Productivity Improvement by Using Lean Manufacturing Tools: A Case Study on the Jishu Hozen Implementation

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ABSTRACT Manufacturing industries rely heavily on machineries and equipment which works to keep up with customer demands. Thus, with the amazing discovery of Lean manufacturing tools, plant maintenance strategy has been more systematic than previous years which had led to improved equipment efficiency. The aim of this paper is to study the impact of Total Productive Maintenance (TPM) implementation on productivity improvement with special focus on the Jishu Hozen (JH) concept. The case study was conducted at two manufacturing companies from two different countries (South Korea and Malaysia), which are Donghai Holesaw Co. Ltd and Kien Nan Industrial Sdn. Bhd., respectively. Implementation of the 7-steps of JH were conducted a month before data collection, then monitoring is conducted for a period of four months. From the results obtained, Donghai Holesaw had an availability, performance, and quality rating of 98.13%, 80.82% and 98.86% respectively whereas Kien Nan Industrials had ratings of 98.26%. 82.89% and 96.10%, respectively. These indicate that the bottleneck departments of Donghai Holesaw Co. Ltd. and Kien Nan Industrial Sdn. Bhd. had improved their Overall Effectiveness Efficiency (OEE) to 78.40% and 78.27% respectively. However, they are still far from the world class rating of 85%. Overall, it can be concluded that the implementation of JH was able to improve overall productivity of the companies.

KEYWORDS: Lean manufacturing; Total productive maintenance; Overall effectiveness efficiency; Jishu Hozen; Productivity
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INTRODUCTION

Lean Manufacturing comes in all sorts of concepts and ideology but serves one major purpose, which is to remove waste for overall improvement of productivity (Vilkas *et al.*, 2015). Lean manufacturing concepts from earlier times such as Just-In-Time (JIT) and Total Quality Maintenance (TQM) had heavily inspired the rise of Total Productive Maintenance (TPM) when the requirement for more reliable maintenance technique arises (Eti *et al.*, 2004). Manufacturing industries relies heavily on machineries and equipment, which works to keep up with customer demands. Moreover, the quality of the product and service provided is closely coupled with equipment performance (Kiran, 2017). Thus, with proper implementation of TPM, there is expected to be visible positive impact on production.

In literature, Chan *et al.* (2003) stated that TPM is an approach with the objective of increasing equipment's availability to reduce the requirement of additional capital expenses. Bupe and Charles (2015) further affirms the statement, by stating that TPM is a Japanese equipment management concept that enables a facility equipment performance to improve assertively in the manufacturing area with the help and involvement of all employees. Nakajima (1988), the Japanese founding father of TPM, personally defined it as a process of encouraging daily awareness for continuous improvement of a production system. Kiran (2017) also defines TPM as a designated methodology that ensures critical machineries involved in production continuously functions without fail to avoid disruption in output rate.

TPM main objectives are to achieve the four zeros of TPM which are zero breakdowns, zero accidents, zero defects and zero pollution (Kiran, 2017). Bhoyar *et al.* (2017) stated, Overall Equipment Efficiency (OEE) is directly related to productivity as it is generally a metric that detects the proportion or percentage of intended production time that is purely productive. It was established to support TPM goals by correctly tracking development towards achieving perfect production. The level of productivity of a manufacturing company can be determined by the percentage of OEE achieved as seen in Table 1.

Table 1. OEE Score Description

OEE Score %	Production level description
100	Perfect Production
85	World Class
60	Fairly Typical
40	Common for "Non-lean Practicing" Manufacturers

OEE breaks down a manufacturing unit performance into three distinct, but measurable sections which are availability, performance rating and quality rate (Shinde & Prasad, 2017). According to Shinde and Prasad (2017), the traditional TPM model consists of eight pillars with 5S being the foundation or main base of the pillars as seen in Figure 1.

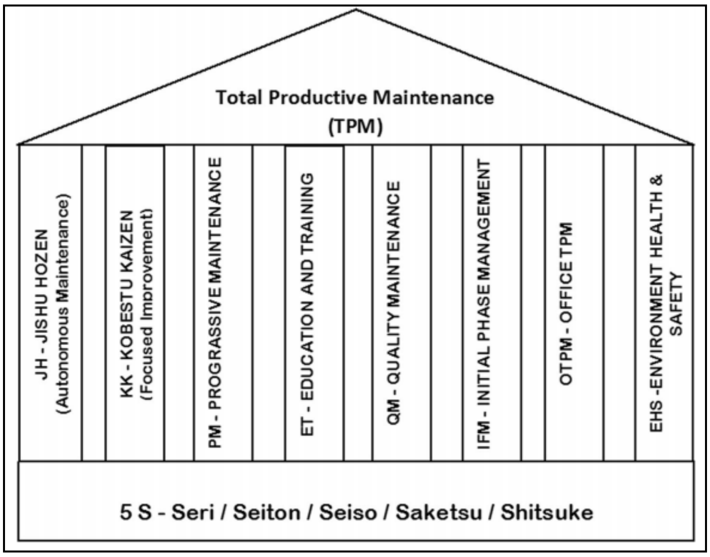

Figure 1. Eight Pillars of TPM

The study conducted by Shinde and Prasad (2017) applied an Analytical Hierarchy Process (AHP) at which the information is used as a guide for management to allocate proper preference and time for each respective pillar. From the study, Jishu Hozen (JH) ranks first in the hierarchy among all the other pillars. JH had a higher weightage in terms of contribution towards productivity, cost, quality, and delivery in time (PCQD) (Shinde & Prasad, 2017). The JH pillar is dedicated to developing the ability of operators to run minor maintenance work as a method of enabling the more skilled maintenance personnel to allocate more time on more crucial activities of repair (Paropate & Sambhe, 2013). Thus, this paper will apply JH as the concept use for implementation during the case study.

METHODOLOGY

Pilot/Bottleneck Areas

Pilot areas are the most crucial areas of production where production needs to be continuous for other departments to function. It was determined that pilot area for Donghai Holesaw is situated at the CNC department which consists of multiple CNC lathe used for the purpose of cutting and forming. For the case of Kien Nan Industrials, the extrusion machine is selected as the pilot area. This is where the bricks are formed into its rectangular shape and is done at the highest speed rate.

Seven Steps of JH Implementation

The seven steps of JH were implemented according to the model used by Gaikwad (2018). Table 2 summarizes the procedure used during implementation.

Table 2. Seven steps of JH

Step	Activity	Description
1	Initial clean up	• Initial clean up and identification of abnormality • Preparation of abnormality tag matrix • List and countermeasure against abnormality • Type and effect of abnormality • Tag removal plan • One point lesson • Audit report of JH step 1.
2	Counter measures against sources of contamination and hard to access areas	• Sources of contamination and hard to access area for CLIRT • List and countermeasure for source of contamination • Audit report of JH step 2.
3	Preparation of tentative standards and visual management	• Preparation of tentative standards and check sheet • Visual control list • Visual controls for clirt time reduction • Implementation of JH check sheet • Audit report of JH step 3.
4 5 6 7	General Inspection Autonomous Inspection Standardization Full Autonomous Maintenance	Consolidates the first three steps by improving production skills and knowledge and developing team independence

OEE Calculations

The OEE Percentages for the months of November 2019 to February 2020 were calculated to determine the productivity rate of both companies before and after implementation of JH. The OEE can be calculated by determining the Availability, Quality and Performance rate. The formula used for calculation are as seen in Equations (1) - (4).

$$\text{Availability} = \frac{(\text{Total downtime})}{\text{Total Time}} \times 100 \quad (1)$$

$$\text{Quality} = \frac{(\text{Good Pieces})}{\text{Total Pieces}} \times 100 \quad (2)$$

$$\text{Performance} = \frac{(\text{Total amount of product produce})}{\text{Targetted amount of Products}} \times 100 \quad (3)$$

$$\text{OEE} = \text{Availability} \times \text{Quality} \times \text{Performance} \quad (4)$$

RESULT AND DISCUSSION

The results collected for the month of November (pre-implementation) to December, January and February were tabulated and used for the determination of the Availability, Performance and Quality rating as seen in Table 3, Table 4 and Table 5 respectively. From Table 3, there is a visible difference in the initial availability rating during the month of November. This data represents the availability rating for each company pre-implementation. Subsequently after the implementation of JH, the availability ratings of both companies increase gradually throughout the month and produced quite similar availability ratings by the end of February. Both companies almost achieving a perfect 100% score indicating an improvement in total production hours. These results are in line with the availability characteristics stated by Gaikwad (2018).

Table 3. Availability Rating

Company	Month	Planned Productive Time (Hrs)	Actual Productive Hours (Hrs)	Availability (%)
Donghai	November	320	290	90.63
	December	328	303	92.38
	January	320	307	95.94
	February	328	314	98.13
Kien Nan	November	480	452	94.17
	December	480	460	95.83
	January	576	558	96.87
	February	576	566	98.26

From Table 4, it can be observed that performance rating has been increasing for both companies. This signifies that the productivity in meeting monthly production number goals had improved significantly after the implementation of JH. However, the performance rating for both companies are quite mediocre as they are still in the 80% range, which is still far from a perfect performance rating. The low performance percentage depicts a similar trend to study conducted by Gaikwad (2018).

Table 4: Performance rating

Company	Month	Total amount of Product	Planned Product amount	Performance (%)
Donghai	November	255 435	320 000	79.82
	December	255 723	320 000	79.91
	January	257 655	320 000	80.52
	February	258 634	320 000	80.82
Kien Nan	November	2 105 024	2 700 000	77.96
	December	2 206 033	2 700 000	81.70
	January	2 222 370	2 700 000	82.31
	February	2 238 030	2 700 000	82.89

Referring to Table 5, the Quality rating had increased for both respective companies. However only Kien Nan showed more noticeable growth while Donghai showed smaller improvements. However, Donghai is closer to a perfect 100% quality rating when compared to Kien Nan. The increase in quality rating proves that both companies were able to produce quality products at a better rate post JH implementation as predicted (Gaikwad, 2018).

Using the data obtained from Table 3, Table 4 and Table 5, the OEE percentages for both companies were calculated. Figure 2 illustrates the monthly OEE rating for both Donghai and Kien Nan in the form of a chart for comparison purposes.

Table 5. Quality Rating

Company	Month	Total Product produce	Good Products produced	Quality (%)
Donghai	November	255 435	252 531	98.13
	December	255 723	252 591	98.77
	January	257 655	254 680	98.84
	February	258 634	255 700	98.86
Kien Nan	November	2 105 024	1 965 520	93.37
	December	2 206 033	2 073 672	94.00
	January	2 222 370	2 124 363	95.59
	February	2 238 030	2 150 746	96.10

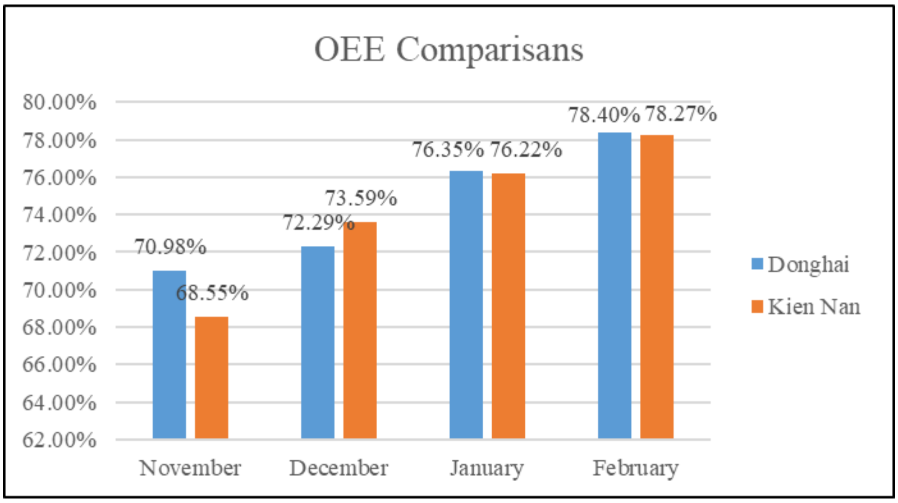

Figure 2. Graph chart of OEE side by side comparison

Before the implementation of JH, Donghai Holesaw and Kien Nan Sdn Bhd had an initial OEE percentage of 70.98% and 68.55% respectively, which is fairly typical for most manufacturing industries. By referring to Figure 2, it can be observed that after implementation from December and onwards, the graph shows a surging trend. The highest rate of OEE percentage increase for Donghai is seen between the months of December and January. The increased margin is determined to be 4.06%. However, for the case of Kien Nan the highest surge was between the initial month of November to December with a decent rate of 5.04%. During the final month of the case study, both companies only increased by a smaller margin of roughly ±2.0 % which is less than half of its highest increase rate. This finding is aligned with the study done by Gaikwad (2018), where the highest surges are seen during the earlier months of the case study and will increase at a lower rate in later months. Both Donghai and Kien Nan had successfully improved their OEE percentage to an impressive 79.40% and 78.27% respectively.

However, both companies had not reached the World Class percentage of 85%. According to Gaikwad (2018), the OEE percentage is inversely proportional to the production loss. Thus, the increase in OEE percentage signifies that the rate of production loss has decreased. To recapitulate, both the Korean and Malaysian companies portrayed a similar growth rate with the Malaysian company producing a higher rate of OEE growth and the Korean company having a slightly higher OEE percentage. Thus, the implementation of JH had improved the productivity of both respective companies.

CONCLUSION

Jishu Hozen (JH) ranks first in the hierarchy among all the Eight Pillars of TPM. JH had a higher weightage in terms of contribution towards productivity, cost, quality, and delivery in time (PCQD). The JH pillar is dedicated to developing the ability of operators to run minor maintenance work as a method of enabling the more skilled maintenance personnel to allocate more time on more crucial activities of repair.

After 4 months of observation on Donghai Holesaw and Kien Nan Sdn Bhd, Donghai Holesaw had an availability, performance, and quality rating of 98.13%, 80.82% and 98.86% respectively whereas Kien Nan Industrials had ratings of 98.26%. 82.89% and 96.10% respectively. Thus, it was concluded that the OEE of the bottleneck areas of Donghai Holesaw Co, Ltd and Kien Nan Industrials Sdn Bhd had increased. However, both companies have yet to reach the 85% world class rating. All in all, the results adequately proved that the implementation of JH had led to the improvement of both companies' productivity.

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