



**ENHANCEMENT OF CLEANER PRODUCTION  
ASSESSMENT TO IDENTIFY WORKPLACE WASTE  
AND HAZARD BY VALUE STREAM MAPPING**

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**MASTER OF SCIENCE IN MANUFACTURING  
ENGINEERING**

**2018**



**Faculty of Manufacturing Engineering**

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**ANUAR BIN ISHAK**

**A thesis submitted in fulfillment of the requirement for the degree of Master of  
Science in Manufacturing Engineering**

**Faculty of Manufacturing Engineering**

**UNIVERSITI TEKNIKAL MALAYSIA MELAKA**

**2018**

## DECLARATION

I declare that this project entitled “Enhancement of Cleaner Production Assessment to Identify Workplace Waste and Hazard by Value Stream Mapping” is the result of my own work except as cited in the references. The project has not been accepted for any degree and is not concurrently submitted in the candidature of any other degree.

Signature :

Name : Anuar Bin Ishak

Date :

## **APPROVAL**

I hereby declare that I have read this dissertation/report and in my opinion, this dissertation/report is sufficient in terms of scope and quality as a partial fulfillment of Master of Science in Manufacturing Engineering.

Signature :

Supervisor Name : Associate Professor. Dr. Effendi Bin Mohamad

Date :

## **DEDICATION**

The sake of Allah, my Creator and my Master, My great teacher and messenger,  
Mohammed (May Allah bless and grant him), who taught us the purpose of life,

My great parents, Ishak Bin Jaafar & Ehsah Binti Hashim who never stop giving of  
themselves in countless ways,

My dearest wife, Nani Ruhaidah Binti Idris, who leads me through the valley of darkness  
with light of hope and support,

My beloved kids: Aina Aimanina Binti Anuar dan Alia Aqilah Binti Anuar, whom I can't  
force myself to stop loving. To all my family, the symbol of love and giving,

My friends who encourage and support me, All the people in my life who touch my heart,

I dedicate this research.

## ABSTRACT

Throughout the years of industrialization, our environment has become severely polluted and contaminated. Sustainable management aims to recover, recycle, reuse and reduce wastes from industrial productions. To counter this problem, the Cleaner Production (CP) is a preventive, company-specific environmental protection initiatives, intended to minimize waste and emissions and maximize product output became an option to the put forward. In order to sustain their businesses, the companies used several methods, such as Lean Manufacturing (LM) as a powerful means employed to improve efficacy in the manufacturing field and get rid of *muda* (Japanese word for “waste”). By means of utilizing a set of tools to improve the manufacturing system for instance capable to eliminate the waste and hazard along the process flow. One of the influential lean visualizing tools known as Value Stream Mapping (VSM) have been used. But previous research has shown that the conventional VSM is difficult to apply to identify the workplace waste and hazard. Therefore, this study aims to investigate the practicality of the VSM with an extended approach introduced from United State Environmental Protection Agency (USEPA) and by the Department of Environment Malaysia was synchronized together known as Cleaner Production Value Stream Mapping (CPVSM) to assess wastes and hazard while promoting sustainable manufacturing. The findings of this study will help by implementing LM, many organizations relish cost reduction, process optimization, improve the quality of the product, improve the production process, reduce the pollution load to the environment and minimize hazards to the workers. To evaluate the CPVSM application, two case studies of local SME’s companies have been successfully implemented. Through this study, the author has investigated and recommended the CPVSM is one of the best, cheapest and holistic methods to identify waste and hazard in the manufacturing process. An extensive array of study outcomes also confirms that the waste and hazard has been easily identified in every possible source. Moreover, the CPVSM method also facilitates the focus on the relevant workstations on improving the Kaizen performance. In addition, this finding can be demonstrated through the previous Malaysian Green Industry Audit method with complicated reporting procedures, difficult to understand, especially for the Lean Practitioner (LP) and hence require substantial monetary funding to carry out Kaizen activities in the industry. In conclusion, the author can verify that through the synergy between CP method through CPVSM, a comprehensive form of discovery and classification of the waste and hazard can easily be implemented to help the industry to perform improvements. This CPVSM has been used to disclose the hot spots of wastes and potential hazards in the operation flows, applied to improve the current state of the operating conditions and to create a better future state process. This study aims to obtain a new testimony by using the CPVSM to identify the wastes and hazards to boost the benefits of economic, environmental controls and societal impact to the manufacturing sectors.

## ABSTRAK

*Sepanjang tempoh industrialisasi persekitaran kita menjadi semakin teruk dicemari dan tercemar. Pengurusan lestari adalah bertujuan untuk memulih, mengitar, mengguna semula buangan bagi mengurangkan sisa pengeluaran perindustrian. Bagi mengatasi masalah ini, Pengeluaran Bersih adalah satu inisiatif khusus bertujuan mencegah pencemaran, melindungi alam sekitar, seterusnya mengurangkan sisa dan memaksima pengeluaran produk telah menjadi pilihan. Bagi mengekalkan perniagaan, industri telah menggunakan beberapa kaedah, seperti Pembuatan Kejut yang merupakan kaedah hebat digunakan untuk meningkatkan keberkesanan pembuatan dan menghilangkan muda (perkataan Jepun yang bermaksud “pembaziran”). Dengan menggunakan kaedah untuk memperbaiki sistem pembuatan misalnya mampu menghapuskan pembaziran dan bahaya di sepanjang aliran proses. Salah satu kaedah Pembuatan Kejut yang berpengaruh bagi menggambarkan proses, dikenali sebagai Value Stream Mapping (VSM) telah digunakan. Tetapi kajian-kajian terdahulu telah menunjukkan bahawa VSM konvensional adalah sukar untuk digunakan untuk mengenalpasti pembaziran dan bahaya di tempat kerja. Justeru itu, kajian ini adalah bertujuan untuk mengkaji kebolegunaan VSM dengan pendekatan lanjutan yang diperkenalkan dari United State Environmental Protection Agency (USEPA) dan Jabatan Alam Sekitar Malaysia yang telah diselaraskan bersama, dikenali sebagai CPVSM bagi menilai pembaziran dan bahaya disamping menggalakkan pengeluaran yang mapan. Penemuan kajian ini akan membantu pelaksanaan Pembuatan Kejut, malah organisasi berupaya mengurangkan kos operasi, mengoptimum proses, meningkatkan kualiti produk, meningkatkan pengeluaran, serta mampu mengurangkan penajaan pembaziran kepada alam sekitar dan bahaya kepada pekerja. Untuk menilai pemakaian CPVSM ini, dua kajian kes di syarikat tempatan telah berjaya dilaksanakan. Melalui kajian kes ini, penulis telah mengkaji dan mencadangkan CPVSM adalah salah satu kaedah terbaik, paling murah serta holistik bagi mengenal pasti pembaziran dan bahaya dalam proses pembuatan. Hasil kajian yang menyeluruh juga menunjukkan pembaziran dan bahaya dengan mudah dapat dikenalpasti di setiap punca yang bermungkinan. Selain itu, kaedah CPVSM juga memudahkan tumpuan kepada stesen kerja yang berkaitan bagi meningkatkan prestasi Kaizen. Disamping itu, penemuan ini turut membuktikan kaedah Audit Industri Hijau Malaysia sebelum ini dengan prosedur pelaporan yang rumit, sukar difahami terutamanya kepada Pengamal Pembuatan Kejut dan memerlukan pembiayaan kewangan yang besar untuk menjalankan aktiviti Kaizen di industri. Kesimpulannya, penulis dapat mengesahkan melalui sinergi di antara kaedah Pengeluaran Bersih melalui CPVSM, satu bentuk komprehensif penemuan serta klasifikasi pembaziran dan bahaya dapat dilaksanakan dengan mudah untuk membantu industri melakukan pembaikan. CPVSM ini digunakan mendedahkan tumpuan pembaziran dan bahaya yang berpotensi di dalam aliran operasi, seterusnya menjana kaedah operasi masa depan yang lebih baik. Kajian ini adalah bertujuan untuk mendapatkan bukti baharu dengan menggunakan Value Stream Mapping (VSM) yang ditambahbaik ini untuk mengenalpasti pembaziran dan bahaya untuk meningkatkan faedah ekonomi, kawalan alam sekitar dan sosial ke atas sektor industri.*



## ACKNOWLEDGEMENTS

In the name of Allāh, Most Gracious, Most Merciful. All praises belong to Allah, the Rabb (Only God, Cherisher and Sustainer) of the Worlds: Most Gracious, Most Merciful; Master of the Day of Judgment. You alone we worship and You alone we seek for help. Guide us to the straight way, the way of those on whom You have bestowed Your Grace, not (the way) of those who earned Your anger and who went astray. I bear witness that there is nothing worthy of worship but Allah, He is One and has no partners; and I bear witness that Muhammad (peace be upon him) is His servant and the last Messenger. May Allah send His blessing and peace to Muhammad, his companions, family and all those who call to his way till the Day of Judgement.

Alhamdulillah and thank to Allah S.W.T. With all gracious and merciful for giving me strength and the ability to accomplish this study successfully. It is my greatest experience to have an opportunity to complete this research of “Enhancement of Cleaner Production Assessment to Identify Workplace Waste and Hazard by Value Stream Mapping”. This research is supported by a scholarship from the Public Service Department of Malaysia (JPA) whose support is greatly acknowledged. I would like to acknowledge the contribution of my supervisor, Associate Profesor. Dr. Effendi Bin Mohamad for his consistent guidance in completing this research. His patience, dedication, precious inspiration and thoughts through the time and effort meant a lot of this research.

My greatest indebtedness is to my wife (Nani Ruhaidah), my mother (Ehsah), my late father (Ishak), and my daughters (Aina Aimanina & Alia Aqilah) for their patience, inspiration, continuous encouragement and thoughtful advice throughout my years as a Master student.

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## LIST OF ABBREVIATIONS

Al	Aluminium
Au	Alternate Universe or Gold
BNM	Bank Negara Malaysia
CEF	Carbon Emission Factor
CM	Crushing Machine
COD	Chemical Oxygen Demand
CO <sub>2</sub>	Carbon Dioxide
CO <sub>2</sub> e	Carbon Dioxide Emission Equivalent
CP	Cleaner Production
CPCSM	Cleaner Production Current State Map
CPFMS	Cleaner Production Future State Map
CPVSM	Cleaner Production Value Stream Map
Cr	Chromium
CrO <sub>3</sub>	Chromic acid
Cr (VI)	Chromium Hexavalent
CSM	Current State Map
Cu	Copper
dBa	Decibels
DAF	Dissolved Air Flootation
DES	Discrete Event Simulation
DI	Distilled
DOE	Department of Environment
DNE	Do Not Exist
EHS	Environmental, Health and Safety

EOP	End of Pipe
EU	European Union
EVSM	Environmental Value Stream Mapping
EnVSM	Energy Value Stream Mapping
FIFO	First In First Out
FGD	Focal Group Discussion
FSM	Future State Map
GDP	Gross Domestic Product
GHG	Green House Gas
HP	Horse Power
ICT	Informations and Communications Technologies
IETS	Industrial Effluent Treatment System
IPCC	Intergovernmental Panel on Climate Change
JIT	Just-In-Time
KgCO <sub>2e</sub>	Kilogram Carbon Dioxide Emission
kW	Kilowatt
LCA	Life Cycle Analysis
LCI	Life Cycle Inventories
LED	Light Emitted Diode
LM	Lean Manufacturing
LP	Lean Practitioner
TNB	Tenaga Nasional Berhad
TPM	Total Productive Maintenance
TPS	Toyota Production System
TWA	Time Weighted Average
MSIC	Malaysian Standard Industrial Classification
MT	Metric Tonne
NC	Not Change
NSDC	National SME Development Council
NVA	Non Value Added
OSHA	Occupational Safety & Health Administration
Pd	Palladium

PPE	Personel Protective Equipment
PLCB	Phenolic Laminated Circuit Board
PLCBA	Phenolic Laminated Circuit Board Assembly
PM	Powderising Machine
Pt	Platinum
RM	Ringgit Malaysia
RoHS	Restriction of Hazardous Substances
SOP	Standard Operation Procedure
Sn	Stannum
SME	Small Medium Enterprise
SME's	Small Medium Enterprises
SMM	Sustainable Manufacturing Mapping
SVCM	Sustainable Value Stream Map
SVSM	Sustainable Value Stream Mapping
SusVSM	Sustainable Value Stream Mapping
TPS	Toyota Production System
TSS	Total Suspended Solid
UK	United Kingdom
UNICED	United Nations Conference on Environment and Development
UNEP	United Nations Environment Programme
UNEP DTIE	United Nations Environment Programme, Division of Technology
UNFCCC	United Nations Framework Convention on Climate Change
UNIDO	United Nations Industrial Development Organization
USEPA	United States Environmental Protection Agency
UTeM	Universiti Teknikal Malaysia Melaka
VA	Value Added
VIP	Vibration Plate
VOC	Volatile Organic Compound
VSM	Value Stream Mapping
WIP	Work In Progress
WSSD	World Summit on Sustainable Development

## LIST OF PUBLICATIONS

1. Anuar Ishak, Effendi Mohamad, LukmanSukarma, Mohd Shukor Salleh, AB Rahman Mahmood, Nor Akramin Mohamad , 2016, Raja Izamshah Raja Abdullah and Mohd Amran Md Ali , Cleaner Production Implementation in an E-Waste Recovery Plant By Using the Value Stream Mapping , 5<sup>th</sup> International Conference on Design and Concurrent Engineering (IDECON2016). (Presented)
2. A., Ishak, E., Mohamad, L., Sukarma , AB R., Mahmood, M.A., A Rahman, S.H. Yahya, M.S., Salleh and M.A., Sulaiman, 2017, Cleaner Production Implementation By Using Extended Value Stream Mapping For Enhancing The Sustainability Of Lean Manufacturing, Journal of Advanced Manufacturing Technology (JAMT), Vol.11, No.1(1), pp. 31-46.

## CHAPTER 1

### INTRODUCTION

#### 1.1 Introduction

Malaysia's economic development through constant transformation of its industrial base into high value added products driven by innovation, automation and amplified productivity to strive in an increasingly competitive and open global market (Oxford Business Group, 2016). The manufacturing sector astonishingly maintaining the growth rate at 5% yearly in moderating global economic circumstances. By the year 2015 with value RM 69 billion, accounting for 22.7% of the RM 303.8 billion total GDP at current prices, making it the largest sector of economy by value to our country (Department of Statistic Malaysia, 2016).

Small Medium Enterprises (SME's) form the pillar of a country's economic development (Thurik and Wennekers, 2004). They are seen to play a very significant part, globally (Veskaisri et al., 2007), and can be launched in any of the urban or rural localities for conducting any type of business (Khalique et al., 2011). In 2014, the Malaysian SME's growth of 13.6% continued to out pace the progress of the overall economy, with 35.9% of GDP share, affecting by strong domestic demand (SME Report, 2014/15). On the contrary, they cannot easily comply in accordance with the environmental regulations as compared to the larger industries (Greenpeace International, 1998; Keijzers, 2002; Walker and Preuss, 2008). Awareness for carrying out sustainable practices amongst the businesses is very essential for broadening their consideration from an economic well being to comprehend the societal and environmental aspects as well (Ageron et al., 2012). This realization can be attributed to the innovation done in manufacturing entities in a bid to overcome the stumbling block hindering in the production scheme's performance (Mohamad et al., 2008). Economic growth and industrialization in Malaysia has lead to better living quality, but at a large cost of excessive waste and pollutants.

Throughout the years of industrialization, our environment has become severely polluted and contaminated (Corbett and Klassen, 2006; Li and Zhang, 2014). Legislative requirements are enforced to contrivance proper waste management systems in all of the industries. Sustainable waste management aims to recover, recycle, reuse and reduce wastes from industrial productions (Jamin et al., 2014). At the United Nations Conference on Sustainable Development in Rio de Janerio, 2012 or known as Rio +20, one of the most significant current discussions in legal and moral philosophy is that fundamental changes in the way of the societies consume and produce are indispensable for achieving the global sustainable development. The responsiveness for the necessity to participate in sustainable practices among businesses is amassed to widen their focus from solely on economic well being to the environmental and societal dimensions into their objectives as shown in Figure 1.1, the 3 pillars of sustainability are defined (Elkington, 1998; Khalili, 2011; United Nations, 2015).

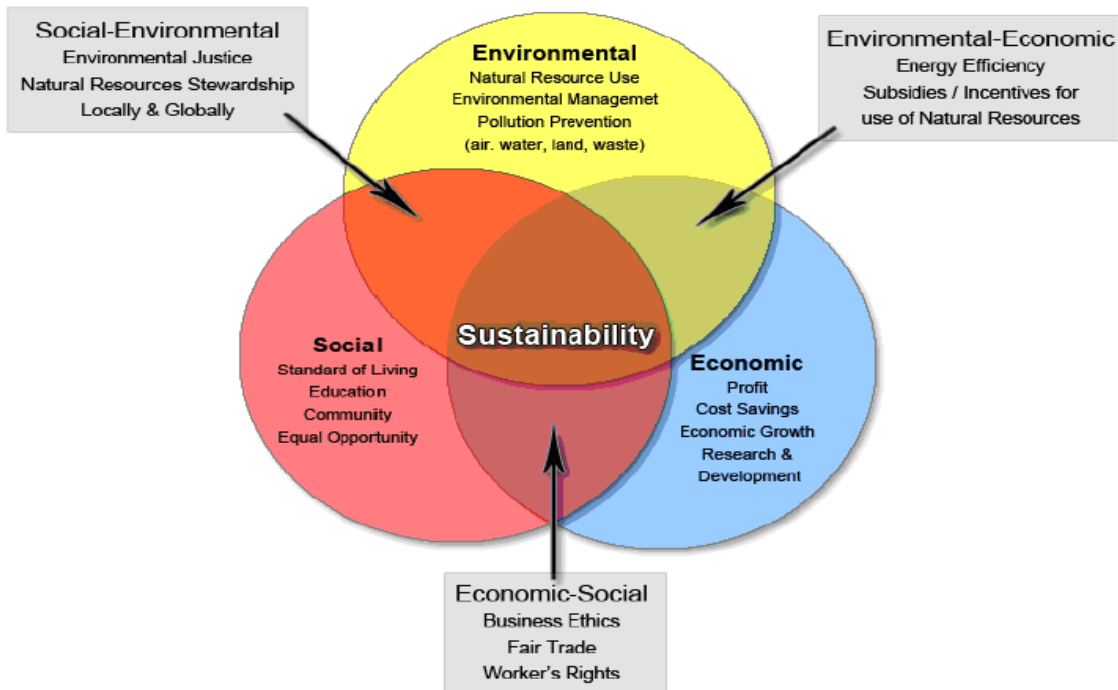


Figure 1. 1: Three Pillars of Sustainability.

A recent progress in the ecological rucksack as a result of today unsustainable patterns in the industry and consuming is the liability restrictive to our way forward. The first serious discussions by UNEP of sustainable production and consumption were emerging all through the year 2011 with intensified the need for minimizing the negative environmental impacts of consumption and production systems, while promoting the quality of life for all parties.

## **1.2 Problem Statement**

Nowadays the production challenges with high customer demand, also with environmentally hazardous and significant job risks to the employees. A number of studies from Frijns & Vliet (1999) have found that CP is a method to minimize waste and pollution load to the environment. Hilson (2000) also claimed CP aims to improve environmental production processes, by adopting a precautionary approach and seeking to reduce environmental waste and waste generation. Meanwhile, Bushell et al. (2002) claimed Lean Manufacturing (LM) seeks to make the most efficient production process by eliminating waste in every stage of the production chain. If the waste is failing to phase out or reduce, it can affect the process in terms of lead time, delivery time, quality, system performance and efficiency, operating cost, energy usage, water consumption and elevated the safety risk to the workers.

Florida (1996), King and Lenox (2001) and Rothenberg et al. (2001) was mentioned that LM has common goals with environmental objectives in some parts, e.g. improving manufacturing efficiency, energy and environmental benefits. However, with limited information about where and how the waste is produced makes the combination between CP and LM was not effective. Conversely, the potential of using lean tools to extend beyond sustainable manufacturing has also been explored (Kuriger et al., 2011; Faulkner et al., 2012). Saurin et al. (2009) proposed a guideline for assessing LM impacts on working conditions on employees either at a plant or departmental level. In addition, by using the lean principles to achieve environmental objectives, it will bring us considerable cost benefits besides CP implementation. The impacts detected in process line may provide insights for other companies concerned with balancing the leaner and better working conditions, but limited to economic metric without environmental and societal performance.