles of Work Design*, 1(June), 9.

Cosgrove, J., Rivas Duarte, M. J., Littlewood, J. and Wilgeroth, P. (2018). An energy mapping methodology to reduce energy consumption in manufacturing operations. *Proceedings of the Institution of Mechanical Engineers, Part B: Journal of Engineering Manufacture*, 232(10), 1731–1740.

Coughlan, P. and Coghlan, D. (2002). *Action research for operations management* , 22 (2), 220-240.

Coyle, A., (2005). Comparison of the rapid entire body assessment and the New Zealand manual handling 'hazard control record', for assessment of manual handling hazards in the supermarket industry. *Work*, 24: 111-116.

Dadashzadeh, M. D. and Wharton, T. J. (2012). A Value Stream Approach For Greening The IT Department. *International Journal of Management & Information Systems (IJMIS)*, 16(2), 125–136.

Davim, P. (2013) Sustainable Manufacturing, Sustainable Manufacturing. Wiley-ISTE

De Mast, J. and Lokkerbol, J. (2012). An analysis of the Six Sigma DMAIC method from the perspective of problem solving. *International Journal of Production Economics,*. 604–614.

Deif, A. M. (2011). A system model for green manufacturing. *Journal of Cleaner Production. Elsevier Ltd*, 19(14), 1553–1559.

Dempsey, P.G., Lowe, B.D., Jones, E., 2018. An international survey of tools and methods used by certified ergonomics professionals. In: *Proceedings of the IEA Congress, Florence,* IT, pp. 223–230.

Despeisse, M., F. Mbaye, P. D. Ball, and A. Levers. 2012. "The Emergence of Sustainable Manufacturing Practices." Production Planning & Control 23 (5): 354–376.

Dobie, R. A. (2008). The burdens of age-related and occupational noise-induced hearing loss in the United States. *Ear and Hearing*, 29(4), 565–577.

Dora, M., M. Kumar, D. Van Goubergen, A. Molnar, and X. Gellynck. (2013). Operational Performance and Critical Success Factors of Lean Manufacturing in European Food Processing SMEs. *Trends in Food Science & Technology* 31 (2): 156–164.

DOSH (2005) *Guidelines for Control of Occupational Noise*. http://www.dosh.gov.my/index.php/ms/list-ofdocuments/guidelines/ industrial-hygiene-1/1416-01-guidelines-for- control-of-occupational-noise-2005/file.

Dubey, R., Gunasekaran, A. and Chakrabarty, A. (2015). World-class sustainable manufacturing: Framework and a performance measurement system. *International Journal of Production Research*, 53(17), 5207–5223.

Duflou, J. R., Sutherland, J. W., Dornfeld, D., Herrmann, C., Jeswiet, J., Kara, S., Hauschild, M. and Kellens, K. (2012). Towards energy and resource efficient manufacturing: A processes and systems approach. *CIRP Annals - Manufacturing Technology*. 61, 587-609.

Eastlick, D. D., Sahakian, M. V. and Haapala, K. R. (2011). Sustainable Manufacturing Analysis for Titanium Components. *International Conference on Design Theory and Methodology; 16th Design for Manufacturing and the Life Cycle Conference*, (9), 711–719.

Easton, G. S. and Rosenzweig, E. D. (2012). The role of experience in six sigma project success: An empirical analysis of improvement projects. *Journal of Operations Management*, 30(7–8), 481–493.

Eastwood, M. D. and Haapala, K. R. (2015). A unit process model based methodology to assist product sustainability assessment during design for manufacturing. *Journal of Cleaner Production*, 108, 54–64.

Egilmez, G., Kucukvar, M. and Tatari, O. (2013). Sustainability assessment of U . S . manufacturing sectors : an economic input output-based frontier approach. *Journal of Cleaner Production*, 53, 91–102.

Engelund, E. H., Breum, G. and Friis, A. (2009). Optimisation of large-scale food production using Lean Manufacturing principles, 4–14.

EPA-USA (2003). Lean Manufacturing and the Environment : Research on advanced manufacturing systems and the environment and recommendations for leveraging better environmental performance. *Contract*,1-65

Erdil, N. O., Aktas, C. B., & Arani, O. M. (2018). Embedding sustainability in lean six sigma efforts. Journal of Cleaner Production, 198, 520–529

Faulkner, W. and Badurdeen, F. (2014). Sustainable Value Stream Mapping (Sus-VSM): Methodology to visualize and assess manufacturing sustainability performance. *Journal of Cleaner Production*. 85, 8–18.

Faulkner, W., Templeton, W., Gullett, D. and Badurdeen, F. (2012) Visualizing sustainability performance of manufacturing systems using sustainable value stream mapping (Sus-VSM). *Proceedings of the 2012 international conference on industrial engineering and operations management.* February. Istanbul, Turkey, 815–824.,

Gao, Q., Lizarazo-Adarme, J., Paul, B. K. and Haapala, K. R. (2016). An economic and environmental assessment model for microchannel device manufacturing: Part 2 – Application. *Journal of Cleaner Production*, 120, 146–156.

Garetti, M., G. Mummolo, and M. Taisch. (2012). Special Issue on 'Sustainable Manufacturing. *Production Planning & Control* 23 (2–3): 79–82

Garza-Reyes, J. A. (2015). Green lean and the need for Six Sigma. *International Journal of Lean Six Sigma*, 6(3), 226–248.

Garza-reyes, J. A., Flint, A., Antony, J. and Soriano-meier, H. (2012). A DMAIRC approach to lead time reduction in an aerospace engine assembly process.*Journal of Manufacturing Technoogy*, 25(1), 27–48.

Garza-Reyes, J. A., Kumar, V., Chaikittisilp, S. and Tan, K. H. (2018).The effect of lean methods and tools on the environmental performance of manufacturing organisations. *International Journal of Production Economics*, 200(October 2017), 170–180.

Garza-Reyes, J. A., Torres Romero, J., Govindan, K., Cherrafi, A. and Ramanathan, U. (2018). A PDCA-based approach to Environmental Value Stream Mapping (E-VSM). *Journal of Cleaner Production*, 180, 335–348.

Gholami, H., Jamil, N., Zakuan, N., Mat Saman, M. Z., Sharif, S., Awang, S. R. and Sulaiman, Z. (2019). Social Value Stream Mapping (Socio-VSM): Methodology to Societal Sustainability Visualization and Assessment in the Manufacturing System. *IEEE Access. IEEE*, 7, 131638–131648.

Giachetti, R. E. 1998.A Decision Support System for Material and Manufacturing Process Selection. *Journal of Intelligent Manufacturing* 9 (3): 265–276.

Gijo, E. V., Scaria, J. and Antony, J. (2011).Application of six sigma methodology to reduce defects of a grinding process. *Quality and Reliability Engineering International*, 27 (8), 1221–1234.

Gitlow, H., Levine, D. and Popovich, E. (2006) *Design for Six Sigma for Green Belts and Champions*. New Jersey, Upper Saddle River: Prentice-Hall.

Goh, T. N. (2002). A strategic assessment of Six Sigma. *Quality and Reliability Engineering International*, 18, 403–410.

Gómez-Galán, M., Pérez-Alonso, J., Callejón-Ferre, Á. J. and López-Martínez, J. (2017). Musculoskeletal disorders: OWAS review. *Industrial Health*, 55(4), 314–337.

Habidin, N. F., Mohd Zubir, A. F., Mohd Fuzi, N., Md Latip, N. A. and Azman, M. N.A. (2018). Critical success factors of sustainable manufacturing practices in Malaysian automotive industry. *International Journal of Sustainable Engineering. Taylor & Francis*, 11(3), pp. 217–222.

Harry, M.J., Mann, P.S., De Hodgins, O.C., Hulbert, R.L., and Lacke, C.J. (2010) *Practitioner's Guide to Statistics and Lean Six Sigma for Process Improvements*. New York: John Wiley & Sons.

Hartini, S., Ciptomulyono, U., Anityasari, M., Sriyanto and Pudjotomo, D. (2018) Sustainable-value stream mapping to evaluate sustainability performance: case study in an Indonesian furniture company. *MATEC Web of Conferences*, 154, 01055.

Hendricks, C.A. and Kelbaugh, R. (1998). Implementing six sigma at GE. *J. Qual. Particip*. 21(4), 48–53.

Henrique, D. B., Rentes, A. F., Godinho Filho, M. and Esposto, K. F. (2016). A new value stream mapping approach for healthcare environments. *Production Planning & Contr*ol, 27(1), 24–48.

Henrique, D. B., Rentes, A. F., Godinho Filho, M. and Esposto, K. F. (2016). A new value stream mapping approach for healthcare environments. *Production Planning & Control*, 27(1), 24–48.

Hignett, S. and McAtamney, L. (2000). Rapid Entire Body Assessment (REBA). *Applied Ergonomics*, 201–205.

Hilton, R. J. and Sohal, A. (2012). A conceptual model for the successful deployment of Lean Six Sigma. *International Journal of Quality and Reliability Management*, 29(1), 54–70.

Hofer, C., C. Eroglu, and A. Rossiter Hofer. (2012). The Effect of Lean Production on financial Performance: The Mediating Role of Inventory Leanness. *International Journal of Production Economics* 138 (2): 242–253

Hollmann, S., Klimmer, F., Schmidt, K. . and Kylian, H. (1999). Validation of a questionnaire for assessing physical work load. *Scandinavian Journal of Work, Environment and Health*, 25(2), 105–114.

Huang, A. and Badurdeen, F. (2018). Metrics-based approach to evaluate sustainable manufacturing performance at the production line and plant levels. *Journal of Cleaner Production*, 192, 462–476.

Jaffar, N., Abdul-Tharim, A. H., Mohd-Kamar, I. F., & Lop, N. S. (2011). A Literature Review of Ergonomics Risk Factors in Construction Industry. *Procedia Engineering*, 20, 89–97

Jamali, D. (2006). Insights into triple bottom line integration from a learning organization perspective. 12(6), 809–821

Janowitz, I., M. Gillen, G. Ryan, D. Rempel and L. Trupin et al., (2006). Measuring the physical demands of work in hospital settings: Design and implementation of an ergonomics assessment. *Applied Ergonom.,* 37: 641-658.

Jawahir Dillon, I. O. and Rouch Kunal J Joshi Anand Venkatachalam Israd H Jaafar, J. K. (2006). Total Life-Cycle Considerations in Product Design for Sustainability: a Framework for Comprehensive Evaluation. 11–15.

Jayal, A. D., Badurdeen, F., Dillon, O. W. and Jawahir, I. S. (2010). Sustainable manufacturing: Modeling and optimization challenges at the product, process

and system levels. *CIRP Journal of Manufacturing Science and Technology*, 2(3), 144–152.

Jéssica Galdino, de F., Helder Gomes, C. and Fernando Toledo, F. (2017). Impacts of Lean Six Sigma over organizational sustainability: A survey study. *Journal of Cleaner Production*, 156, 262–275.

Jin, X. and High, K. A. (2004). A new conceptual hierarchy for identifying environmental sustainability metrics. *Environmental Progress*, 23(4), 291–301.

John, A. O., and L. N. Ngoasong. (2008). *Budgetary and Management Control Process in a Manufacturing Organization.* Master diss., Malardalen University.

Johnston, P., Everard, M., Santillo, D. and Robèrt, K. (2007) *Johnston 2007 Reclaiming the definition of Sustainability*. 14(1), 60–66.

Jose Arturo, Garza-Reyes, I. O. H. S.-M. P. L. F. D. (2012). The development of a lean park homes production process using process flow and simulation methodse. *Journal of Manufacturing Technology Management*, 23(2), 178–197.

Jovane, F., Yoshikawa, H., Alting, L., Boër, C. R., Westkamper, E., Williams, D., Tseng, M., Seliger, G. and Paci, A. M. (2008). The incoming global technological and industrial revolution towards competitive sustainable manufacturing. *CIRP Annals - Manufacturing Technology*, 57(2), 641–659.

Julianus, H. (2019). Work Posture Analysis by Using Rapid Upper Limb Assessment (RULA) and Rapid Entire Body Assessment (REBA) Methods (Case Study: Rice Milling In Malang - East Java of Indonesia). *IOP Conference Series: Materials Science and Engineering*, 469, 012012

Karhu, O., Kansi, P. and Kuorinka, I. (1977). Correcting working postures in industry: A practical method for analysis. *Applied Ergonomics*.

Karim, A., and K. Arif-Uz-Zaman. (2013).A Methodology for Effective Implementation of Lean Strategies and Its Performance Eval- uation in Manufacturing Organizations. *Business Process Management Journal* 19 (1): 169–196.

Kirkham, L., Garza-Reyes, J. A., Kumar, V. and Antony, J. (2014). Prioritisation of operations improvement projects in the European manufacturing industry. *International Journal of Production Research*, 52(18), 5323–5345.

Kee, D. and W. Karwowski,(2007). A comparison of three observational techniques for assessing postural loads in industry. *Int. J. Occupat. Safety Ergonom.*, 13: 3-14

Kluczek, A. (2017). An environmental sustainability assessment of energy efficiency for production systems. Icpr, 691–696

Kosky, P., Balmer, R., Keat, W., & Wise, G. (2013). Manufacturing Engineering. *Exploring Engineering*, 205–235.

Kumar, S. and Phrommathed, P. (2006). Improving a manufacturing process by mapping and simulation of critical operations. *Journal of Manufacturing Technology Management*, 17(1), 104–132.

Kurdve, M., Shahbazi, S., Wendin, M., Bengtsson, C. and Wiktorsson, M. (2015). Waste flow mapping to improve sustainability of waste management: A case study approach. *Journal of Cleaner Production*, 98, 304–315.

Kurdve, M., Zackrisson, M., Wiktorsson, M. and Harlin, U. (2014). Lean and green integration into production system models - Experiences from Swedish industry. *Journal of Cleaner Production*, 85, 180–190.

Kuriger, G. W. and Chen, F. F. (2010). Lean and green: A current state view. *IIE Annual Conference and Expo 2010 Proceedings*, 2010.

Lai, J., Harjati, A., McGinnis, L., Zhou, C., & Guldberg, T. (2008). An economic and environmental framework for analyzing globally sourced auto parts packaging system. *J.Clean. Prod.* ,16, 1632-1646.

Lee, H.-T., Song, J.-H., Min, S.-H., Lee, H.-S., Song, K. Y., Chu, C. N. and Ahn, S.-H. (2019). Research Trends in Sustainable Manufacturing: A Review and Future Perspective based on Research Databases. *International Journal of Precision Engineering and Manufacturing-Green Technology. Korean Society for Precision Engineering*, (0123456789).

Lee, J. H., Garza-reyes, J. A., Kumar, V., Rocha-lona, L. and Mishra, N. (2013a). A Comparative Study of the Implementation Status of Lean Six Sigma in South Korea and the UK.

Lee, J. H., Garza-reyes, J. A., Kumar, V., Rocha-lona, L. and Mishra, N. (2013b) *Advances in Sustainable and Competitive Manufacturing Systems*.

Lie, A., Skogstad, M., Johannessen, H. A., Tynes, T., Mehlum, I. S., Nordby, K. C., Engdahl, B. and Tambs, K. (2016). Occupational noise exposure and hearing:

a systematic review. *International Archives of Occupational and Environmental Health*. Springer Berlin Heidelberg, 89(3), 351–372.

Li, L., & Xu, X. (2019). A deep learning-based RULA method for working posture assessment. *Proceedings of the Human Factors and Ergonomics Society Annual Meeting*, 63(1), 1090–1094.

Lu, T., Gupta, A., Jayal, A. D., Badurdeen, F., Feng, S. C., Dillon, O. W. and Jawahir, I. S. (2010). A Framework of Product and Process Metrics for Sustainable Manufacturing. *Advances in Sustainable Manufacturing*, 333–338.

Lu, T., Gupta, A., Jayal, A. D., Badurdeen, F., Feng, S. C., Dillon, O. W. and Jawahir, I. S. (2011) *Advances in Sustainable Manufacturing*.

Lu, T., Rotella, G., Feng, S. C., Badurdeen, F., Dillon, O. W., Rouch, K. and Jawahir, I. S. (2012) *Metrics-Based Sustainability Assessment of a Drilling Process*, 59–64.

Loskyll, M., I. Heck, J. Schlick, and M. Schwarz. (2012).Context-based Orchestration for Control of Resource-Efficient Manufacturing Processes. *Future Internet* 4 (4): 737–761.

Machado, C. G., Winroth, M. and Ribeiro da Silva, E. H. D. (2018). Sustainable Manufacturing and Industry 4.0: an emerging research agenda. *International Journal of Production Research*, 0(0), 1–20.

Madani, D. A., & Dababneh, A. (2016). Rapid Entire Body Assessment: A Literature Review. *American Journal of Engineering and Applied Sciences*, 9(1), 107–118.

Mader, D. P. (2008) *Lean Six Sigma's evolution*, Quality Progress.

Mahmood, S., Saman, M. Z. M. and Yusof, N. M. (2015). Proposed framework for assessing the sustainability of membrane Life Cycle. *Procedia CIRP*, 26, 35–39.

Mani, M., J. Madan, J. H. Lee, K. W. Lyons, and S. K. Gupta. (2014). Sustainability Characterisation for Manufacturing Processes. *International Journal of Production Research* 52 (20): 5895–5912.

Mason-Jones, R., Naylor, B. and Towill, D. . (2000). Lean, agile, or leagile? Matching your supply chain to the marketplace. *International Journal of Production Research*, May 2013, 38, 4061–4070.

McAtamney,L. and Corlett,E.N (1993) RULA :A survey method for the investigation of work-related upper limb disorders. *Applied Ergonomics*, 24(2),91-99.

Melton, T. (2005). The Benefits of Lean Manufacturing. *Chemical Engineering Research and Design*, 83(6), 662–673. doi:10.1205/cherd.04351

Miguélez, M. S., Errasti, A. and Alberto, J. A. (2014) *Lean-Six Sigma Approach put into Practice in an Empirical Study*, 255–262.

Millar, H. H., and S. N. Russell. 2011. "The Adoption of Sustainable Manufacturing Practices in the Caribbean." Business Strategy and the Environment 20 (8): 512–526.

Mokthsim, N. and Salleh, K. O. (2014). Malaysia's Efforts toward Achieving a Sustainable Development: Issues, Challenges and Prospects. *Procedia - Social and Behavioral Sciences*.

Montgomery, D. C. (2013) *Introduction to statistical quality control*, John Wiley & Sons Inc.

Nagi, A. and Altarazi, S. (2017). Integration of value stream map and strategic layout planning into DMAIC approach to improve carpeting process. *Journal of Industrial Engineering and Management*, 10(1), 74–97.

Nedra, A., Yassine, C., & Morched, C. (2019). A new lean Six Sigma hybrid method based on the combination of PDCA and the DMAIC to improve process performance : Application to clothing SME. 70(5), 447–456.

Nelson, D. I., Nelson, R. Y., Concha-Barrientos, M. and Fingerhut, M. (2005). The Global Burden of Occupational Noise-Induced Hearing Loss. *Am J Ind Med*, 48(6), 446–458.

Norton, A. and Fearne, A. (2009). *Sustainable value stream mapping in the food industry*. Handbook of waste management and co-product recovery in food processing: Volume 2.

OSHA (2012) OSH (Notification of Accident, Dangerous Occurrence, Occupational Poisoning and Occupational Disease) regulation 2004.

Paju, M., Heilala, J., Hentula, M., Heikkilä, A., Johansson, B., Leong, S. and Lyons, K. (2010). Framework and indicators for a sustainable manufacturing mapping methodology. *Winter Simulation Conference*, 3411–3422.

Pande, P. S., Neuman, R. P. and Cavanagh, R. R. (2000) The Six Sigma Way: How GE, Motorola, and Other Top Companies are Honing Their Performance. *Quality Progress.*

Pande, P.S. and Holpp, L. (2002) *What is Six Sigma*. Columbus: McGraw-Hill.

Pepper, M P J and Spedding, T. A. (2010) *The evolution of lean Six Sigma*.

Pepper, M. P.J. and Spedding, T. A. (2010). The evolution of lean Six Sigma. *International Journal of Quality and Reliability Management*.

Pereira, A. M. H., Silva, M. R., Domingues, M. A. G., & Sá, J. C. (2019). Lean Six Sigma Approach to Improve the Production Process in the Mould Industry : a Case Study. 1745, 103–121.

Phuong, N. A. and Guidat, T. (2018). Sustainable value stream mapping and technologies of Industry 4.0 in manufacturing process reconfiguration: A case study in an apparel company. *Proceedings of the 2018 IEEE International Conference on Service Operations and Logistics, and Informatics, SOLI 2018*, 85–90.

Powell, D., Lundeby, S., Chabada, L. and Dreyer, H. (2017). Lean Six Sigma and environmental sustainability: the case of a Norwegian dairy producer. *International Journal of Lean Six Sigma*, 8(1), 53–64.

Prasara-A, J. and Gheewala, S. H. (2016). Sustainability of sugarcane cultivation: case study of selected sites in north-eastern Thailand. *Journal of Cleaner Production*, 134(Part B), 613–622.

Prashar, A. (2017). Adopting PDCA (Plan-Do-Check-Act) cycle for energy optimization in energy-intensive SMEs. *Journal of Cleaner Production*, 145, 277–293.

Pyzdek, T. (2014) The Six Sigma Handbook: A Complete Guide for Green Belts, Black Belts, and Managers at all Levels. New York: McGraw-Hill.

Pyzdek, T. and Keller, P. (2010) *Building the Responsive Six SIgma Organization,* The Six Sigma Handook. A complete guide for Green Belts, Black Belts and Managers at all levels.

Rahman, Chowdury M. L. (2014). Study and analysis of work postures of workers working in a ceramic industry through Rapid Upper Limb Assessment. *International Journal of Engineering and Applied Sciences*, Vol. 5, No. 3, pp. 14 – 20.

Rand, G., Womack, J. and Jones, D. T. (2006). Lean Thinking-Banish Waste and Create Wealth in Your Corporation.. *Journal of the Operational Research Society*.

Ray, S. and Das, P. (2010). Six Sigma project selection methodology. *International Journal of Lean Six Sigma*, 1(4), 293–309.

Reich-weiser, C., Vijayaraghavan, A. and Dornfeld, D. A. (2016) *Metrics for sustainable manufacturing*.

Rosen, M. A., and H. A. Kishawy. (2012).Sustainable Manufacturing and Design: Concepts, Practices and Needs. *Sustainability* 4 (12): 154–174.

Rother, M. and Shook, J. (2003). Learning to see: Value stream mapping to create value and eliminate muda. Lean Enterprise Institute.

Russell, R. S. and Taylor, W. (2000). *Operations Management: Quality and Competitiveness in a Global Environment*. John Wiley & Sons, Inc. 5th Edition, 832.

Saboo, A., Reyes, J. A. G., Er, A. and Kumar, V. (2014). A VSM improvement-based approach for lean operations in an Indian manufacturing SME. *International Journal of Lean Enterprise Research*.

Salah, S., Rahim, A. and Carretero, J. A. (2010). The integration of Six Sigma and lean management. *International Journal of Lean Six Sigma*.

Sánchez, A. M., and M. P. Pérez. (2001). Lean Indicators and Manufacturing Strategies. *International Journal of Operations & Production Management*, 21 (11): 1433–1452.

Satolo, E. G., Andrietta, J. M., Miguel, P. A. C. and Calarge, F. A. (2009). Analysis on the usage of techniques and tools from the Six-Sigma program on a survey-type assessment. 400–416.

Shah, R. and Ward, P. T. (2003). Lean manufacturing: Context, practice bundles, and performance. *Journal of Operations Management*, 21(2), 129–149.

Shah, R. and Ward, P. T. (2007). Defining and developing measures of lean production. *Journal of Operations Management*, 25(4), 785–805.

Shah, R., Chandrasekaran, A. and Linderman, K. (2008). In pursuit of implementation patterns: The context of Lean and Six Sigma. *International Journal of Production Research*, 46(23), 6679–6699.

Shanahan, C., P. Vi, E. Salas, V. Reider and L. Hochman et al., (2013). A comparison of RULA, REBA and Strain Index to four psychophysical scales in the assessment of non-fixed work. *Work,* 45: 367-378

Sheridan, J.H. (2000). *Lean Sigma' synergy'Industry Week*, 249 (17), 81-82.

Shuaib, M., Seevers, D., Zhang, X., Badurdeen, F. and Rouch, K. E. (2014). Product Sustainability Index (ProdSI) A Metrics-based Framework to Evaluate the Total Life Cycle Sustainability of Manufactured Products, 18(4).

Silva, S. K. P. N., Perera, H. S. C., & Samarasinghe, G. D. (2011). Viability of Lean Manufacturing Tools and Techniques in the Apparel Industry in Sri Lanka. *Applied Mechanics and Materials,* 110-116, 4013–4022.

Silveira Torres, J. A. and Gati, A. M. (2009). Environmental Value Stream Mapping (EVSM) as sustainability management tool. *International Conference on Management of Engineering & Technology*. Portland: PICMET 09, 1689–1698.

Simpson, D. F., and D. J. Power. (2005).Use the Supply Relationship to Develop Lean and Green Suppliers. *Supply Chain Management: An International Journal* 10 (1): 60–68.

Smętkowska, M. and Mrugalska, B. (2018). ScienceDirect SIM 2017 / 14th International Symposium in Management Using Six Sigma DMAIC to improve the quality of the production process: a case study. *Procedia -Social and Behavioral Sciences*, 238, 590–596.

Song, Q., Wang, Z. and Li, J. (2013). Sustainability evaluation of e-waste treatment based on emergy analysis and the LCA method: A case study of a trial project in Macau. *Ecological Indicators*, 30, pp. 138–147.

Stock, T. and Seliger, G. (2016). Opportunities of Sustainable Manufacturing in Industry 4.0. *Procedia CIRP*.

Taj, S., and C. Morosan. (2011). The Impact of Lean Operations on the Chinese Manufacturing Performance. *Journal of Manufacturing Technology Management* 22 (2): 223–240

Taylor, P., Antony, J., Gijo, E. V and Childe, S. J. (no date) . The Management of Operations Case study in Six Sigma methodology : manufacturing quality improvement and guidance for managers. *Production Planning & Control* . October 2012, 37–41.

Taylor, P., Shah, R., Chandrasekaran, A. and Linderman, K. (2008) In pursuit of implementation patterns : the context of Lean and Six Sigma. *International Journal of Production*. September 2012, 37–41.

Tjahjono, B., Ball, P., Vitanov, V. I., Scorzafave, C., Nogueira, J., Calleja, J., Minguet, M., Narasimha, L., Rivas, A., Srivastava, A., Srivastava, S. and Yadav, A. (2010). Six sigma: A literature review. *International Journal of Lean Six Sigma*, 1(3), pp. 216–233.

Thawani, S. (2004). Six Sigma – strategy for organizational excellence. *Total Quality Management*, Vol. 15 Nos 5-6, pp. 655-64.

Thomas, A., Barton, R. and Chuke-Okafor, C. (2009). Applying lean six sigma in a small engineering company - A model for change. *Journal of Manufacturing Technology Management*, 20(1), 113–129.

Thomas, A., Barton, R., Okafor, C. C., Barton, R. and Chuke-okafor, C. (2008). Applying lean six sigma in a small engineering company – a model for change. *Journal of Manufacturing Management*, 20(1), 113-129.

Thun, J. H., M. Drüke, and A. Grübner. (2010). Empowering Kanban through TPS-Principles – An Empirical Analysis of the Toyota Production System. *International Journal of Production Research* 48 (23): 7089–7106.

Torugsa, N. A., W. O'Donohue, and R. Hecker. (2012). Proactive CSR: An Empirical Analysis of the Role of Its Economic, Social and Environmental Dimensions on the Association between Capabilities and Performance. *Journal of Business Ethics* 115 (2): 383–402.

Tyagi, S., Choudhary, A., Cai, X. and Yang, K. (2015). Value stream mapping to reduce the lead-time of a product development process. *International Journal of Production Economics*. 160, 202–212.

U.S Department of Commerce (2012). How does commerce define sustainable manufacturing, United States Department of Commerce.

Urtiaga, A. and Irabien, A. (2013). Environmental Sustainability Assessment of an Innovative Cr (III) Passivation Process, (Iii).

US EPA (2007). The Lean and Environment Toolkit. *Prevention*, 96.

Veleva, V. and Ellenbecker, M. (2001). Indicators of sustainable production: Framework and methodology. *Journal of Cleaner Production*, 9(6), 519–549.

Vinodh, S., Ben Ruben, R. and Asokan, P. (2016). Life cycle assessment integrated value stream mapping framework to ensure sustainable manufacturing: A

case study. *Clean Technologies and Environmental Policy*. Springer Berlin Heidelberg, 18(1), 279–295.

Vinodh, S., Kumar, S. V. and Vimal, K. E. K. (2014). Implementing lean sigma in an Indian rotary switches manufacturing organisation. *Production Planning and Control*, 25(4), 288–302.

Waters, T. R., Putz-Anderson, V., Garg, A. and Fine, L. J. (1993). Revised NIOSH equation for the design and evaluation of manual lifting tasks. *Ergonomics*.

WCED, U. (1987) Our common future. World Commission on Environment and Development. Oxford University Press.

Wheeler, D. J. (2010). The Six Sigma Practitioner's Guide to Data Analysis. *Technometrics*, 48(2), 306.

Wills, B. (2009). Green intentions: Creating a Green Value Stream to Compete and Win.Taylor & Francis, New York.

Winroth, M., Almström, P. and Andersson, C. (2012). Sustainable Indicators at Factory Level - A Framework for Practical Assessment. *IIE Annual Conference. Proceedings*, 21, 1–14.

Womack, J. P. and Jones, D. T. (1996). Beyond Toyota: How to Root Out Waste and Pursue Perfection. *Harvard Business Review*, 74(October), 140–158.

Yang, Q. Z., Qi, G. J., Low, H. C. and Song, B. (2011). Sustainable recovery of nickel from spent hydrogenation catalyst: Economics, emissions and wastes assessment. *Journal of Cleaner Production*, 19(4), 365–375.

Zhou, Z., Cheng, S. and Hua, B. (2000). Supply chain optimization of continuous process industries with sustainability considerations. *Computers and Chemical Engineering*, 24(2–7), 1151–115

LIST OF PUBLICATIONS

Journals

1. Jamil, N., Gholami, H., Saman, M.Z.M. DMAIC-based approach to sustainable value stream mapping : towards a sustainable manufacturing system. (Economic Research-Ekonomska Istraživanja. Routledge : Q2 33(1):331-360 : Published)
2. Gholami, H., Jamil, N., Zakuan, N., Saman, M. Z. M, Sharif, S.,Awang, S. R. and Sulaiman, Z. (2019) . Social Value Stream Mapping (Socio-VSM): Methodology to Societal Sustainability Visualization and Assessment in the Manufacturing System. (IEEE Access. IEEE, 7, 131638–131648. Q1 IF : 4.098 : Published)
3. Gholami, H., Jamil, N., Saman, M. Z. M., Sharif, S., Zakuan, N., Streimikiene, D. The application of Green Lean Six Sigma. (Journal of Cleaner Production : Under Review)
4. Jamil, N., Gholami, H., Saman, M. Z. M., Sharif, S., Zakuan, N. The implementation of sustainable value stream mapping in the substrate manufacturing system (Journal of Cleaner Production : Under Review)