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# TPM IMPLEMENTATION CAN PROMOTE DEVELOPMENT OF TQM CULTURE: EXPERIENCE FROM A CASE STUDY IN A MALAYSIAN MANUFACTURING PLANT

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**ABSTRACT**

The purpose of this study is to investigate the results of Total Productive Maintenance (TPM) implementation in developing Total Quality Management (TQM) culture in a Malaysian industry. A systematic implementation of TPM framework is applied in a manufacturing firm. Interviews, line inspections and data analysis are done to measure results of the implementation. The case study company was having high rejection in their products in as much as 3000ppm (acceptable level: 1000ppm). The research study shows that a well-planned TPM implementation not only improves the equipment availability and reliability, but also brings about the improvements in increased production output, quality in products and creates a culture of team-work spirit to own the equipment, while increases the work skills among individuals. The reported study is done at an electronics manufacturing factory, where the manufacturing process is in mass production. The results of findings shows that proper TPM implementation in a Malaysian industry can improve manufacturing efficiency. This paper also provides valuable information to measure a successful TPM implementation in developing a TQM culture.

**Keywords:** Total Preventive Maintenance, Total Quality Management, 5S.

## 1. INTRODUCTION

Manufacturing industry has been growing rapidly with the invention of modern machines, computer controlled equipment and a wide array of automated processes. Many companies began to invest in the new technologies and highly sophisticated machines. These machines demand high investments, and thus need good maintenance to operate them at an optimum level. Good maintenance can be best brought about by the application of Total Productive Maintenance (TPM) programs (Pomorski, 2004), where the machines breakdown frequency is reduced, the maintenance cost come down at higher rates. TPM is also supportive to the effectiveness of TQM in improving business performance (Seth and Tripathi, 2005). Experience from TQM practitioners have shown that TQM requires long term strategy and substantial benefits that could benefit after certain period of time. TPM is actually TQM zeroing into improvement of machine maintenance. TPM applies the concepts of TQM to the production floor (Jostes and Helms, 1994) in bringing various levels of employees to work together for continuous improvements in machines and to deliver the best production output for customer. This study places specific emphasis on creation and enhancement of organization wide TQM culture through the application equipment maintenance TPM approaches.

## 2. THE CASE STUDY

This study is an investigation on the results of TPM application towards quality enhancement in manufacturing products in a large manufacturing company in Malaysia. In this Case Study Company, a TPM promotion office was set-up to promote and monitor the state of its implementation throughout the manufacturing plant. This office promotes the company wide step by step application of TPM-eight-pillars. The goals are to achieve higher equipment availability, better performance, zero defects, zero accidents, zero failures, and create cross-functional job responsibilities and develop cellular group activities.

The study developed a scenario stating the problems related to equipment maintenance, standard operating conditions, loss conditions, product and process quality, and knowledge-base and involvement of workers. Hereunder, the goals of TPM implementation are set to:

(1) Achieve zero defects, zero accidents and zero failures.

(2) Create cross-functional job responsibilities

(3) Develop cellular group activities

Based on detailed literature review, the study prepared TPM implementation framework. The eight pillars for successful implementation of TPM are shown in Table 1. These involve various parties and factors as depicted in Figure 1.

Table 1: Key factors for TPM implementation

| | | |
|---|---|---|
| 1 | Focus Improvement | Continuous Improvement to eliminate 6 big losses |
| 2 | Autonomous Maintenance | Do basic calibrations/maintenance and to have sense of ownership |
| 3 | Preventive Maintenance | Plan periodical maintenance to arrest major breakdowns |
| 4 | Training & Education | Upgrade the skills and knowledge among employees |
| 5 | Maintenance Prevention | Work with supplier to improve new design |
| 6 | Quality Maintenance | Promote zero defects through proper 5M management |
| 7 | Administrative Maintenance | Manage proper administration system to support productions |
| 8 | Safety and Environment | Promote safe work environment and zero accidents |

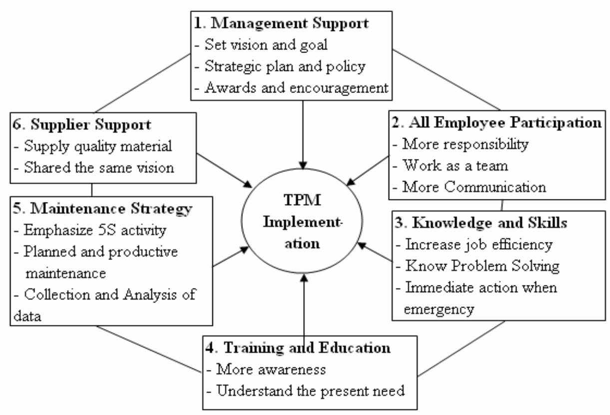


Fig 1: Involvement of various parties and factors to TPM implementation

A TPM system has a good match with the popular 5S housekeeping program: *seiri* (orderliness), *shitsuke* (discipline), *seiketsu* (cleanliness), *seiton* (tidiness), and *seiso* (simplicity) set by Nakajima (1984). 5S approach depicted in Figure 2 was applied to clean and manage a proper workstation.

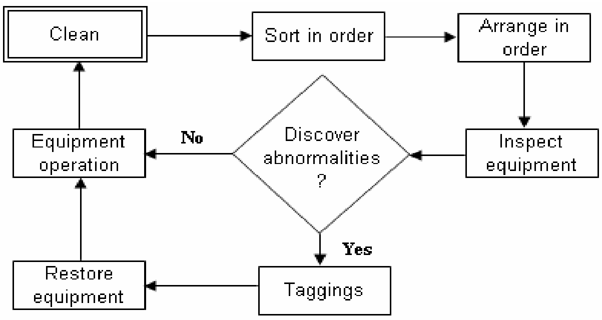


Fig 2: Cycle of 5S implementation

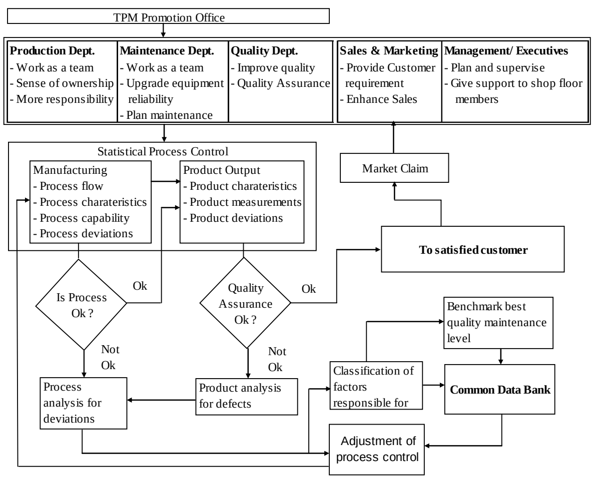


Fig 3: Framework of TPM implementation

The major activities and their linkage are shown in Figure 3. These were coordinated by TPM promotion office.

## 3. RESULTS OF TPM IMPLEMENTATION

This section summarizes the collected data and places some comments on the situation before and after TPM implementation. The data were collected from daily production data record, daily maintenance report and quality control record. The chapter presents a discussion on key factors towards the successful implementation of TPM, and the benefits achieved at the time of its application.

The major activities and their linkage are shown in Figure 3. These were coordinated by TPM promotion office.

### 3.1 Equipment and the monthly equipment trouble losses

The diagrams below show some of the major equipment used in the production with the respective equipment problem losses throughout the years. The major equipment are Board Tester, Vacuum Sucker, Dipping, Adjustment Spec, Function, Jig, C/R and other portable equipment. The equipment problem losses at the beginning of the year are actually the start-up time losses due to adjustments after equipment planned maintenance and major calibrations at the end of the previous year. The losses are not significant as the production line would stabilize thereafter. Figure 4 shows the trouble losses during the introductory period of TPM implementation. The losses are very high and quite unpredictable. It is after TPM implementation that production line began to show less trouble loss as shown in Figure 5, Figure 6 and Figure 7 progressively.


| | Months | Jan Yr 1 | Feb Yr 1 | Mac Yr 1 | April Yr 1 | May Yr 1 | June Yr 1 | July Yr 1 | Aug Yr 1 | Sept Yr 1 | Oct Yr 1 | Nov Yr 1 | Dec Yr 1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Plan | 1.50 | 1.30 | 1.00 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 |
| | Actual | 1.90 | 1.80 | 1.47 | 1.41 | 1.34 | 1.43 | 1.21 | 0.93 | 1.10 | 1.31 | 1.31 | 1.22 |
| Equipment | Board Tester | 0.20 | 0.40 | 0.30 | 0.30 | 0.20 | 0.20 | 0.20 | 0.20 | 0.10 | 0.20 | 0.20 | 0.20 |
| | Vacuum | 0.30 | 0.20 | 0.20 | 0.20 | 0.20 | 0.30 | 0.20 | 0.10 | 0.30 | 0.20 | 0.20 | 0.20 |
| | Dipping | 0.05 | 0.05 | 0.04 | 0.04 | 0.05 | 0.03 | 0.03 | 0.05 | 0.02 | 0.02 | 0.03 | 0.04 |
| | Adjustment | 0.15 | 0.15 | 0.15 | 0.10 | 0.10 | 0.11 | 0.10 | 0.10 | 0.10 | 0.12 | 0.10 | 0.10 |
| | Function | 0.30 | 0.20 | 0.20 | 0.20 | 0.20 | 0.10 | 0.10 | 0.10 | 0.10 | 0.20 | 0.20 | 0.10 |
| | Jig | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 |
| | C/R | 0.80 | 0.70 | 0.50 | 0.50 | 0.50 | 0.60 | 0.50 | 0.30 | 0.40 | 0.50 | 0.50 | 0.50 |
| | Others | 0.05 | 0.05 | 0.03 | 0.02 | 0.04 | 0.04 | 0.03 | 0.03 | 0.03 | 0.02 | 0.03 | 0.03 |

Fig 4: Year 1 equipment trouble loss


| | Months | Jan Yr 2 | Feb Yr 2 | Mac Yr 2 | April Yr 2 | May Yr 2 | June Yr 2 | July Yr 2 | Aug Yr 2 | Sept Yr 2 | Oct Yr 2 | Nov Yr 2 | Dec Yr 2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Plan | 1.50 | 1.30 | 1.00 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 |
| | Actual | 1.86 | 1.75 | 1.33 | 1.41 | 1.33 | 1.21 | 1.20 | 1.12 | 1.10 | 1.21 | 1.10 | 0.88 |
| Equipment | Board Tester | 0.40 | 0.40 | 0.30 | 0.30 | 0.20 | 0.20 | 0.20 | 0.20 | 0.10 | 0.20 | 0.10 | 0.10 |
| | Vacuum | 0.30 | 0.20 | 0.10 | 0.20 | 0.20 | 0.20 | 0.20 | 0.10 | 0.30 | 0.20 | 0.20 | 0.10 |
| | Dipping | 0.05 | 0.05 | 0.04 | 0.04 | 0.05 | 0.03 | 0.03 | 0.05 | 0.02 | 0.03 | 0.03 | 0.01 |
| | Adjustment | 0.12 | 0.11 | 0.11 | 0.10 | 0.10 | 0.11 | 0.10 | 0.10 | 0.10 | 0.11 | 0.10 | 0.10 |
| | Function | 0.20 | 0.20 | 0.20 | 0.20 | 0.20 | 0.10 | 0.10 | 0.10 | 0.10 | 0.20 | 0.20 | 0.10 |
| | Jig | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 |
| | C/R | 0.70 | 0.70 | 0.50 | 0.50 | 0.50 | 0.50 | 0.50 | 0.50 | 0.40 | 0.40 | 0.40 | 0.40 |
| | Others | 0.04 | 0.04 | 0.03 | 0.02 | 0.03 | 0.02 | 0.02 | 0.02 | 0.03 | 0.02 | 0.02 | 0.02 |

Fig 5: Year 1 equipment trouble loss


Fig 6: Year 1 equipment trouble loss

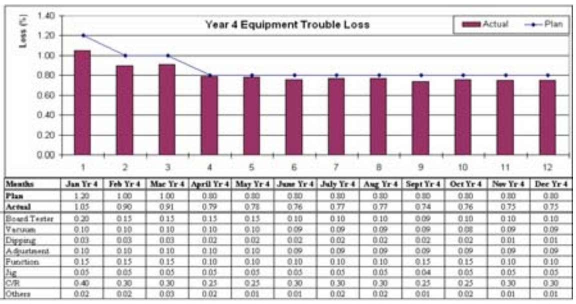


Fig 7: Year 1 equipment trouble loss

## 3.2 Production Line Efficiency

The line efficiency compares the actual operating time to the net cycle time planned for the production. The Figure(s) 8 below shows Year 1-4 Overall Line Efficiency which is the period at the initial TPM implementation. The line efficiency is only 75 percent. There are too many delays and stoppages in the production lines, which affects the lower availability of the production lines in operation.


Fig 8: Line efficiency at manufacturing lines

There are some improvements in the Year 2 Line Efficiency after the TPM implementation. Then, the Line Efficiency continues to improve from 75 to 85 percent as in Year 4. At the time of this report, it is learned the Line Efficiency is around 86 percent.

## 3.3 Overall Equipment Effectiveness (OEE)

The fundamental measure of TPM performance is the overall equipment effectiveness (OEE). It is the driving force that provides the direction for improvement (Davis, 1995). In the experience of this company, OEE has had better coverage than the other tools like Root Cause Analysis (RCA) or Fault Tree Analysis (FTA). This may be due to the fact that Overall Equipment Effectiveness is a measure of benchmarking and an understandable analysis in the production floor.

In Figure 9 the Year 1 result shows the OEE for all production lines during the stage of TPM introductory implementation. Then, the following graphs in this figure show the improvements of OEE.

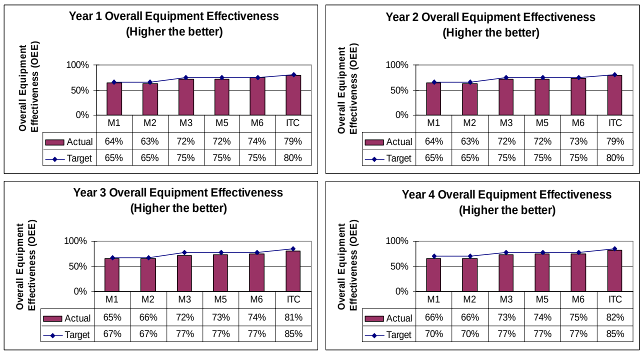


Fig 9: TPM introductory implementation Overall Equipment Effectiveness

Production Lines M1, M2 and M3 are three of the main production lines in the company. The equipment in these lines are older compared to other production lines. Despite the older equipment, the proper implementation of TPM enables to benefit from the increase of OEE in these three production lines.

## 3.4 Kaizen (Improvement) activities in the manufacturing lines

Figure 10 shows the results of tagging after 3 months into TPM official take off. Tagging activities identify equipment defects hidden in and around the workstations. There are certain places or part of equipment, which are thought to be in good condition but are actually deteriorating to breakdown in the near future. The tagging activity later became part of daily chores to identify abnormalities and to keep up the awareness of their proper workstations.

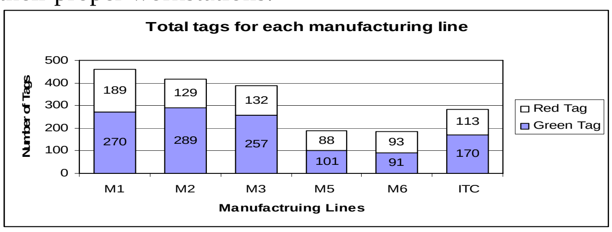


Fig 10: Number of tags or abnormal conditions found

After the tagging activity, there are several improvement activities over the years as shown in Table 2. The improvement activities are mainly 5S activities, which include reorganizing workstations, removing unwanted materials, rearranging and labeling items, and setting up proper work procedures.

Table 2: Improvement activities carried out to solve abnormal conditions

| Manufacturing Lines | April 02 ~ Sept 02 | Oct 02 ~ March 03 | April 03 ~ Sept 03 | Oct 03 ~ March 04 | April 04 ~ Sept 04 | Oct 04 ~ March 05 | April 05 ~ Sept 05 |
|---|---|---|---|---|---|---|---|
| M1 | 28 | 27 | 29 | 33 | 20 | 29 | 31 |
| M2 | 27 | 27 | 28 | 17 | 21 | 25 | 26 |
| M3 | 22 | 22 | 13 | 19 | 24 | 25 | 28 |
| M5 | 15 | 15 | 16 | 9 | 11 | 18 | 20 |
| M6 | 13 | 16 | 17 | 14 | 13 | 17 | 19 |
| ITC | 34 | 35 | 18 | 17 | 27 | 29 | 33 |
| Total | 139 | 142 | 121 | 109 | 116 | 143 | 157 |

## 3.5 Autonomous Maintenance Training

Table 3 shows that the number of trained workers deployed to do autonomous maintenance at their own workplaces. These workers are the operators who have been to a series of training, and they understand their job and know how to handle well their equipment. As there are more skilled workers in the workplace, they can actually do inspections and simple maintenance to their machines. This would reduce the reliability on maintenance team and instill the sense of ownership in the workers.

Table 3: Number of trained workers for Autonomous Maintenance

| | Yr 2002 | Yr 2003 | Yr 2004 | Yr 2005 |
|---|---|---|---|---|
| M1 | 30 | 42 | 71 | 88 |
| M2 | 30 | 43 | 70 | 90 |
| M3 | 31 | 46 | 62 | 83 |
| M5 | 25 | 29 | 56 | 61 |
| M6 | 25 | 28 | 53 | 66 |
| ITC | 20 | 33 | 66 | 79 |
| Total | 161 | 221 | 378 | 467 |

## 3.6 Number of stoppages in manufacturing line

Table 4 is the statistics of equipment/process stoppages based on equipment failures, sudden breakdowns and abnormal adjustments. These do not include stoppages due to factors like material shortage or man-power shortage.

Table 4: Number of Production Line Stoppages

| | Year 1 | | | | | | | | | | | | Year 2 | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Apr | May | June | July | Aug | Sept | Oct | Nov | Dec | Jan | Feb | Mac | Apr | May | June | July | Aug | Sept | Oct | Nov | Dec | Jan | Feb | Mac |
| M1 | 2 | 4 | 3 | 2 | 2 | 4 | 6 | 3 | 1 | 2 | 2 | 2 | 2 | 2 | 3 | 2 | 2 | 2 | 5 | 1 | 1 | 1 | 1 | 1 |
| M2 | 2 | 5 | 5 | 3 | 3 | 4 | 4 | 4 | 2 | 3 | 1 | 2 | 3 | 3 | 4 | 3 | 1 | 2 | 2 | 1 | 2 | 2 | 2 | 2 |
| M3 | 3 | 4 | 5 | 4 | 3 | 5 | 6 | 4 | 2 | 2 | 3 | 3 | 2 | 3 | 2 | 3 | 2 | 3 | 5 | 1 | 2 | 2 | 3 | 2 |
| M5 | 3 | 6 | 6 | 3 | 4 | 4 | 6 | 5 | 1 | 4 | 2 | 2 | 1 | 2 | 4 | 1 | 3 | 4 | 3 | 0 | 2 | 1 | 3 | 1 |
| M6 | 2 | 4 | 6 | 2 | 2 | 5 | 3 | 3 | 1 | 3 | 3 | 4 | 2 | 3 | 5 | 2 | 4 | 2 | 2 | 1 | 1 | 2 | 2 | 2 |
| ITC | 2 | 3 | 5 | 3 | 3 | 6 | 6 | 4 | 1 | 4 | 4 | 4 | 3 | 2 | 5 | 3 | 2 | 3 | 5 | 0 | 1 | 1 | 1 | 1 |
| Total | 14 | 26 | 30 | 17 | 17 | 28 | 31 | 23 | 8 | 18 | 15 | 17 | 13 | 15 | 23 | 14 | 14 | 16 | 22 | 4 | 9 | 9 | 12 | 9 |

| | Year 3 | | | | | | | | | | | | Year 4 | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Apr | May | June | July | Aug | Sept | Oct | Nov | Dec | Jan | Feb | Mac | Apr | May | June | July | Aug | Sept | Oct | Nov | Dec | Jan | Feb | Mac |
| M1 | 2 | 2 | 3 | 1 | 2 | 1 | 3 | 2 | 1 | 2 | 2 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 0 | 1 | 0 | 1 | 0 |
| M2 | 2 | 3 | 2 | 3 | 3 | 3 | 3 | 1 | 2 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 1 | 0 | 1 | 1 |
| M3 | 2 | 2 | 3 | 1 | 2 | 3 | 1 | 0 | 2 | 2 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 1 | 0 | 0 |
| M5 | 1 | 2 | 1 | 3 | 2 | 1 | 2 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| M6 | 1 | 1 | 2 | 1 | 2 | 3 | 1 | 2 | 1 | 2 | 3 | 2 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 1 |
| ITC | 1 | 2 | 2 | 1 | 1 | 1 | 2 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 2 | 0 | 1 | 0 | 1 |
| Total | 9 | 12 | 13 | 10 | 12 | 12 | 12 | 6 | 6 | 8 | 8 | 6 | 3 | 2 | 2 | 3 | 4 | 3 | 3 | 4 | 2 | 2 | 4 | 4 |

= machines stop for major maintenance upgrade

| | Year 1 | Year 2 | Year 3 | Year 4 |
|---|---|---|---|---|
| Num. of stoppages | 244 | 160 | 114 | 36 |

After the planned maintenance, equipment are in better operating condition. Frequency of equipment stopping due to breakdown has been decreasing as a result of proper preventive maintenance. Then, proper scheduled calibrations also ensure the equipment performing at high reliability and accuracy in measurements.

## 3.7 Maintenance Cost

This maintenance cost refers to the cost for 'fire-fighting' maintenance, unnecessary breakdowns before the equipment due time and breakdowns due to operators' mishandling. After preventive maintenance, the major breakdowns are reduced. Hence, the cost for major repairs could be reduced. This cost will not, then, be passed to the cost of the product manufacturing.

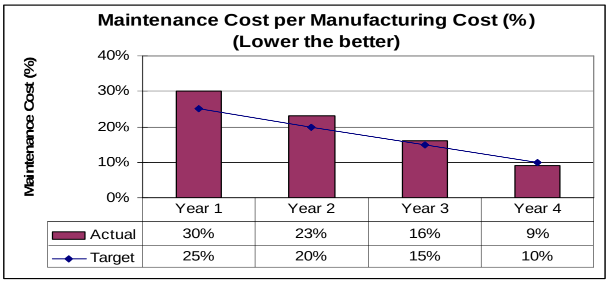


Fig 11: Maintenance Cost per Manufacturing Cost (%)

## 3.8 Autonomous Maintenance (One Point Lesson)

One Point Lesson (OPL) is the lessons learnt by the operators after carrying out the autonomous maintenance or kaizen (improvement) activity. The small-group-activity leader marks the activities into this OPL report. The increasing of OPL reflects the increase the improvements done by the operators, and thus an indicator that the operators are becoming more skillful.

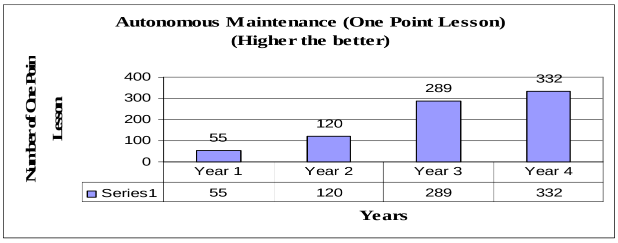


Fig 12: Number of One Point Lesson

## 3.9 Product Rejection

Different manufacturing lines shown in the table produce different models of product. Table 5 shows the in-house rejection of defective products before being sent to warehouse. All the manufacturing lines show the improvement in producing quality product except M3. This table also shows the product rejection by customers, which also has shown great improvement for all products. This is a very important result to show the improvement of manufacturing line to produce quality products. This measurement infers that TPM program has the impact on TQM.

Table 5: In house and customer product rejection (ppm)

| | In-house product rejection | | | | | |
|---|---|---|---|---|---|---|
| Year | Factory 1 | | Factory 2 | | Factory 3 | |
| | ***M1*** | ***M2*** | ***M3*** | ***ITC*** | ***M5*** | ***M6*** |
| 1 | 3045 | 3045 | 2784 | 2883 | 1302 | 1899 |
| 2 | 1691 | 1691 | 1921 | 1843 | 1189 | 1720 |
| 3 | 1252 | 1252 | 1756 | 1593 | 989 | 1129 |
| 4 | 1141 | 1141 | 1112 | 1334 | 967 | 981 |
| | **Customer product rejection** | | | | | |
| Year | Factory 1 | | Factory 2 | | Factory 3 | |
| | ***M1*** | ***M2*** | ***M3*** | ***ITC*** | ***M5*** | ***M6*** |
| 1 | 1393 | 1203 | 1159 | 1034 | 1130 | 1293 |
| 2 | 1204 | 1194 | 1245 | 972 | 1145 | 1222 |
| 3 | 1154 | 1139 | 1210 | 895 | 994 | 1004 |
| 4 | 1102 | 1098 | 1004 | 872 | 982 | 990 |

### 3.10 Business Plan Achievement

Business plan refers to the target of product sales achievement. Since the quality of production had improved, this has build up customer's trust and satisfaction. The business plan achievement also increased over the years.

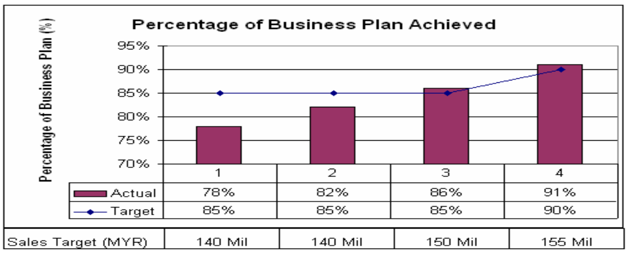


Fig 13: Percentage of Business Plan achieved (%)

## 4. ANALYSIS AND DISCUSSION

This section provides some analyses on the results obtained above.

### 4.0.1 Production Line Analysis

The case study company suffers from high equipment trouble losses. Figures 4 through 7 detail the different types of equipment bound losses in the production line. The losses include equipment breakdown, setup time and adjustments. As determined from the list of equipment, Board Tester, Vacuum and C/R has the higher record of losses compared to other equipment, thus contributes to the higher total equipment trouble loss. After some years of TPM implementation, the equipment trouble loss has dropped significantly. The results may still not fully satisfactory, but it is evident that the equipment is well managed with proper planned maintenance.

Figure 8 shows the Line Efficiency. There are six main production lines at the case study company. The manufacturing processes are similar for each production line, of which different production line produces different models of product. Production lines M1, M2 and M3 are, first, setup at the beginning of the company operation. Thus, the line efficiency is lower compared to other production lines such as M5, M6 and ITC due to the fact equipment is getting old. Nevertheless, this fact has been proven to be wrong with the significant increase of line efficiency over the years of TPM implementation. Eventually, the Line Efficiency also increased to 85 percent, which is a very satisfactory level.

Figure 9 shows the Overall Equipment Effectiveness (OEE) for all production lines. OEE is a measure of Line Efficiency, Actual Product Output, and Good Quality Product. Thus, it is not true that old equipment has always to be replaced by new equipment to improve the OEE. It is a matter of production management with suitable planned maintenance that will contribute to the OEE.

### 4.0.2 Product Quality Analysis

The product rejections are due to defects in the products, which are measured in parts per million (ppm). Product output defects could be due to defective incoming materials, human handling, environment and processing equipment. Table 5 shows the defective products found at the end of production. There is significant decrease in the product defects especially in Factory 1 and Factory 2 which house production line M1 to M3. The equipment here is older, and that could explain the higher product defects compared to other production lines. The rejection ratio towards Year 4 has been reduced to a satisfactory level (target: 1000ppm) after TPM implementation. Although this level is still far from TQM objectives, zero defects, the authors believe that the target is achievable given another period of years for the entire implementation to stabilize and take root. Thus, it can be concluded that proper equipment management and maintenance has contributed to producing good quality products.

### 4.0.3 Work Environment Analysis

Figure 10 shows the exercise of production floor operators to identify the abnormal conditions around their workstations. Then, Table 2 shows the improvement activities done in the small group activities. Figure 12 also shows the increasing number of One Point Lesson in the small group activities. These results could, indirectly, show that the operator had develop a certain degree of ownership sense (Cooke, 2000) in taking care of their workstations, improving their equipment and make sure a safe and clean working environment.

### 4.0.4 Customer Satisfaction Analysis

There is no direct measure of customer satisfaction in the case study. Nevertheless, Figure 13 that shows the higher percentage of business plan achieved gives a strong indication that the product has gain high market recognition and customers are happy to make business with the company.

### 4.1 Benefit Achieved

Based on the analysis discussed above, the potential benefits which can be gained by the case study company are summarized as below:

(1) Increased equipment productivity
(2) Reduced equipment downtime
(3) Increased plant capacity
(4) Lower maintenance and production costs
(5) Approaching zero equipment-caused defects

(6) Enhanced job satisfaction
(7) Increased customer satisfaction

## 5. CONCLUSIONS

TPM in conjunction with 5S is an important maintenance approach in this manufacturing age where highly sophisticated equipment and machineries are used. Proper implementation of this blend can bring about enormous changes and improvements to equipment performance, production output and quality of products delivered to the customers. The results placed above show the impact of implementation could uplift the entire organization to better working environment and morale. This will drive to the development of TQM culture, where the focus of organization is changed from production centered to the need and requirement of customers. In conclusion, TPM works more than a maintenance strategy, and should be considered as an investment than costs to an organization.

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