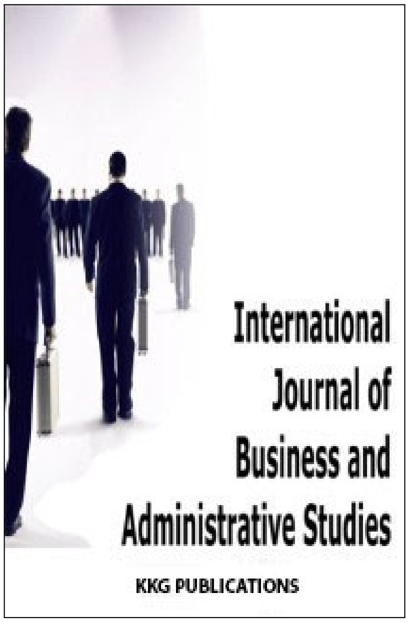

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KAIZEN EVENT ASSESSMENT THROUGH PERFORMANCE AND ECONOMIC INVESTMENT ANALYSIS

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Abstract. Kaizen event is about implementing structured continuous improvement projects, using a dedicated cross-functional team to improve a targeted work area, process or product. Usually, it is executed within an accelerated timeframe by applying proven process tools and human creativity to improve the overall performance. Thus, this paper shows the enhancement a company has experienced with the implementation of kaizen events in one of its production areas. The main aim is to share how assessment methodologies were systematically conducted on the areas that should be empirically measured and evaluated to maximize the impact of kaizen events on the overall performance. All the measurements, techniques, and methods were described clearly, thus underlining its potential benefits and pitfalls. The case proposed refers to a manufacturing components company for the automotive industry in Malaysia. This case study evaluates one particular event of many events done by the company every day. Through performance analysis, results were measured and analyzed by comparing the lean metrics such as productivity, quality, space, cycle time, and setup time reduction between the existing against the improved area. Findings show that the company managed to reduce its operational cost and production lead time significantly. As for the cost saving analysis assessment, a total of RM 31,661.22 per year of saving is targeted to be achieved through the long-term commitment from the kaizen team and top management. On the other hand, the economic analysis shows that the investment made for this event is viable and less risky to be implemented in other production areas or other manufacturing disciplines.

INTRODUCTION

Lean Manufacturing (LM) is a team-based approach towards identifying and eliminating wastes in terms of non-value-added activities such as waiting, inventory, transportation, and others, through continuous improvement for the product flow. It is a generic process management philosophy in the Japanese manufacturing industry which originated from the TPS and later identified as "Lean" in the 1990s (Sahoo, Singh, Shankar & Tiwari, 2008).

Nowadays, LM is well-known as an effective technique towards cost saving and maintaining stability with the help of a set of powerful tools such as Kanban, Kaizen, Single Minute Exchange of Dies (SMED), Total Productive Maintenance (TPM) and others (Sahoo et al., 2008). However, among these tools, Kaizen can be considered as one of the main tools in achieving the LM's objectives. This is because Kaizen is promoting continuous improvement and focusing on waste elimination in any process or system.

The term Kaizen is often coupled with another word to create the phrase "Kaizen events". Kaizen event is about the implementation of structured continuous improvement projects, using a dedicated cross-functional team to improve a targeted work area, process or product. Usually, it is executed within an accelerated time frame by applying proven process tools and human creativity with a goal of improving the overall performance of the work area, process or product.

As a part of Kaizen event activity, performance analysis is usually conducted to close the loop of the Kaizen cycle. It is an activity of evaluating the performance of an improved system after Kaizen took place.

According to Flynn and Flynn, 2004, performance analysis should be measured in the form of company's performance. Parameters that are commonly applied are production cost per piece, quality, flexibility, availability, productivity and manufacturing cost (Awad & Shanshal, 2017; Glover, Farris, & Van Aken, 2015; Smalley, 2004). By referring to Plan-Do-Check-Act (PDCA) cycle or also known as Deming's Cycle, this activity is at the third stage, which is Check before proceed with the Act stage.

The reduction in manufacturing cost is the primary mission of many companies to remain competitive in the market demand and to gain more profits. Many methods have been suggested to reduce manufacturing cost.

However, the methods that are to be applied depend on the types of system or process to be improved. For example, a

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study has been done by Ho, Chu and Mok (2005) to minimize the manufacturing cost of thin injection plastic components. The cost reduction activities were conducted on the part design process, mould making and moulding process, thus improved the company's cash flow. Another example is the study by Pavlovcic, Krajnc, and Berg (2004), where the reduction of manufacturing cost of planner frames process was achieved by optimizing the existing manufacturing process.

As in actual practice, the manufacturing cost can be calculated in many ways depending on how the company defines the cost and how they want to control their system. According to Jung (2002), the manufacturing cost is defined as the total of fixed cost and variable cost. The variable costs such as labour cost, machine cost, material cost and overhead cost are volume-related, which vary depending on the level of product or service produced. The fixed cost such as rent, utility bills, and management salary is defined as time-related, which does not change as a function of the activity of a business within the relevant period.

This paper focuses on the method of evaluating the performance of an improved process after Kaizen events took place. A set of LM tools namely Material and Information Flow Chart (MIFC), Single Minute Exchange of Dies, Standardized Work (SW), Continuous Flow Manufacturing System (CFMS) and 5S were applied to assist the implementation of Kaizen activities, such as setup time reduction, line balancing, re-layout and improvement of material supplying system within the process. Results were measured and analysed by comparing the lean metrics, such as productivity, quality, and space, cycle time and setup time reduction between the existing against the improved area. On the other hand, the economic analysis was also conducted to show that the investment made for this event is viable and has less risk to be implemented in other production areas or other manufacturing disciplines (Liu, Asio, Cross, Glover, & Van Aken, 2015; Phyoe, 2015).

The case study subject is a local auto-component manufacturing company in Malaysia. The focus area is at an assembly line, producing auto-component by the semi-manual process. The main internal problems they were facing were high set-up time, inconsistent line productivity, high operator overtime, and poor quality products. In order to increase profit and reduce operational cost as well as to overcome the problems, the management had decided to improve their production process by implementing LM at their production system.

METHODS OF PERFORMANCE ANALYSIS

Productivity

Many companies seek for productivity improvement with the main objectives to reduce manufacturing cost and optimize the effectiveness of capital investment (Sakamoto, 2010). In the manufacturing area, productivity can be measured as follows:

$$\text{Produtivity} = \frac{\text{Unit produced (Output)}}{\text{Recources used (Input)}}$$

However, in this research, productivity is measured based on the output per man hour.

Cost Saving

Cost saving on the manufacturing cost is calculated based on manufacturing time and material cost. The manufacturing time is composed of set-up time, operation time and non-operation time. On the other hand, the material cost includes the cost of raw materials or components from external suppliers. The manufacturing cost can be calculated as follows:

$$\text{Manufacturing Cost=(Operator's rate+Machine rate)}\left(\left(\frac{\text{Set-up time}}{\text{Batch size}}\right)\text{Total operation time+ Total non-operation time}\right)\text{+ Material cost+ Factory expenses}$$

Operator's rate is a direct labour cost of a factory, machine rate is an amortized cost of the lifetime of the machine and total non-operation time is the loading time added to the tool engaging time and operator's allowances.

Economic Investment Analysis

Economic investment analysis is conducted to provide valuable feedback for investment that has been made. It highlights the effectiveness and efficiency of the activities associated with the given investment budget. It also shows the risk level of the investment to the company. In this research, two methods have been applied which are Return on Investment (ROI) and Payback Period (PP).

The ROI or also known as Rate of Return (ROR) is the ratio of money gained or lost on the cost investment made. It is expressed as a percentage. While the PP refers to the period of time required for the return on an investment to recover the sum of the original investment that has been made. To calculate the ROI and the PP, the following formulas used by Myint, 2007 are considered:

$$\text{ROI} = \frac{\text{Total cost saving per year-Total cost of investment-Annual mantainance cost}}{\text{Total cost of investment}\times 100\%}$$

$$\text{PP} = \frac{\text{Total cost of investment}}{\text{Total cost saving per year-Annual mantainance cost}}$$

THE METHODOLOGY OF MEASUREMENT

Step 1: Debugging Process

Before performing the evaluation process, cell debugging process should be carried out to closely monitor the stability of the improved process within a period of time. It is also to validate whether the process has achieved the target exactly as what has been set in the early stages. Usually, three-month monitoring is carried up continuously every day until the management is fully satisfied with the performance of the line and achieves the targeted results. Along the process, any abnormal conditions such as shortage of materials, bottleneck, and the others were immediately reviewed, analysed and corrected. As a rule of thumb, once the problem was identified, immediate action must be taken to eliminate it with short-term countermeasures to avoid minor or major stoppages. Then the root causes were identified through detail analysis and observation. Lastly, the corrected actions were monitored again to ensure the effectiveness of the actions taken and stability of the line. From the last day of observation, it is noted that most of the targets for the checkpoints were achieved. This proved that stability of the improved case study area has been attained.

Step 2: Evaluation by using Lean Metrics

Evaluation of the final results was carried out by comparing the metrics between existing, target from future MIFC and final achievements, as shown in table 1 for the Cell Kaizen Target Sheet (CKTS). It can be concluded that all the metrics were improved with most of them exceeding the target value.

TABLE 1
Completed Cell Kaizen Target Sheet

Cell Kaizen Target Sheet (CKTS)					
Metrics	**Note**	**Existing**	**Target from future MIFC**	**Final Achievement**	**Final Achievement**
Lead time (day)	Total	3.23	0.544	0.533	83.50% Decreased
Quality (RM)	Total reject cost components (Average)	RM 156	RM 0.00	RM 0.00	100% Improved
Line cycle time (second)	Manual + auto time	80.7	69.2	66.5	17.60% Decreased
Set-up time (minute)	Downtime from last good piece to first good piece	40	10	6.03	84.93% Decreased
Breakdown time (hour)	Total hour/ month (Average)	4.1	0.00	0.00	100% Improved
Continuous flow manufacturing system	Make one move one	No	Yes	Yes	100% Improved
Shop floor area (ft^2)	Size of the improved area	22	15	18	18.18% Decreased

Step 3: Performance Analysis via Line Productivity

After three months of monitoring the line, the result obtained has been compared with the existing productivity to evaluate performance. It is shown in table 2.

TABLE 2
Line Productivity Comparison

Average productivity (pieces/ man hour)			
Model	**Existing**	**Improved**	**Increasing (%)**
D55D	45.1	53	17.52%

The result shows significant improvement in the productivity. With this new capacity, it will lead to a significant reduction in the product cost hence; it will also help in reducing total factory cost of the product.

Step 4: Performance Analysis Cost Saving

Cost saving analysis was conducted to measure factory cost reduction based on changes that were identified in the improved process. The calculations are based on one-year production output. All the necessary information for the calculations is collected from the company's systems which are Bill of Material (BOM) and Production Control System (PCS).

Cost Saving from Reduction of Total Factory Cost

The company defines its total factory cost as:

$$\text{Total Factory Cost} = \text{Total operation cost} + \text{Tooling cost} + \text{Reject cost}$$

For the operation cost, it is calculated as:

$$\text{Total Operation Cost= Machine cost+ Labour cost+Material cost+ Overhead cost}$$

In this case, the machine cost is zero because the machines had to exceed the amortization volumes given by the company. As for the labour cost, it is measured as below for before Kaizen condition.

$$\text{Labour Cost (RM)= Total worker}\times\frac{\text{Labour rate per hour}}{\text{Production rate per hour}} = 2.45 \times \frac{\text{RM9.30}}{45} = \text{RM0.51 per piece}$$

TABLE 3
Labour Cost Comparison

	Total labor cost/ piece		Cost reduction
Model	**Existing**	**Improved**	**(Existing Improved)**
D55D	RM 0.51	RM 0.42	RM 0.09/ piece

With a number of workers of 2.45, which denotes 2 operators at the line and 0.45 for the material handler, labour rate is RM 9.30. From table 3.0, it shows that the labour cost is reduced because it is proportional to the production output.

$$\text{Overhead Cost (RM)=}\frac{\text{Overhead rate per hour}}{\text{Production rate per hour}} = \frac{\text{RM30.0}}{45} = \text{RM0.67 per peice}$$

TABLE 4
Overhead Cost Comparison

	Total overhead cost/ piece		Cost reduction
Model	**Existing**	**Improved**	**(Existing Improved)**
D55D	RM 0.67/ piece	RM 0.56/ piece	RM 0.11/ piece

With company's overhead rate of RM 30.00 and production rate per hour of 45 pieces, the overhead cost is reduced by RM 0.11 per piece as shown in table 4.0. Therefore, it can be concluded that the reduction of overhead costs is also proportional to the increase in production output. Thus, total operation cost for the existing process is:

$$\text{Total Operation Cost (RM)} = \text{RM 0.51+RM 2.68+RM 0.67=RM 3.86 per piece}$$

TABLE 5
Total Operation Cost Comparison

	Total operation cost/ piece		Cost reduction
Model	**Existing**	**Improved**	**(Existing Improved)**
D55D	RM 3.86/ piece	RM 3.66/ piece	RM 0.20/ piece

Table 5 reveals that the total operation cost was successfully reduced by RM 0.20. It is clearly shown that the increase in production output is the main factor for the reduction of product's operation cost.

To calculate the reject cost, it is known that the tooling cost is zero since both machines had exceeded the amortization volumes given by the company. While for the reject cost, the company declared it as 0.50% from the total operation cost. For the existing process, it is measured as below:

$$\text{Reject Cost (RM)} = 0.50\% \times \text{Total operation cost} = 0.5\% \times \text{RM3.86} = \text{RM0.019 per piece}$$

As shown in table 6, the reject cost was reduced by RM 0.001. By substituting all the relevant information into equation below, total factory cost for the existing process is:

$$\text{Total Factory Cost (RM)=Total operation cost+Tooling cost+Reject cost=RM 3.86+RM 0.0+RM0.019=RM3.88 per piece}$$

TABLE 6
Reject Cost Comparison

Model	Reject cost/ piece Existing	Improved	Cost reduction (Existing Improved)
D55D	RM 0.019/ piece	RM 0.018/ piece	RM 0.001/ piece

TABLE 7
Factory Cost Comparison

Model	Total factory cost/ piece Existing	Improved	Cost reduction (Existing Improved)
D55D	RM 3.879/ piece	RM 3.678/ piece	RM 0.201/ piece

Table 7 shows that the factory cost was reduced by RM 0.201 per piece. With an average monthly volume of 5,869.40 pieces, cost saving from the reduction of total factory cost is shown in table 8.

TABLE 8
Cost Saving from Reduction of Total Factory Cost

Model	Average monthly order (pieces)	Total factory cost/ piece Cost reduction	Monthly saving	Cost reduction Yearly saving
D55D	5,869.40	RM 0.201/ piece	RM 1,179.749	RM 14,157.00

Therefore, it can be concluded that the total cost saving from the reduction of factory cost is RM 1,179.75 per month or equal to RM 14,157.00 per year.

Cost Saving From Elimination of Machine Breakdown Time

Cost saving is also obtained from the elimination of machine breakdown time. It is calculated as below, as has been practiced by the company:

$$\text{Total Cost Saving (RM)} = ((\text{Total breakdown time} \times \text{Production rate per hour}) \times \text{Seeling price per piece}) + (\text{Total Breakdown time} \times \text{Technician rate per hour}) = ((2.1 \times 45) \times \text{RM5.06}) + (2.1 \times \text{RM20.10}) = \text{RM520.38per month}$$

From the calculation above, total cost saving from breakdown time elimination (average; 2.10 hour per month) is RM 520.38 per month or equal to RM 6,244.56 per year.

Cost Saving from Reduction of Manpower Overtime

Under the new improved system, operator's overtime was managed to be reduced by 77.03% (105.94 reduced to 24.33 man hour). Main reductions came from the elimination of unplanned and planned overtime due to the increasing of production capacity. With labour rate of RM 9.30 per hour, existing overtime cost is calculated as below:

$$\text{Overtime Cost (RM)} = \text{Average overtime} \times \text{Labour rate} = 105.94 \times \text{RM9.30=RM985.24}$$

Before Kaizen, the overtime cost was RM 985.25 per month. After Kaizen, the cost manages to be reduced to only RM 24.33 per month. Therefore, the monthly saving from this improvement is RM 758.97 or equal to RM 9,107.64 per year.

Cost Saving from Elimination of Reject Components

Information from the historical data shows that the average reject cost for the existing process is RM 156.00 per month. After improvement, the reject cost due to components' defect was successfully eliminated. Therefore, yearly saving is equal to RM 781.20.

Cost Saving from Reduction of Shop Floor Area

After Kaizen, the shop floor area of the assembly line has been reduced by 18.18% which is from 22 ft^2 to 18 ft^2. Since this plant is rented at a rate of RM 2.00 for 1 ft^2, therefore, rental cost for existing area is calculated as below:

$$\text{Rental Cost} = \text{Rental rate per month} \times \text{Area occupied} = ((\text{RM2.04})(ft^2) \times 22ft^2) = \text{RM44.89 per month}$$

With only 18 ft^2 of the area, the amount of savings from shop floor area reduction is RM8.16 per month or equal to RM 97.92 per year.

Cash Flow Improvement from Reduction of Inventories

Table 9 shows the comparison between in-line inventories for plastics components, WIP and FG before and after the improvement activities. As discussed before, reduction in inventory level is one of the main factors for lead time reduction. Outcomes from the reduction could help the company to improve its cash flow.

TABLE 9
Cash Flow Improvement through Reduction of Inventories

Components	Price/ piece	Inventory level (Before)		Inventory level (After)		Cash flow improvement
		Quantity (pieces)	Cost (RM)	Quantity (pieces)	Cost (RM)	
Component 1	RM0.95	99	RM94.05	26	RM24.70	RM69.35
Component 2	RM0.98	108	RM105.84	26	RM25.48	RM80.36
Component 3	RM0.55	540	RM297.00	26	RM14.30	RM282.70
Component 4	RM2.13	7	RM14.91	2	RM4.26	RM10.65
Component 5	RM5.06	299	RM1,512.94	135	RM683.10	RM829.84
Total	RM2.48	747	RM496.89	78	RM751.84	RM1,272.90

From here, it can be concluded that the cash flow of the company has been improved by RM1, 272.90. By summarizing all the savings, total annual cost saving from the improved process is equal to RM31, 661.22.

Step 5: Economic Investment Analysis

Return on Investment (ROI)

According to the company, the maintenance cost (M) is RM 1,000.00 per year and total cost of investment (I) for this kaizen event is RM 10,920.00. With the annual saving of RM 31,661.22, the ROI for this research is:

$$\text{ROI} = \frac{\text{RM31,661.22-RM10,920-RM1,000}}{\text{RM10,920}} \times 100\% = 180.78\%$$

With the annual rate of return of 180.78%, it indicates that the capital investment that has been made in this research will be successfully returned in the first year of implementation. In other words, the company will pass its investment rate within the first year of the investment.

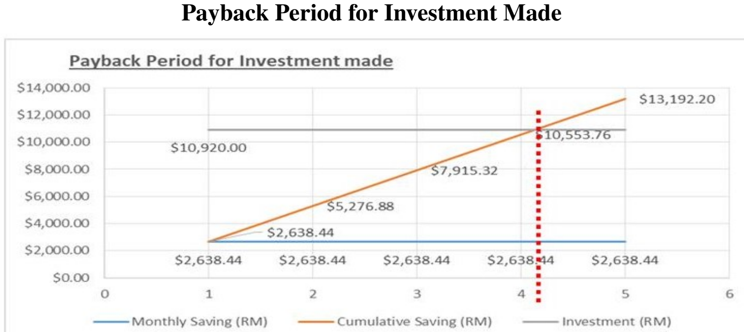
Payback Period (PP)

With total investment of RM 10,920, monthly cost saving is RM 2,638.44 (RM 31,661.22/ 12 months) and monthly maintenance cost is RM 83.33 (1,000/ 12 months), the payback period for this research is:

$$\text{PP} = \frac{\text{RM10,920}}{(\text{RM2,638.44-RM83.33})} = 4.27 \text{ months}$$

From the calculation, it can be concluded that the payback period for this investment is less than 5 months of production running. However, it could be shorter with the increase of customer's order volumes. This analysis was clearly illustrated in figure 1.

FIGURE 1
Payback Period for Investment Made



The blue line rising from the lower left to upper right is the cumulative monthly cost saving achieved from this research. The red dotted line indicates the period when the investment made could be returned to the company. Since the payback period for this investment is short, therefore, it can be concluded that the investment made is viewed as a low risk and practical to be implemented in other production areas.

CONCLUSION

In this paper, a Kaizen event assessment methodology was described and used to measure, evaluate and maximize the impact of Kaizen events on the business performance of the company. It is suggested to apply the methodology used in this research to other research studies with a larger number of Kaizen events for a deeper understanding of the factors that influence Kaizen event success and sustainability from business as well as human resource perspective.

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