The influence of lean six sigma and Kaizen to reduce defect products in automotive industry

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ABSTRACT

The purpose of this study is to measure the influence of Lean Six Sigma (LSS) and Continuous Improvement (KAIZEN) to reduce the defect products in practising Quality Management System (QMS) for the automotive industry. Data were obtained from questionnaires which has been returned from 78 respondents among production operators in assembly section. The data has been analyzed using the Statistical Package for the Social Sciences (SPSS). Result shown that Lean Six Sigma (LSS) and Continuous Improvement (KAIZEN) have positive influence for solving the problem of defect products. The findings of this study will help the industry for giving serious enforcement and attention for these two methods in reducing the defect products thus will reduce the scrap management cost. This study contributes to the advancement of knowledge on methods to reduce defect products for automotive industry.

1. Introduction

Over the years, the automotive industry has been continuously despoiled by the continuous recall of vehicles because of manufacturing defects. The recall of automotives by manufacturers has been attributed to one form of "defect" or another, vehicle recalls can pose a serious problem for manufacturers (Kumar & Schmitz, 2011). The defects issue in any production activities will contribute to the waste problem thus occurring the undesired additional cost. It can come in all shapes and sizes. This problem can significantly affect the company performance and profitability. According to Ohno (1987), waste could be classified into seven categories. The seven categories of wastes are over production, waiting, transportation, inappropriate processing, unnecessary inventory, unnecessary motions, and defects (Monden, 2012). Thus, defect products are wastes in the company. In manufacturing firms, it is common to the company to be faced by the problems of defect products. However, it is important to the company to find the best solutions to minimize the number of defect products as it can decrease the loss. There are

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two methods in Quality Management System that can be applied in solving the issue of defect products in manufacturing. Lean Six Sigma (LSS) deploys data and statistical analysis to expose the root cause of variation that results in inadequate process outputs. In addition, Continuous Improvement (KAIZEN) can be defined as a process of incremental, focused and continuous innovation, involving the entire organisation (Bessant, Caffyn, Gilbert, Harding & Webb, 1994). Thus, the methods to reduce defect products utilized in this study are Lean Six Sigma (LSS) and Continuous Improvement (KAIZEN). This study is important to understand more about the ways to reduce product defects in the production process among automotive manufacturers. From managerial perspectives this study will provide insight why a proper consideration should be applied in deciding the factors that need to be adopted in achieving ways to reduce product defects.

1.1 Defect products

Slack, Chambers and Johnston (2013) justified that quality defects increase service, inspection/test, warranty, rework, and scrap costs as well as inventory and processing time. Defective parts require rework, this can increase the levels of work in progress inventories (Hoerl & Gardner, 2010). It shows that defects can affect company profitability which had to bear the losses and pay for costs involved. Producing defective products is another type of the waste which increases expenses and interrupts the flow of production. Sui and Wee (2001) justified complete lot could be rejected due to poor quality of the products, the costs of which are much higher and need to be eliminated. Thus, defect products can incur high cost for rework and repair. The company should find the best solutions to reduce the defect products to produce high quality products and achieve customer satisfaction.

1.2 Lean six sigma (LSS)

LSS is recognized as "a business strategy and methodology that increases process performance resulting in enhanced customer satisfaction and improved bottom line results" (Snee, 2010). Meanwhile, Johnstone, Pairaudeau and Pettersson (2011) defined LSS is a well-established methodology for improving the speed, quality and cost of manufacturing and service industries. According to Burch, Strawderman and Bullington (2016) LSS is an approach that focuses on improving the quality of finished products and continuous improvement during the creation of these products by reducing variation and eliminating nonvalue-add work within an organisation. Furterer (2012) stated that LSS is an approach focused on improving quality, reducing variation and eliminating waste in an organisation. It is the combining of two improvement programs, Six Sigma and Lean Enterprise. Whereas, according to Cournoyer, Nobile, Williams, Monsalve-Jones, Renner, and George (2013), LSS program is a customer-focused, systematic approach based on utilizing data to manage and improve process performance quality. Hence, the definition of LSS focusses on cost reduction through waste minimisation.

⌐ Eliminate waste

Eliminate waste is one of the dimensions in LSS. Besides that, the objective of lean practice is to ensure the smooth manufacturing flow by upgrading productivity to the level of quality products, utilisation of production labor, reduced delivery time and effective manufacturing cost through continuous improvement process. Consequently, it helps organisations to improve the targeted performance and to gain benefit from the environment. The elimination of waste can bring good impact towards an organisation in achieving target and profitability. Moreover, lean manufacturing can eliminate waste in production. Lean manufacturing monitors production to reduce overproduction. It also avoids depletion of stock by monitoring inventory for low stock numbers. Furthermore, lean manufacturing system can eliminate waste through monitoring and identifying what specific processes are needed in the line (Womack & Jones, 1994). It also finds proper solutions to the problem through automation processes,

which decrease the need for underutilised people. Then, the motion of the manufacturing line must be streamlined and improved to cut down time and energy for more production.

〕 *Improve quality*

It is critical to the success of business to provide customers with a quality product especially when manufacturing a quality product, all participation of the organisation must ensure profits and sales continually improve as gain a competitive advantage in the industry. Quality creates customer loyalty and repeat business and satisfied customers are likely to delight the product quality of others. However, quality control is easily lost in the attempt to gain the customer preferences while minimizing manufacturing costs for profit maximization. Without quality control procedures, all organisations could face product recalls or safety hazards that lead to expensive liability. According to Koskela, Bølviken and Rooke (2013), increase output value and build continuous improvement into the process can improve quality. The manufacturing with output value can achieve customer satisfaction and receive high demand of products from customers. Besides that, every organisation must build continuous improvement into the process to ensure the products produced are high quality. Continuous improvements in the process is also important in ensuring the elimination of defect products by improving the quality through immediate actions. Thus, improve quality is one of the factor in achieving LSS.

〕 *Increase speed*

Increase Speed Manufacturing efficiency improvements deliver something else, something that is less obvious, yet just as important. Eliminate wastes and inefficiencies, and manufacturing processes speed up because less time is spent on manufacturing scrap, or on over-production, or operating slowly, or spending excessive amounts of time on things such as setups. Increase speed in manufacturing also using lean manufacturing. According to Shah and Ward (2003), lean results in improvement of lead times, quality levels, labor productivity, inventory levels, and manufacturing costs. As a result, lean production has proven highly successful in elevating overall performance of manufacturing organisations (Vinodh, Kumar & Vimal, 2014). It shows that increase speed through reducing lead times can help an organisation produce finish products within given time and achieve customer satisfaction. The organisations must also improve inventory levels by increasing the speed.

1.2 Continuous improvement (KAIZEN)

Kaizen (Kai – do, change, Zen – well) is a kind of thinking and management, it is a philosophy being used not only in management field, but also in the everyday life in Japan. It means gradual and continuous progress, increase of value, intensification, and improvement (Karkoszka & Szewieczek, 2007). The continuous improvement is characterised by incremental actions of step, which when viewed in isolation bring little return to the organisation. This way, the continuous improvement programme requires a large participation of employees to achieve a significant performance in the organisation (Wu & Chen, 2006; Upton & McAfee, 1996).

〕 *Employee commitment*

Baird, Jia Hu, and Reeve (2011) found that an organisation's culture which is emphasizing teamwork and respect for people, was associated with the use of several TQM practices, such as quality data and reporting, supplier quality and management and product/service design. In addition, to management support, an important construct underlying successful TQM implementations is employee involvement (Ahire, Golhar, & Wallerdone, 1996). He considered four contextual factors underlying employee commitment to participation: explicitness of performance target, revocability of actions, consequent

publicity, and ownership of actions. Besides that, one effort that managers must make for human resources is to develop and use different effective managerial skills to build better relationships between them and the other employees. The commitment in fact grows when employees positively develop a sense of belonging towards the company, which makes them feel more interested in achieving specific objectives for the success and wellbeing of the organisation (Han & Kamber, 2000). Thus, employee commitment is important to achieve continuous improvement in an organisation.

⟩ *Management support*

Management Support One of the key factors often cited in the literature as essential to a successful quality management program is top management support (Kathuria, Porth, Kathuria & Kohli, 2010). The support of an organisation's leadership team is usually cited as the number one factor for the success of a continuous improvement initiative. Leaders must exhibit behaviour that not only demonstrate support for the initiative, but also the behaviour that they wish all employees to emulate. This ultimately comes down to guidance and the support within the organisation to make the change. If there is no adequate support for a continuous improvement programme to be implemented, then the team charged with implementing it will be operating on what will be, in effect, a series of isolated efforts. Thus, management support is important in achieving continuous improvement.

2. Method

This study applied a conclusive research because it is much more formal and structured compared to the exploratory research. The objective of using conclusive research is to test the research hypothesis and to identify the methods to reduce the defect products. Conclusive research can be classified into descriptive research and causal research (Sekaran & Bougie, 2013). This study used causal research as the main goal is to identify the cause and effect relationship between variables. Thus, the purpose of the study is causal research or hypothesis testing. This research intends to recognise what are the methods to reduce defect products. Causal design is used as a type of investigation because this research is to measure methods to reduce defect products by practising Lean Six Sigma (LSS) and Continuous Improvement (KAIZEN).

Other than that, this study is conducted with minimal deliberately changes of certain variables in the setting and interferences with the events as they normally occur in the organisation. This study setting is non-contrived setting because it carried out in the natural environment where work proceeds normally. In this study, unit analyses used are the individuals. The sample size use in this study is about 100 which consists of employees from production department in assembly section from a company which is categorized as an automotive industry. The sampling procedure used for this study was the probability sampling. However, only 78 respondents returned the questionnaire. The research wants to investigate on the methods to reduce defect products in automotive industry and the individual employees are chosen as respondents to this study to find out their knowledge about the methods to reduce defect products. Each employee of the organisation may have different views and opinions. The time horizons used are cross sectional studies or one shot.
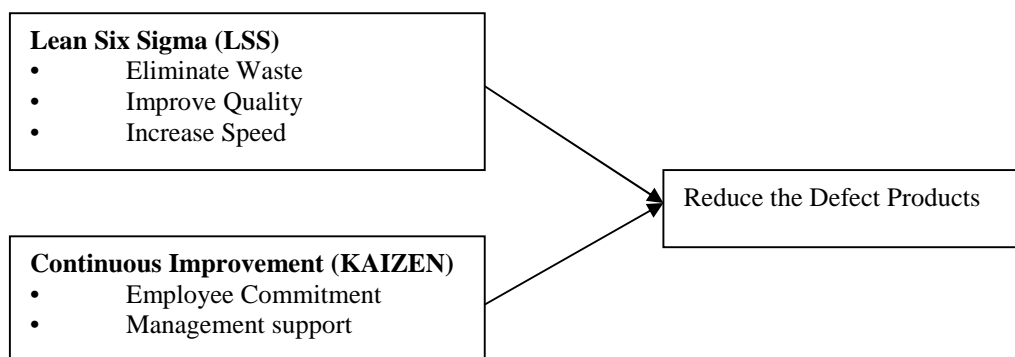
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┌─────────────────────────────────┐
│ Lean Six Sigma (LSS)            │
│   •        Eliminate Waste      │
│   •        Improve Quality      │
│   •        Increase Speed       │
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                                        ┌──────────────────────────────┐
                                        │ Reduce the Defect Products   │
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┌─────────────────────────────────┐
│ Continuous Improvement (KAIZEN) │
│   •        Employee Commitment  │
│   •        Management support   │
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Fig. 1. Research framework

3. Results and Analysis

From Table 1, it shows that the operators contributed more in participating in this survey as compared to others. This is shown by the questionnaire answered by all the 78 respondents namely a manager (1.3 percent), two supervisors and engineers respectively (2.6 percent), three leaders, staffs and technicians respectively (3.8 percent), five super control (6.4) and 59 operators (75.6 percent). It also shows that more female respondents involved which represents the distribution at a frequency of 68 (87.2 percent) compared to male respondents only 10 respondents (12.8 percent). It is shown that the most respondents are in between age of 31-40 years old which is frequency of 28 (35.9 percent) followed by respondents in age of 41-50 years old (30.8 percent), 20-30 years old (25.6 percent) and from age of 51-60 years old (7.7 percent) over the 78 respondents involved.

Table 1. Profile of respondents

Demographic	Categories	Frequency	Percentage
Job Title	Manager	1	1.3
	Supervisor	2	2.6
	Leader	3	3.8
	Staff	3	3.8
	Engineer	2	2.6
	Technician	3	3.8
	Super Control	5	6.4
	Operator	59	75.6
Gender	Male	10	12.8
	Female	68	87.2
Age	20-30 years old	20	25.6
	31-40 years old	28	35.9
	41-50 years old	24	30.8
	51-60 years old	6	7.7
Working Experience	Less than 2 years	1	1.3
	2-5 years	23	29.5
	6-10 years	21	26.9
	More than 10 years	33	42.3
Race	Malay	54	69.2
	Indian	24	30.8

The respondents who have answered this survey have been in the job for more than 10 years which represents the distribution of 33 workers (42.3 percent), whereas, for 2 to 5 years is 23 (29.5 percent), for 6 to 10 years represents 21 (26.9 percent) of the number of distribution. Thus, the minority respondents that took part in this survey are those who have been in the job for less than two years with only one respondent (1.3 percent). The majority respondents are Malay who have answered this survey that represent 54 respondents (69.2 percent) and the rest of the respondents are Indian that represent 24 respondents (30.8 percent).

Reliability analysis is conducted to measure the goodness of the data. The Cronbach's Alpha is a reliability coefficient that indicates how well the items in a set are positively correlated to one another. Cronbach's Alpha is computed in terms of the average intercorrelations among the items measuring the concept. The closer Cronbach's Alpha is to 1, the higher the internal consistency reliability. EA relatively high internal consistency of reliability analysis must have a reading of Cronbach's Alpha that is more than 0.80. Thus, it is shown that all the variables have a result of 'good' because more than 0.8 which are 0.948, 0.955 and including the methods to reduce defect products also have high internal consistency of reliability with 0.925. Therefore, the entire items are fit to be used to measure the variables

Table 2. Reliability analysis

Variable	Items	Cronbach Alpha
Lean Six Sigma (LSS)	12	0.98
Continuous Improvement (KAIZEN)	9	0.955
Reduce Defect Products (RDP)	4	0.925

A Pearson Correlation Analysis will indicate the direction, strength and significance of the bivariate relationships among all the variables that were measured at an interval or ratio level (Sekaran & Bougie, 2013). Therefore, the output confirms that a significant positive relationship exists between methods to reduce defect products and all methods variables which are LSS and KAIZEN with the result of 0.719 ($p < 0.01$) and 0.727 ($p < 0.01$) respectively. Thus, the correlation indicates that all of the variables are the factors that have relationship with the methods to reduce defect products in automotive industry.

Table 3. Correlations analysis

Variable	LSS	KAIZEN	RDP
LSS	1		
KAIZEN	.880**	1	
RDP	.719**	.727**	1

** Correlation is significant at the 0.01 level (2-tailed)

Multiple Regression Analysis provides a means of objectively assessing the degree and the character of the relationship between the independent variables and the dependent variable: the regression coefficients indicate the relative importance of each of the independent variables in the prediction of the dependent variable (Sekaran & Bougie, 2013).

Table 4. Regression between LSS, KAIZEN and defect products

		Model Summary			
Model	R	R Square	Adjusted R Square		Std Error of the Estimate
1	.746a	.556	.545		.49665

a. Predictors: (Constant), CIK, LSS

b. Dependent Variable: DFP

Table 4 shows that the R is 0.746 which means there is high linear relationship between the two independent variables and the dependent variable which is methods to reduce defect products. R-Squared (coefficient of determination) provides information about the goodness of fit of the regression model. In this case, the R2 for the model is 0.556. This means that 55.6% of the variation in the dependent variable (methods to reduce defect products) is explained by the variation in the independent variables which are Lean Six Sigma (LSS) and Continuous Improvement (CIK). It also shows that the value of Lean Six Sigma and Continuous Improvement can predict the value of the dependent variable (methods to reduce defect products) by 55.6%. Meanwhile, another 44.4% of the variance in the dependent variable is not explained by the independent variables in this study. This indicates that there are other independent variables which are not included in this study and could further strengthen the regression equation. Finally, overall findings are summarized as below:

Hypothesis 1:
There is a positive influence of Lean Six Sigma (LSS) for solving the defect products. - Accepted

Hypothesis 2:
There is a positive influence of continuous improvement (KAIZEN) for solving the defect products. - Accepted

4. Conclusion

This study aims is to determine the methods to reduce defect products by evaluating the implementation of Lean Six Sigma (LSS) and continuous improvement (KAIZEN) in automotive industry in Malaysia. The reviewed of past literatures and theories that are related to this study has been discussed in literature review part. This intention is to bring forward the values and the analytical tools that have been used by past researchers, which can be adopted in this research study. Data for the study were collected from a sample of 78 respondents which consisted of employees from production department in assembly section of a company categorised as automotive industry. The research model was tested using SPSS. Based on reliability testing, all the variables have a result of 'good' because more than 0.8 which are 0.948, 0.955 and including the methods to reduce defect products also have high internal consistency of reliability with 0.925. Therefore, the entire items are fit to use to measure the variables. For correlation analysis, the output confirms that a significant positive relationship exists between methods to reduce defect products and all methods variables which are LSS and KAIZEN with the result of 0.719 (p < 0.01) and 0.727 (p < 0.01) respectively. Thus, the correlation indicates that all variables are the factors that have relationship with the methods to reduce defect products in automotive industry. Finally, the result of this study shows that LSS and KAIZEN have the positive relationships to reduce the defect products for Malaysian automotive industry. In other words, there is positive progress in adopting and practising LSS

and KAIZEN implementation so as to reduce product defects. These have been proven through the two hypotheses tested in this study. The hypotheses were to test for the significant difference on methods to reduce defect products. The findings of this study were also supported by Fadly and Mohd Yusof (2013) and Vieira, Balbinotti, Varasquin, and Gontijo (2012) found that by implementing LSS and KAIZEN improvement in business operation and organisational performance is possible.

5. Recommendations

For future recommendation, the main reason is to encourage more researchers to get involved in investigation of various academic fields especially in manufacturing industry. Firstly, this survey is based only on the automotive industry in Malaysia, and therefore it is not generalizable to other industries. It is to recommend this study to be conducted in other manufacturing industry to gain more knowledge about the right way to associate well the methods to reduce defect products. Secondly, the finding from this study is based on limited and short period of observations. Thus, it is recommended to other researchers to increase the range of the period study should be carried out for a longer duration than this study so that the results become more significant, then, the researcher also can use the data or the sample from other countries to conduct comparison study. Finally, it is recommended to study the structural relationship between LSS and organisational performance in automotive industry in Malaysia.

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