UNIVERSITI PUTRA MALAYSIA

DEVELOPMENT OF A SYSTEMATIC METHOD IN LEAN TOOL SELECTION FOR AUTOMOTIVE INDUSTRY

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DEVELOPMENT OF A SYSTEMATIC METHOD IN LEAN TOOL SELECTION FOR AUTOMOTIVE INDUSTRY

By

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DEVELOPMENT OF A SYSTEMATIC METHOD IN LEAN TOOL SELECTION FOR AUTOMOTIVE INDUSTRY

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The efficiency and effectiveness of lean practices have always been the major concerns for manufacturers. The current research highlighted the role of lean tools on leanness level in automotive industry. The main problem of automotive industry is its focus on process Kaizen instead of flow Kaizen. As a matter of fact, selecting and applying lean tools should comprehensively and holistically be considered in the principles and concepts within a systematic approach. Therefore, developing a systematic method to facilitate lean tool selection more precisely is required in this industry.

The proposed method was developed within a five step group decision making procedure to reach the desired aims. To fulfill the objectives of this study, a variety of Multi Criteria Decision Making (MCDM) and Data Envelopment Analysis (DEA) methods were employed, also the designed software used MATLA to experience the systematic lean tool selection.

The results of the study displayed that each of the lean attributes (lead time, cost, defect, and value) did affect the tool selection among companies. Furthermore, based on the results of the current research, a modified VIKOR method was developed. It is noteworthy to state that the suggested model for lean tool selection (defined in software) was validated within a panel of experts and companies indicating the effectiveness and usefulness of the model. There is the likelihood that this new developed method may enhance the competence and qualifications of practitioners to spot the possible problems and find solutions once the alternatives (lean tools) possess their own exclusive criteria.

The developed software probably assists manufacturers in applying the systematic lean tool selection. Based on the systematic features of this algorithm, the efficiency and effectiveness of the model in presenting optimizing techniques for lean tool selection with the automotive industry seems reasonable and useful. According to the findings of this study, lean practitioners can choose tools systematically via this recommended method in a dual approach i.e. attribute based (individually) and/or leanness based (wholly).

The current research paves the path to propose a generalized method that makes it possible for a user to holistically recognize and evaluate the tools influencing the application of lean manufacturing developments. Consequently, it should be borne in mind that taking tools performance into consideration while implementing lean practices has been of a great benefit for companies.

Abstrak tesis yang dikemukakan kepada Senate Universiti Putra Malaysia sebagai kerperluan untuk ijazah Doktor Falsafah

PEMBANGUNAN KAEDAH SISTEMATIK DALAM PEMILIHAN ALAT LEAN BAGI INDUSTRI AUTOMOTIF

Oleh

ALIREZA ANVARI

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Kecekapan dan keberkesanan amalan lean telah sentiasa menjadi kebimbangan utama bagi pengeluar. Penyelidikan semasa telah menekankan peranan alat lean pada tahap leanness dalam industri automotif. Masalah utama industri automotif adalah tumpuan pada proses Kaizen bukannya Kaizen aliran. Malah, memilih dan menggunakan alat lean harus komprehensif dan holistik dari segi prinsip dan konsep dalam pendekatan yang sistematik. Oleh itu, membangunkan kaedah yang sistematik untuk memudahkan pemilihan alat lean dengan lebih tepat diperlukan dalam industri ini.

Kaedah yang dicadangkan telah dibangunkan dalam prosedur kumpulan lima langkah membuat keputusan untuk mencapai matlamat yang diingini. Untuk memenuhi objektif kajian ini, kaedah pelbagai kriteria membuat keputusan (MCDM) dan kaedah analisis menyelubungi data (BEA) telah digunakan dan dimasukkan ke dalam operasi dalam perisian MATLAB untuk pemilihan alat lean yang sistematik.

Keputusan kajian yang dipaparkan bahawa setiap sifat-sifat lean (masa, kos, kecacatan, dan nilai) tidak menjejaskan pemilihan alat di kalangan syarikat. Tambahan pula, berdasarkan keputusan penyelidikan semasa, kaedah VIKOR yang diubahsuai telah dibangunkan. Kaedah baru yang membangun ini dapat meningkatkan kecekapan dan kelayakan pengamal untuk mengesan masalah yang mungkin timbul dan juga dapat mencari penyelesaian apabila alternatif- alternatif (alat lean) mendapatkan kriteria eksklusif mereka sendiri.

Perisian yang dibangunkan dimasukkan untuk membantu pengeluar dalam memohon pemilihan alat lean yang sistematik. Berdasarkan ciri-ciri sistematik algoritma ini, kecekapan dan keberkesanan model membentangkan teknik untuk mengoptimumkan pemilihan alat lean dengan industri automotif nampaknya munasabah dan berguna. Menurut penemuan kajian ini, pengamal-pengamal lean boleh memilih alat dengan sistematik melalui kaedah ini yang disyorkan dalam dua pendekatan iaitu attribute based (individu) dan / atau leanness based (keseluruhannya).

Penyelidikan semasa membuka jalan untuk mencadangkan satu kaedah umum yang membolehkan pengguna untuk mengiktiraf dan menilai pengaruh alat dalam mengaplikasi perkembangan pembuatan lean secara holistik. Oleh itu, syarikat-syarikat boleh mempertimbangkan untuk mengambilkira prestasi alat dalam melaksanakan amalan lean telah memberikan manfaat yang besar.

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October 2012

Alireza Anvari

APPROVAL

I certify that an Examination Committee met on 23 July 2012 to conduct the final examination of Alireza Anvari on his thesis entitled "Development of Systematic Method in Lean Tool Selection for Automotive Industry" in accordance with the Universitis and University Colleges Act 1971 and the Constitution of Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that the student be awarded the Doctor of Philosophy.

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DECLARATION

I declare that the thesis is my original work except for quotation and citations, which have been duly acknowledged. I also declare that it has not been previously, and is not concurrently, submitted for any other degree at Universiti Putra Malaysia or any other institutions.

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Alireza Anvari

Date: 23July2012

TABLE OF CONTENTS

LIST OF TABLES

Table

LIST OF FIGURES

LIST OF ABBREVIATIONS

AHP	Analytical Hierarchy Process
AP	Anderson & Peterson
BCC	Banker-Charnes-Cooper
CCR	Charnes–Cooper–Rhodes
CM	Continuous Process Manufacturing
CR	Consistency Ratio
CRS	Constant Returns to Scale
CTs	Critical Techniques
DEA	Data Envelopment Analysis
DM	Discrete Manufacturing
DMU	Decision Making Units
FIFO	First In First Out
FMEA	Failure Mode and Effects Analysis
IR	Inconsistency Ratio
JIT	Just In Time
LM	Lean Manufacturing
LP	Linear Programming
MADM	Multi Attribute Decision Making
MCDM	Multi Criteria Decision Making
NIS	Negative Ideal Solution

PIS	Positive Ideal Solution
QFD	Quality Function Deployment
SAW	Simple Additive Weights
SMED	Single Minute Exchange of Dies
SPC	Statistical Process Control
TOC	Theory Of Constraint
TOPSIS	Technique for Order Preference by Similarity to Ideal Solution
TPM	Total Productive Maintenance
TPS	Toyota Production System
TQM	Total Quality Management
VF	Visual Factory
VIKOR	the Serbian name, Visekriterijumska optimisacija I KOmpromisno Resenje, means multi-criteria optimization and compromise solution
VRS	Variable Returns to Scale
VSM	Value Stream Mapping

CHAPTER 1

INTRODUCTION

1.1 Background of the study

Companies today are facing an increasing number of challenges in a competitive environment. Most organizations are looking for ways to continuously improve, and many of them have turned to lean manufacturing (LM) for a solution. LM is not just a management style or a way of producing better products rather it is a production philosophy (Wan, 2006). LM can also be described as a way of mapping the overall production process from raw materials to finished products or all the way to customers (Yamashita, 2004). It is called 'lean' because this technology, or process, helps manufacturers to produce more by using less time, inventory, capital, and fewer resources while adding the value customer satisfaction. To be lean is to manufacture only what is needed by the customer (Mika, 2006), when it is needed, and whether it is ordered by quantities. In fact, the manufacture of goods is done in minimal time, at the lowest cost, with zero defects, and the highest quality in order to create the customer value.

Therefore, lean tools selection is the most important factor in the success or failure of achieving leanness (Li, 2011). A successful level in implementing techniques and achieving desired goals can be defined as the leanness level (Wan, 2006). Tools selection and their implementation play a crucial role in the leanness level. Without a measure of leanness, manufacturers might base their decisions on inaccurate information that comes from a variety of sources such as information about alternatives with respect to the attributes of lean tools (Li *et al.*, 2009). However, it seems that an effective measure of the leanness level is absent. The leanness level for supporting improvements has not been well developed (Wan, 2006). Without a leanness measure, the leanness level of the implementation of tools and techniques is unknown, and improvement in leanness cannot be traced.

According to the existing body of literature and the researcher‘s knowledge, it is not likely to find database on developing a systematic model in lean tool selection for automotive industry. Although tool selection was reported by a number of researchers (e.g., Mahapatra and Mohanty, 2007; Li, 2011; Saurin *et al.*, 2011), they did not develop a model to be a help in finding remedies for the problems.

The systematic approach considers system as a whole (Allen, Robinson, and Stewart, 2001). As a matter of fact, selecting and applying lean tools should comprehensively and holistically be considered in the principles and concepts within a systematic approach. Hence, developing a systematic method to facilitate lean tool selection more precisely is in the scope of this research work. The current research has highlighted the role of lean tools on leanness level in automotive industry.

Problem statement

Many businesses have been trying to adopt new business initiatives in order to stay afloat in the new competitive marketplace. LM is one of these initiatives that focus on lead time and cost reduction efforts by eliminating non-value added activities. The tools and techniques of LM have been widely used in automotive industry starting with the introduction of the original Toyota production system (TPS).

Selection of appropriate lean practices to address the problems identified is a challenging task (Abdullah, 2003; Amin and karim, 2011); hence selecting and applying lean practices in a system, the efficiency and effectiveness of the lean implementation are always the major concerns for manufacturers (Wan and Chen, 2008).

During the last one decade, the notion of lean has drastically changed the way automotive industry and around the world think about manufacturing their products or providing their services. Still, the amount of firms truly converted into a lean state is estimated by experts to be less than 50% (Moutabian, 2005). This dissatisfying number leads to the question of why a number of companies fail in sustaining the implemented lean practices and the resulting improvements.

One of the problem is an effective measure of the role of tools in a successful ratio to the leanness level is absent (Wan and Chen, 2008). An inadequate understanding of the purpose of tools leads to misapplications of existing LM tools (Pavanskar *et al.*, 2003).

Therefore, there seems to be a need for a leanness process to evaluate the achieved attributes through group decision making.

Another problem with this kind of application is lean tools selection. The main problem of automotive industry is focusing on process Kaizen instead of flow Kaizen (Moutabian, 2009). Improvements were made at an individual process or in a specific area, and departmentalisation (Brown *et al.*, 2006) or tools selection was based on the waste (Mahapatra and Mohanty, 2007; Li, 2011); while LM is a systematic approach; to integrate the systems as a whole (Allen *et al*., 2001).

Hence, the guidelines on how to select and apply the tools, techniques and methods to extract added value are still absent (Little and McKinna, 2005; Bhasin, and Burcher 2006). Selecting and applying lean tools should be comprehensively and holistically in principles and concepts (Crute *et al.*, 2003; James, 2006) within systematic approach (Liker and Morgan, 2006; Wan and Chen, 2008) in automotive industry.

1.3 Objectives of the study

The objective of this research is to develop a systematic method in lean tool selection for automotive industry and to help lean practitioners ensure the effectiveness of the implementation of lean initiatives. Three aspects of the objective are listed below:

1. To identify and develop measures of lean attributes to leanness;
2. To develop a modified VIKOR method to select lean tools; and
3. To develop and validate a systematic method for lean tool selection.

1.4 Scope and limitations of the study

Due to the availability of resources, the scope of the research on systematic lean tool selection and the impact of the tools on the leanness level are focused on the automotive industry. In the development of the methodology, the mathematical models for Data Envelopment Analysis (DEA) and Multi Criteria Decision Making (MCDM)/Multi Attribute Decision Making (MADM) are adapted to develop measures of tools for leanness.

Moreover, within the scope of this research, there is a link between lean tools and lean attributes relating to literature which are defined. This research does improve operational performance of lean tools and techniques as measured by lead time, cost, defects, and value.

Consequently, the scope of study is automotive manufacturing plants (automakers and auto parts) in Iran. Meanwhile, the scope of those techniques is not limited to automotive industry; it covers multiple manufacturing plants in different countries and companies. Furthermore, this research includes a study on leanness by asking if lean tools and techniques create value when they are applied properly but it does not study how these tools can be implemented.

1.5 Significance of research

There are many opportunities for improvements; it is necessary for industries to analyze how they operate their business today, to see their biggest constraints, and to learn where there are opportunities for improvements. Many manufacturers realize the importance of practicing lean techniques. However, few organizations apply lean techniques with the necessary knowledge and proven tools to achieve it.

Although it seems that the ideal lean state is typically not achievable, tools selection based on availability, adaptability, capability, and adequacy, it helps manufacturers improve the efficiency and effectiveness of their manufacturing activities.

Accordingly, the benchmark of leanness should be updated when production technologies and management skills are gradually improved. Therefore, the lean tools selection that will be resulted from this study can reduce lead time, costs, and defects, as well as improve quality and increase productivity. It helps companies remove various types of waste and non-value added activities. It handles multiple inputs and outputs and it develops the efficiency and effectiveness of the manufacturing activities.

1.6 The structure of the thesis

The thesis is organized into five chapters based on the framework of this research. The chapters are developed to present the components of the framework; also the order of the chapters corresponds to the timeline of the research activities. The components of this research are listed as follows:

Chapter 2 introduces the previous research on LM, leanness measurement, and lean tools selection, further the background information is provided proper evidence. The details of leanness, the choice of tools and techniques from the literature, a detailed description of DEA and MCDM history, and their applications are presented.

Chapter 3 presents the methodologies used in the study. Firstly, to be presented is a detailed discussion on the methodology used in this research, the leanness target for the system is identified, and then some extended applications of the proposed tools selection based on the leanness measure, the variables employed, and the information needed to be extracted are given. A discussion of the 'DEA Leanness and MCDM' procedure and how the prioritizing was developed and the interviews conducted with employees using DEA, VIKOR (the Serbian name, means multi-criteria optimization and compromise solution) model are mentioned. This chapter ends with the presentation of a systematic approach and validation of the method.

In Chapter 4, the information collected from the decision makers associated with the methodology proposed in Chapter 3 is evaluated. Next, an analysis of the findings and a discussion of the results in details with the proper illustrations in the forms of tables and figures that can assist readers to easily realize and extract the information are discussed. In addition, this chapter presents a step-by-step procedure of the “DEA-MCDM” study in developing the methodology to lean tools selection, and the interviews conducted with a panel of experts. A conclusion is therefore drawn from this chapter and then, it leads to Chapter 5.

Chapter 5, the most important chapter of this thesis, discusses the outcomes of the research and explains how the objectives of the research are fulfilled. This chapter provides benchmarks for academicians and industry managers and sets recommendations for the relevant institutions and industrial sectors. The chapter ends in setting a direction for future research which could incorporate some aspects of this research for further study.

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