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Process Improvement and Kaizen Study: An Application in a Tire Company

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Abstract

In today's conditions where intense competition conditions are experienced and customer expectations are increasing rapidly, companies have had to constantly increase quality, ensure profitability and reduce costs in all processes. The automotive sector where continuous improvement and renewal takes place in the natural environment also frequently uses improvement methods such as Lean Manufacturing and Kaizen in their processes. Kaizen, which is a combination of the words "KAI" (change) and "ZEN" (better) in Japanese and which is meaning "better change", is a problem-solving approach applied in process development. With Kaizen approach, unnecessary activities are eliminated and low performance processes are being developed. This study describes a Kaizen application in the curing process called "vulcanization" in production department of a tire company is described. The implementation is performed to reduce number of scrap during vulcanization process. As a result, 38.7% improvement was achieved in the scrape rate.

Key words: Lean Manufacturing, Kaizen, Tire Curing Process

1. Introduction

In the manufacturing sector, the most majority of losses create irregular, small pieces. Each problem must be addressed individually to eliminate these losses. The Kaizen method is used as one of the important tools in the identification and elimination of such losses.

Chandrasekaran et al., in their work, applied the Kaizen technique to solve the 'part mismatch problem' in the automobile assembly production line. In order to solve the problem, they followed the basic Kaizen procedure by taking data collection, root cause analysis, selection of the best solution method, corrective action and documentation steps [1].

With the increasing popularity of Kaizen studies as a process improvement initiative, the amount of Kaizen case study literature has also increased. Glover et al. [2], in addition to Kaizen's knowledge, have conducted a systematic literature research on close, varied, and different applications.

In another study which searched literature on Kaizen applications, it was also observed that in

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terms of innovation, continuous improvements in Toyota over a certain period of time were observed on the basis of 7 cases, and it is expressed that Kaizen administration needed for organizational design. For example, in Toyota, it has been found that not only the working teams but also the product / process design engineers contribute to Kaizen, and that the coordination between the design and engineering departments is important [3].

In a tire company operating in India, a waste management study was conducted to reduce the harmful effects by using lean manufacturing and Kaizen approach techniques. [4].

This study was carried out in a tire manufacturing enterprise in an automotive subsidiary industry. Tire production consists of mixture, semi-finished product, tire building and curing. In this study, a problem which caused scrap and loss of production during the vulcanization process, which is referred to as curing process in the tire sector manufacturing section, is investigated. The enterprise wants to use low-costed improvement opportunities by establishing small working groups in line with the basic principles of the Kaizen approach. The problem is solved by applying the Kaizen method with interdisciplinary team. With the performed Kaizen work, a noticeable reduction in the scrap rate, breakdown caused machine standby and equipment changes has been achieved.

As a result of researches on the business, one of the problems that are caused by the scrap is a breakdown which occurs during loading operation in the vulcanization phase before the curing process. In order to improve this breakdown, firstly trainings were given and then a team was formed.

2. Materials and Method

The Kaizen term, which means "better change" in combination with the Japanese words "KAI" (change) and "ZEN" (better), is one of the problem-solving approaches used in process improvement. In the current literature, Kaizen is often thought of as the accumulation of small, interdependent, progressive process innovations carried out by workers, working teams and leaders.

This term comes from Gemba Kaizen and means 'continuous improvement' (CI). Continuous Improvement is one of the core strategies for excellence in production and has vital importance in today's competitive environment. The Kaizen approach calls for that including everyone in the organization for continuous development and improvement [5, 6].

In Japan, Kaizen is used as slow progressing and constantly increasing improvement over time. In America, it is known as "Kaizen Blizt" or "Kaizen Events" as a gradual, regular systematic approach for improvements [7].

Womack and Jones [8] describe Kaizen as a part of lean production and indicate that they it reveals systematic approach to reduce waste.

Kaizen practices have been the keys of lean implementation for many companies, and in

Toyota's Regulations, the sentence “be ahead of time by means of infinite creativity, curiosity and development seeking. Has become a constantly emphasized thought [9].

Slack defines Kaizen as the participation and mobilization of the worker in process improvement by creating a main channel for employees to contribute to the development and success of the organization' [10].

Kaizen is an approach that, starts with people, focuses its attention on people‘s efforts, processes are continually improved, improved processes will improve results, improved results will satisfy the customers [11].

The Kaizen approach is generally expressed in six steps. These are discover improvement potential, analyze the current methods, generate original ideas, develop an implementation plan, implement the plan and evaluate the new method [12]

The steps of the Kaizen approach have been adapted for the implementation study as follows.

1. Subject Selection: The reason for choosing the Kaizen topic is revealed by data.
2. Team Building: The people to be involved in the Kaizen project are identified.
3. Current Situation Analysis: The current situation analysis is performed to highlight how the problem occurred and details are highlighted.
4. Project Plan: The Kaizen Project Activity Plan is created, and the tasks and responsibilities of the team and the project schedule are established.
5. Analysis: Root causes and improvement areas are. The identified by appropriate problem solving techniques (Cause Cause Analysis, Process Analysis, Pareto Analysis, Comparison Matrix, etc.)
6. Improvement: Suggested solutions applied related with the problem are included.
7. Verification and Gaining’s: When it is confirmed to reach to target by questioning whether the target has been reached, and the Kaizen annual return account is established.
8. Standardization: Standardization methods (Instruction creation, company contracts, etc.) are taken in order to prevent backward movement.

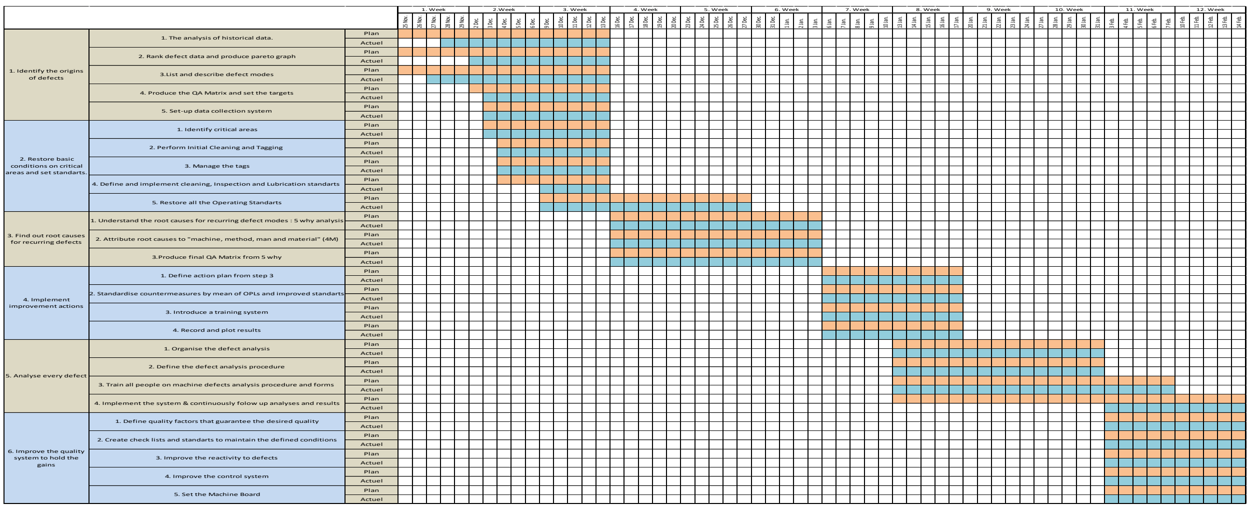
In this work carried out in an automotive supplier industry, the Kaizen steps mentioned above were applied. As a result of the researches carried out in the business, a breakdown which occurred during the tire loading in vulcanization phase was improved by applying the Kaizen method. While this improvement work was being put forward, basic problem solving tools were utilized.

3. Application

This study was carried out on a set of quality, maintenance, manufacturing department staff and researchers to reduce bladder folding breakdown in R17.5 curing machine in truck tire manufacturing. In the study, 5 Why, Ishikawa diagram, Pareto chart, Gantt chart and Histogram tools are used. A regular meeting with the team was held on Wednesdays during 12 weeks.

After training the team on the stages of Kaizen method and Kaizen concept, the aim and master plan of the project were put forward. With the designated master plan, planned and actual times were followed. This plan shows the stage at which the project should occur in the week.

Table 1. Master Plan of Study



The breakdown records in the Enterprise Resource Planning (ERP) program, was used to determine the project subject with the team.

Figure 1 shows the distribution of scrap quantity based on the breakdown code in a given period. The breakdown which the team decided was a C3 breakdown. The reasons for selecting these breakdowns are listed below:
- A single focal point of the breakdown
- Visual inspection of the breakdown, easy to see
- Missing sub-codes of the breakdown

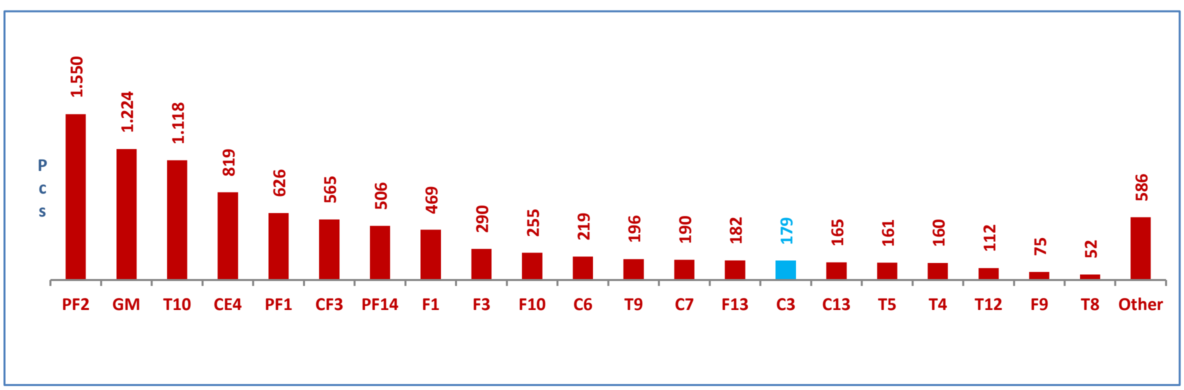


Figure 1. Scraps quantities according to breakdowns codes in a given period

In Figure 1, the number of scraps according to breakdown type of business. Breakdown types are categorized by short codes. The numbers are taken from the ERP program used by the business.

As can be seen from the Figure 1, the scrap arising from the C3 breakdown is 1.7% of total scrap. The trend of the C3 breakdown is shown in Figure 2.

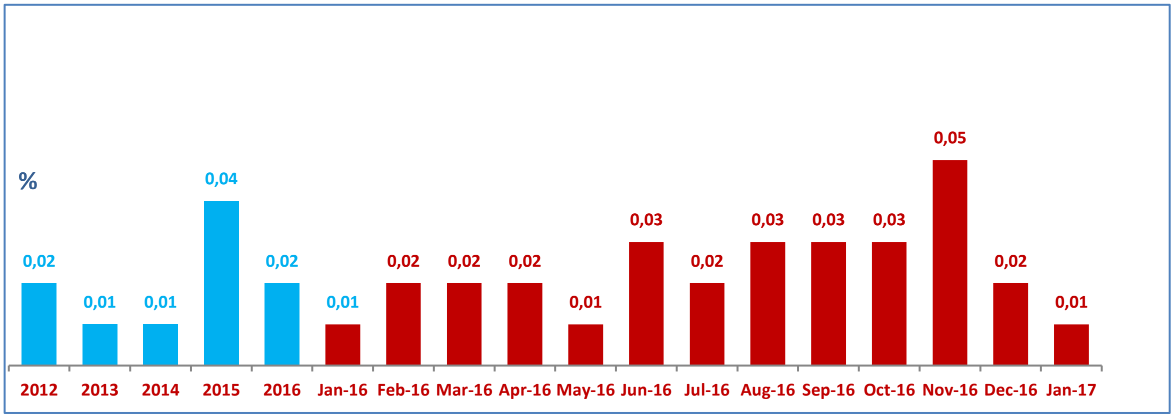


Figure 2. Trend of C3 breakdown

Pareto Chart in Figure 3 show the trend of C3 scraps based on tire rim crust at a certain time. As seen in the graph, 93% of C3 scrap is coming from R17.5 dimensions. The area to be focused is seen as the reason for this problem in R17.5 size.

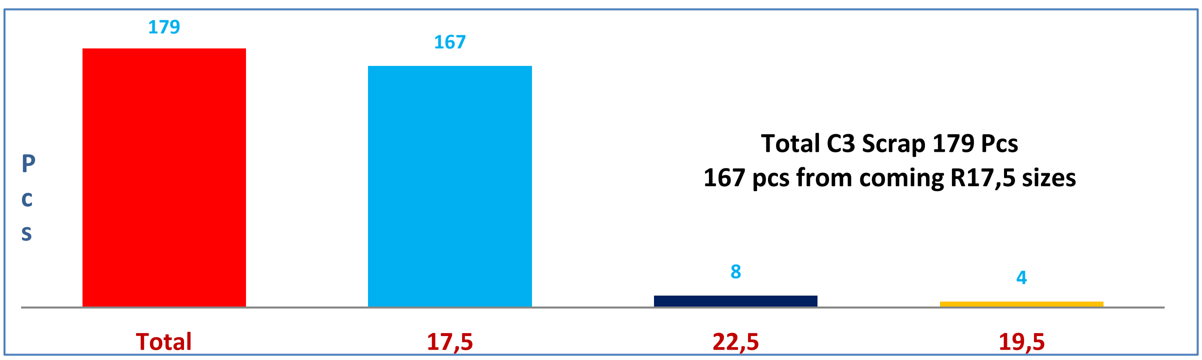


Figure 3. Trend of C3 breakdown on the basis of tire rim

Figure 4 shows the distribution of C3 scrap quantities in presses which R17.5 size tires are cured. When the dispersion is examined, a machine where the breakdown is intensified is not seen.

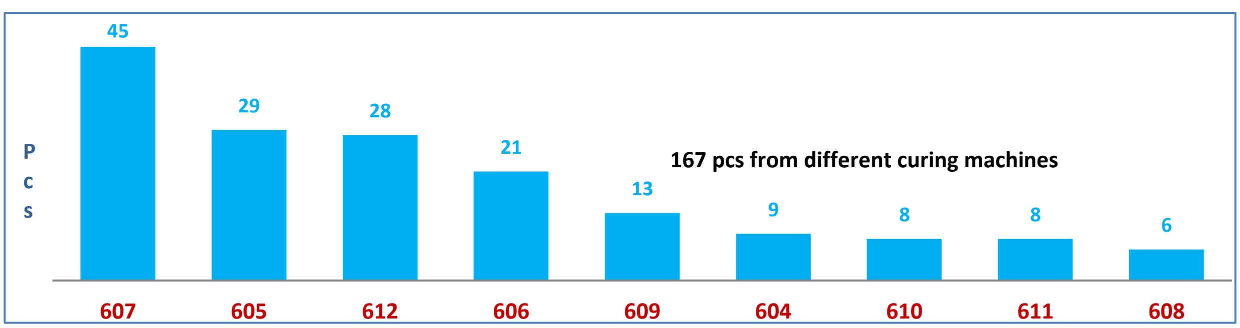
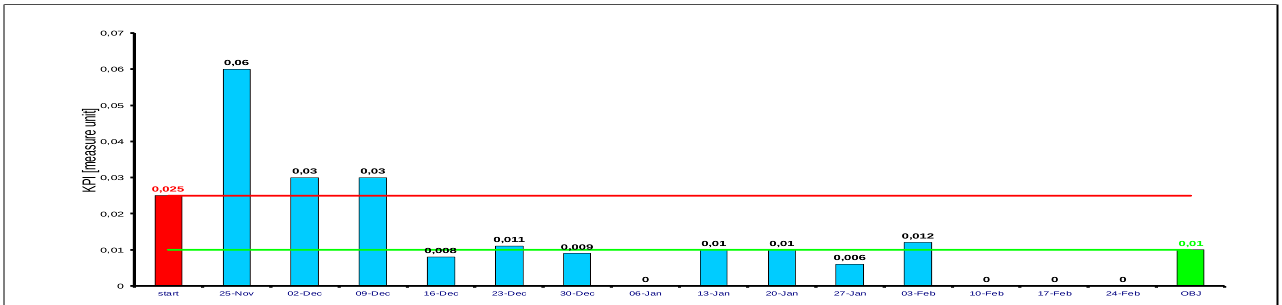


Figure 4. C3 scrap quantity in press which R17,5 size tires is cured

The goal of the study is determined as to reduce number of C3 scrap from 179 units /year to 110 units/year. When this target is provided, the loss of machinery and equipment that may occur will be avoided and a profit of 15,000 euro / year will be provided.

The breakdown rate at the initial stage of the work and the trend in the master plan were followed.



KPI:																
Week	start	25-Nov	02-Dec	09-Dec	16-Dec	23-Dec	30-Dec	06-Jan	13-Jan	20-Jan	27-Jan	03-Feb	10-Feb	17-Feb	24-Feb	OBJ
KPI Value	0,025	0,06	0,03	0,03	0,008	0,011	0,009	0	0,01	0,01	0,006	0,012	0	0	0	0,01
Starting point	0,025	0,025	0,025	0,025	0,025	0,025	0,025	0,025	0,025	0,025	0,025	0,025	0,025	0,025	0,025	0,025
Target	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01

Cell to be filled manually

Figure 5. Result Graph of Key Performance Indicator (Scrap Tyres)

In the matrix in Table 2, the process steps and equipment and materials that could cause a breakdown are presented. These indications are created according to analysis result of team employees. Analyzes were created from entered explanations of breakdown reasons in the ERP program. Process step corresponding to each defect is graded. The matrix leads us to the phase in which the maximum problems occur.

Table 2. Equipments and materials that can cause breakdown by process steps

			PROCESS PHASES					Process Flow	
Defects	ppm*	ΣWeight ‰**	Green Tyre Painting (1–5)	Get to the loader (1–5)	Vauto (1–5)	Lock the Arelli (1–5)	Top Heel Down (1–5)	Loader Contraction (1–5)	TOTAL (1–5)
001 - Top Saragio Daimater	5	6 / 22		1: 7	1: 7		4: 7		1: 14; 4: 7
002 - Green Tyre Painting	50	22 / 217	3: 79	1: 10	4: 49	4: 49	2: 10		1: 10; 2: 10; 3: 79; 4: 99
003 - Bladder Height	70	17 / 304	1: 36	1: 36	2: 143		1: 90		1: 161; 2: 143
004 - Loader Leavs	5	15 / 22	2: 7	1: 12			1: 3		1: 14; 2: 7
005 - Pivot Distansiyel Height	80	26 / 348	3: 67		1: 107	1: 67	1: 107		1: 281; 3: 67
006 - Tema Problem	20	8 / 87	4: 87						4: 87
-		- / -							
-		- / -							
-		- / -							
-		- / -							
Total ppm*		230	36; 7; 146; 87	74	114; 143; -; 49	67; -; -; 49	111; 10; -; 7	-	411; 171; 144; 193
Normalised Index		1.000	276	74	307	116	226	-	

The photographs in Figure 6 show step by step tire curing process. First, the carcasses to be cured are brought in front of the curing machine. Then get the loader. After the machine is turned on, the loader takes carcasses into the machine. The carcasses are loaded on to bladder and bladder gets into the forming position. Thus curing process is started. The loaders go to their first position and the machine becomes ready for closing position. The machine is closed and curing starts as soon as it is deemed appropriate by the operator.

Figure 6. Steps of tire curing process

In photographs above Figure 6, the process steps are followed and the moment of occurrence of the breakdown is detected by the team. The breakdown occurs as a result of deformation of the material in the carcass bead area where the bladder set to the forming position. Figure 7 presents wires which should not be in a cured tire as result of this deformation

Figure 7. Breakdown occurrence during process steps

The Ishikawa diagram was created with the team members and the parameters that could cause the breakdown were classified. The ishikawa diagram is presented in Figure 8. These reasons are defined as Bladder height is not enough, Not suitable ring is expressed as daimater, Incorrect painting, Insufficient vacuum.

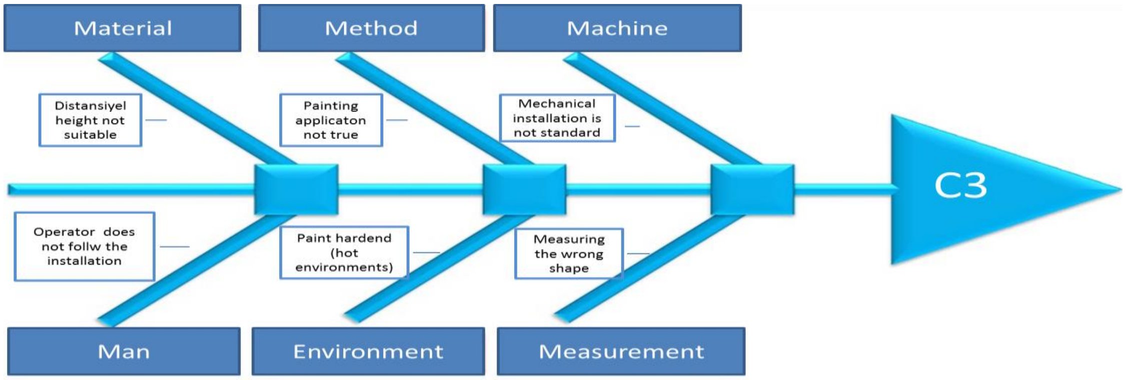
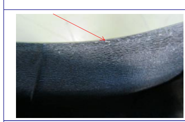
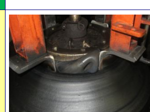
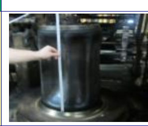


Figure 8. Ishikawa diagram

5 why analysis were made based on the items which are identified in Ishikawa diagram. Results of 5 why analysis are presented in Table 3.

Table 3. 5 Why analysis

FIVE WHY ANALYSIS													
Problem Description	Potential Causes										4M	Actions	
	Why (1)	Check	Why (2)	Check	Why (3)	Check	Why (4)	Check	Why (5)	Check		PREVENTIVE ACTION	CORRECTIVE ACTION
Creased Bag	Wire appear on tyre bead	OK	There is not enough vacuum	OK	Insufficient vacuum on the main line.	OK	The value of the spec is not true.	stop					
											Environmental	Vacuum value will be calculate.	
	Wire appear on tyre bead		Incorrect painting		The operator is mistaken		Untrained operator.	stop					
											Man	Operators will be trained	
	Wire appear on tyre bead		Not enough tension on bladder		Distant size is insufficient.		Mile length changed when manufacturing system changed	stop					
											Machine	Mil lengts will be changed.	

The result of the 5 why analysis showed that correct painting was not done, some errors were arised from the untrainedness of the operators, and the adjustment of the shaft size was required.

4. Results

As a result of the analyzes, the team decided to make changes in the following subjects.

- Bladder height should be changed.

- Ring diameter should be changed.
- Standard painting.
- Stable vacuum.
- Correct compound thickness values.
- Training of operators.

A standard measurement method is selected in order to close gap between measurement methods of operators which is measuring distentional shaft inside length and operators which are preparing.

The photos of the changes performed are given in Figure 9. The performed changes were standardized with Standard of Procedure (SOPs) and required trainings were given to operators.



Figure 9. Photographs' of performed changes

Gains of the study can be summarized as follows. As a result of the application aimed at reducing the breakdowns that may occur during the vulcanization process, a 38.7% improvement in the breakdown rate has been achieved in total. The scrap rate has been reduced, operators have been trained, working instructions have been created and announced, and team motivation has been provided for further study. The return of the work done is calculated as 15,200 Euros per year.

Conclusions

Businesses use a variety of techniques, methods and tools to improve productivity and quality in the long run by the aims of maximizing competitive advantage. As the international competitiveness increases especially in the automotive industry, many methods have been devised to reduce production and raw material costs, to reduce waste and activities that do not add value to the production process.

Improving performance and improving workplace conditions by using Kaizen (Continuous Improvement) methodology, which is one of these developed methods, has become a way for businesses to frequently resort to and achieve successful results.

In this study; Kaizen application is carried out in a business. This business manufactures truck tire. Truck tire manufacturing process consists of mixture, semi-finished product, building and curing stages. Kaizen application was performed in order to reduce a frequent breakdown in the production of tires of size R17.5 during the curing process. Scrap which occurs during loading operation and bladder folding defect were analyzed with a team including workers from different departments and researchers.

As a result of the Kaizen application for the reducing breakdowns that could occur, breakdown rate was improved rate of 38.7% and the economic value was calculated as 15,200 Euros per year.

References

[1] Chandrasekaran M, Kannan S, Pandiaraj P. Quality improvement in automobile assembly production line by using Kaizen, Manufacturing Technology Today.2008: Vol. 7, No. 3: 38-33.
[2] Glover WJ, Farris JA, Van Aken EM. Kaizen Events: Assessing the existing literature and convergence of practices. Engineering Management Journal: 2014:26:61-39.
[3] Iwao S. Revisiting the existing notion of continuous improvement (Kaizen): literature review and field research of Toyota from a perspective of innovation. Evolutionary and Institutional Economics Review 2017: 4(1):59-29.
[4] Gupta V, Narayanamurthy G, Acharya P. Can lean lead to green? Assessment of radial tyre manufacturing processes using system dynamics modeling. Computers & Operations Research 2017:4:23-1.
[5]Malik SA, YeZhuang T. Execution of continuous improvement practices in Spanish and Pakistani industry: a comparative analysis. IEEE International Conference on Management of Innovation and Technology, 2006: 2: 761-765.
[6] Singh, J, Singh, H. Kaizen philosophy: A review of literature. IUP Journal of Operations Management, May 2009: 72-51.
[7] Asaad MN, Saad R, Yusoff RZ. 5S, Kaizen and organization performance: examining the relationship and level of implementation using Rasch Model in Malaysian automotive company.International Journal of Business and Technology 2015:1(2):226-214.
[8] Womack J P, Jones D T. Lean Thinking, New York: Simon & Schuster: 1996.
[9] Kılıç A, Ayvaz B. Türkiye otomotiv yan sanayinde yalın üretim uygulaması, İstanbul Ticaret Üniversitesi Fen Bilimleri Dergisi 2016:15(29):60-29.
[10] Slack N, Chambers S, Johnston R. Operations Management, London: Prentice Hall Financial Times:2007.
[11] Bhoi JA, Desai DA, Patel RM. The concept &methodology of Kaizen, International Journal of Engineering Development and Research 2014:2(1):820-812.
[12] Kato I, Smalley A. Toyota Kaizen Methods Six Steps to Improvement, New York: CRC Press: 2011.