A STUDY OF LEAN SIX SIGMA IMPLEMENTATION ON IMPROVING AUTOMOTIVE OPERATIONAL PERFORMANCE

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Report submitted in partial fulfilment of the requirements
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SUPERVISOR'S DECLARATION

I hereby declare that I have checked this project and in my opinion, this project is adequate in terms of scope and quality for the award of the degree of Bachelor of Industrial Technology Management with Honors.

Signature :

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STUDENT'S DECLARATION

I hereby declare that the work in this project is my own except for quotations and summaries which have been duly acknowledged. The project has not been accepted for any degree and is not concurently submitted for award of other degree.

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Date :

DEDICATION

Dedicated to my beloved parents, my great brothers,
my honourable supervisor, and my best friends

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Having come thus far I have learned that life's achievements are seldom attained by doing things alone. Without the help of God and others I would not have come thus far and it is only right to acknowledge with thankfulness the contribution of those who have been with me in this academic journey.

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To my mother and father, I am eternally grateful for your tireless guidance and support. Last but not least, I would like to thank my brothers and all my friends who have crossed my path in life and have helped me grow. I appreciate everything you have done to get me where I am today. Your support and encouragement means a great deal to me.

ABSTRACT

As global competition continues to grow, the pressure to improve to be the best becomes more and more intense. Thus, a combination of both Lean and Six Sigma which is called Lean Six Sigma (LSS) is born. This LSS method provides an over-arching improvement philosophy that incorporates powerful data-driven tools to solve problems and create rapid transformational improvement at lower cost. However, there are very few researches on LSS in Malaysian automotive industry. There still exists the gap in the body of knowledge in LSS in Malaysian automotive industry context which needs to be filled. Therefore, this research is aimed to investigate the practices of LSS implemented in a Malaysian automotive company, Vacuumschmelze (Malaysia) Sdn Bhd to identify the challenges of implementing LSS in Malaysian automotive company and to examine the impacts of LSS implementation on improving automotive company's operational performance. First, a conceptual framework was developed based on a review of the literature, where "Define, Measure, Analysis, Improve, and Control'' (DMAIC) are set as independent variables while operational performance (OP) variables including Cost and Waste Reduction (OPC), Quality (OPQ), Flexibility (OPF), Delivery (OPD), and Productivity (OPP) are dependent variable. While forming research design, interview with five interviewees from top management are carried out and 64 questionnaires are collected from employees in related department. Then, both of content analysis and statistical technique are used to analyse those data. Generally, all research objectives have been achieved. Through data collected from interview, different key processes and tools of LSS are found out in "Define, Measure, Analyse, Improve and Control" (DMAIC) stages. Challenges that are faced during implementation of LSS in the case study company include budget and time constraints, resistance from employees, fractured organizational culture, shortage of black belt, green belt and yellow candidates and picking the "right" projects. Beside this, findings also shown that LSS implementation brings positive impacts toward operational performance. Finally, managerial implication and recommendation for future study are proposed.

ABSTRAK

Persaingan yang sengit dalam pasar global sekarang ini, tekanan untuk menjadi lebih baik daripada pesiang telah semakin meningkat. Oleh itu, gabungan kedua-duanya amalan Lean dan Six Sigma yang dipanggil Lean Six Sigma (LSS) telah dilahirkan. Metodologi LSS merupakan falsafah peningkatan kualiti dalam menyelesaikan masalah dan mewujudkan penambahbaikan transformasi pada kos yang lebih rendah dengan pengunaan penggabungan alat-alat daripda Lean dan Six Sigma. Walau bagaimanapun, melalui penyelidikan di sistem penyimpanan jurnal, hanya terdapat beberapa kajian mengenai LSS dalam industri automotif di Malaysia. Oleh itu, objektif penyelidikan ini adalah untuk menyelidik amalan LSS yang selalu dilaksanakan di syarikat automotif Malaysia, mengenal pasti cabaran ketika pelaksanaan keadah LSS di syarikat automotif Malaysia tersebut dan mengkaji tentang kesan pelaksanaan Lean Six Sigma (LSS) terhadap peningkatan prestasi operasi automotif (OP). Pertama sekali, rangka kerja konsep untuk kajian ini telah ditubuh berdasarkan kajian literatur, di mana "Takrifkan, Langkah, Analisis, Meningkatkan dan Kawalan" (DMAIC) akan menjadi pembolehubah bebas manakala prestasi operasi (OP) pembolehubah termasuk Kos dan Pengurangan Sisa (OPC), Kualiti (OPQ), Fleksibiliti (OPF), Penghantaran (OPD) dan Produktiviti (OPP) akan menjadi pembolehubah bersandar. Selepas itu, reka bentuk penyelidikan disediakan di mana kaedah soal selidik dan temubual dipilih untuk pengumpulan data. Selepas pengumpulan data, analisis kandungan akan digunakan untuk menjalankan analisis data yang diperolehi daripada temubual manakala perisian Pakej Statistik untuk Sains Sosial (SPSS) akan digunakan untuk menganalisis data bagi soal selidik. Secara umumnya, semua objektif kajian telah dicapai. Melalui data yang diperoleh daripada temu bual, pelbagai proses-proses utama dan alat-alat LSS telah didapati di setiap peringkat "Takrifkan, Langkah, Analisis, Meningkatkan dan Kawalan " (DMAIC). Cabaran yang dihadapi semasa pelaksanaan LSS dalam syarikat tersebut juga dikenal pasti. Ia termasuk kesuntukan masa dan bajet, batahan daripada pekerja, budaya organisasi yang lemah, kekurangan calon-calon yang pakar dalam bidang LSS dan pemilihan projek yang "betul". Selain ini, keputusan dalam penyelidikan ini telah menunjukkan bahawa pelaksanaan LSS memberi kesan positif terhadap prestasi operasi.

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LIST OF ABBREVIATIONS

ASEAN	Association of Southeast Asian Nations
BB	Black Belt
C/O	Changeover Time
CTQ	Critical to Quality
DMADV	Define, Measure, Analysis, Design and Verify
DMAIC	Define, Measure, Analyse, Improve and Control
DOE	Design of Experiment
DPMO	Defects per Million Opportunities
DPU	Defects per Unit
FMEA	Failure Mode Effects Analysis
FTY	First Time Yield
GB	Green Belt
IWA	Interviewee A
IWB	Interviewee B
IWC	Interviewee C
IWD	Interviewee D
IWE	Interviewee E
JIT	Just In Time
KPIVs	Key Process Input Variables
LSS	Lean Six Sigma
M	Mean
MSA	Measurement System Analysis
NAP	National Automotive Policy

LIST OF ABBREVIATIONS (CONTINUED)

OEE	Overall Equipment Effectiveness
OP	Operational Performance
OPC	Cost and Waste Reduction
OPD	Delivery
OPF	Flexibility
OPP	Productivity
OPQ	Quality
PROTON	Perusahaan Otomobil Nasional Berhad
QSE	Quality, Safety, Environment department
SD	Standard Deviation
SIPOC	Suppliers, Inputs, Process, Outputs, Customers
SPSS	Statistical Package for the Social Sciences software
SQM	Supplier Quality Management department
SS	Six Sigma
TPM	Total Production Maintenance
TQM	Total Quality Management
VAC	Vacuumschmelze (Malaysia) Sdn Bhd
VOC	Voice of Customer
VSM	Value Stream Mapping
YB	Yellow Belt

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

Automotive in Malaysia is perhaps one of the freshest markets compared with Germany, Japan and Korea although it has been more than two decades in the market competition. Thus, there are still much to do in order to compete with competitors. Moreover, the demand of customer seeking quality goods and services with low price is getting higher and higher. Thus, manufacturers must be able to produce goods or services by using the most economical and cost effective ways and capable to produce new goods or services with short lead times in order to satisfy the demand of customer.

Lean is an approach that seeks to improve flow in the value stream and eliminate waste. It's about doing things quickly. Six Sigma uses powerful framework which are "Define, Measure, Analyse, Improve and Control" (DMAIC) or "Define, Measure, Analysis, Design and Verify" (DMADV), and statistical tools to uncover root causes to understand and reduce variation. It's about doing things right (defect free). As global competition continues to grow, the pressure to improve becomes more and more intense. Thus, a combination of both Lean and Six Sigma is born. This method provides an over-arching improvement philosophy that incorporates powerful data-driven tools to solve problems and create rapid transformational improvement at lower cost.

Based on studies of Lean Six Sigma (LSS), many benefits have been reported such as reducing the service time, reducing the turnover, reducing waste, lowering the cost of production, leading to innovation and increasing customer satisfaction (Kumar et al., 2006; Su et al., 2006; Byrne et al., 2007; Thomas et al., 2009; Laureani et al., 2010;

Vinodh et al., 2011; Anderson and Kovach, 2014). Thus, this research is aimed to investigate the practice of LSS that implemented in Malaysian automotive company, and to identify the challenges faced when implementing LSS and also to examine how the LSS contributes to the automotive industry in Malaysia.

This chapter introduces the research outline of the study. It begins with background study of the LSS, followed by problem statement, research objectives, research questions and scope of study. Besides that, this chapter also includes the significance of study and the expected result. The key terms will also be elaborated under the section of operational definition.

1.2 BACKGROUND OF STUDY

The journey of automotive industry in Malaysia began with manufacturing the first national car, Proton Saga in July 1985 by Perusahaan Otomobil Nasional Berhad (PROTON). Then, in 1993, Perusahaan Otomobil Kedua Sdn Bhd (PERODUA) was established and produced the second national car project. Now, Malaysian automotive industries not only assembly those car parts from oversea, but also manage the local design, engineering, and even full scale manufacturing operation.

Although Malaysian automotive industry grew steadily in the past two decades, it is still not as competitive as other countries even in ASEAN (Association of Southeast Asian Nations) area. Figure 1.1 shows the total motor vehicle sales in the 4 major ASEAN countries, namely Thailand, Indonesia, Philippines and Malaysia.

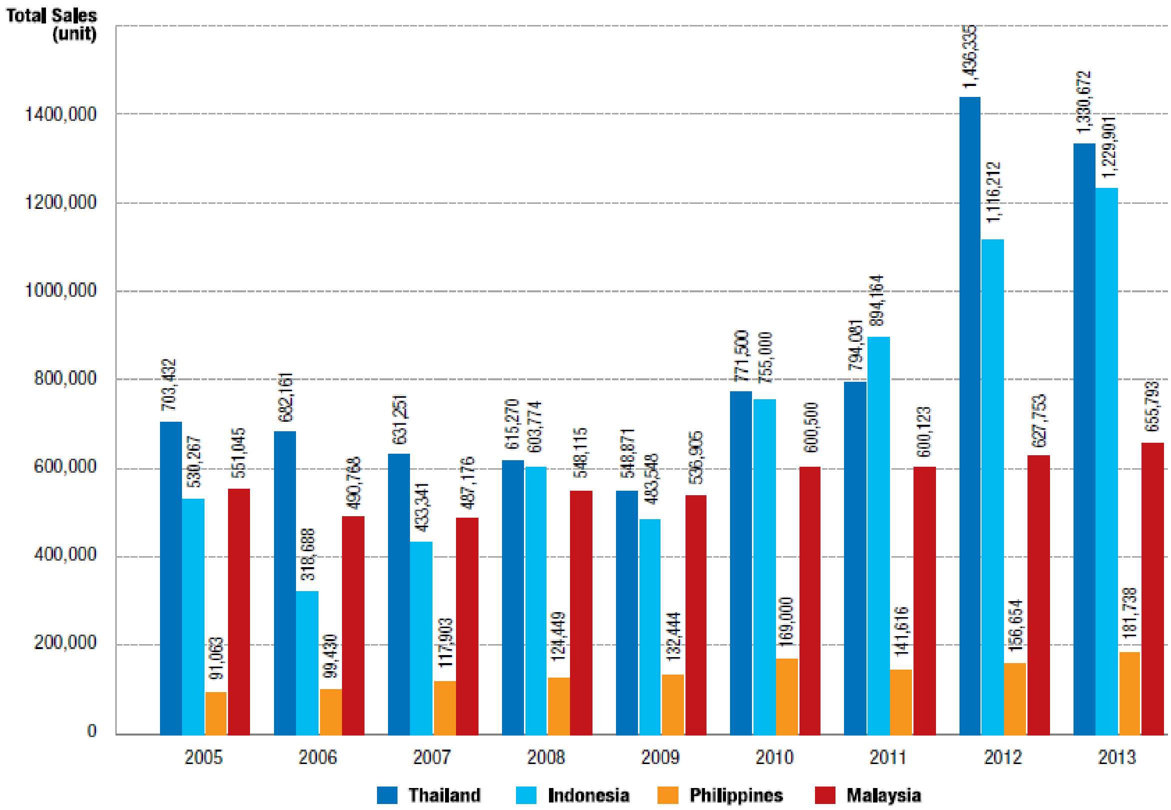

Figure 1.1: Total Motor Vehicle Sales in the 4 Major ASEAN Countries

Source: (Business Opportunity: Malaysia's Automotive Industry, 2014)

According to Figure 1.1, the total vehicle sales of Malaysia reached 655,793 units in 2013 which increased 19.01% in nine years period since 2005. However, comparing with the total vehicle sales of Thailand (1,330,672 units) and Indonesia (1,229,901 units) in 2013, Malaysia Automotive expresses its incompetitiveness.

The automotive industry is extremely competitive. Automotive companies have to effectively manage very complex production processes in order to fulfil customers' needs for customised cars on time. The automobile assembly plants have highly stabilised production systems. However, uncertainties are still exit in those systems. In order to ensure Malaysian automotive industry to be competitive, it is crucial to improve operational performance of Malaysian automotive industry. And to achieve it, Lean Six Sigma (LSS) is widely regarded as one promising approach (Achanga et al., 2006).

In the beginning, Lean and Six Sigma were implemented in isolation with different project objective priorities, which caused conflict of interest and resource drain. Companies had problems in the control phase of Six Sigma “Define, Measure, Analyse, Improve and Control” (DMAIC) method after implementing Lean Manufacturing to reduce all the sources of waste during sub optimization of processes (Bendell, 2006). However, as the process of combining lean and Six Sigma keeps improving, researchers realized that actually both approaches are complementary.

Up to date, Lean and Six Sigma (SS) have been promoted as a new organizational change and improvement approach that has been popularized by several high-profile companies (Achanga et al., 2006; Singh et al., 2010). The complementary nature of these methods has led to their successful combination into a single methodology, commonly called Lean Six Sigma or Lean Sigma (Antony et al., 2003). The LSS is a new concept used to improve operational uniformity and quality, and reduce variations and waste (Snee, 2010). One of the latest case study by Vinodh et al. (2011) on an automotive valve manufacturing organization located in Tamil Nadu, India shows that there has been 50% reduction in defects per unit (DPU); 17.64% increase in overall equipment effectiveness (OEE); 25% reduction in changeover time (C/O); 0.99% improvement in first time yield (FTY) and 18.53% reduction in manufacturing lead time and thus, saving 28,000 valves per month from being rejected after implementing LSS. Since organizations around the world are reaping the benefits of competitive advantages through reduced costs, more and more companies are promoting LSS in their processes.

However, the implementation of LSS is not very common among local automotive industries due to lack of disclosure and many companies are afraid to take high risks. Automotive industry is one of the most active industries which not only stress on development of supply chains and adoptability of advanced technology but also quality effort, low production cost, and continuous improvement activities. In order for automotive industries in Malaysia to achieve global competitive advantage and to help the National Automotive Policy (NAP) 2014 achieve one of their objectives which is to develop high value-added manufacturing activities in niche areas, it is imperative to conduct a research on Malaysian automotive industry to encourage more automotive companies to implement LSS since this LSS approach really brings a lot of benefits to the industry.

1.3 PROBLEM STATEMENT

A review on the past and recent LSS literature shows that previous researches on LSS have focused on different industries, such as automotive industry (Vinodh et al., 2011), health industry (Jackson & Woeste, 2008), Engineering industry (Thomas et al., 2009), service industry (Su et al., 2006; Laureani et al., 2010), military and etc. And the majority of the studies were conducted mainly in overseas countries where there are clearer and more comprehensive processes of quality improvement practices. There are very few researches on LSS in Malaysian automotive industry.

Habidin and Yusof (2013) have identified and evaluated seven critical success factors of LSS for Malaysian automotive industry including Leadership (LP), Structured Improvement Procedure (SIP), Quality Information and Analysis (QIA), Supplier Relationship (SR), Just in Time (JIT), Customer Focus (CF) and Focus in Metric (FM). Moreover, Habidin and Yusof (2012) have also investigated relationships between LSS, environmental management systems, and organizational performance in the Malaysian automotive industry where it proves that organizational performance for ISO 14001 certified companies is higher than that of uncertified companies although ISO 14001 certification does not significantly moderate the relationship between LSS and organizational performance in the Malaysian automotive industry.

Although three conceptual researches propose there are positive relationships between LSS practices implementation and organizational performance in Malaysian automotive industry (Habidin et al., 2012); positive relationships between Green Lean Six Sigma (GLSS) practices and managerial innovation in Malaysian automotive industry (Zamri et al., 2013); and positive relationships between GLSS and financial performance practices in Malaysian Automotive Industry (Zamri et al., 2013); none of them has empirically examined the relationships between LSS and operational performance. Hence, there still exists the gap in the body of knowledge in LSS in Malaysian automotive industry context which needs to be filled.

1.4 RESEARCH OBJECTIVES

Thus, this research is aimed to explore the implementation of LSS in a Malaysian Automotive Industry. The specific objectives of this study are as follows:

RO1: To investigate the practices of Lean Six Sigma implemented in a Malaysian automotive company;

RO2: To identify the challenges of implementing Lean Six Sigma in a Malaysian automotive company;

RO3: To examine the impacts of Lean Six Sigma implementation on improving the automotive company's operational performance.

1.5 RESEARCH QUESTIONS

There are three questions developed for this research, which are:

RQ1: What are the practices of Lean Six Sigma implemented in a Malaysian automotive company?

RQ2: What are the challenges of implementing Lean Six Sigma in a Malaysian automotive company?

RQ3: What are the impacts of Lean Six Sigma implementation on improving the automotive company's operational performance?

1.6 SCOPE OF THE STUDY

The scope of study is focusing on investigating the practice of LSS that implemented in a Malaysian automotive company based on 1’’ (DMAIC) framework. This research also indicate the challenges faced when implementing LSS in the Malaysian automotive company based on the phases of “Define, Measure, Analysis, Improve, and Control’’ (DMAIC) framework. Last but not least, this research highlights the impact of LSS implementation on improving automotive company’s operational performance based on the operational performances variables including Cost and Waste Reduction (OPC), Quality (OPQ), Flexibility (OPF), Delivery (OPD), and Productivity (OPP).

Meanwhile, there are many industries in Malaysia but this research only focus on the Malaysian automotive industry. Although automotive industry only contributed 3.2 % to GDP in year 2012 through RM5.3 billion in exports of vehicles and automotive components, investments of RM5 billion and provided 550,000 employment opportunities, however, there is a forecasting which shows that the industry will not only create an additional 150,000 employment opportunities by 2020 but also contribute 10 per cent to the country’s GDP in the same year where the vehicle production is expected to increase to 1.25 million units (Singh Sidhu et al., 2014). Therefore, automotive industry as one of the significant sectors in Malaysia that contribute toward Malaysia economy is chosen for this research.

1.7 SIGNIFICANCE OF STUDY

This study can contribute to the improvement of automotive industries in Malaysia through Lean Six Sigma (LSS) implementation on improving automotive operational performance. Although there is a conceptual research on examining relationship of LSS practices implementation and organizational performance in Malaysian automotive industry (Habidin et al., 2012), empirical study on it still has not been carried out by using the proposed conceptual model. Beside this, there is no research investigating the relationship between LSS implementation and operational performance in Malaysian Automotive Industry where it can provide significant guidelines and indicators for automotive companies to apply LSS practices in order to enhance operational performance. By ascertaining the practice of LSS that implemented in Malaysian automotive company, this research could not only filling the research gaps of LSS in Malaysia, but also provide a better understanding and benchmarking for other automotive companies to review and restructure their operation process.

On the other hand, due to implementation of LSS practices is not totally zero cost program, for those companies intending to implement this approach need to invest cautiously and of course they will confront challenge first before obtaining the gain and benefits from this program. The results on identifying challenges of implementing LSS would provide indicators and guidelines to local automotive companies in order to help them implement of LSS practices successfully. This will avoid the companies from losing investment and effort in LSS implementation without enhancing company’s performance. With the success of LSS implementation, the automotive industry will stay competitive and growth to fulfil the demand of customers.

Meanwhile, as mentioned previously, an Indian automotive valve manufacturing organization managed to get positive impact on operational performance through implementation of LSS by reducing the defects per unit (DPU), increasing the percentages of overall equipment effectiveness (OEE), reducing changeover time (C/O); improving the percentages of first time yield (FTY) and reducing manufacturing lead time (Vinodh et al., 2011). Hence, this research would provide real case examples in Malaysian Automotive Industry with positive impacts of implementing LSS towards operational performance. Hence, it would encourage more automotive companies to adopt LSS approach, in order to bring benefits to the important stakeholders such as investors of automotive industries and consumers.

1.8 OPERATIONAL DEFINITION

The following definitions of the terms are used in this research.

Six Sigma (SS)

Six Sigma is a quality methodology developed by Motorola that stress on setting extremely high objectives, collecting data, and analysing results in order to decrease manufacturing defects in products and services where it cannot produce more than 3.4 defects per million opportunities" (George, 2003).

Lean Manufacturing (LM)

Lean manufacturing is an approach that emphasizes on the removing of waste and just-in time manufacturing that results in minimized inventory for work-in-process and finished goods through pulling of material from downstream operations only when needed (Womack et al., 2008).

Lean Six Sigma (LSS)

Lean Six Sigma developed from combination of Lean and Sigma approaches through complementation between each other, where it focuses on improving quality, reducing variation, eliminating waste and attaining statistical control by decreasing variation (Smith, 2003).

Operational Performance

Operational performance is a measurable aspect to the performance of internal operation of an organization including cost and waste reduction, the quality of products improvement, flexibility improvement, delivery performance improvement and productivity improvement (Munizu, 2013; Salaheldin, 2009).

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

Chapter 2 introduces the fundamental concepts that are necessary to understand and use Lean, Six Sigma (SS) and Lean Six Sigma (LSS) in an organization. These concepts include a definition, history and philosophy of Lean, SS and LSS. For better understanding of the present study, a comprehensive search of previous literature and relevant articles published by accredited scholars and researches has been undertaken. As such, this chapter was organized in the manner to give an overview of literature, discusses the benefits of LLS and condition of Automotive Industry.

2.2 OVERVIEW OF LEAN MANUFACTURING (LM)

Lean manufacturing is a management philosophy that aimed to achieve smooth production flow by eliminating waste through a focus on exactly what the customers want, and increase the activities value. It is derived mostly from the Toyota Production System (TPS) which is pioneered by the Japanese engineers Taiichi Ohno and Shigeo Shingo in the 1950's (Womack et al., 2008). However, James P. Womack, Daniel T. Jones, and Daniel Roos are the ones who introduced this concept to the United States which brings important changes to the ways of US manufacturers operated through their 1990's best seller book called *The Machine That Changed the World: The Story of Lean Production*. The lean concept evolved as time goes on and from lean production meaning extended to a whole enterprise model and now even to an extended lean enterprise model (Ricondo and Viles, 2005).

Lean operations are also driven by workflow initiated by the "pull" of the customer order. It is aimed at the elimination of waste in every area of production including customer relations, product design, supplier networks, and factory management (Phillips, 2000). As a result, "companies have substantially cut lead times, drastically reduced raw material, working-process and finished goods inventories, and effectively increased asset turnover" (Claycomb et al., 1999). This philosophy was based on lean principles.

There are three core principles stated by Womack et al. (2008) which are identification of value, elimination of waste, and the generation of smooth flow. However, these principles were further expanded by into five principles (Womack and Jones, 2010) as shown in the Figure 2.1.

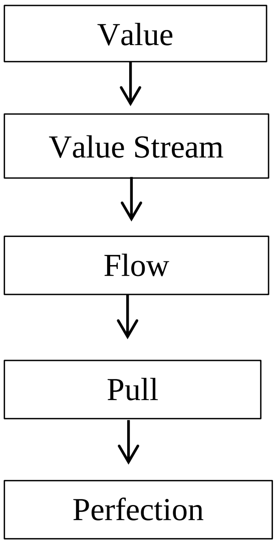

Figure 2.1: Lean methodology

Source: Modified from Womack and Jones (2010)

The first principle is identifying customer defined value. Lean thinking must start with defining value precisely by providing specific goods and services which meets the customer's requirements at the right time with appropriate price. Value is only meaningful when expressed in terms of a specific product.

Value stream is all the specific activities needed to produce a product through problem solving during design and production, information management during order-taking until delivery, and physical transformation of raw materials to a finished product to the customer. However, value stream has three type activities which are uniquely activities that create value (value-added), activities not has value but cannot avoidable with current technologies or production assets (Type One muda), and activities not has value and are immediately avoidable (Type Two muda). Thus, it is necessary to optimize value stream.

The next principle is converting the value flow smoothly by controlling and eliminating wastes. Flow is progressive achievement of tasks along the value stream so that a goods proceeds from design to launch, order to delivery and raw materials into customer's hand with good conditions. This means ignore the traditional batch and queue and change in tools for manufacturing include use right size machine and find the sequential step beside each other.

The fourth lean principle is activating the demand pull by synchronizing customer demand and information flow. It is a "system of cascading production and delivery instructions from downstream to upstream in which nothing is produced by the upstream supplier until the downstream customer signals a need" (Womack and Jones, 2010). This approach relies on customers' orders to produce and deliver products. Therefore, pull approach will enhance the company by reduce the inventory costs and avoid overproduction.

The final lean principle is perfection of all processes and services through elimination of *muda* or waste. It is the "complete elimination of muda so that all activities along a value stream create value" (Womack and Jones, 2010). The principle of perfection aim to achieve zero wastes and makes the lean principle is a never-ending process. For example, Kaizen is implemented to ensure the continuous improvement of the production process.

According to Nave (2002), Lean methodology is founded on five main assumptions which are:

1. People value the visual effect of flow.
2. Waste is the main restriction to profitability.
3. Many small improvements in rapid succession are more beneficial than analytical study.
4. Process interaction effects will be resolved through value stream refinement.

There are seven Ohno's wastes in concept of Lean including overproduction, wait time, transportation, inventory, motion, overprocessing and defects (Womack and Jones, 2010). Overproduction is goods and services that are in excess to present customer needs. To eliminate this waste, Lean companies is encouraged using automation in their process automation to smoothies scheduling. Wait time is the time that work in progress (WIP) is not directly related to a customer needs. This problem can be solved by maximizing the use of employees through analysing work load and work flow, production and maintenance schedules, sets up times and procedures. The meaning of transportation in the waste concepts is moving raw materials, product, or information unnecessarily. The lean managers can identify the process flow, the inefficient site layout and lead-times in order to eliminate this waste.

On the other hand, excess inventory which including WIP that is not directly related to a customer need are also a waste to the company. This problem is caused by inefficiencies, product complexity, bad scheduling, unreliable deliveries and poor communications between suppliers and department. There is also a waste in motion due to the unnecessary movement by people. Thus, the companies must improve the efficiency of motions by designing the most convenient workplace.

Beside this, overprocessing is also another waste where the company add some value to a process or product the customer would not pay for. Thus, employees must questions every step whether it is necessary. Last but not least, defects which include flaws in the WIP, final products, or services that do not meet the customer's requirements where the products or services have to reworking and repairing is also an unnecessary cost to the companies. This problem may due to inadequate process control, poor quality, insufficient training, poor product design and unclear about customer needs.

However, as time goes on, the seven wastes have increased to eight wasted which add in “unused human resources”. It means having excess workforce for the process (McAdam and Donegan, 2003). Thus, in Lean approach, the companies will emphasizes on improving hiring practices, provide better and continuous training to their employees. Thus, it will provide right people into right place with the right skills. Consequence, it manages to reduce waste, bring higher financial benefits and better organizational culture.

This is proved through Singh et al. (2010) research where it is found that implementing one of the Lean tools, value stream mapping (VSM) manage to reduce 83.14 percent of lead time, 12.62 percent of processing time, 89.47 percent of work-in-process inventory and around 30 percent of manpower requirement. As a result, there is 42.86 percent increase in productivity per operator. Beside this, a case study of lean implementation at a small manufacturer in the United States proved that the manufacturer manage to eliminate rework time, improve productivity, increase system flexibility and consequently reduce inventory levels between work stations after implementation of Lean (Chen et al., 2010). Recently, Agus and Shukri Hajinoor (2012) also found that there is a strong connection between lean production, product quality performance, and business performance to Malaysian manufacturing companies.

2.3 OVERVIEW OF SIX SIGMA (SS)

Beside Lean, there is another powerful quality methodology apply in worldwide organization which is called Six Sigma (SS). SS method was first introduced in 1987 by Motorola engineering scientist William Smith when they were facing the threat of Japanese competition in the electronics industry, and its purpose was to enhance company's performance by decreasing process output variation (Gijo and Scaria, 2010). As a result, Motorola Corporation successfully increased their net income from $2.3 billion in 1978 to $8.3 billion in year 1988 within 10 year time (Taghizadegan, 2010). In the same year, The Malcom Baldrige National Quality Award is presented to Motorola by President Reagan. Although not all the companies which implement SS are successful, there are still many companies have gained substantial benefits from SS implementation (Coronado and Antony, 2002).

SS has two meanings in Total Quality Management (TQM). In statistical terms, SS is a program with a goal of reducing output variation so that no more than 3.4 defect parts per million opportunities (Aboelmaged, 2010). It requires a process to produce 99.99966% of the products or service units to be defect free with an extremely high capability. For example, if 1 million passengers pass through the St. Louis Airport with checked baggage each month, a Six Sigma program for baggage handling will result only 3.4 passengers with misplaced luggage(Heizer and Render 2011).

The second TQM definition of Six Sigma is an approach developed to reduce defects in order to help lower costs, save time, and improve customer satisfaction(Heizer and Render, 2011). This approach focuses on tackling the variation in production processes, determining and reducing the defects or variations to improve quality and performance of business processes (Mortimer, 2006). This approach adopt sophisticated process analysis, data collection, quality management and control and statistical techniques in an integrated framework (Soti et al., 2010). The SS approach pushes a process to produce 99.99966% of the goods or service units to be defect free. It means that there can only be 3.4 defected units per million.

According to Harry and Lawson (1992), Motorola started a four-phase process during early in its development for improving the quality of its products, which include ‘‘Definition,’’ ‘‘Analysis,’’ ‘‘Optimization,’’ and “Control’’. As times goes by, this four-phase process are developed into five-phase process. There are two additional major processes were developed which form the “Define, Measure, Analysis, Improve, and Control’’ (DMAIC) framework (Harry and Schroeder, 2006) as shows in Table 2.1. This DMAIC framework is usually implemented in a conditions where there are existing products or processes that do not meeting customer specification or is not performing adequately.

Table 2.1: DMAIC methodology

Phase	**Key processes**	**Tools**
D– Define	Define the project’s purpose, scope, and outputs and then identifies the required process information, keeping in mind the customer’s definition quality.	Pareto analysis; Project charter
M– Measure	Measure the process to determine current performance and collects data.	Descriptive statistics; Process capability analysis
A– Analyse	Analyse the data, ensuring repeatability, and reproducibility.	Detailed process map; Fish-bone diagram
I– Improve	Improve by modifying or designing, existing processes and procedures.	Experimentation; New process
C– Control	Control the improved process to make sure performance levels are maintained.	Statistical process control

Source: Modified from Kumar and Sosnoski (2009), and Heizer and Render (2011)

However, there is another roadmap which is “ Define, Measure, Analysis, Design and Verify” (DMADV). DMADV methodology which is also called Design for Six Sigma (DFSS) only will be used when new product need to be developed or the existing product or process that has been optimized but still does not meet the level of customer specification or SS level (Joshi, 2012).

Meanwhile, SS approach runs on two assumptions where the outcome of the entire process will be improved. Those assumptions are figures and numbers can represent features and characteristics of a process where those data can be used to produce improvement and provide new and different perspectives and the overall performance where it will be improved through the reduction of variation of entire the processes (Nave, 2002).

Näslund (2008) also argued SS implementation involved eight characteristics, which are

1. an understanding of project expectations from the shop floor;
2. leadership of top management;
3. disciplined application of DMAIC;
4. fast application of the project (3–6 months);
5. clear definition of results to be reached;
6. supplying of infrastructure to implement improvements;
7. focus on the consumer and the process;
8. focus on the statistical approach to improvement.

Ericsson in Borås, Sweden managed save the total cost of approximately 200-300 million euro between 1997 and 2003 with implementation of 50 Black Belt projects and 200 Yellow Belt projects of SS between 1997and 2004 (Mousa, 2013). Recently, a survey which conducted among Indian software companies proved that the application of SS not only enable them to produce better quality software, but also able improve product performance, achieve greater productivity, reduce costs and increase customer satisfaction (Mahanti and Antony, 2009).

2.4 CRITICISM ON LEAN AND SIX SIGMA (SS)

Despite the several success stories associated with the lean approach and Six Sigma approach, they have their own weaknesses. First, lack of flexibility of lean concept decrease the ability of the organization to react to the new conditions and circumstances which may cause the lean organization to become very susceptible to the impact of changes (Dove, 1999). This is due to Lean concept is focus on perfection, there is no space for flexibility, thus, Lean cannot apply in a highly dynamic conditions as it requires a stable platform where scale efficiency can be maximised (Andersson, et al 2006; Mousa, 2013). Second is failure in application of JIT deliveries well may cause congestion in the supply chain, thus lead to delays, pollution, shortage of workers, etc. (Cusumano, 1994; Mousa, 2013). Thus, Pepper and Spedding (2010) suggested integrating Lean with the use of targeted data to make decisions and adopt a more scientific approach to quality within the system.

On the other hand, Six Sigma is also facing different kind of criticism. According to Magnusson et al. (2003), it is complicated to reach the customer's needs and hence increase the customer satisfaction by applying six sigma method. Thus, some companies use voice of the customer tools in their define phase to avoid this problem. Beside this, Andersson et al. (2006) found that only project with given a certain amount of saving is only allowed to start in Six Sigma training project. Moreover, this project usually only involve in the department of the project members which leads to an improvement in the department but also may cause another department to experience deterioration due to change. As a result, SS is sometimes accused for not having a system view.

Nowadays, due to high competition in the market more demanding consumers and a relatively unstable economic climate in many countries which leads to constant change in the external environment, running operation with Lean approach or Six Sigma approach is no more enough to survive in such competitive environment even though Lean approach and Six Sigma approach still brings improvement to the company. People tend to find a greater reliability and better improvement approach.

2.5 OVERVIEW OF LEAN SIX SIGMA (LSS)

Therefore, there is evolving of a new principle in improvement methods - Lean Six Sigma (LSS), starting in the 2000s, when consultants trained in both techniques realized the synergy between Lean and Six Sigma (Byrne et.al, 2007; Salah et.al, 2010). LSS is defined as the combination of two most powerful improvement methodologies, Lean (focused on removing waste) and Six Sigma (focused on improving quality) (Antony et al., 2003). The goal is to boost quality and reduce costs through elimination of waste and variation reduction in the processes (Kamensky, 2008). Since, organizations around the world are reaping the benefits of competitive advantages and reduced costs, more and more companies are promoting Lean Six Sigma in their processes. The Figure 2.2 shows how LSS followed two completely different paths and converged to become what is now the most accepted methodology namely Lean Six Sigma.

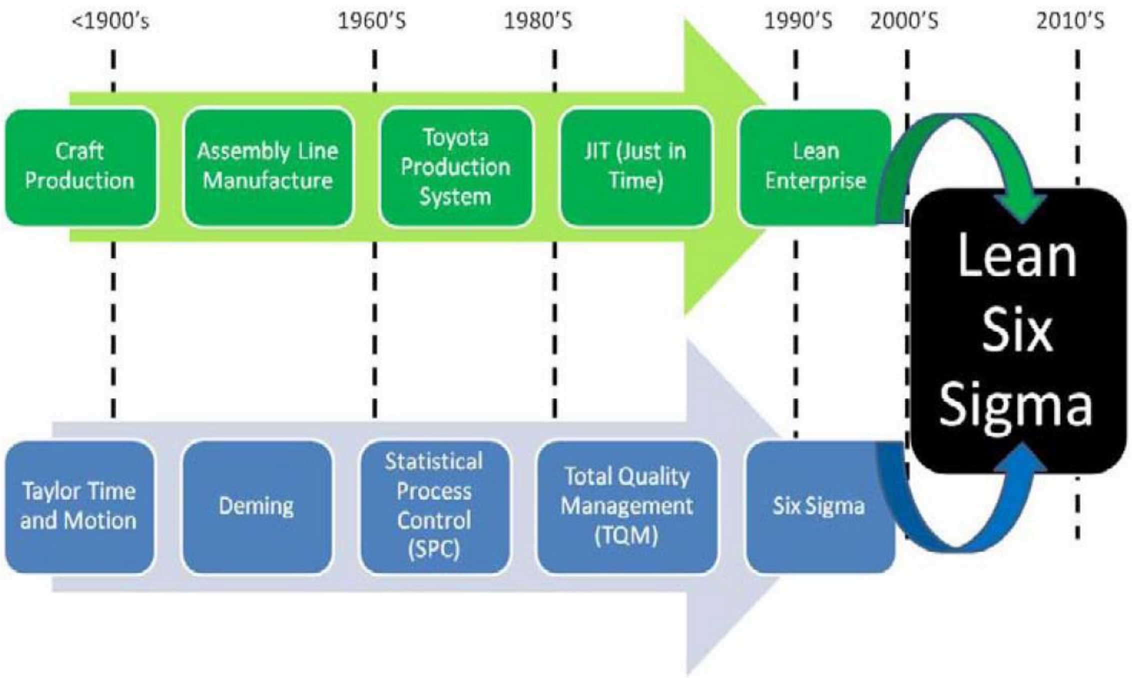

Figure 2.2: Evolutions of Lean Six Sigma

Source: Marsh et al. (2011)

As shown in the Figure 2.1, both approaches, Six Sigma and Lean existed in parallel and had separate developments for many years. Six Sigma developments was driven by the need for quality improvement in manufacturing complex products since there was a high probability of defective final products, while the elimination of waste was the main motive for LM development (Arnheiter and Maleyeff, 2005).

The main principles of Lean is optimize the value-adding components of all processes, constant evaluation of the incentive systems in order global optimization to be assured, and optimization of decision-making process to be based on a customer's impact, whereas Six Sigma is stressed on scientific decision making using data-driven methodology that strives to minimize variations of quality characteristics and company-wide introduction of a structured training and education regime. Therefore, company that would like to apply LSS, should implement the main principles from both Lean and Six Sigma in order to capitalize the strengths of both methods (Arnheiter and Maleyeff , 2005)

2.5.1 Integration of Lean and Six Sigma (SS)

Lean and Six Sigma (SS) are total different quality approach. How can both of them integrated together and evolve as a new improvement approach – Lean Six Sigma? In order to understand the integration of Lean and SS, it is crucial to know the main differences between Lean and SS. Table 2.2 shows the comparison between Lean and SS regarding various characteristics.

Table 2.2: The differences between Lean and SS regarding various characteristics

Characteristic	Six Sigma	Lean
Origin	Evolution in Motorola	Evolution in Toyota
Objectives	Product and process improvement; minimisation of variation	Provide high value to the customer by reducing waste
Principles	• Keep the number of defects below 3.4 per million opportunities.	• Use the best practices and processes to improve efficiency • Reduce costs • Speed up the process.
View of waste	Variation	Non-value adding activities
Focus	• Customer • stakeholder value • process variation • statistical decision making	• Efficiency • Flow • JIT • Standardization, • Cost and waste reduction
Methodology	1. Define 2. Measure 3. Analyse 4. Improve 5. Control	1. Identify value 2. Optimize value stream 3. Convert flow smoothly 4. Active demand pull 5. Perfection of process
Primary effect	• Uniform process output	• Reduce flow time
Secondary effect	• Less variation • Fluctuation - performance measure for managers.	• Less waste • Fast throughput • Flow – performance measure for managers.
Tools and Techniques	• Regression • Statistical process control charts (histograms, normal distribution graphs, flowcharts, etc.) • Design of experiments • Analysis of means & variance • Measurement analysis • Capability analysis • Robust design	• TPM • Kaizen • Visual Workplace • Work cell design • Single piece flow • Layout planning • Pokayoke • Kanban • 5 S • Value stream mapping
KPI	• Number of defects, customer satisfaction	• Value provided to the customer

Source*:* Modified from Bhuiyan and Baghel (2005); Mousa (2013)

As seen in Table 2.2, there are many differences between these two methodologies. However, there have been attempts to combine the two methodologies under titles such as “Lean Six Sigma”. Let’s see how Lean Six Sigma integrated.

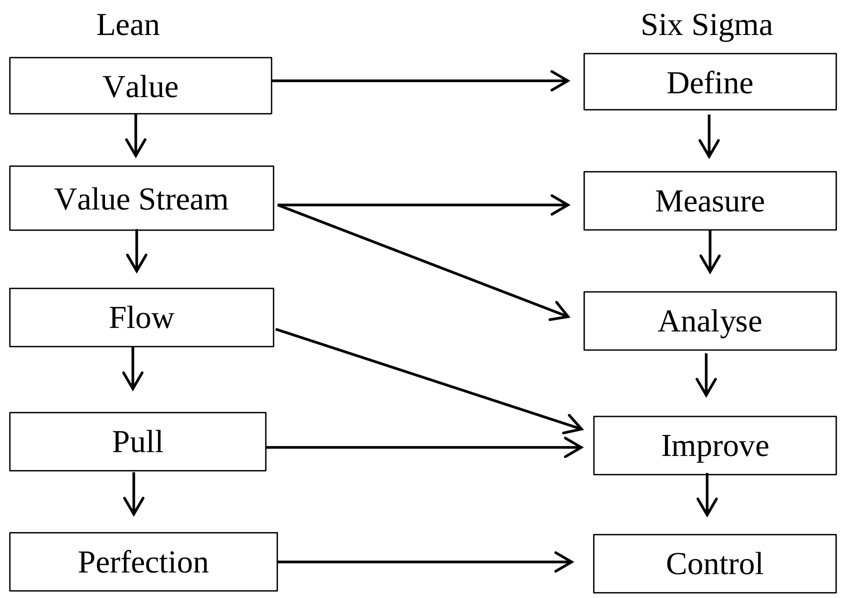

Figure 2.3: The integration of Lean and Six Sigma.

Source: Salah et al. (2010)

The Figure 2.3 shows the integration of Lean and Six Sigma. In order to integrate these two methodologies together, Six Sigma DMAIC methodology usually is used as its core structure while Lean being established improvement on it by fitting itself into each phase of the DMAIC methodology. This is due to the DMAIC method is robust and flexible enough to subject the proper lean tools in at a certain phase based on problems that need to solve. Through the combination of LSS methodologies, both approach key element are incorporated together, the principles and tools are applied in each phase. Thus, this integration of the two methodologies strengthens the process analysis stages in higher level. Salah et al. (2010) also proposed a model of LSS approach which is DMAIC methodology as shown in Table 2.3.

Table 2.3: DMAIC methodology of LSS

Phase	Key Processes and Tools

Define	• Introduce: Lean; Value Stream Mapping (VSM); and LSS methodologies and tools
	• Draft the project; develop the charter, time-line plan, change management plan, financial case (Cost of Poor Quality and waste) and scope (the charter gets updated as the project progresses).
	• Understand the customer requirements or the Voice of Customer (VOC):
	  o Use the suppliers, inputs, process, outputs, customers (SIPOC) diagram to document the high-level process and the critical to quality (CTQ) characteristics; it also helps in preparing for the VSM exercise by understanding the basic flow and who the suppliers and customers are.
	  o Use the quality function deployment Introduce process baseline performance including VSM metrics; inventory; lead time; cycle time; value-added versus non-value-added activities; and downtime.
	• Identify the LSS suitable tools and approach to the selected project: determine if the focus is on product flow or variability.

Measure	• Measure the baseline performance of the current process.
	  o Build the measure phase data collection plan (especially for baseline data).
	  o Understand the data and present it graphically using: control charts, run charts, bar charts, pie charts, histograms, box plots, scatter diagrams and Pareto charts, which can also be used in other phases.
	  o Use descriptive statistics to measure the central location and variability of data.
	• Measure process capability (use process capability indices, defects per million opportunities (DPMO) and process sigma level).
	• Map the current state value stream.
	• Identify waste and quantify it financially.
	• Use a Kaizen event approach and identify any quick improvement actions.

Table 2.3: Continued

Phase	Key Processes and Tools
Analyse	• Implement the quick hits as they do not require further analysis • Build a data collection plan to analyse which of the potential inputs is critical. • Use graphical tools to investigate the reasons for variation and differences in processes by different factors (e.g. use interval effects plots, multi-vari cause charts, box plots and other tools). • Develop hypotheses on the sources of variation and strength of relationships (using hypothesis tests, confidence intervals and other statistical tools). • Use correlation, regression and analysis of variance to study how inputs relate to and impact outputs. • Identify a list of the few critical inputs or key process input variables (KPIVs) to pass to the next phase for improvements. • Analyse the current state VSM. For example: analyse unnecessary steps and ways to minimize waste within and between steps; analyse flow of products and information; analyse lead time, cycle times and rework; and analyse downtime and changeover time • Design a lean future state VSM to execute in the next phase
Improve	• Optimize and standardize the process; eliminate unnecessary steps or at least minimize waste within it; design standard operating procedures and best practices; build an improvement implementation action plan • Use a Kaizen event to implement improvements. For example: improve time and motion; improve cell design, consider human factors and work balance; implement single piece flow (reduce batching) and standardize processes. • Tools: Kanban; 5S method; Total Production Maintenance (TPM) and quick changeover approach; mistake-proofing techniques; visual workplace approach; benchmarking, regression analysis, process simulation, design of experiment (DOE) and other graphical tools such as box plots and control charts

Table 2.3: Continued

Phase	Key Processes and Tools
Control	• Validate and update the failure mode effects analysis (FMEA), Measurement System Analysis (MSA), process capability, sigma level and control charts. • Develop a control plan using mistake-proofing method; design and implement corrective actions; design an audit plan; and design visual work place controls. • Reconfirm the financial analysis by conducting a cost-benefit analysis, review and approve the analysis by finance. • Train process owner on using the control plan and monitor constantly

Source: Salah et al. (2010)

After integrated, Lean Six Sigma uses tools from both toolboxes which results better product and process improvement, minimisation of variation, and in the same time, provide high value to the customer by reducing waste. Beside this, while Lean emphasizes on efficiency, flow, JIT, standardization, cost and waste reduction, Six Sigma can be more effective at handle process variation and statistical decision making.

Therefore, integration of LSS leads to greater quality improvement results. Salah et al. (2010) suggested that all projects should follow DMAIC and use the proper LSS tools in accordance with the issues and condition faced. Different level of LSS experts and companies will have different choices on the selection of lean tools in each phase of DMAIC, technique and even practice. LSS experts can be trained at various levels. The most common level of LSS knowledge levels are Yellow Belt (YB), Green Belt (GB) and Black Belt (BB).

According to Pyzdek (undated), BB and GB experts have a thorough understanding of all aspects in DMAIC phases, whereas YB experts have an understanding of the aspects within three phases, which are “Define”, “Measure” and “Analyse” phase. However, BB experts are responsible in leading LSS projects on full-time basis while YB experts are responsible to support LSS training team while implementing the LSS projects (Karthi et al., 2011). The proper selection and decision on the implementation strategies which match to organisation culture, problem and circumstances faced is critical to success.

According to Arnheiter and Maleyeff (2005), if a company wishes to implement LSS successfully to achieve the world class performance criteria, the company should follow the following rule when designing and processing a LSS project:

- Maximising the value-added content in all operations and processes should be focused;
- Decision-making process that bases every decision on its impact on the customers should be implemented;
- All the incentive systems should be evaluated constantly to ensure that they result in global optimisation;
- Data-driven methodologies should be utilised to ensure that all the changes are made based on scientific studies rather than making ad hoc decisions.
- Six Sigma methodologies should be utilised to improve the variable and minimise variations in quality characteristics.
- Companywide and highly structured education and training programs should be implemented

2.5.2 Benefits of Lean Six Sigma (LSS)

Lean Six Sigma (LSS) brings additional value to process improvement, as it integrates Six Sigma focus on elimination of defects and reduction of variation with Lean Manufacturing focus on waste and cycle time elimination (Kumar et al., 2006). Beside the case study by Vinodh et al. (2011) on an automotive valve manufacturing organization that mentioned in Chapter 1, there is another case study in a small engineering company which located in the United Kingdom prove the benefits of the integrated implementation of LSS on the production line where the pilot was implemented. There was a 55% reduction in scrap costs, an increase in overall equipment effectiveness (OEE) from 34 to 55%, a 34% increase in the time available for production and a 12% reduction in energy consumption per year (Thomas et al., 2009).

Although LSS originated from manufacturing environment, it also effectively implemented in other areas such as construction area and service sector. JV Industrial Companies (JVIC), Ltd., which is an industry-leading turnaround, construction, and fabrication services organization headquartered near Houston, Texas managed to reduce weld repair rate decreased by more than 25% and therefore cause a savings of $90,000 for this company through application of Lean Six Sigma methodology (Anderson and Kovach, 2014). On the other hand, it been used in shorten the customer fulfilment lead times for company. Su et al. (2006) carried out a case study on a help-desk service company in the area of information technology. As the main results, the authors found that with the implementation of LSS the company reduced the service time by nearly 52%.

Besides that, LSS can reduce the turnover and thus lower costs of production. This can be prove through the case study which been conducted by Laureani et al. (2010) in a call centre. They found that the service company able to reduce call time, decrease operator turnover and streamline the process with the implementation of LSS. Thus, the annual turnover of the service company fell from 35 to 25% and result a reduction of US$ 1.3 million per year in the costs for hiring process, training and dismissal, among others. Kumar et al. (2006) also found that the implementation of LSS is resulted in a significant decrease in the number of defects occurred in the final product and an overall savings of around $140 000 per year in a die casting manufacturer.

In addition, Lean Six Sigma is also led to innovation. According to Byrne et al.'s (2007) report, at first, Caterpillar Inc. facing stagnant revenue growth and thus the company decided to implement Lean Six Sigma to gain competitive advantage by breakthrough improvements in January 2001. Implementation of Lean Six Sigma led to product innovation which grows the revenue of the company by 80 percent in year 2005.

2.5.3 Challenges to Practice Lean Six Sigma

However, the principles of LSS as a method to process improvement has yet to fully mature into a specific area of academic research (Bendell, 2006). This has been supported by a statement of Smith (2003) where practically the majority of efforts to fully and comprehensively implement LSS initiative to its full potential have not been realised. There are numerous barriers and challenges of LSS implementation that lead to decelerate and complexity in implementing LSS initiative. According to Cusumano (1994), lack of commitment from management could lead to the failure to sustain a change towards continuous improvement. Thus, one needs to be careful when implementing LSS concepts.

Beside this, the challenges of implementing LSS may include convincing top management, encounter resistance from employees and resistance from management as mentioned by Kumar et al. (2006). Meanwhile, O'Rourke (2005) has identified some barriers and challenges of LSS implementation which are resistance to change, budget and time constraints, unique implementation by internal organizations, Black Belt candidate selection process, lack of cohesive business strategy, fractured organizational culture and picking the “right” projects.

Recently, there also has been effort to study on barriers and challenges of LSS implementation. In the study of Mallick et al. (2012), there are a few barriers that have been identified for the implementation of LSS in the Indian manufacturing sectors such as new employees are reluctant, little steps initiate to eliminate waste, quality leaders implements less tools of LSS, employee follow mind numbing rules, few employees implement quality tools, quality of product still lag to world class, and suppliers not involved in organization SPC.

2.6 OPERATIONAL PERFORMANCE

Performance measurement is one of the significance factors to decide effectiveness of management, whether an operation meets performance objectives, and customer needs. Without having a measurement of the performance, top managements are very difficult to fix any problems in it or improve the performance of the organization. Therefore, Jones et al. (2013), defined organizational performance as a measure of how efficiently and effectively managers use available resources to reach or excess customer satisfaction and reach company objectives. That's means it increases in direct proportion to increases in efficiency and effectiveness

According to Munizu (2013), organizational performance can be three specific areas of firm outcomes, which are operational performance or quality performance and organizational performance. However, in relation to the subject of the study in this research, the researcher is only interested to measure the impact of Lean Six Sigma (LSS) towards the operational performance. Thus, this research will begin from identification some variables that influence of performance and measure it accurately in order to improve the operational performance.

As mentioned in operational definition, operational performance is a measurable aspect to the performance of internal operation of the organization which including cost and waste reduction, improving the quality of products, improving flexibility, improving delivery performance; and productivity improvement (Munizu, 2013; Salaheldin, 2009). Operational performance conversely affects organization performance measures such as market share and customer satisfaction. Measurements of operational performance become extremely critical and an essential for many organizations because without them, organizations would have no way of knowing where they stand and the ability to satisfy corporate goals and targets will be difficult.

There are many variables that can that influence of performance; however, this research will only focus to the five main operational performance variables which are Cost and Waste Reduction (OPC), Quality (OPQ), Flexibility (OPF), Delivery (OPD), and Productivity (OPP). Table 2.4 shows the main variables and definitions of those variables.

Table 2.4: Variables related to operational performance.

Operational performance (OP) variables	Measures/definition	Sources
Cost and Waste Reduction (OPC)	Total production cost, scrap/rework cost, warranty cost, average of quality costs, inventory turnover	Christiansen et al., (2003); Jabbour et al., (2013)
Quality (OPQ)	Finished product first time yield (FTY), in plant defect fall out rate and customer reject rate.	Christiansen et al., (2003); Jabbour et al., (2013)
Flexibility (OPF)	Quick changes in product design, quick introduction of new products, quick changes in production volume, broad variety of products, or quick changes in product mix.	Jabbour et al., (2013)
Delivery (OPD)	Quick delivery (short lead time) which include lead time in purchasing, manufacturing and to customer, and also increase reliability in timely deliveries.	Christiansen et al., (2003); Madapusi and D'Souza, (2012); Jabbour et al., (2013)
Productivity (OPP)	Increase labour productivity and machine productivity.	Stevenson, (2011).

2.6.1 Cost and Waste Reduction (OPC)

Cost is a general variable to measures the amount of resources used to produce the goods and service. However, waste is closely related with cost as waste like scrap and rework can increase the cost of operation and production. Good performance in reducing or eliminating waste can result in impressive savings on costs and increasing the profit of the organization. That’s means every Ringgit reduced from the operational cost is a Ringgit added to the organization profits. Thus, all producers always try to keep their costs low even those whose primary source of competitiveness is different from product selling price, (Slack and Lewis, 2011). In order to measure the impact of Lean Six Sigma (LSS) toward operational performance, the indicators of cost and waste reduction variable will focus on total production cost, scrap/rework cost, warranty cost, average of quality costs and inventory turnover.

2.6.2 Quality (OPQ)

According to American National Standards Institute (ANSI) and the American Society for Quality Control (ASQC) in 1978, quality is defined as "the totality of features and characteristics of a product or service that bears on its ability to satisfy given needs." It indicates all the organizations must be able to determine the aspect and characteristics of goods and services that determine customer satisfaction and form the base for measurement and control.

Quality is aim for reaching zero-defect manufacturing or manufacturing of durable products but it is expensive. However, it can lead to a lower cost through producing quality products which without defect. If workers can produce defect free goods, the organization not only eliminate defect-free goods inspection but also create customer loyalty. In order to measure the impact of Lean Six Sigma (LSS) toward operational performance, the indicators of quality variable will focus on the finished product first pass yield, in plant defect fall out rate and customer reject rate.

2.6.3 Flexibility (OPF)

Flexibility may be defined as the capability of a production system to respond cost effectively and rapidly to changing production needs and requirements with little penalty in time. Since production systems do operate in highly variable and unpredictable environments, flexibility is becoming increasingly important for the design and operation of production systems. According to Awwad, S. A. (2007), there are nine dimensions of flexibility which are product flexibility, volume flexibility, mix flexibility, machine flexibility, labour flexibility, market flexibility, process flexibility, new product flexibility and expansion flexibility. However, in this research, we will only focus on product flexibility which leads to quick changes in product design, new product flexibility which leads to quick introduction of new products, volume flexibility which leads to quick changes in production volume, expansion flexibility which leads to broad variety of products, and mix flexibility which leads to quick changes in product mix as the indicators of flexibility variable.

2.6.4 Delivery (OPD)

Delivery is a critical element for operational performance. Failures of delivery on time will not only cost the organization but also brings negatively impact to the organization reputation and loss of customer loyalty. According to Ward et al. (1996), there are two main dimensions of delivery performance, which are delivery reliability and delivery speed. Delivery reliability is on-time delivery which relate to the ability of delivering according to a promised schedule or plan, while delivery speed is related with the length of the delivery cycle include lead time in purchasing, manufacturing and to customer. In order to satisfy customers, quick delivery will be done, that’s means shorter the lead time of delivery. Therefore, this research will focus on these two main dimensions for delivery performance.

2.6.5 Productivity (OPP)

Productivity is an average measure of the ability to produce a good or service. It is critical for the long-term competitiveness and profitability of organizations. It is the relationship between the quantity of output and the quantity of input, where basically used to measure the effectiveness and efficiency of company in generating output with the resources available used to generate that output. Labour productivity and machine productivity are two of the common productivity indicators.

Labour productivity is usually defined as units of output per labour hour, units of output per shift and value-added per labour hour where it reflects the effectiveness and efficiency of labour in the production (Stevenson, 2011). On the other hand, machine productivity is defined as units of output per machine hour and value-added per machine hour where it measures the effectiveness and efficiency of machine in the generation of output (Stevenson, 2011). The effectiveness and efficiency of machine also can be through overall equipment effectiveness (OEE) and machine changeover time (C/O).

2.7 Summary

Through a review of the available literature on Lean, Six Sigma and Lean Six Sigma, it was shown that although there are many differences between Lean and Six Sigma, the integration of the two methodologies is concluded to be possible and beneficial. A description of the Lean Six Sigma (LSS) model following the “Define, Measure, Analysis, Improve, and Control” (DMAIC) structure was presented in the literature review proved the successful of integration of Lean and Six Sigma. As mentioned by Näslund (2008), LSS is the likely to be the next popular methodology for continuous improvement

However, as the same case as Six Sigma, there is another roadmap which is “Define, Measure, Analysis, Design and Verify” (DMADV) for LSS too. The DMAIC phase is usually used when there are existing products or processes that do not meeting customer specification or is not performing adequately while DMADV methodology only will be used when new product need to be developed or the existing product or process that has been optimized but still does not reach the level of customer specification. However, due to this research only focuses on DMAIC methodology, thus, DMADV methodology didn’t mention in this literature review.

As mentioned previously, LSS consists of a lot of practices including techniques and tools. In order to successfully implement LSS, the company must do proper selection and decision on the implementation of LSS. Meanwhile, through a review of the available literature on Lean Six Sigma, there are still some uncovered areas of LSS for obstacle and challenges during implementation of LSS especially on automotive industry.

CHAPTER 3

RESEARCH METHODOLOGY

3.1 INTRODUCTION

This chapter begins with a description about the context in which this study was conducted. This research is conducted using mixed methods which are draw from qualitative and quantitative methods. In an attempt to understand that the reality and practice of Lean Six Sigma (LSS) in Malaysian automotive industry which is including the practice of LSS and the challenges face when implementing LSS, a qualitative methods - interview approach with the automotive company operation manager was conducted. Beside this, in order to achieve the objectives of examining the impacts LSS implementation on improving automotive company’s operational performance, structured questionnaire is used to acquire quantitative data for statistical testing on reliability, normality test, mean and standard deviation.

Methodology is one of important elements to ensure that this research will perform smoothly as planning. Flow charts in Figure 3.1 show the flow of work which is done in this research. It is also act as a guideline in developing this research in order to make sure the research reach the objectives formulated in chapter 1. Thus, all the work in this research is done step by step according the flowchart. Meanwhile, there is a Gantt chart that illustrates my research schedule is located at appendix A.

This section also involves the conceptual framework, hypothesis development, research design, population, sampling procedure, data collection technique, development of measures: design of questionnaire and statistical analysis.

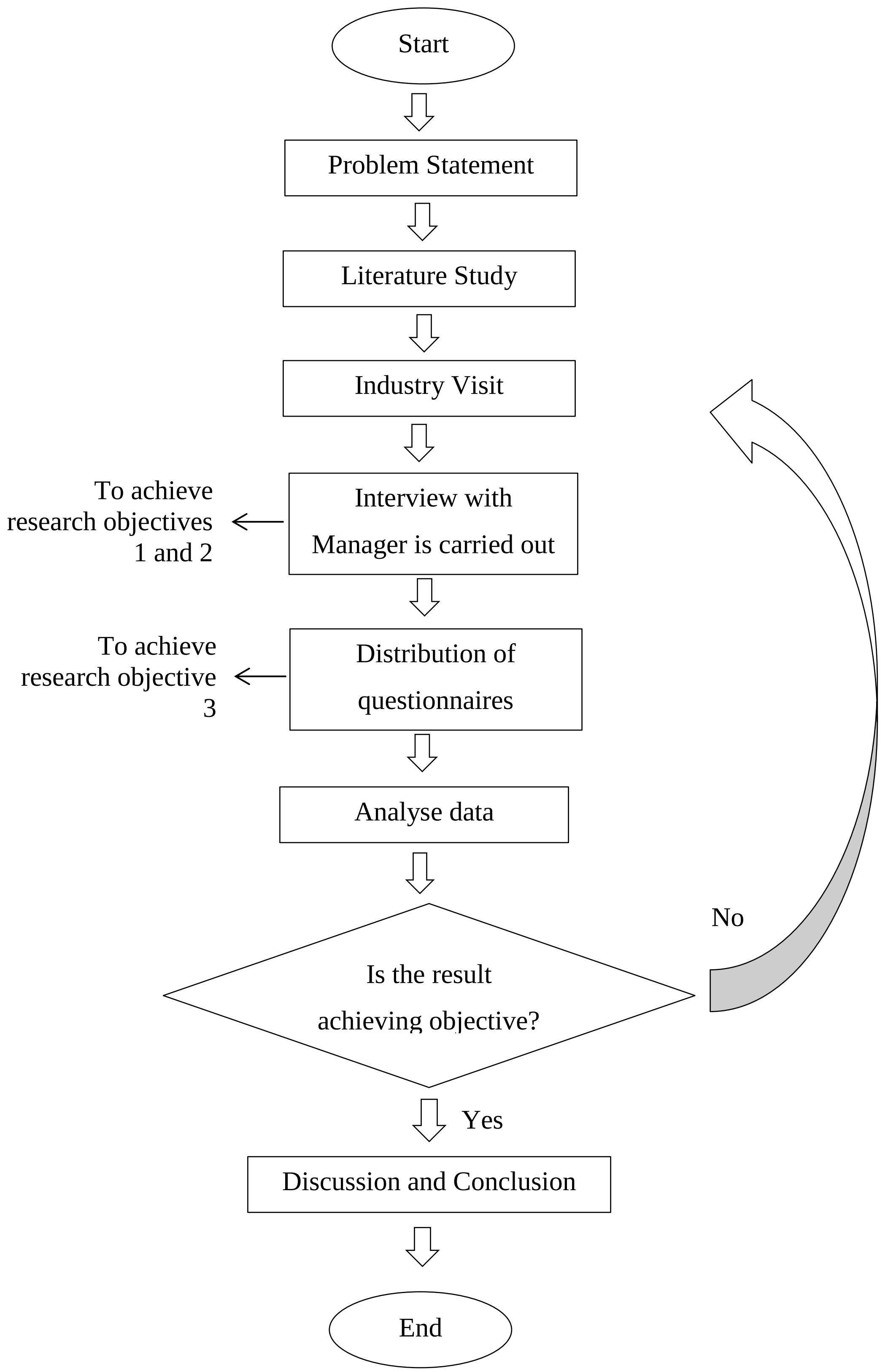

Figure 3.1: Flow Chart of Methodology

3.2 CONCEPTUAL FRAMEWORK

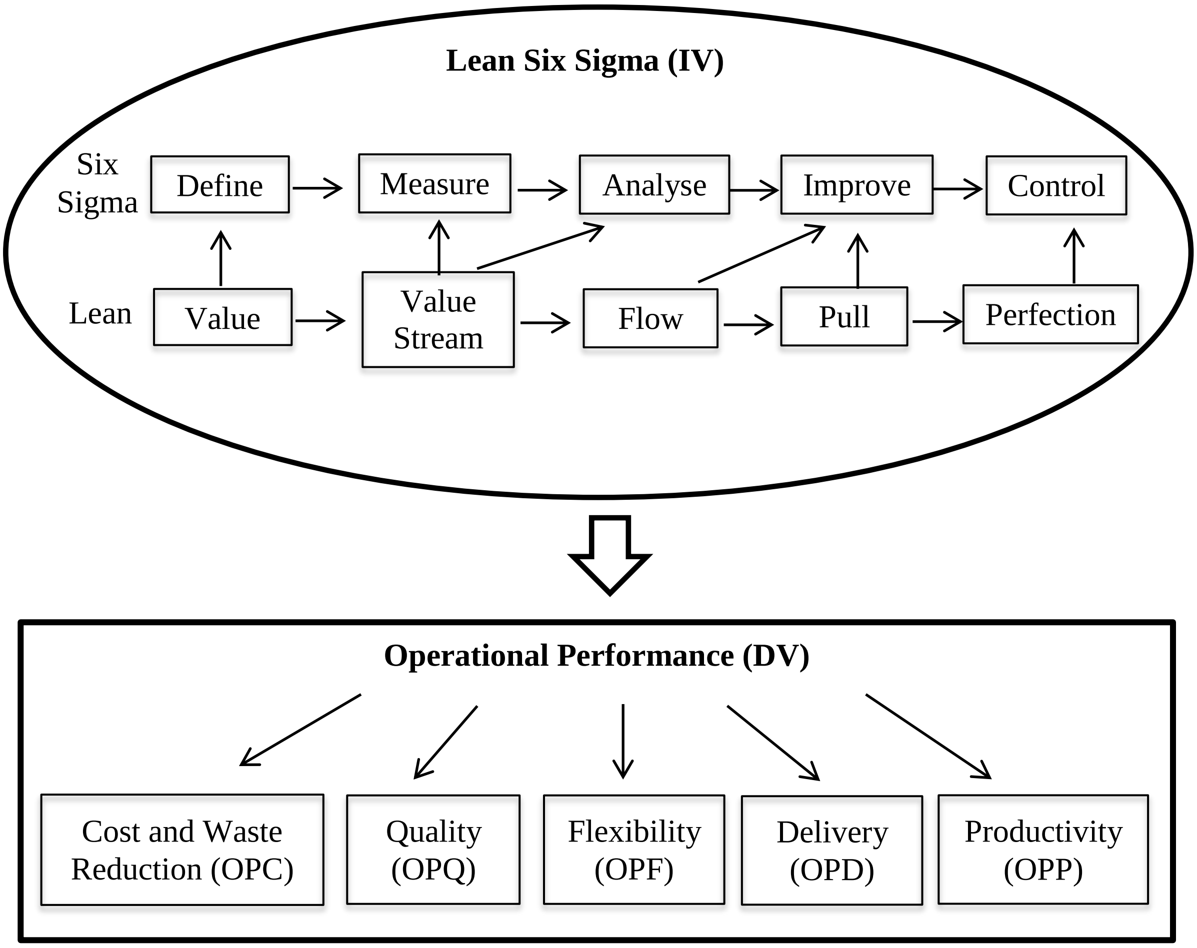

Figure 3.2: Conceptual Framework

In an effort to move the field forward, this research developed a conceptual framework to shows a theoretically anchored rationale for the relationship between LSS implementation and operational performance. Figure 3.2 shows the conceptual model of this research. The independent variables are Lean Six Sigma practices while dependent variables are operational performance. There are five phases of LSS implementation which are Define, Measure, Analysis, Improve, and Control. On the other hand, there are five operational performance (OP) variables including Cost and Waste Reduction (OPC), Quality (OPQ), Flexibility (OPF), Delivery (OPD), and Productivity (OPP).

3.3 CASE STUDY BRIEFING

This research is designed as a case study where Vacuumschmelze (Malaysia) Sdn Bhd is selected as the case company. The following sub-section is briefly discussing about the company background and the research design regarding to this case study.

3.3.1 Company Background

VACUUMSCHMELZE GmbH & Co. KG is an outstanding worldwide manufacturer of advanced magnetic materials and related products which established in 1923 in Hanau, Germany. Nowadays, this organization manufacture wide range of advanced semi-finished materials and parts, inductive components for the electronics, magnets and magnet assemblies which is wide used in watch-making and medical technology, renewable energies, shipbuilding, automotive and aviation industries.

In 1996, Vacuumschmelze (Malaysia) Sdn Bhd (VAC) was founded together with VAC USA. VAC in Malaysia is located at Tanah Putih, 26600 Pekan, Pahang Darul Makmur, Malaysia. This company is an automotive manufacturer which focuses on manufacturing products such as filter module, electronic micro assembly, inductors, magnet systems, permanent magnets, transformers, and etc. These products are mainly to export to overseas.

In order to ensure good quality product, quality standards such as ISO 9001:2000, ISO/TS 16949 and ISO 14001 are implemented in VAC. Lean Six Sigma also implemented in VAC since 2011. Beside this, it also take care the welfare of employees by setting their policy on providing a conducive, ergonomics and quality work environment to employees through implementing quality practice in work. Its motto is “conducive environment and work effectively”.

There is total of 11 departments in VAC as shows in Figure 3.3. Those departments are Account, Information Technology (IT), Operational Purchasing, Human Resource, Logistics, Manufacturing 1 Core, Manufacturing 2 Production, Quality, Safety, Environment (QSE), Technical Services, Process Technology and Supplier Quality Management department. General Manager of VAC in Malaysia is Mr. Mohd Arif bin Zakaria. There are around 700 employees currently working in this company.

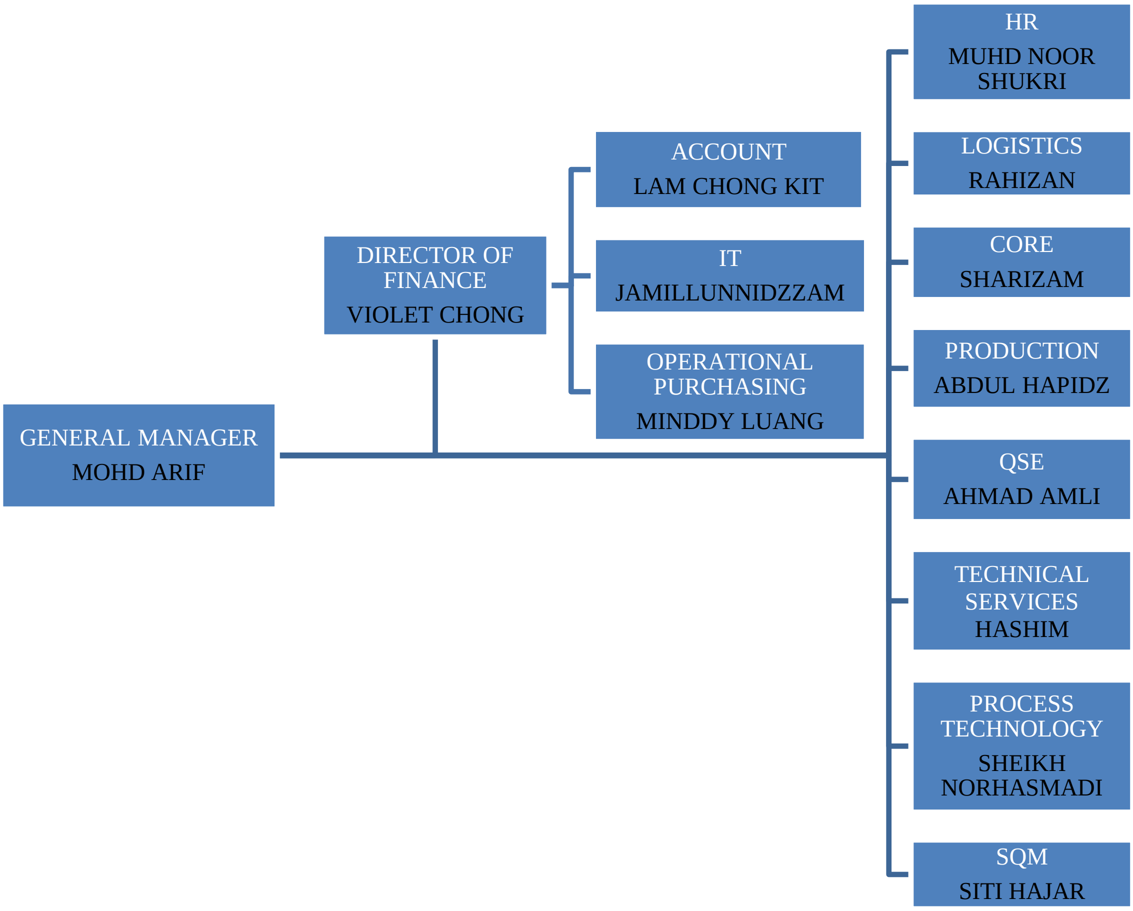

Figure 3.3: Organization Chart of Vacuumschmelze (Malaysia) Sdn Bhd

3.3.2 Research Design

Table 3.1 shows the overall details of research design in simplified form. This research is based on both qualitative and quantitative study. Qualitative study is used to investigate the research objective 1 and 2 while quantitative study is used to examine objective 3 as stated in Chapter 1.

Table 3.1: Research Design

Type of Study	Qualitative Research	Quantitative Research
Research Purpose	To investigate objective 1 and 2	To examine objective 3
Time Dimension	Cross-sectional	Cross-sectional
Data Collection Method	Individual Interviews (face-to-face interview)	Questionnaires (non-face-to-face distribution)
Sampling Method	Judgement sampling (Size = 5 to 10)	Random sampling (Size = 248)
Unit of Analysis	LSS experts of Automotive Company	Employees of Automotive Company
Data Analysis	Content Analysis	Statistical Package for Social Science Software (SPSS)

For qualitative study, the time dimension of first and second objectives researches is cross-sectional where data are collected at one point in time. Data collection method is face-to-face interview with 5 to 10 experts of Lean Six Sigma. The sampling method is used is judgement sampling. After collection of data, data is analysed by using content analysis.

For quantitative study, the time dimension of third objective research is also cross-sectional where data are collected at one point in time. Hardcopies of questionnaires is sent to HR executive for distribution to employees. VAC is having around 700 employees work there. According to the tabulation formula of Krejcie and Morgan (1970), this research needs to select 248 target respondents for sample size. The sampling method used is random sampling. Unit analysis is employees of automotive company. However, there is only 64 employees respond to this research's questionnaires. After collection of data, data is analysed by using Statistical Package for the Social Sciences (SPSS) software.

3.4 POPULATION AND SAMPLING METHOD

A population is a complete collection of measurements, outcomes, objects, or individuals under research. However, it is hard to collect all the information from all individuals of the population. Thus, sampling method usually used to produce a sample that is representative of the population under investigation and from which generalizations can be drawn. There are different types of sampling methods. The three basic of sampling methods for non-probability data are judgment sampling, voluntary sampling and convenience sampling, while the four basic of sampling methods for probability data are random sampling, system sampling, stratified sampling and cluster sampling.

In this research, random sampling is chosen for quantitative research where each data has an equal chance to be selected as sample by using random selection method. However, a sample is only a subset of population. In order to generalization to the whole population, an ideal sample size in a research should be large enough to serve as adequate representative of the population. Moreover, the larger the sample size, the smaller the magnitude of sampling errors would be. Thus, in 1970, Krejcie and Morgan have created a table for identifying required sample size given a finite population. Table shown in appendix B is applicable to any population of a defined (finite) size. Therefore, the targeted sample size for this quantitative research is 248 after referring to the tabulation formula of Krejcie and Morgan (1970).

Meanwhile, judgement sampling is used for qualitative research where data is selected based on opinion of experts. However, qualitative research is unlike quantitative research which can exact sample sizes needed for the study. According to Marshall et al. (2013), there is number of factors that can affect the number of interviews needed to achieve saturation. Those factors are the nature and scope of the study, quality of interviews, number of interviews per participant, sampling procedures, and researcher experience (Marshall et al., 2013). After considering those factors, the sample size of this qualitative research only focuses to five to ten people of LSS expert of the automotive company which are professionals of Lean Six Sigma to ease for analyse the data of the interview.

3.5 DATA COLLECTION TECHNIQUE

Data collection is a systematic approach of gathering information to address those critical evaluation questions that have been determined earlier in the evaluation process. There are various techniques available to gather information from a variety of sources such as observation, interviews, questionnaires, experimental study and etc. In this research, interviews approach is used as data collection technique for qualitative research, while questionnaires technique is used as data collection for quantitative research.

Interviews approach is selected as an instrument of data collection as to it is able to provide comprehensive and thorough information pertaining to respondents' experiences and opinion of the given topic especially for complicated objectives such as objective 1 and 2 which need opinion and experiences from experts. Face-to-face interview with those professionals of Lean Six Sigma is carried out since VAC location is near to UMP Gambang which only need one hour driving. However, telephone interview is made with those interviewees when there is lack of information from previous interviews in order to save the budget and times.

There are three common interview methods, which are informal conversational interview, general interview guide approach, and standardized open-ended interview (Gall et al., 2003). For this research, standardized open-ended interview is used in order to gain as much detailed information from those professionals. During those interviews, all the conversations between professionals are voice recorded, in order to avoid bias and provides a permanent record of interview information (Gerrish and Lacey, 2010).

Questionnaire approach is selected as an instrument of data collection as it is able to acquire a huge quantity of data with low cost compare to other data. Questionnaires were sent to HR executives and HR executives distribute those questionnaires to VAC employees to answer. Face-to-face distribution is not allowed to carry out due to there are some concerns on this method that will cause some disturbance to their routine job. Collection of questionnaires is done during the time of industry visit. The sampling method used is random sampling to ease the job of the person in charge.

Beside this, in the purpose of maximizing the response rate, the length of questionnaires is not too lengthy. The feedback from the respondents is the significant element to get the right data collection which is to identify whether the objectives of this research t are reached or not.

3.6 RESEARCH INSTRUMENT

There are two different research instruments in this research due to this research is using qualitative and quantitative study. Design of interview question is mainly for qualitative research which is use to investigate the practices of Lean Six Sigma that was implemented in Malaysian automotive company and to identify the challenges of implementing LSS in Malaysian automotive company. While design of questionnaires is mainly for quantitative research which is used to examine the impacts of Lean Six Sigma implementation on improving automotive company's operational performance.

3.6.1 Design of Interview Question

One of the most crucial components to interview design is developing effective interview questions for the interview process. In order to achieve that, McNamara (1999) recommends the wording of the designed questions should be open-ended where respondents should be able to choose their own terms when answering questions. In the same time, the researchers not only should avoid wording that might influence answers when design the question, they also should ensure those questions are worded clearly. During interview, the researchers should only ask those questions one by one and be careful asking "why" questions.

This session covers the questions mainly related to the practice of LSS that implemented in Malaysian automotive company and the challenges of implementing LSS in Malaysian automotive company. The interview guide is shown in Appendix C (English version) and D (Malay version).

3.6.2 Design of Questionnaires

The questionnaire consists of 2 sections: Section A and Section B. Section A asks general profile of the respondents. Section B is designed with questions regarding the operational performances. The design of questionnaire is shown in Appendix E and F with dual language versions.

Section A: Respondent Background

This section A is typically about the personal information of respondents, such as the name of company, name of respondent, gender, age, nationality, number of years working experience in the company, highest qualification of education level, current position and department they are working in. Nominal scale is used for categorical such as gender, nationality, religious, highest qualification of education level, current position and department they are working in. On the other hand, ratio scale is used to measures age and number of years working experience in the company.

Section B: Operational Performances Variables

While, section B is measuring the impacts of Lean Six Sigma (LSS) implementation on improving automotive company's operational performance. The measurement scales are adopted from previous research on operational performance. Meanwhile, 6-point Likert scale is used for measuring the responses. Likert (1932) established the concept of constructing attitudes by requesting respondents to respond to a set of statements about a topic, in terms of the level to which they agree with them, and so tapping into the cognitive and affective components of attitudes. Recently, Gonzalez (2008) also did apply this 6-point Likert in his research to identify the executive coaching effectiveness. Levels of agreement of 6-point Likert are shown as below:

1 – Very ineffective

2 - Ineffective

3 - Somewhat ineffective

4 - Somewhat effective

5 - Effective

6 - Very effective

3.7 DATA ANALYSIS TECHNIQUES

Due to this research is using both qualitative and quantitative approaches, two data analysis methods are also used in this research. Qualitative data is analysed using content analysis method while quantitative study is using Statistical Package for Social Science Software (SPSS) to do data analysis.

3.7.1 Non-statistical Techniques

After all the interviews with those professionals are conducted, all the conversations during the interviews that have been tape recorded are transcribed verbatim. To analyse this transcripts, content analysis is used for this research. In order to measure variables in qualitative research, it is one of widely used research methods to study and analyse communication in a systematic, objective, and quantitative manner. (Kerlinger, 1986).

Generally, there are two types of content analysis which are conceptual analysis and relational analysis. Conceptual analysis is used to identify concepts in a text through forming the presence and frequency of the concepts while relational analysis goes one step beyond the conceptual analysis where it is used to examine the relationships between the occurrences of the multiple concepts identified in the text. However, in this research, there is no involvement in examining the relationships between the occurrences of the multiple concepts; so, conceptual analysis is selected to analyse the data acquired from the interviews.

Before starting to examine the data from transcripts, those transcripts verbatim with transcribed are read through and organize those data. When there are some interesting or relevant information found, those information are highlight by making notes in the margins of words. In order to sum up what is being said in the text, short phases are made under each paragraph.

Then, the researcher discovers the themes in the organized transcripts by searching through the data. The same process is repeated to find out further themes. It is aimed to summarize the statement of each element in the transcript into manageable categories on theme where tables are developed according to the theme. It is called initial coding framework. For the five transcripts, all the previous steps are repeated each transcript one.

After all of the transcripts are initially coded, data are classified into tables according to the themes that discovered. The framework is read through again with all duplications crossed out. Once the shorter list of categories has been compiled, the researcher checks whether those information fits its relevance. Then, the researcher read through all categories and verifies whether these categories need to further refine by merging or sub-categorising. The original transcripts are reviewed backs to ensure that all the needed information have been categorised.

After all the data are categorized nicely, examination of data is started to draw out some key findings and conclusions. Key findings under each category are interpreted into meaningful wholes and appropriate verbatim quotes are also been used to illustrate those findings.

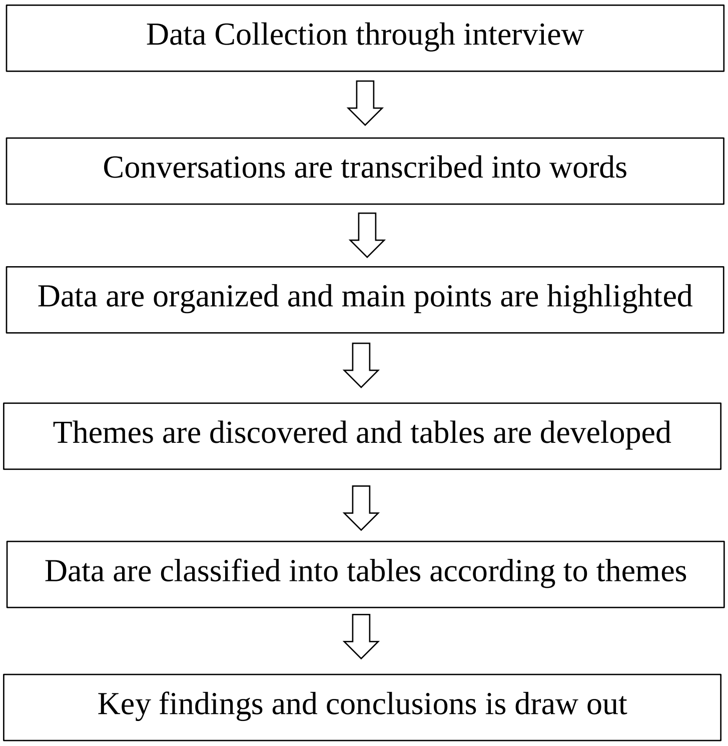

Figure 3.4: Flow Chart of Qualitative Analysis Process

3.7.2 Statistical Techniques

After collecting all the feedback from those workers, the Statistical Package for the Social Sciences (SPSS) software is used to analyse the quantitative data and provide descriptive analyses about the samples. SPSS is useful software which is widely applicable by researchers for statistical analysis in social science. First version of SPSS was developed by Norman H. Nie, C. Hadlai Hull and Dale H. Bent in 1968 and released in the early 1980’s. By using SPSS, researchers can carry out several analysis procedures such as Descriptive Analysis, Reliability test and Normality test.

Descriptive Analysis

Descriptive statistics is the discipline of quantitatively describing, presenting or summarizing data in graphical and numerical methods when performing empirical and analytical analysis. In other meaning, it is used to present quantitative descriptions in a manageable form. For example, the information of respondent profile regarding gender, age, educational level, and years of working experience can be summarized in the descriptive statistics such as frequency table, histogram, pie chart, and etc. Some commonly used graphical and numerical methods are measures of central tendency (mean, median and mode) and measures of variability or dispersion (range, means, standard deviations, variance, the minimum and maximum values of the variables, kurtosis and skewness).

Reliability Test

Reliability test is an analysis concerned with the ability of an instrument to measure consistently. The reliability of a measure demonstrate the extent to which it is without bias in order to ensures the instrument provides consistent measurement across time and across the various items (Sekaran, 2006). Cronbach's Alpha coefficient is the most common measure of reliability especially in the evaluation of assessments and questionnaires (Tavakol and Dennick, 2011).

Cronbach's Alpha coefficient is a measurement of internal consistency scale that show how closely related a set of items are as a group, which normally ranged from 0 to 1. The closer Cronbach's alpha coefficient is to 1.0, the greater the internal consistency of the items in the scale. According to Darren and Mallery (2010), they provide the following rules of thumb: "≥ 0.90 – Excellent, ≥ 0.80 – Good, ≥ 0.70 – Acceptable, ≥ 0.60 – Questionable, ≥ 0.50 – Poor and Unacceptable". That means, Cronbach's Alpha of 0.7 or higher is an acceptable and appropriate level of reliability. However, if the Cronbach's Alpha value is less than 0.5, it is unacceptable and the poor questionnaire item must be deleted to increase the reliability.

Normality Test

Normality test is used to identify whether a data set is distributed normal. There are many types of normality tests. However, the most popular normality tests are Kolmogorov-Smirnov (K-S) test, Lilliefors corrected K-S test, Shapiro-Wilk test, Anderson-Darling test, Cramer-von Mises test, D’Agostino skewness test, Anscombe-Glynn kurtosis test, D’Agostino-Pearson omnibus test , and the Jarque-Bera test (Öztuna et al., 2006). The two well-known normality tests are the Kolmogorov-Smirnov Test and the Shapiro-Wilk Test. The Kolmogorov-Smirnov is more appropriate for big sample sizes which is having more than 2000 samples while Shapiro-Wilk Test is more appropriate for small sample sizes which is having less than 50 samples (Ghasemi and Zahediasl, 2012). Due to the sample size of this research is more than 50 but less than 2000, Kolmogorov-Smirnov Test (> 2000 samples) and the Shapiro-Wilk Test (< 50 samples) is not suitable to be used in this research. Therefore, skewness (lack of symmetry) and kurtosis (pointiness) is selected to do normality test since this research’s actual sample size is only 64.

3.8 Summary

Research design is the framework that is created to seek evidences and answers to research questions as unambiguously as possible. Thus, in order to ensure this research achieve more desirable results and done successfully, the research design is formed carefully. This research is using mix method which is qualitative and quantitative study. Qualitative study is used to investigate the research objective 1 and 2 while quantitative study is used to examine objective 3 which stated in Chapter 1. Data collection method for qualitative study is face-to-face interview, while for quantitative study, hardcopies of questionnaires is sent to HR executive for distribution to employees. After collection of data, data from qualitative study is analysed by using content analysis. On the other hand, Statistical Package for the Social Sciences (SPSS) software is used to analyse the data for quantitative study.

CHAPTER 4

DATA ANALYSIS

4.1 INTRODUCTION

This chapter reveals the results and findings from data analysis to study the research objectives. The first part of the analysis is qualitative analysis, which presents data collected from interview method. Interviewees' profile and results from interviews are presented in table form accordingly. Whereas the second part of the analysis is quantitative analysis for the data collected by using questionnaires. Statistical Package for Social Science Software (SPSS) version 22 is used for quantitative analysis such as pilot test, demographic analysis, reliability test, normality test and etc. All the findings are presented accordingly in the forms of tables, graphs and pie charts.

4.2 QUALITATIVE ANALYSIS

In this research, interviews are conducted to investigate the practice of Lean Six Sigma (LSS) and to identify the challenges of implementing LSS in an automotive company. There are totally five interviewees were selected as this research's respondents. Those interviews are conducted one-to-one in Vacuumschmelze (Malaysia) Sdn Bhd (VAC) which located in Pekan. Those interviewees are experts in LSS. Details regarding interviewees, results of LSS's practice in VAC and result of challenges of implementing LSS in VAC are presented in the tables below.

4.2.1 Respondents Profile for Interview

Table 4.1: Interviewees profile

Details of Interviewee	IWA	IWB	IWC	IWD	IWE
Job Title	Senior Engineer in Production department	Assistance Manager of Core department	Engineer in SQM department	Supervisor in QSE department	Process Technician in Process Technology department
Job Scope	In charge of production engineering, Lean Six Sigma, Cost Savings, Measurement System Analysis (MSA)	In charge of production	In charge of Raw Material Inspections	Observe all the process of operation and production	In charge on reducing scrap rework
Years of interviewee involved in LSS Program	2 years since 2012	2 years since 2013	3 years since 2012	3 years since 2012	2 years since 2013
LSS Knowledge	Black Belt	Green Belt	Green Belt	Yellow Belt	Yellow Belt

These five interviewees are from different departments, various levels of organization, and different positions in the company. Interviewee A (IWA) is a senior engineer in Production department from Industrial Engineering division. He is in charge of production engineering, Lean Six Sigma, Cost Savings, Measurement System Analysis (MSA). Interviewee B (IWB) is an Assistance Manager of on Core department who is also in charge of production whereas, Interviewee C (IWC) is an Incoming Quality Control Engineer of Supplier Quality Management (SQM) department who is in charge of raw material inspections; and Interviewee D (IWD) is a supervisor at Quality, Safety, Environment (QSE) who in charge of observing all the processes of operation and production. Last but not least, Interviewee E (IWE) is a process technician who is in charge of reducing scraps rework.

There are two interviewees who are IWC and IWD involved in LSS program for 3 years while the other three interviewees who are IWA, IWB and IWE only involved in LSS program for 2 years. However, only IWA has LSS Black Belt knowledge, whereas IWB and IWC have LSS Green Belt knowledge. IWD and IWE have LSS Yellow Belt knowledge.

4.2.2 Result of Lean Six Sigma's Practice in VAC

Table 4.2: Result of Lean Six Sigma's Practice in VAC on DEFINE Phase

Key Processes and Tools	**IWA**	**IWB**	**IWC**	**IWD**	**IWE**
Draft the project.	✓	✓	✓	✓	✓
Develop the charter, time-line plan, change management plan, financial case (Cost of Poor Quality and waste) and scope.	✓	✓	✓	X	X
Use VOC to capture customer requirements	✓	✓	✓	✓	X
Use the SIPOC diagram to document the high-level process and the CTQ characteristics;	✓	✓	✓	✓	X
Use Fishbone diagram to brainstorm	✓	X	X	X	X

Based on Table 4.2, it shows there are only five key processes and tools of LSS implemented in VAC. Due to different job scope they work on and different levels of authority they have, there are different key processes and tools of LSS are used in each stage. In "Define" phase of LSS, all the interviewees will draft the project they work on before they start. However, in term of developing the charter, time-line plan, change management plan, scope of project and financial case which focus on Cost of Poor Quality and waste, there are only three interviewees who are IWA, IWB and IWC responsible to do it.

IWA, IWB, IWC and IWD are using Voice of Customer (VOC) to capture customer requirements in order to provide quality products to their customers. In the same time, they also use suppliers, inputs, process, outputs, customers (SIPOC) diagram to document the high-level process and the Critical to Quality (CTQ) characteristics. Beside this, IWA also apply brainstorm by using Fishbone (Cause & Effect) Diagram which focuses on man, machine, material, method, measurement to find out the main cause of problems which rise in previous batch of products. When the main cause of problems found, it is easier for him to tackle the problems.

Based on the results, it shows only IWA from Production department apply all practices of LSS (100%) which implemented in VAC in "Define" phase, whereas IWB from Core department and IWC from SQM department apply four LSS practices (80%). On the other hand, IWD from QSE department apply three LSS practices (60%) while IWE from Process Technology Department apply one LSS practice (20%). In a nutshell, Production department applies more LSS practices in the "Define" phase comparing with other departments while Process Technology department applies least LSS practices among other departments.

Table 4.3: Result of Lean Six Sigma's Practice in VAC on MEASURE Phase

Key Processes and Tools	**IWA**	**IWB**	**IWC**	**IWD**	**IWE**
Use control charts to present data.	✓	X	✓	✓	X
Use run charts to present data.	✓	X	✓	X	X
Use bar charts to present data.	✓	X	✓	X	✓
Use pie charts to present data.	✓	X	✓	✓	X
Use histograms to present data.	✓	X	✓	✓	X
Use box plots to present data.	✓	X	✓	✓	X
Use scatter diagrams to present data.	✓	X	✓	X	X
Use Pareto charts to present data.	✓	✓	✓	✓	✓

Table 4.3: Continued

Key Processes and Tools	IWA	IWB	IWC	IWD	IWE
Use descriptive statistics to measure the central location and variability of data.	✓	X	✓	X	X
Use process capability indices, DPMO and process sigma level to measure process capability.	✓	X	✓	X	X
Identify waste and quantify it financially.	✓	X	✓	X	X
Use Fishbone diagram.	✓	✓	✓	✓	✓
Use Flow chart.	X	✓	✓	✓	✓

As the basis for improvement, all interviewees measure the baseline performance of the current process consistently in this stage to identify the gap between current and required performance. Based on Table 4.3, there are two commonly used tools in VAC which is Pareto charts and Fishbone diagrams. All of the interviewees use these two types of tools to understand the data easily. Other than Pareto charts and Fishbone diagrams, IWA, IWC and IWD present data graphically by using control charts, histograms, pie charts and boxplots. Meanwhile, IWA, IWC and IWE also use bar charts to understand the data.

Beside this, flow chart also been used by four interviewees who are IWB, IWC, IWD and IWE to show steps of activities carried out in a process. Measuring process capability is also needed for IWA and IWC's job scope to measure the baseline performance of the current process by using process capability indices, defects per million opportunities (DPMO) and process sigma level.

Through those interviews, it is found that there are 5 key processes and tools that commonly used by IWA and IWC in this "Measure" phase. Both of them will use run charts and scatter diagrams to present the data graphically. This is because charts and diagrams are easier for other people to understand the data than explain in text. Furthermore, descriptive statistics is used by both of them to measure the central location and variability of data. In the same time, both of them also identify waste and quantify it financially.

Based on the results, it is found that IWC is applying the all LSS practices (100%) in her departments when coming to this phase. IWA is using practices twelve out of thirteen practices (92.31%), while IWD is only applying seven LSS practices, which is 53.85%, followed by IWE is applying four LSS practices (30.77%). It is surprising to see that IWB only apply three LSS practices in “Measure” phase, which is only 23.08% of types of LSS practices among the total amount of LSS practices found through interviews. In summary, SQM department apply the highest amount of LSS practices in “Measure” phase among other departments, while Core department and Process Technology department apply the lowest amount of LSS practices in “Measure” phase among other departments.

Table 4.4: Result of Lean Six Sigma’s Practice in VAC on ANALYSE Phase

Key Processes and Tools	**IWA**	**IWB**	**IWC**	**IWD**	**IWE**
Build a data collection plan to analyse which of the potential inputs is critical.	✓	✓	✓	X	X
Use graphical tools to investigate the reasons for variation and differences in processes by different factors.	✓	X	✓	X	X
Develop hypotheses on the sources of variation and strength of relationships by using hypothesis tests and confidence intervals	✓	✓	✓	X	X
Study how inputs relate to and impact outputs by using correlation.	✓	✓	✓	X	X
Study how inputs relate to and impact outputs by using regression.	✓	✓	✓	X	✓
Study how inputs relate to and impact outputs by using analysis of variance.	✓	✓	✓	✓	✓
Analyse unnecessary steps and ways to minimize waste within and between steps.	✓	X	✓	X	X

Table 4.4: Continued

Key Processes and Tools	IWA	IWB	IWC	IWD	IWE
Analyse lead time, cycle times and rework.	✓	X	✓	X	X
Analyse downtime and changeover time.	✓	X	✓	X	X
Design a lean future state VSM to execute in the next phase.	✓	X	X	X	X
Software used for analysis: QS-Stat, Minitab, Excel.	✓	✓	✓	✓	✓

In this "Analyse" phase, it is important to identify root cause of problems in order to eliminate them. First of all, a data collection plan is built by IWA, IWB and IWC to analyse which of the potential inputs is critical. Due to building data collection plan is involved only with senior engineer and higher management people, IWD and IWE didn't involve it in. However, only IWA and IWC use graphical tools such as interval effects plots, multi-vari cause charts and box plots to investigate the reasons for variation and differences in processes by different factors.

Through those interviews, it is found that hypothesis tests and confidence intervals are used by IWA, IWB and IWC to develop hypothesis on the sources of variation and strength of relationships in this "Analyse" phase. The findings in the interviews also shows all the interviewees study how inputs relate to and impact outputs by using analysis of variance in "Analyse" phase. Other than analysis of variance, regression is used by IWA, IWB, IWC and IWE while correlation is only use by IWA, IWB and IWC to study how inputs relate to and impact outputs.

Furthermore, IWA and IWC did analyse the current state of Value Stream Mapping (VSM). Both of them analyse the current state of VSM by focusing on analysing unnecessary steps and ways to minimize waste within and between steps. Analyse lead time, cycle times, rework, downtime and changeover time is also needed by them. After that, a lean future state VSM to execute in the next phase is created by

IWA during this “Analyse” phase. Last but not least, data analysis software such as QS-Stat, Minitab and Excel are used in VAC.

Based on Table 4.4, it shows that IWA implement the all LSS practices (100%) among the LSS practices found in “Analyse” phase, whereas, IWC implement ten LSS practices out of eleven LSS practices (90.91%), followed by IWB who implement six LSS practices (54.54%) in this phase. The least LSS practices implemented is by IWE who only implements three LSS practices (27.27%) and IWD who only implements two LSS practices (18.18%). In a nutshell, Production department implements the most LSS practices in “Analyse” phase whereas, QSE department and Process Technology department implement the least LSS practices.

Table 4.5: Result of Lean Six Sigma’s Practice in VAC on IMPROVE Phase

Key Processes and Tools	**IWA**	**IWB**	**IWC**	**IWD**	**IWE**
Optimize and standardize the process	✓	✓	X	X	✓
Design standard operating procedures and best practices	✓	✓	X	X	X
Use a Kaizen event to improve time, motion, cell design and standardize processes	✓	X	✓	X	X
Use Kanban	✓	X	X	X	X
Use 5S method	✓	✓	✓	✓	✓
Use TPM	✓	X	X	X	X
Use mistake-proofing techniques	✓	X	✓	X	X
Use visual workplace approach	✓	X	✓	X	X
Use benchmarking	✓	X	X	X	X
Use regression analysis	✓	X	✓	X	X
Use DOE	✓	X	✓	✓	X
Cost Calculation	✓	✓	X	X	X

In this "Improve" phase, it is important to find the solution for the problems and implement improvement for it. Through those interviews, it is found that 5S approach is widely used in VAC. Design of experiment (DOE) is used again in this phase by IWA, IWC, and IWD. Standard operating procedure (SOP) is developed by IWA, IWB and IWE in the same time to optimize and standardize the process. Meanwhile, IWA and IWC implement Kaizen event to improve time, motion, cell design and standardize processes in their department. Mistake-proofing techniques, visual workplace approach and regression analysis also used by them in this phase.

Based on Table 4.5, IWA and IWB will develop standard operating procedures and best practices and do cost calculation consistently. Through the interview with IWA also, it is found that Kanban, Total Production Maintenance (TPM) and benchmarking is implementing in this phase. Consistence training to employees also is a necessary key process in this phase.

Through the finding in table 4.5, it is found that IWA implements the all LSS practices (100%) among the LSS practices found in "Improve" phase, whereas, IWC implement six LSS practices out of twelve LSS practices (50%), followed by IWB who implement four LSS practices in this phase which 33.33%. The least LSS practices implemented is by IWD who is only implementing two (16.67%) LSS practices and IWE who is only implementing one (8.33%) LSS practices. This is due to those practices is enough to fulfil IWD and IWE job scope due to IWD responsible in observing all the process of operation and production is in control while IWE in charge on reducing scrap rework. In a nutshell, Production department implements still the most LSS practices in "Improve" phase whereas, QSE department and Process Technology department implement the least LSS practices.

Table 4.6: Result of Lean Six Sigma's Practice in VAC on CONTROL Phase

Key Processes and Tools	**IWA**	**IWB**	**IWC**	**IWD**	**IWE**
Validate and update the FMEA	✓	✓	✓	✓	✓
Use MSA	✓	X	✓	X	X
Update process capability, sigma level and control charts	✓	X	✓	X	X
Develop a control plan using mistake-proofing method	✓	X	✓	✓	X
Design and implement corrective actions	✓	X	✓	✓	X
Design visual work place controls	✓	X	✓	✓	X
Reconfirm the financial analysis by conducting a cost-benefit analysis, review and approve the analysis by finance.	✓	X	✓	X	X
Train process owner on using the control plan and monitor constantly.	✓	✓	✓	✓	X
Develop work instruction, update in the procedure and observe performance after implementation	X	✓	✓	X	X

In order to ensure the improvement in previous phase continued and sustainable success, all the interviewees agree that validate and update the failure mode effects analysis (FMEA) is necessary for this phase. Due to IWE is a process technician, he didn't involve much in this phase. Train process owner on using the control plan and monitor constantly is usually carried out by managerial position employees such as IWA, IWB, IWC, and IWD. Beside this, IWA, IWC and IWD will develop a control plan by using mistake-proofing method. Then, corrective actions will be implemented and a design visual work place control is developed in this phase to minimum those mistake and variable.

Based on Table 4.6, IWA and IWC will use Measurement System Analysis (MSA) to identify the amount of variation within the measurement process that contributes to total process variability. Both of them will update process capability, and sigma level and data in control charts from time to time. In this phase, they also will reconfirm the financial analysis by conducting a cost-benefit analysis, review and approve the analysis by finance. Last but not least, IWB and IWC also develop work instruction, update in the procedure and observe those performances after implementation.

Findings in "Control" phase shows that only IWA from SQM department apply all practices of LSS (100%) which implemented in VAC in "Control" phase, whereas IWA is using eight practices out of nine practices (88.88%), while IWD is applying five LSS practices (55.56%). It is surprising to see that IWB only apply three LSS practices in control phase, which is only 33.33% of types of LSS practices among the total amount of LSS practices found through interviews. The least LSS practices implemented is by IWE who is only implementing one (11.11%) LSS practices. In summary, SQM applies the highest amount of LSS practices in "Control" phase among other departments, while Core department and Process Technology department apply the lowest amount of LSS practices in "Control" stage among other departments.

Table 4.7: Summary of Lean Six Sigma Practices in Five Departments of VAC

Phase	**IWA**		**IWB**		**IWC**		**IWD**		**IWE**	
	f	Percent	*f*	Percent	*f*	Percent	*f*	Percent	*f*	Percent
Define	5	100%	4	80%	4	80%	3	60%	1	20%
Measure	12	92.31%	3	23.08%	13	100%	7	53.85%	4	30.77%
Analyse	11	100%	6	54.54%	10	90.91%	2	18.18%	3	27.27%
Improve	12	100%	4	33.33%	6	50%	2	16.67%	1	8.33%
Control	8	88.88%	3	33.33%	9	100%	5	55.56%	1	11.11%
Total	48		20		42		19		10	

There are totally 50 LSS practices implemented by various departments in VAC. There are five LSS practices in "Define" phase, thirteen LSS practices in "Measure" phase, eleven LSS practices in Analyse "phase", twelve LSS practices in "Improve" phase, and nine LSS practices in "Control" phase.

However, not every LSS practices are implemented by all interviewees. Based on Table 4.7, interviewee A (IWA) from Production department apply 48 LSS practices (96%), whereas interviewee C (IWC) from SQM department apply 42 LSS practices (84%), followed by interviewee B (IWB) from Core department apply 21 LSS practices (42%), interviewee D (IWD) from QSE department apply 19 LSS practices (38%) and interviewee E (IWE) from Process Technology department apply 10 LSS practices (20%) in descending order.

In a nutshell, IWA from Production department implement the most LSS practice in DMAIC phases due to his job scope is quite wide as senior engineer, whereas IWE from Process Technology implement the least LSS practice in DMAIC phases due to the job scope of the individual's job only involve with reducing work scrap. Employees from top management are more familiar with LSS knowledge, practices and tools used by them are more various, whereas employees from lower position only focus to use tools that related to their projects only. Beside this, different department have different function and job scope. Some of the department implement less LSS practices due to there is not much requirements on the projects they execute.

4.2.3 Result of Challenges of Implementing LSS in VAC

Table 4.8: Result of Challenges of Implementing LSS in VAC

Challenges	IWA	IWB	IWC	IWD	IWE
Resistance from employees	✓	X	X	✓	X
Budget and time constraints	✓	✓	✓	✓	✓
Shortage of Black Belt, Green belt and Yellow Belt candidates	✓	X	X	X	X
Fractured organizational culture	✓	X	X	X	X
Picking the "right" projects	X	X	✓	X	X

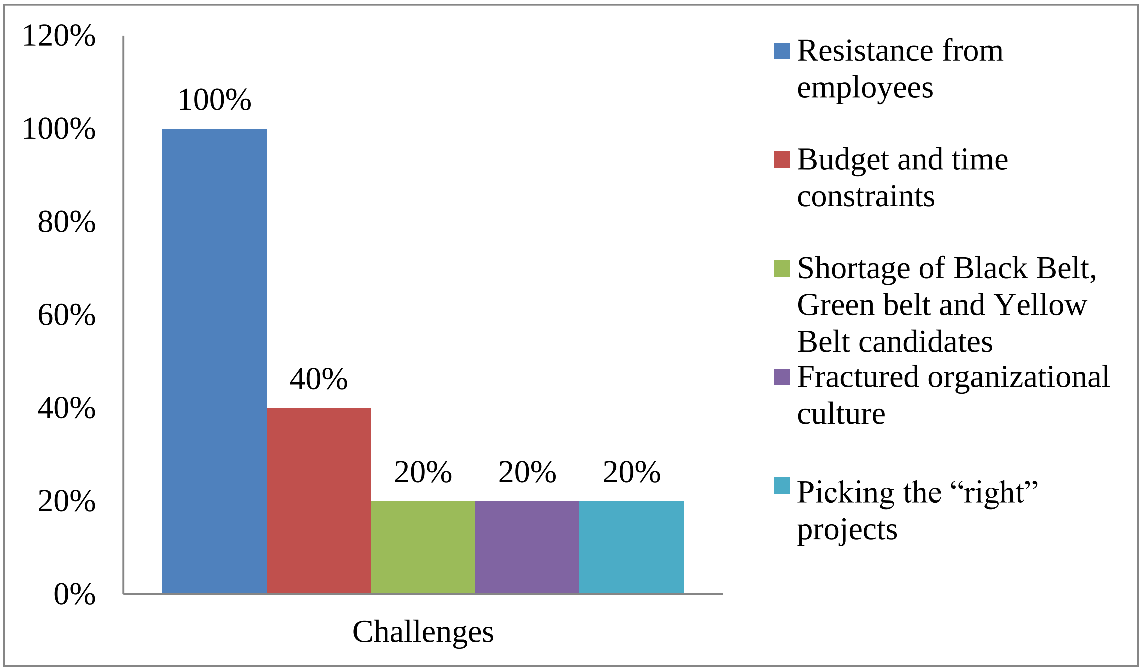

Figure 4.1: Challenges of Implementing LSS in VAC

The implementation of LSS in VAC gains a good support from top management. However, the implementation of LSS still faces some challenges from different factors as shows in Table 4.8 and Figure 4.1. The main challenge is resistance from employees to change. Most of the employees in VAC are lack of knowledge on LSS which causes misunderstanding about the need of LSS implementation. Some of them do believe that the current way of doing things works well since they have already done for years and changing the routines makes them feel uncomfortable. This causes some of them refuse to learn new practice and tools of LSS. Therefore, explanation and training of LSS is given to enhance those employees' understanding on LSS.

Beside this, budget and time constraints are also one of the major challenges. Implementation of certain LSS tools needs some investments from finance and it takes times to come out with an obvious result. VAC implements LSS by projects. Some projects may only take around 6 months; however, some project may need to take around 24 months to get an obvious result. During implementation, modifications on the production process and procedure do consume quite a lot of money. Thus, they need to be always alert regarding time and cost to spend during the implementation of LSS in a project.

Meanwhile, fractured organizational culture is also one of the challenges due to the low spirit of keep improving in Pekan is not high. Beside this, most of employees in Pekan are lack of competence if comparing with urban area such as Kuala Lumpur. Implementation of LSS may involve the changing of production process which causes changing of skills. As a result, some people feel that they won't be able to make the transition very well. Therefore, training, refreshment and monitoring are provided to employees to encourage them to implement LSS in their works. Token of Appreciation is also given by VAC according to the effort they made to implement Lean Six Sigma in order to encourage more employees to apply Lean Six Sigma.

Moreover, VAC is currently shortage of Black Belt, Green belt and Yellow belt of LSS expert. They have no much people including engineers in VAC know how to use Lean Six Sigma. It is quite hard to get those experts due to not much LSS experts in Malaysia. Currently, VAC manages to hire a black belt Lean Six Sigma expert from outside. In order to solve the shortage of LSS experts, VAC provides opportunities for engineers who would like to learn more about Green Belt knowledge, whereas Yellow Belt knowledge for technicians and operators.

In addition, picking the "right" projects is also very challenging in implementing LSS. Some implementation of LSS may need to modify the design of product. Due to VAC in Malaysia only has authority to modify the process of production but do not have any authority to modify the design of their products, it may cause the project outcome not as good as expectation or even fail to reach the project target. All the products' designs come from the headquarter in Germany. Modification on the design of their products is only allowed after getting the approval from the headquarter in Germany and their customers. Moreover, it is time consuming to get the approval from both parties due to their targeted customers are also from oversea.

However, the implementation of LSS did bring some benefits to VAC. Through interviews with those respondents, it is found that a project which mainly focuses on reducing scraps did manage to reduce production scraps from 1.6% to 0.01%. This result helps VAC to save around RM28810 after 12 months of implementation.

4.3 QUANTITATIVE RESULT

Quantitative method which is questionnaires is used to examine the impacts of Lean Six Sigma implementation on improving automotive company's operational performance. The questionnaire consists of 2 sections: Section A and Section B. Section A asks respondents' demographic profile while Section B is developed with questions regarding to the operational performances which consists of 21 questions. First, this questionnaire is sent to Lean Six Sigma Experts to review it. Next, reliability analysis for pilot test is carried out by using 10 set of questionnaires collected from Vacuumschmelze (Malaysia) Sdn Bhd. Then only, 248 questionnaires are distributed to other employees in Vacuumschmelze (Malaysia) Sdn Bhd to fill it. After collection of data, Statistical Package for the Social Sciences version 22 (SPSS 22) software is used to analyse those data collected through questionnaires.

4.3.1 Pilot Test

Pilot test is a small-scale trial, which is conducted to test the questionnaires before carrying out the research. It is a vital method to determine the reliability and content validity of questionnaires. There are two steps of pilot test conducted in this research, which are get feedbacks from experts and then carry out Reliability Analysis using SPSS.

Feedbacks from Experts

First, questionnaires are e-mailed to Lean Six Sigma experts before distributing the questionnaires to the selected respondents for the pilot test. There is three Lean Six Sigma experts from MBizM Sdn Bhd[1] and Lean Partner[2] respond to my request. After getting their feedbacks and comments through e-mail and phone interviews, amendments have been made to the errors and problems found in the questionnaires. Those amendments are including questions regarding races and religion are removed since it is a sensitive issue and unused data, advise to write in full for those abbreviation used in the questions due to some of the respondent may not understand it, and modification on certain terms that used in the questions to be more appropriate.

Reliability Analysis for Pilot Test

Then, 10 sets of corrected questionnaires were distributed to Vacuumschmelze (Malaysia) Sdn Bhd to conduct the reliability analysis. As mentioned in previous chapter, Cronbach's Alpha test is a measurement of internal consistency scale that shows how closely related a set of items are as a group to gauge its reliability. Amendments have to make if the results of the Cronbach's alpha test shows the variables are not in the acceptable range. Usually, if the Cronbach's Alpha value is less than 0.50, then, it is unacceptable and the poor questionnaire item must be deleted to increase the reliability. While, Cronbach's alpha value within 0.50 to 0.70 is consider as questionable and poor. Nevertheless, the best level of Cronbach's alpha value should be more than 0.70 or closer to 1.00 to indicate high consistency and reliability of questionnaire data.

Table 4.9: Reliability of Questionnaires (Pilot Test)

Operational performance (OP) variables	Cronbach's Alpha	Number of Items (N)	Items Deleted
Cost and Waste Reduction (OPC)	0.725	5	0
Quality (OPQ)	0.813	5	0
Flexibility (OPF)	0.887	4	0
Delivery (OPD)	0.763	4	0
Productivity (OPP)	0.709	3	0

Table 4.9 shows the result of reliability for questionnaires (Pilot Test). There are total of 21 items in the questionnaires. The result shows that Flexibility (OPF) having the highest Cronbach's alpha values which is 0.887 followed by Quality (OPQ) which is 0.813, and then, Delivery (OPD) with value of 0.763. While, Cronbach's alpha values for Cost and Waste Reduction (OPC) is 0.725. The variable that has lowest Cronbach's alpha value is Productivity (OPP), which is only 0.709.

From Table, it is concluded that the Cronbach's alpha values of all variables are in the acceptable level, which are ranging from 0.709 to 0.887. Since all the Cronbach's alpha values gained are above 0.70, which indicate the high consistency and reliability of the questionnaire data. Thus, no items need to be deleted from the questionnaire.

4.3.2 Response Rate

After the reliability analysis for pilot test is conducted on 10 sets of questionnaires which were distributed to ensure the consistency and reliability of questionnaire data, those corrected questionnaires are distributed to the targeted respondents by using non-face-to-face distribution. In order to come out an ideal sample size in a research which is large enough to serve as adequate representative of the population, tabulation formula of Krejcie and Morgan (1970) is used. According to the table, this research needs to collect data from 248 employees since there are around 700 employees working in this company. Thus, 248 questionnaires are sent to the company. The questionnaires will be collected after a week of distribution. In this research, the targeted respondents are employees who involves with Lean Six Sigma (LSS) implementation in Automotive Industry. Table 4.1 shows the response rate yielded for the questionnaires.

Table 4.10: Response Rate

Number of Questionnaires Distributed	Number of Questionnaires Received	Number of Completed Questionnaires	Response Rate (%)
248	84	64	25.81

Based on Table 4.10, a total of 85 questionnaires were received. However, there is only 64 questionnaires are completed, which yielded 76.19% of completion rate and 25.81% of the response rate. This number of completed questionnaires are excluded the number of questionnaires been used as pilot test. Those missing data from the uncompleted questionnaires are including data demography of respondents, didn’t circle the Linkert scale of certain questions especially in question 11, 12 and 14.

However, according to Saiful (2011) states that a sample size larger than 30 and less than 500 are appropriate for most research. Furthermore, Roscoe (1975) also supported that sample sizes between 30 and 500 are appropriate random sampling method. Thus, this research sample size is within acceptable level.

4.3.3 Demographic Analysis

The purpose of conducting demographic analysis of respondents is to provide the descriptive statistics of the gender, age, nationality, number of years working experience in the company, highest qualification of education level, current position and department they are working in.

Gender of Respondents

Table 4.11: Gender of Respondents

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Male	22	34.4	34.4	34.4
	Female	42	65.6	65.6	100.0
	Total	64	100.0	100.0	

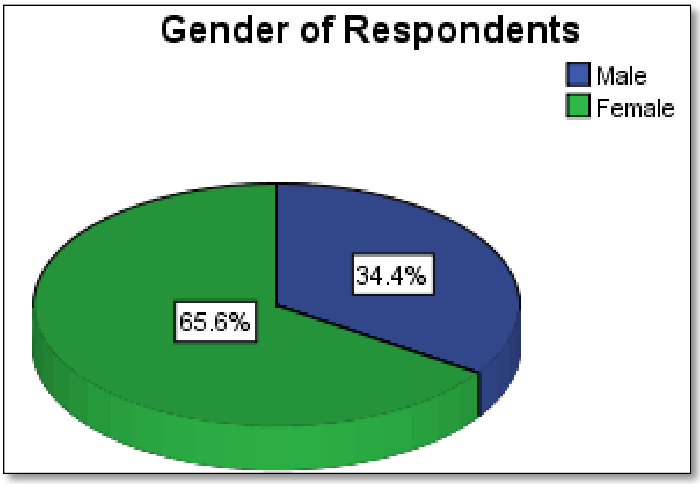

Figure 4.2: Gender of Respondents

Table 4.11 and Figure 4.2 show gender of respondents. Based on the table and figure above, there are 22 males (34.4%) and 42 females (65.6%) are involved in this research. Thus, most of the respondents are female.

Age Group of Respondents

Table 4.12: Age Group of Respondents

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	18-19 years old	1	1.6	1.6	1.6
	20-29 years old	43	67.2	67.2	68.8
	30-39 years old	18	28.1	28.1	96.9
	40-49 years old	2	3.1	3.1	100.0
	Total	64	100.0	100.0	

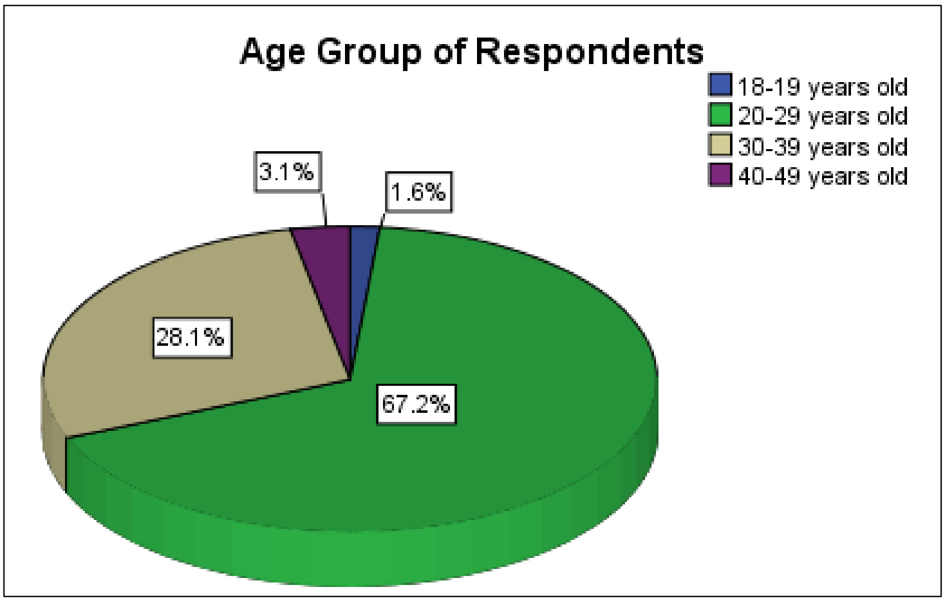

Figure 4.3: Age Group of Respondents

Table 4.12 and Figure 4.3 show most of the respondents are in the age group of 20-29 years old, with a frequency of 43 respondents (67.2%), whereas the least frequent on the age group is 18-19 years old, with a frequency of 1 respondent (1.6%). Meanwhile, the age group of 30-39 years old is yielded with a frequency of 18 respondents (28.1%). Lastly, there are 2 respondents (3.1%) are in the range of 40-49 years old.

Nationality of Respondents

Table 4.13: Nationality of Respondents

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Malaysian	64	100.0	100.0	Valid

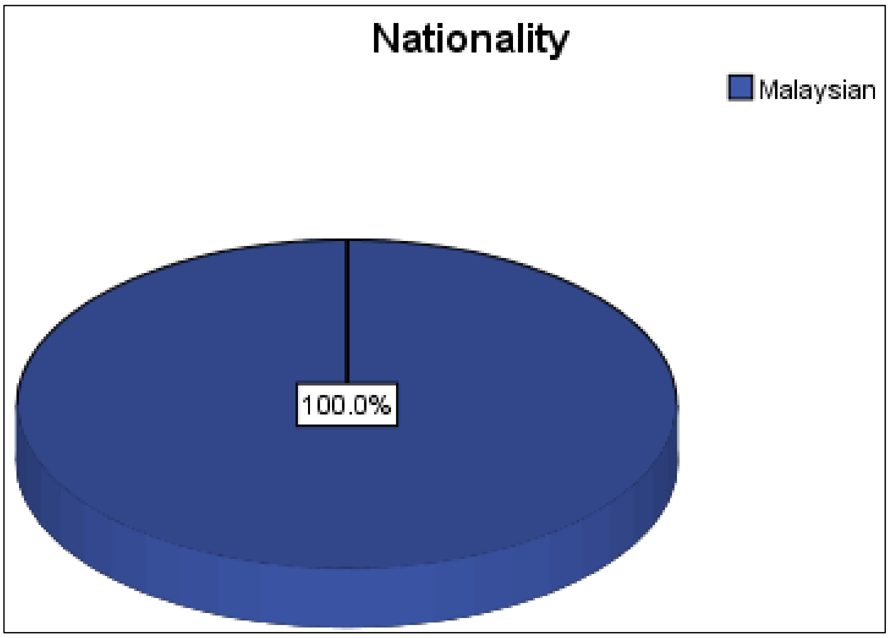

Figure 4.4: Nationality of Respondents

Table 4.13 and Figure 4.4 show nationality of respondents. Statistics displays that all of the respondents who filled in questionnaires are Malaysian. There is no foreigner filling the questionnaires.

Years of Working Experience in the Company

Table 4.14: Years of Respondents' Working Experience in the Company

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Less than 2 years	19	29.7	29.7	29.7
	Between 2-3 years	13	20.3	20.3	50.0
	Between 4-5 years	10	15.6	15.6	65.6
	Between 6-7 years	5	7.8	7.8	73.4
	Between 8-9 years	4	6.3	6.3	79.7
	More than or Equal to 10 years	13	20.3	20.3	100.0
	Total	64	100.0	100.0	

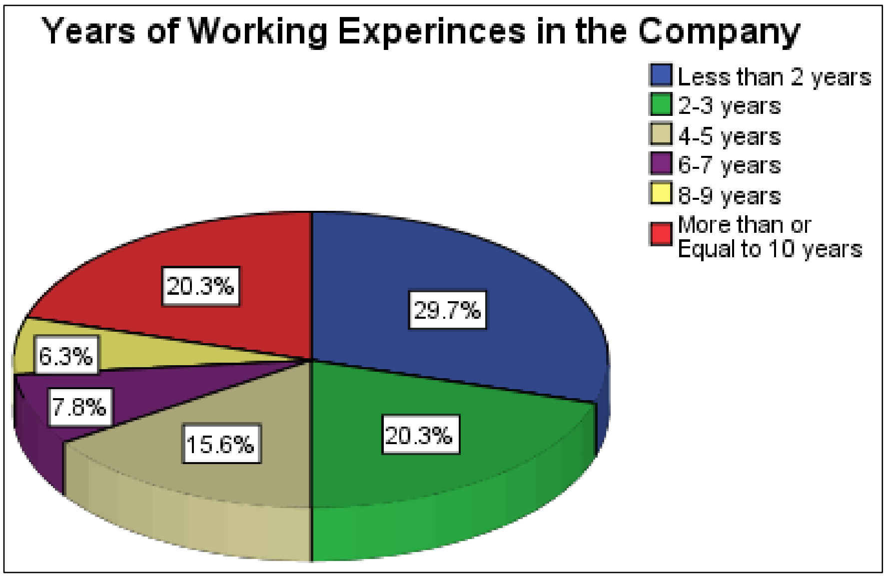

Figure 4.5: Years of Respondents' Working Experience in the Company

Table 4.14 and Figure 4.5 show most of the respondents' working experience in VAC is less than 2 years, with a frequency of 19 respondents (29.7%). Meanwhile, respondents who having 2 -3 years working experience in VAC, and more than or equal to 10 years working experience in VAC are having the same frequency of respondents which is 13 respondents (20.3%) for each group. There are 10 respondents (15.6%) served the company for 4-5 years, followed by 5 respondents (7.8%) with 6-7 years of working experience and 4 respondents (6.3%) with 8-9 years of working experience.

Education Level of Respondents

Table 4.15: Education Level of Respondents

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Primary School	1	1.6	1.6	1.6
	SPM	31	48.4	48.4	50.0
	STPM / Diploma	23	35.9	35.9	85.9
	Bachelor	8	12.5	12.5	98.4
	Master	1	1.6	1.6	100.0
	Total	64	100.0	100.0	

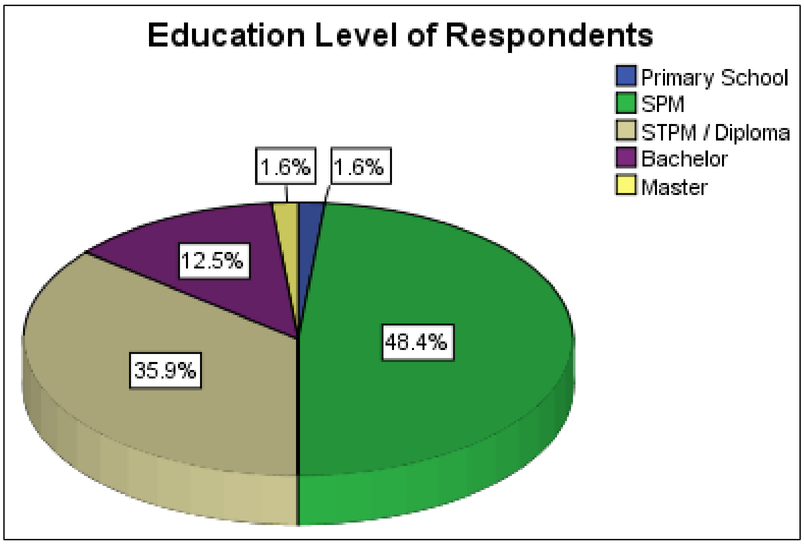

Figure 4.6: Education Level of Respondents

Table 4.15 and Figure 4.6 show the education level of respondents in VAC. Statistics displays that most of the respondents (48.4%) with the frequency of 31 respondents have their education until SPM level, followed by 23 respondents (35.9%) with qualification of STPM, 8 respondents (12.5%) with qualification of Bachelor, 1 respondent (1.6%) with qualification of Master, and 1 respondents (1.6%) with qualification of Primary School in descending order.

Current Department of Respondents

Table 4.16: Current Department of Respondents

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Production	33	51.6	51.6	51.6
	Quality, Safety, Environment (QSE)	21	32.8	32.8	84.4
	Supplier Quality Management	5	7.8	7.8	92.2
	Process Technology	4	6.3	6.3	98.4
	Core	1	1.6	1.6	100.0
	Total	64	100.0	100.0	

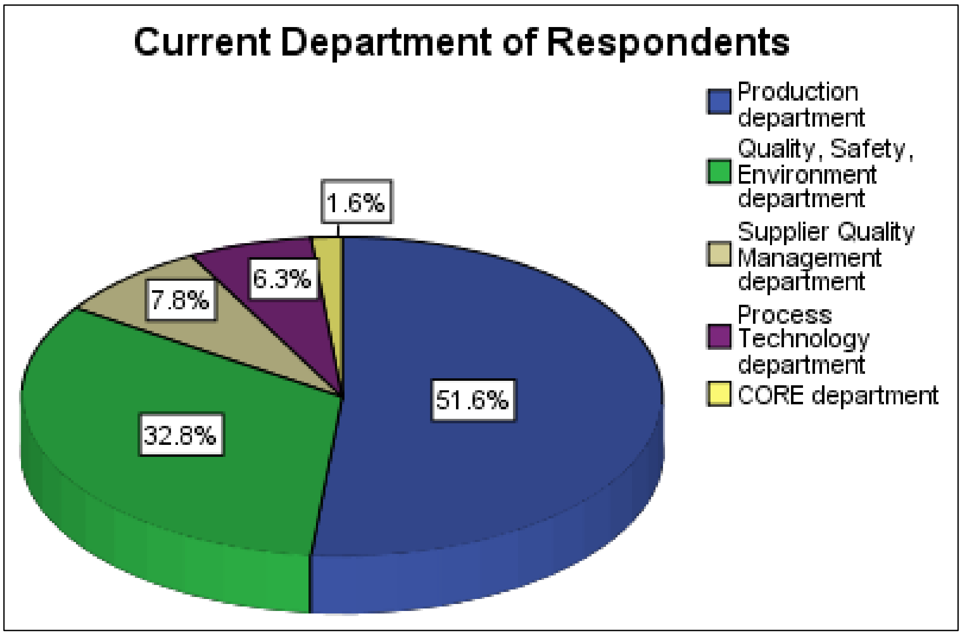

Figure 4.7: Current Department of Respondents

Based on Table 4.16 and Figure 4.7, those respondents are from five departments which is Production department, Quality, Safety, Environment (QSE) department, Supplier Quality Management department, Process Technology department and Core department. Statistics displays that most of the respondents are from

Production department, with a frequency of 33 respondents (51.6%), whereas the least frequent of respondents is Core department, with a frequency of 1 respondent (1.6%). Meanwhile, there are 21 respondents (32.8%) from Quality, Safety, and Environment (QSE) department, followed by 5 respondents (7.8%) from Supplier Quality Management department, and 4 respondents (6.3%) from Process Technology department.

Current Position of Respondents

Table 4.17: Current Position of Respondents

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Employee	64	100.0	100.0	100

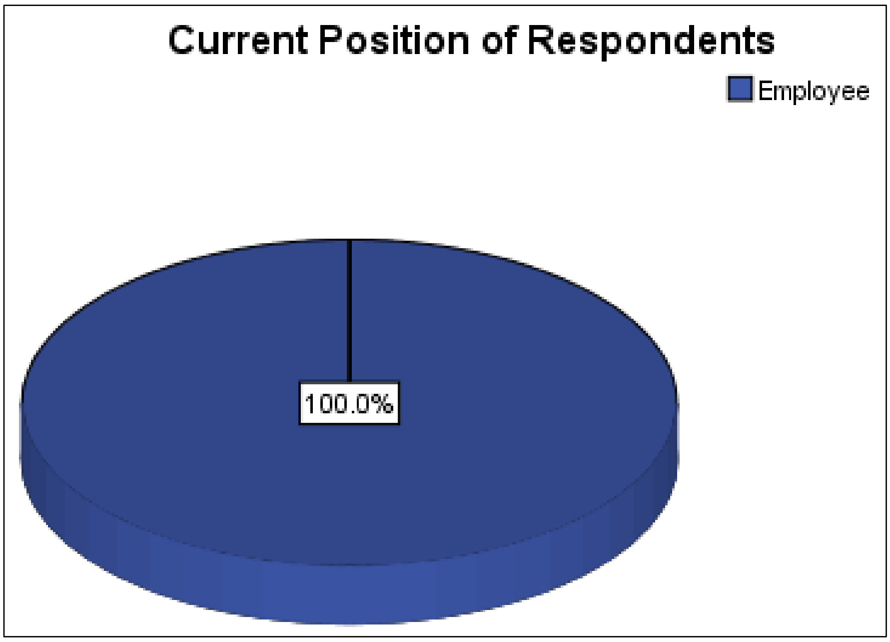

Figure 4.8: Current Position of Respondents

Table 4.17 and Figure 4.8 show current position of respondents. Statistics displays that all of the respondents who filled in questionnaires are from employee category.

4.3.4 Normality Test

Then, these completed questionnaires are used to conduct the Normality Test for real test whether the data in this research are normally distributed. If the data is normally distributed, those data will be presented in a symmetrical bell-shaped curve. Due to the sample size of this research is more than 50 but less than 2000, Kolmogorov-Smirnov Test (> 2000 samples) and the Shapiro-Wilk Test (< 50 samples) is not suitable to be used in this research. Therefore, skewness (lack of symmetry) and kurtosis (pointiness) is selected to do normality test since this research's sample size is only 64.

Table 4.18: Skewness Test of Operational Performance (OP) Variables

Skewness			
Operational performance (OP) variables	**Statistic**	**Std. Error**	**Z-values**
Cost and Waste Reduction (OPC)	-0.140	0.299	-0.468
Quality (OPQ)	-0.103	0.299	-0.344
Flexibility (OPF)	-0.103	0.299	-0.344
Delivery (OPD)	-0.103	0.299	-0.344
Productivity (OPP)	-0.270	0.299	-0.903

Table 4.19: Kurtosis Test of Operational Performance (OP) Variables

Kurtosis			
Operational performance (OP) variables	**Statistic**	**Std. Error**	**Z-values**
Cost and Waste Reduction (OPC)	-0.825	0.590	-1.398
Quality (OPQ)	-0.837	0.590	-1.419
Flexibility (OPF)	-0.837	0.590	-1.419
Delivery (OPD)	-0.959	0.590	-1.625
Productivity (OPP)	-0.760	0.590	-1.288

Due to only statistic and standard error of Skewness and Kurtosis are provided in SPSS software, the z-value of Skewness and Kurtosis can be calculate by using the equation mentioned by Ghasemi and Zahediasl (2012) which is expressed as in Eq. (4.1) and Eq. (4.2):

$$Z_{Skewness} = \text{Skewness-0} / SE_{Skewness} \quad (4.1)$$

$$Z_{Kurtosis} = \text{Kurtosis-0} / SE_{Kurtosis} \quad (4.2)$$

After calculating the z-value of Skewness and Kurtosis, the results are inserted in the Table 4.18 and Table 4.19 accordingly. If the data are in normal distribution, the values for these parameters should be zero. However, the z-value of Skewness and Kurtosis shown in the tables above are in negative value. Based on table 4.18, the variable that highest negative z-value is productivity ($Z_{Skewness} =$ -0.903), followed by cost and waste reduction ($Z_{Skewness} =$ -0.468). There are three variables are having same value of $Z_{Skewness} =$ -0.344, which are quality, flexibility, and delivery. It can be concluded that all the variables are left-skewed. The tail of the distribution of all variables is more stretched on the side below the mean and the mean is less than the median.

Meanwhile, Table 4.19 presents that the $Z_{Kurtosis}$ values of all variables are negative value where delivery ($Z_{Kurtosis} =$ -1.625) has the highest negative values, followed by flexibility and quality ($Z_{Kurtosis} =$ -1.419). The variables that have lowest negative values of $Z_{Kurtosis}$ are cost and waste reduction ($Z_{Kurtosis} =$ -1.398), and productivity ($Z_{Kurtosis} =$ -1.288). A $Z_{Kurtosis}$ value characterizes a distribution's peakedness or flatness. All variables in this research are relatively flatter distribution due to they has negative value of $Z_{Kurtosis}$.

According to by Ghasemi and Zahediasl (2012), when the z-values of Skewness and Kurtosis are within -1.96 to +1.96 limits, the data can be accepted as normal distribution. Since all the variables' $Z_{Skewness}$ and $Z_{Kurtosis}$ are between -1.96 to +1.96 limits, it is concluded that the departure of those data from normality is not too extreme and thus, all of the variables in this research are normally distributed.

4.3.5 Result of Impacts of Lean Six Sigma Implementation on Improving Operational Performance

Table 4.20: Impacts of LSS Implementation on Improving Operational Performance

Operational Performance (OP) Variables	Mean (M)	Standard Deviation (SD)
Cost and Waste Reduction (OPC)	4.15	0.75
Quality (OPQ)	4.05	0.74
Flexibility (OPF)	4.00	0.78
Delivery (OPD)	4.14	0.71
Productivity (OPP)	4.20	0.68

Levels of agreement of 6-point Likert: (1) - Very ineffective, (2) – Ineffective, (3) - Somewhat ineffective, (4) - Somewhat effective, (5) – Effective, (6) - Very effective

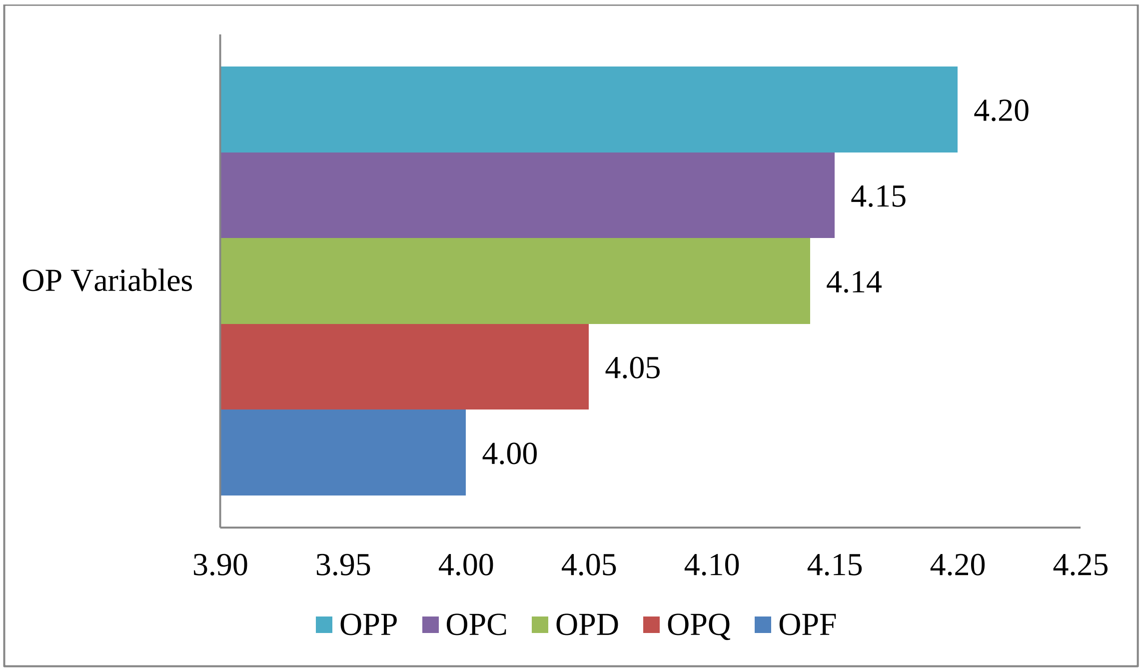

Figure 4.9: Ranking of OP variables

Table 4.20 shows impacts of Lean Six Sigma (LSS) implementation on improving operational performance. By using those mean values, an overall ranking of those OP variables can be demonstrated in the Figure 4.9. The highest ranking of variable yielded belongs to productivity with mean value of 4.20, followed by the cost and waste reduction (M = 4.15), delivery (M = 4.14) and quality (M = 4.05). The variable that receive least impact of LSS implementation is flexibility (M = 4.00).

Therefore, it shows that LSS implementation did bring some effectiveness to all the OP variables that this research focuses since all the mean value are equal to or more than 4.00. It can be concluded that implementation of LSS is most effective to the company's productivity and least effective to the company's flexibility.

Table 4.20 also shows the standard deviation of each variables which range from 0.68 to 0.78. The highest variability among variables is flexibility (SD = 0.78) while the lowest variability of variables is productivity which is SD = 0.68.

4.4 Summary

Content analysis is carried for qualitative study. All the result regarding LSS' practice in VAC and challenges of implementing LSS in VAC are presented in table form. From the interview, it is found that there are different key processes and tools of LSS are used in "Define, Measure, Analyse, Improve and Control" (DMAIC) stage by those interviewees because of different job scope and different department they work in. IWA from Production department implement the most LSS practice in DMAIC phases due to his job scope is quite wide as senior engineer, whereas IWE from Process Technology implement the least LSS practice in DMAIC phases due his job scope only involve with reducing work scrap. Due to VAC just start on implementation of LSS in few years ago, the implementation of LSS still not firm and stable yet. Improving is keep doing in VAC.

Beside this, although implementation of LSS in VAC gains a good support from top management, but it still faces some challenges during implementation. Those challenges are budget and time constraints, resistance from employees, fractured organizational culture, shortage of black belt, green belt and yellow belt candidates and picking the "right" projects.

For quantitative study, pilot test is carried out first by sending those questionnaires to LSS expert to review on it and then, testing 10 sets of questionnaires by using reliability analysis. All questionnaire items are proved reliable with Cronbach's Alpha of 0.70 above. After questionnaires is collected, all data were test with demographic analysis, normality test by using skewness and kurtosis, effectiveness analysis by using mean and standard deviation. All the data are normally distributed with the z-values of Skewness and Kurtosis are within -1.96 to +1.96 limits. The highest ranking of variable yielded belongs to productivity with mean value of 4.20, followed by the cost and waste reduction (M = 4.15), delivery (M = 4.14) and quality (M = 4.05). The variable that receive least impact of Lean Six Sigma implementation is flexibility (M = 4.00).

[1] MBizM Sdn. Bhd. is a consultant company offering a range of training and consultancy programmes in the fields of Six Sigma, Lean, Lean Six Sigma, Quality and Soft Skills.

[2] Lean Partner is a consultant company offering a range of training and consultancy programmes in the fields of Lean Six Sigma, Change Management, Transformation and Business Process Improvement.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

5.1 INTRODUCTION

The main purpose of this research is to study Lean Six Sigma (LSS) Implementation towards Improving Automotive Operational Performance. Interview and questionnaires are conducted for data collection. All the collected data are analysed and presented in previous chapter. Therefore, this chapter elaborates and conclude the results of this research as mentioned in the previous chapter. Managerial implication, research contributions, limitations, and recommendations for the future research are included in this chapter.

5.2 CONCLUSIONS

Generally, all research objectives have been achieved by using interview and questionnaires methods. Content analysis is carried for qualitative study to answer research objective 1 and 2. Through data collected from interview, it is found that there are different key processes and tools of LSS are used in "Define, Measure, Analyse, Improve and Control" (DMAIC) phase by those interviewees because of different job scope and different they work on. There are total 50 LSS practices been implemented in VAC. However, not every LSS practices are implemented by all interviewees. Interviewee A (IWA) apply 48 LSS practices (96%), whereas interviewee C (IWC) apply 41 LSS practices (82%), followed by interviewee B (IWB) apply 21 LSS practices (42%), interviewee D (IWD) apply 19 LSS practices (38%) and interviewee E (IWE) apply 10 LSS practices (20%) in descending order.

In a nutshell, IWA from Production department implement the most LSS practice in DMAIC phases due to his job scope is quite wide as senior engineer, whereas IWE from Process Technology implement the least LSS practice in DMAIC phases due his job scope only involve with reducing work scrap. Employees from top management are more familiar with LSS knowledge, practices and tools used by them are more various, whereas employees from lower position only focus to use tools that related to their projects only. Beside this, different department have different function and job scope. Some of the department implement less LSS practices due to there is not much requirements on the projects they execute. Moreover, due to VAC just start on implementation of LSS in few years ago, the implementation of LSS still not firm and stable yet. The practices and tools used in VAC are limited. Thus, there is still has space for VAC to do improvement to be better.

Furthermore, although implementation of LSS in VAC gains a good support from top management, but it still faces some challenges during implementation. Those challenges are resistance from employees, budget and time constraints, fractured organizational culture, shortage of black belt, green belt and yellow belt candidates and picking the “right” projects. The main challenge is resistance from employees to change. Most of the employees in VAC are lack of knowledge on LSS which causes misunderstanding about the need of LSS implementation. Some of them do believe that the current way of doing things works well since they have already done for years and changing the routines makes them feel uncomfortable. This causes some of them refuse to learn new practice and tools of LSS. Therefore, explanation and training of LSS is given to enhance those employees’ understanding on LSS.

On the other hand, Statistical Package for the Social Sciences version 22 (SPSS 22) software is used to analyse those data collected through questionnaires. Based on the analysis result in Chapter 4, all the variables are left-skewed and relatively flatter distribution due to the all the value of Z_{Skewness} and Z_{Kurtosis} are negative value. The tail of the distribution of all variables is more stretched on the side below the mean and the mean is less than the median. However, all the data are normally distributed with the z-values of Skewness and Kurtosis are within -1.96 to +1.96 limits.

Beside this, findings also show that LSS implementation brings positive impacts toward operational performance since all the mean values for all operational performances are equal to or more than 4. The highest ranking of variable yielded belongs to productivity with mean value of 4.20, followed by the cost and waste reduction (M = 4.15), delivery (M = 4.14) and quality (M = 4.05). The variable that receive least impact of Lean Six Sigma implementation is flexibility (M = 4.00). According to levels of agreement of 6-point Likert in this research, implementation of LSS is somewhat effective to all the variables due to the mean values yielded are more than 4 but less than 5.

5.3 MANAGERIAL IMPLICATION

Findings in this research show that the practices and tools used in VAC are limited. This is due to VAC just start on implementation of LSS in four years ago, the implementation of LSS still not firm and stable yet. There is total of 11 departments in VAC. However, there are only five departments are implementing LSS practices. There is still has space for improvement. According to Interviewee B, top management encourage the increase usage of different type of LSS practice among the employees according to the need of the projects by giving Token of Appreciation according to the effort they made to implement LSS. Interviewee A also mentioned training employees on application LSS tools in VAC are conducted constantly.

Based on the findings from previous chapter, it shows that there is resistance of employees when implementation of LSS. According to Johnson (2009), many employees would not accept LSS on blind faith. It is suggested the company must establish a compelling reason for implementing LSS which acts as a burning platform to create awareness and motivation for employees to implement LSS practices in their daily routine jobs (Gates, 2007).

Simply training employees on application LSS tools is not enough to implement LSS fully. According to Scotty (2013), employee engagement is the key to achieving the success of Lean Six Sigma program. Providing Token of Appreciation to employees implement Lean Six Sigma sometimes is not enough to encourage employees. Since there is resistance from employees to change, top management should give an opportunity express their thoughts and suggestions regarding implementation of LSS. Through this method, top management may found out the main reasons of resistance from employees.

Moreover, since employees are very familiar with operation processes, they may have a unique perspective on production processes. The company may identify inefficient or unnecessary steps in operation and production from their feedback (Scotty, 2013). Therefore, feedback platform such as survey, meeting and social media should be established to allow communication between top management and employees consistently. Top management can do explanations regarding the questions from employees, but criticism on suggestion from employees also should avoid in order making employees feel free to voice out their opinions.

On the other, it is found that VAC is currently lack of availability of LSS experts especially Black belt and Green Belt. Through interview, it is found that as a black belt of LSS, Interviewee A did try to provide training to employees regarding the implementation of LSS constantly. However, VAC only has one Black Belt of LSS expert who is Interviewee A. Thus, the training he can provide is quite limited. The lack of those experts can cause the difficult on LSS implementation. VAC should to invest in the education and training of project leaders to the level of Green or Black Belt. It is suggested by Galloway (2014), green belts should be trained as project leaders to lighten the job scope of Black Belt.

Beside this, in order to minimize the budget and resources, VAC can focus on training about a few talented people to Black belt and Green Belt in the organization in each batch. Therefore, the number of LSS experts will increase as time goes. Education and training should be conducted consistently and closely connected to the execution of projects in order to make employees who involve in this LSS program are familiar with necessary practices and tools.

Furthermore, it is found that VAC is more focusing on productivity as it gains highest impact among other variables. VAC may try to focus on other variables especially in flexibility to gain the better results and larger benefits when implementing LSS. Although VAC in Malaysia does not have authority to change of products or come out a new design of products for customer, they may try to increase other aspects in flexibility variable such as increasing the speed of changing in production volume and etc.

5.4 RESEARCH CONTRIBUTIONS

First of all, by ascertaining the practice of LSS that implemented in a Malaysian automotive company through case study, this research could not only filling the research gaps of LSS in Malaysia, but also provide a better understanding and benchmarking for other automotive companies to review and restructure their operation process.

Besides this, the results on identifying challenges of implementing LSS would provide local automotive industries with indicators and guidelines for implementation success of LSS concepts and methods. This will avoid the companies from losing investment and effort in LSS program without improving any company.

Meanwhile, conceptual framework of LSS model which follows the DMAIC structure as provided in Chapter 3 is a useful framework that graphically presents relationship between LSS implementation and operational performance. Through interview and questionnaires, it is found that LSS implementation give positive impacts toward operational performance. Moreover, real case study provided in this research would encourage more automotive companies to adopt LSS approach.

5.5 LIMITATIONS

Private and confidential policy set by company is the main limitation for this research. In order to understand reality of Lean Six Sigma in automotive industry in Malaysia, interviews with the companies' expert have to be carried out. However, due to private and confidential policy, most of the companies reject the request of interviews for this research. Furthermore, during interview, some questions are rejected by interviewees and very detail information cannot reveal by them. Limitation to this research occurs due to this factor. As a consequence, this research only manages to do case study on one automotive company and present some basic knowledge regarding practice and challenges of LSS.

Moreover, this research is only targeted on an automotive company which is Vacuumschmelze (Malaysia) Sdn Bhd (VAC) due to constraint in time and data collection method. As walk-in interviews need transportation to reach there, the research could only target automotive companies which are near the North of Malaysia and East Coast region. Unfortunately, only VAC approved the application of interview for this research after four months calling and e-mails to those companies. As, one company results cannot represent all the companies in automotive industries, for anyone who interested to further study regarding this topic, it is suggested to start searching for target companies earlier.

On the other hand, the researcher is not experienced in interview; there are some problems to guide the interviewees to main questions during conducting open-ended interview. It also consumes a lot of time to ensure the data collected from interviews are sufficient to achieve research objectives. Sometimes, interviewees also need some time to recall what type of tools and practices they have implemented and challenges they faced. Researcher has to go to the company to do walk-ins interviews a few times. This cause data collection process is quite slower than expected due to booking interviews with those experts needs some time.

Furthermore, due to VAC just start on implementation of LSS in a few years ago, the implementation of LSS still not firm and stable yet and the number of LSS experts in VAC are limited. Currently, there are only one black belt expert and five green belt experts in VAC. This research only manages to interview with one Black Belt expert, two Green Belt experts and two Yellow Belt experts. The data collected from Yellow Belt experts is not sufficient due to both of them are not from managerial level employees. Their knowledge regarding LSS is not as wide as experts from Black Belt level and Green Belt level. Meanwhile, the practice and tools of LSS implemented in VAC are limited. Thus, the results gained from VAC may not as good as expect and cannot develop a deeper insight regarding practice and tools of LSS.

Beside this, this response rate for questionnaires is quite low and disappointed. There is only 64 questionnaires are completed, which yielded and 25.81% of the response rate. This is because most of the employees do not have any knowledge regarding Lean Six Sigma and not every department are implementing Lean Six Sigma. Thus, most of the employees who didn't involve in Lean Six Sigma projects cannot answer those questionnaires. Moreover, there are only five departments' employees filling in these questionnaires. It didn't cover all the departments which implement LSS practices. Low respondents rate may cause the research finding does not concisely reflect and represent the actual population.

Last but not least, the interviews are conducted with interviewees from different level of position. Due to they are having different level of authority, it is quite hard to do comparison on departments that implement the most LSS practices. Employees from lower position such as Process Technician do not have much knowledge on LSS practices and they only focus to use tools that related to their projects only. This may cause the research finding does not concisely reflect the actual LSS practices implemented in some departments.

5.6 RECOMMENDATIONS FOR FUTURE RESEARCH

There are some recommendations for future study regarding this topic. First, this research is focus on five operational performances (OP) variables which are including cost and waste reduction (OPC), quality (OPQ), flexibility (OPF), delivery (OPD) and productivity (OPP). In future study, it is advisable to study the other dimensions of the variables such as reliability, innovation, inventory, compliance, employee satisfaction and etc.

Moreover, future researchers are encouraged to change the method of collection data from open-ended interview to closed, fixed-response interview for the main questions especially regarding the practice and tools of LSS implemented in VAC. All respondents not only are asked the same questions but also been provided same set of alternatives to choose. Further information can elaborate or be added after getting to know practice and tools of LSS implemented for each stage. Data collection will be easier and save more time for both parties.

It is also suggested to change the method of collection data from questionnaire to documentation review or focus group discussion, field work by observing their process and attending their meeting. Future researchers may try to get the company operational documents which have exact figure and value on the impact of LSS. For example, production scraps is reduced from 1.6% to 0.01%, cost saving is around RM28810 after 12 months of LSS implementation. By having exactly value on those benefits, it certainly looks like more convincing to encourage more company to implement LSS.

Due to this case study focuses on one company for case study, future researches are advised to get more respondents for a more accurate and precise outcome that is able to represent the actual population in Malaysian automotive companies. Future researches may start to search for research companies as earlier as possible due to the companies may need to assess the request.

Beside this, this research is only focus on studying Lean Six Sigma (LSS) approach in automotive industries in Malaysia. LSS research focus on manufacturing industry is very common especially in oversea and the use of LSS in service organizations as a business strategy to increase company profitability and accomplish service excellence are growing quickly. So, future studies should extend research on LSS topic to service industry which may grab attention from public to the research although it is challenging.

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APPENDIX A

Gantt Chart

Research Activities	Month												
	Dec 14	Jan 15	Feb 15	Mac 15	Apr 15	May 15	June 15	July 15	Aug 15	Sep 15	Oct 15	Nov 15	Dec 15
Identification of a research topic													
Initial research objectives & question													
Review of Related Literature													
Formulation of problem statement													
Formulation of research objectives & question													
Selection of study design													
Selection of research scope													
Come out a plan of action: Gantt Chart													
Writing a proposal and getting approval													
Industry finding													
Data collection													
Data analysis													
Preparation of report													
Submission of report													
Presentation of findings of research in front of peers													

APPENDIX B

Sample Size Table from a Given Population

N	S	N	S	N	S
10	10	220	140	1200	291
15	14	230	144	1300	297
20	19	240	148	1400	302
25	24	250	152	1500	306
30	28	260	155	1600	310
35	32	270	159	1700	313
40	36	280	162	1800	317
45	40	290	165	1900	320
50	44	300	169	2000	322
55	48	320	175	2200	327
60	52	340	181	2400	331
65	56	360	186	2600	335
70	59	380	191	2800	338
75	63	400	196	3000	341
80	66	420	201	3500	346
85	70	440	205	4000	351
90	73	460	210	4500	354
95	76	480	214	5000	357
100	80	500	217	6000	361
110	86	550	226	7000	364
120	92	600	234	8000	367
130	97	650	242	9000	368
140	103	700	248	10000	370
150	108	750	254	15000	375
160	113	800	260	20000	377
170	118	850	265	30000	379
180	123	900	269	40000	380
190	127	950	274	50000	381
200	132	1000	278	75000	382
210	136	1100	285	100000	384

Note.—N is population size and S is sample size.

Source: Krejcie and Morgan (1970)

APPENDIX C

A General Guideline for Conducting Research Interviews

Good day, Sir. I want to thank you for spending your valuable time to meet with me today. My name is Koay Boon Hui, final year student from UMP. I would like to talk to you about your experiences participating in Lean Six Sigma (LSS) program for my final year project.

The expected time for this interview will less than half an hour. I will be voice recording the session if you agree. All responses will be kept confidential. This means that your interview responses will only be shared with research panels. We also will ensure that any information we include in my research don't identify you as the respondent.

May I know your job title?
What are the primary functions does your job involve?

How many years did your company have implemented LSS practices?

How long have you been involved in the LSS program?

What are the practices of LSS implemented in your company for each phases of D, M, A, I, C?
Can you elaborate more?
(Question will be based on the Table 2.3: DMAIC methodology of LSS)

What are the common techniques and tools that are used for each phase of DMAIC?
Value Stream Mapping? Control Chart? JIT?
Please explain more about _______?

What techniques and tools should be discontinued? Why?
Would you explain that further?

What is your opinion on implementation of Lean Six Sigma?
Does your company evaluate the practises of LSS implementation? How do you do it?
Does Lean Six Sigma work well in improving operational performance?

I would now like to move on to a different topic.

What were the challenges or barriers during implementation of Lean Six Sigma, if any, that you encountered?

What did you do then? How did you overcome those challenges or barriers during implementation of Lean Six Sigma?

Is there anything more you would like to highlight for implementing Lean Six Sigma?

After I analyse the information you and others gave me, I will submit a draft report to VAC. If you are interested to review my draft report, I will be happy to send you a copy. Thank you for your time.

APPENDIX D

Garis Panduan Temubual Penyelidikan (Versi Melayu)

Salam Sejahtera, Tuan/Puan. Saya ingin mengucapkan terima kasih kepada Tuan / Puan kerana telah meluangkan masa untuk berbicara dengan saya hari ini.
Nama saya ialah Koay Boon Hui, pelajar UMP tahun tiga. Saya ingin berbicara dengan Tuan/Puan berkaitan dengan pengalaman Tuan/Puan dalam mangambil bahagian Program Lean Six Sigma.

Temubual ini akan mengambil masa Tuan/Puan lebih kurang setengah jam. Saya juga akan buat rakaman audio sebab Saya tidak mahu terlepas apa-apa maklumat penting daripada Tuan/Puan. Walaupun saya akan ambil nota waktu sesi temubual ini, tetapi saya tak dapat mungkin tulis dengan begitu cepat untuk rekod semua maklumat yang Tuan/Puan bagitahu. Saya juga harap Tuan/Puan dapat meninggikan suara Tuan/Puan supaya saya dapat rakam suara Tuan/Puan secara jelas.

Segala maklumat yang diberikan akan dianggap sulit dan dirahsiakan. Ia hanya digunakan untuk kepentingan kajian kerja kursus ini sahaja.

Boleh saya tahu jawatan Tuan/Puan ?
Apakah fungsi utama kerja Tuan/Puan?

Berapa lamakah syarikat Tuan/Puan telah melaksanakan amalan Lean Six Sigma?

Berapa lamakah Tuan/Puan telah melibat diri dalam program Lean Six Sigma ini?

Apakah amalan Lean Six Sigma dilaksanakan di syarikat Tuan/Puan bagi setiap fasa D, M, A, I, C?
Bolehkah Tuan/Puan menerangkan lebih lanjut lagi?
(Soalan seterusnya akan berdasarkan kepada jadual 2.3: metodologi DMAIC daripada LSS)

Apakah teknik umum dan alat-alat yang selalu digunakan dalam syarikat Tuan/Puan untuk setiap fasa DMAIC?

Value Stream Mapping? Control Chart? JIT?

Boleh Tuan/Puan jelaskan lebih lanjut mengenai ___________?

Adakah ada apa-apa teknik dan peralatan LSS yang Tuan/Puan rasa perlu dihentikan? Mengapa?

Boleh Tuan/ Puan menjelas lebih lanjut berkaitan dengan ini?

Apakah pandangan Tuan/Puan mengenai pelaksanaan Lean Six Sigma?

Adakah syarikat Tuan/Puan menilai amalan pelaksanaan LSS? Bagaimana Tuan/Puan melakukannya penilaian ini?

Adakah Lean Six Sigma berkesan dalam meningkatkan prestasi operasi?

Apakah cabaran atau halangan yang Tuan/Puan hadapi semasa pelaksanaan Lean Six Sigma,?

Bantahan daripada pihak pengurusan? Bantahan daripada pekerja? Bantahan terhadap sebarang perubahan? Bajet dan peruntukan masa? Proses pemilihan calon LSS Black Belt? Kekurangan strategi perniagaan yang padu?

Apa tindakan yang Tuan/Puan telah ambil? Bagaimana Tuan/Puan mengatasi cabaran-cabaran dan halangan semasa pelaksanaan LSS?

Adakah Tuan/Puan masih ada sebarang nasihat berkaitan dengan LSS ingin berkongsi dengan lain-lain?

Saya benar-benar gembira kerana Tuan/Puan memberikan saya peluang untuk bertemu dengan Tuan/Puan secara peribadi untuk membincangkan pengalaman berkaitan dengan pelaksanaan LSS. Maklumat yang saya perolehi daripada temubual ini sangat berharga.
Terima kasih, Tuan/Puan.

APPENDIX E

SURVEY QUESTIONNAIRE

FACULTY OF INDUSTRIAL MANAGEMENT

Research Title:

A STUDY OF LEAN SIX SIGMA IMPLEMENTATION ON IMPROVING AUTOMOTIVE OPERATIONAL PERFORMANCE

To managers and employees:

This research purpose is to study the impacts of the Lean Six Sigma (LSS) Implementation on Improving Automotive Operational Performance. Section A asks general profile of the respondents while section B is measuring the impacts of LSS implementation on improving automotive company's operational performance. Information gathered from this survey will be used solely for academic purposes. The data collected regarding your profile will be treated strictly confidential. Therefore, your responses are extremely valuable and appreciate if you could spare a few minutes to fill the questionnaires.

Best Regards,

Koay Boon Hui (Matric No: PC12045)
Bachelor of Industrial Technology Management with Honours
Faculty of Industrial Management
Universiti Malaysia Pahang
Any enquires:
Email: boonhui.koay@gmail.com
Tel: +6012 549 8107

Section A: Respondent Background

Please fill the questionnaires and tick in the appropriate boxes as provided below.

1. Name of company : ______________________________

2. Name of respondent : ______________________________

3. Gender : ☐ Male ☐ Female

4. Age :______________________________

5. Nationality : ☐ Malaysian
   ☐ Non-Malaysian (Please specific):____________

6. Working experience :__________ year(s) working in the company

7. Highest qualification : ☐ Primary School
   ☐ SPM
   ☐ STPM/Diploma
   ☐ Bachelor
   ☐ Master
   ☐ PHD

8. Current department :______________________________

9. Current position : ☐ Manager
   ☐ Employee

Section B: Impacts of Lean Six Sigma toward Operational Performance

Please circle for the appropriate answer for each statement.

No.	Impact Lean Six Sigma toward Operational Performance	Very ineffective	Ineffective	Somewhat ineffective	Somewhat effective	Effective	Very effective
1	Your organization's total production cost reduces relative to competitors after implementation of Lean Six Sigma.	1	2	3	4	5	6
2	Scrap and rework cost is reduced after implementation of Lean Six Sigma.	1	2	3	4	5	6
3	Warranty claims cost is reduced after implementation of Lean Six Sigma.	1	2	3	4	5	6
4	Average of poor quality costs is reduced after implementation of Lean Six Sigma.	1	2	3	4	5	6
5	Inventory turnover is increased after implementation of Lean Six Sigma.	1	2	3	4	5	6
6	There is improvement in finished product first time yield (FTY).	1	2	3	4	5	6
7	Final product failure rate is lower after implementation of Lean Six Sigma.	1	2	3	4	5	6
8	There is a decrement in customer reject rate after implementation of Lean Six Sigma.	1	2	3	4	5	6
9	There is a general improvement in the quality of products relative to competitors after implementation of Lean Six Sigma.	1	2	3	4	5	6
10	The process variance decreases after implementation of Lean Six Sigma.	1	2	3	4	5	6
11	Speed of changing in product design increases after implementation of Lean Six Sigma.	1	2	3	4	5	6

No.	Impact Lean Six Sigma toward OP	Very ineffective	Ineffective	Somewhat ineffective	Somewhat effective	Effective	Very effective
12	Speed of introduction of new products increases after implementation of Lean Six Sigma.	1	2	3	4	5	6
13	Speed of changing in production volume increases after implementation of Lean Six Sigma.	1	2	3	4	5	6
14	Organization has broader variety of products after implementation of Lean Six Sigma	1	2	3	4	5	6
15	There is a reduction in purchasing lead time after implementation of Lean Six Sigma.	1	2	3	4	5	6
16	There is a reduction in manufacturing lead time after implementation of Lean Six Sigma.	1	2	3	4	5	6
17	Delivery of end-product to customer is fully on time after implementation of Lean Six Sigma.	1	2	3	4	5	6
18	There is an increment of reliability in timely deliveries after implementation of Lean Six Sigma.	1	2	3	4	5	6
19	Management is satisfied with improving employee productivity after implementation of Lean Six Sigma.	1	2	3	4	5	6
20	There is an increase in overall equipment effectiveness (OEE) after implementation of Lean Six Sigma.	1	2	3	4	5	6
21	There is a reduction in machine changeover time (C/O) after implementation of Lean Six Sigma.	1	2	3	4	5	6

END OF QUESTIONNAIRES & THANKS FOR YOUR COOPERATION!!

APPENDIX F

BORANG SOAL SELIDIK (VERSI MELAYU)

FAKULTI PENGURUSAN INDUSTRI

Tajuk Kajian:
PENYELIDIKAN BERKAITAN PELAKSANAAN LEAN SIX SIGMA TERHADAP PENINGKATAN PRESTASI OPERASI AUTOMOTIF

Kepada pengurus dan pekerja:

Kajian ini adalah untuk mengkaji tentang kesan perlaksanaan Lean Six Sigma (LSS) terhadap peningkatan prestasi operasi automotif (OP). Bahagian A merupakan data ciri-ciri demografi yang mengandungi soalan profail peribadi responden manakala Bahagian B adalah untuk mengkaji tentang kesan perlaksanaan Lean Six Sigma (LSS) terhadap prestasi operasi automotif. Segala maklumat yang diberikan akan disimpan secara sulit dan rahsia. Ia hanya digunakan untuk kepentingan kajian kerja kursus ini sahaja. Kerjasama anda meluangkan masa untuk mengisi borang soal selidik ini amatlah dihargai.

Yang benar,
Koay Boon Hui (No. Matrik: PC12045)
Sarjana Muda Pengurusan Teknologi Industri dengan Kepujian
Fakulti Pengurusan Industri
Universiti Malaysia Pahang
Jika terdapat sebarang pertanyaan, sila hubungi:
Email: boonhui.koay@gmail.com

Tel: +6012 549 8107

Bahagian A: Data Demografi Responden

Arahan: Sila isi borang soal selidik ini dan tandakan (√) pada ruangan yang disediakan

1. Nama Syarikat : ____

2. Nama Responden : ____

3. Jantina : ☐ Lelaki ☐ Perempuan

4. Umur : ____

5. Warganegara : ☐ Warganegara
   ☐ Bukan Warganegara (Sila nyatakan):____________

6. Pengalaman pekerjaan :__________ tahun bekerja dalam syarikat ini

7. Tahap pendidikan : ☐ Sekolah rendah
   ☐ SPM
   ☐ STPM/Diploma
   ☐ Sarjana Muda
   ☐ Master
   ☐ PHD

8. Jabatan bertugas :______________________________

9. Jawatan semasa : ☐ Pengurus
   ☐ Pekerja

Bahagian B: Kesan Perlaksanaan Lean Six Sigma (LSS) kepada Prestasi Operasi

Sila bulatkan tahap persetujuan anda bagi kenyataan-kenyataan berikut

No.	Kesan Perlaksanaan Lean Six Sigma kepada Prestasi Operasi	Sangat tidak berkesan	Tidak berkesan	Agak tidak berkesan	Agak berkesan	Berkesan	Sangat berkesan
1	Jumlah kos pengeluaran organisasi anda berjaya dikurangkan berbanding dengan pesaing selepas perlaksanaan Lean Six Sigma.	1	2	3	4	5	6
2	Kos sekerap dan kerja buat semula dikurangkan selepas perlaksanaan Lean Six Sigma.	1	2	3	4	5	6
3	Kos tuntutan jaminan dikurangkan selepas perlaksanaan Lean Six Sigma.	1	2	3	4	5	6
4	Purata kos kualiti rendah dikurangkan selepas perlaksanaan Lean Six Sigma.	1	2	3	4	5	6
5	Pusing ganti inventori meningkat selepas perlaksanaan Lean Six Sigma.	1	2	3	4	5	6
6	Terdapat peningkatan dalam pelepasan produk akhir selepas penghasilan pertama kali.	1	2	3	4	5	6
7	Kadar kegagalan produk akhir adalah lebih rendah selepas perlaksanaan Lean Six Sigma.	1	2	3	4	5	6
8	Terdapat penyusutan dalam kadar penolakan daripada pelanggan selepas perlaksanaan Lean Six Sigma.	1	2	3	4	5	6
9	Terdapat peningkatan umum dalam kualiti produk berbanding dengan pesaing selepas perlaksanaan Lean Six Sigma.	1	2	3	4	5	6
10	Varians yang dihasilkan dari proses berkurangan selepas perlaksanaan Lean Six Sigma.	1	2	3	4	5	6
11	Kelajuan perubahan dalam reka bentuk produk meningkat selepas perlaksanaan Lean Six Sigma.	1	2	3	4	5	6

No.	Kesan Pelaksanaan Lean Six Sigma kepada Prestasi Operasi	Sangat tidak berkesan	Tidak berkesan	Agar tidak berkesan	Agar berkesan	Berkesan	Sangat berkesan
12	Kelajuan pengenalan produk baru meningkat selepas perlaksanaan Lean Six Sigma.	1	2	3	4	5	6
13	Kelajuan perubahan dalam jumlah pengeluaran meningkat selepas perlaksanaan Lean Six Sigma.	1	2	3	4	5	6
14	Organisasi mempunyai kepelbagaian jenis produk selepas perlaksanaan Lean Six Sigma.	1	2	3	4	5	6
15	Terdapat pengurangan dalam pemborosan waktu tunggu dalam pembelian selepas perlaksanaan Lean Six Sigma.	1	2	3	4	5	6
16	Terdapat pengurangan dalam pemborosan waktu tunggu pada pembuatan selepas perlaksanaan Lean Six Sigma.	1	2	3	4	5	6
17	Penghantaran produk akhir kepada pelanggan adalah tepat pada masa selepas perlaksanaan Lean Six Sigma.	1	2	3	4	5	6
18	Terdapat peningkatan keyakinan dalam kebolehpercayaan penghantaran tepat pada masanya selepas perlaksanaan Lean Six Sigma.	1	2	3	4	5	6
19	Pengurusan berpuas hati dengan peningkatan produktiviti pekerja selepas perlaksanaan Lean Six Sigma.	1	2	3	4	5	6
20	Terdapat peningkatan dalam keberkesanan peralatan keseluruhan (OEE) selepas perlaksanaan Lean Six Sigma.	1	2	3	4	5	6
21	Terdapat pengurangan dalam masa pertukaran di mesin (C/O) selepas perlaksanaan Lean Six Sigma.	1	2	3	4	5	6

SOAL SELIDIK TAMAT & TERIMA KASIH DI ATAS KERJASAMA ANDA!!

APPENDIX G

Reliability Analysis for Real Test

Those completed questionnaires were used to conduct the reliability analysis again for real test. This analysis purpose is to ensure the consistency of collected data. The Cronbach's alpha value should reach more than 0.50 to be considered as reliable and acceptable.

Table for Reliability of Questionnaires (Real Test)

Operational performance (OP) variables	Cronbach's Alpha	Number of Items (N)	Items Deleted
Cost and Waste Reduction (OPC)	0.873	5	0
Quality (OPQ)	0.890	5	0
Flexibility (OPF)	0.840	4	0
Delivery (OPD)	0.818	4	
Productivity (OPP)	0.783	3	0

Table above shows the result of reliability for questionnaires on real data. There are total of 21 items in the questionnaires. The result shows that Quality (OPQ) having the highest Cronbach's alpha values which 0.890, followed by for Cost and Waste Reduction (OPC) which is 0.873, and then, Flexibility (OPF) with value 0.840. While, Cronbach's alpha values for Delivery (OPD) is 0.818. The variable that has lowest Cronbach's alpha value is Productivity (OPP), which is only 0.783.

From the table, it is concluded that the Cronbach's alpha values of all variables are in acceptable level, which are ranging from 0.783 to 0.890. Since all the Cronbach's alpha values gained are above 0.70, which indicate the high consistency and reliability of the questionnaire data. Thus, no items needed to delete from the questionnaires.