การปรับปรุงประสิทธิภาพการทำงานของสายการผลิตบรรจุภัณฑ์เครื่องดื่ม

Operational Performance Improvement of Beverage Production Lines

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บทคัดย่อ

งานวิจัยนี้มีวัตถุประสงค์ในการลดความสูญเปล่าเพื่อปรับปรุงประสิทธิภาพการทำงานของสายการผลิตระบบบรรจุภัณฑ์เครื่องดื่มให้สูงขึ้น โดยใช้การประชุมระดมสมอง กับทุกหน่วยงานที่เกี่ยวข้อง และ ใช้แผนผังเหตุและผล ในการหาปัญหาและต้นเหตุของปัญหาที่แท้จริงจากนั้นทำการประเมินและจัดลำดับความสำคัญของข้อบกพร่องที่พบด้วยเทคนิคการวิเคราะห์ข้อบกพร่องและผลกระทบ และใช้เทคนิคการตั้งคำถาม ทำไม-ทำไม เพื่อกำหนดแนวทางการแก้ไขโดยพบข้อบกพร่องรวมทั้งสิ้น 34 หัวข้อ และสามารถกำหนดเป็นแนวทางการแก้ไขข้อบกพร่องได้ 3 แนวทาง ซึ่งประกอบด้วย การดำเนินการบำรุงรักษาเครื่องจักรด้วยตนเอง การจัดการอะไหล่ และ การดำเนินการปรับปรุงการสื่อสารภายในทีมที่เกี่ยวข้องกรณีเครื่องจักรชำรุด โดยเมื่อเปรียบเทียบผลดำเนินงานวิจัยคือค่า ดัชนีชี้วัดประสิทธิภาพการทำงาน ก่อนการปรับปรุงมีค่าเฉลี่ยเท่ากับ 76.21% ภายหลังการแก้ไขและปรับปรุง แล้วพบว่ามีค่าเฉลี่ยเท่ากับ 83.34 % คิดเป็นค่าที่เพิ่มขึ้น 7.13%

Abstract

This research study aims to reduce waste of beverage production lines with increasing of operational performance improvement score by brainstorming with all departments of relevant workers to use the cause and effect diagram to define the problems and underlying causes. After that, evaluating and sorting on priority issues problems by Failure Mode and Effect Analysis (FMEA) and using Why-Why Analysis technique for guideline to problem solving in all 34 topics of total defects and define 3 implementation solutions to problems plans that consist of Autonomous Maintenance (AM) implementation, spare part inventory management and improve internal communications in case of faulty machine. Comparison results of operational performance improvement (OPI) before improvement the average was 76.21% and after improvement the average was 83.34% that calculated percentage increasing by 7.13%.

1. Introduction

Each of beverage manufacturing technology is quite similar to the one in particular beverage cans that is extremely popular from manufacturers and consumers because of convenience use, creating unique packaging design and a wide variety of shaping options that move forwards dynamic competition for being most highly valued market share in their industry. The important thing is that all manufacturing plants focusing on maintaining to the quality products, safety, and security of industrials standards; moreover, high efficiency in manufacturing operations is challenged organizational target. The case study factory is currently faced with the problem of inefficiency machine that affected to the unexpected plan of the result in Operational performance Indicator (OPI) score by management at 80% as shown in the Figure 1.

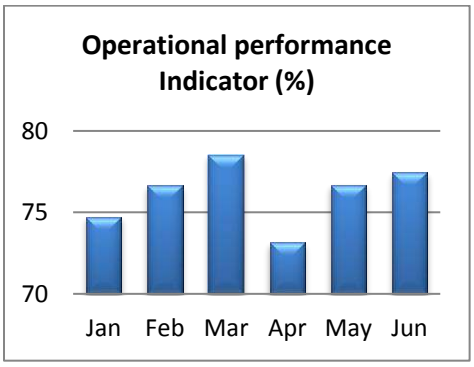


Figure 1. Operation Performance Indicator (OPI) of the year 2017

The Figure 1 shows the information in each month that is less than 80% of OPI targets. In primary hypothesis, it may cause frequently machine downtime to occur the waste of time in imperfect production available time as presented in the Table 1.

Table 1. Information using for calculating 1 OPI between Jan-Jun 2017 before improvement.

Month	Performance (%)	Quality (%)	Available time (%)	OPI (%)
Jan	93.00	99.20	81.00	74.73
Feb	94.00	99.45	82.00	76.66
Mar	95.00	99.60	83.00	78.53
Apr	92.00	99.40	80.00	73.16
May	94.00	99.50	82.00	76.69
Jun	94.00	99.30	83.00	77.47
Average	93.83	99.48	81.83	76.21

According to the mentioned problems that bring to this research study aiming to OPI to achieve the target.

For implementing research will analyze the main cause of the problems and utilize tools for supporting continuously running of machine and overall equipment effectiveness that is under of the condition; the more life-timing, the more machine hours, including to study and to analyze aluminum can packaging system in order to establish the solutions to get rid of waste reduction in production lines with expecting to rise the score of OPI up.

2. Theory and Literature Review

2.1 Theory

2.1.1 Total Productive Maintenance

Total Productive Maintenance (TPM) is a combination of American preventive maintenance and Japanese concepts of total quality management and total employee involvement. TPM is a methodology originated by Japan to support its lean manufacturing system. TPM is a proven manufacturing strategy that has been successfully employed globally for achieving the organizational objectives of core competence in the competitive environment.

2.1.2 Failure mode and effects analysis

Failure mode and effects analysis (FMEA) is a reliability tool, which requires identifying failure modes of a specific product or system, their frequency and potential causes. FMEA is carried out by a cross-functional team of experts from various departments.

2.1.3 Risk Priority Number

Risk Priority Number (RPN) is a numerical assessment of risk level associated with each potential failure mode of product or process in Failure mode and effects analysis (FMEA) analysis. RPN is calculated by multiplication of 3 indexes: Severity, Occurrence, and Detection of the failures.

RPN's formula is:

RPN = Severity(S) X Occurrence (O) X Detection (D)

2.1.4 Autonomous maintenance

Autonomous maintenance (AM) is performed by the operators and not by dedicated maintenance technicians. It is a crucial component of the Total Productive Maintenance (TPM). The core idea of AM is to provide the operators with more responsibility and allow them to carry out preventive maintenance tasks.

2.2 Literature Review

Total Productive Maintenance (TPM) and to present an overview of TPM implementation practices adopted by the manufacturing organizations [1]. Modern manufacturing requires that, to be successful, organizations must be supported by both effective and efficient maintenance practices and procedures [2]. Effective communication techniques and top management support help the functionality of TPM [3]. TPM has a positive and significant relationship with low cost high levels of quality [4].

Failure Mode and Effects Analysis (FMEA) is a proactive process aimed to evaluate a system, design, process and service for possible ways in which failures can occur [5]. Traditional FMEA is made by addressing problems in an order from the biggest RPN to the smallest ones [6]. FMEA has been used as a decision making tool to prioritize the corrective

actions so as to enhance product/system performance by reducing the failure rate [7].

Autonomous maintenance (AM) management of machine tools and flexible manufacturing systems. The paper considers the steps needed to develop and implement truly, AM implementation framework is developed based on four systematic stages: initial preparation, training, execution and audit [8, 9]. The propose of AM to increase the machine and equipment availability [10].

Risk Priority Number (RPN) is computed making pairwise comparisons, so that qualitative judgments and reliable quantitative data can be easily included in the analysis, evaluate a system, design, process and service for possible ways in which failures can occur [11,12]. The higher risks (RPN) are reduced to top RPNs by considering the severity(S), occurrence (O) and detection (D) rankings [13,14].

3. Methodology

To study and to implement research are divided into 5 steps as follows;

1. To study current conditions and the production process of beverage factory in a case study.

2. To classify and to analyze for finding root cause of the problems by studying information of problems and brainstorming.

3. To study and to find the solutions towards implementation accordingly.

4. To compare the results before and after operation performance indicators, OPI improvement.

5. To summarize of the case study research and suggestions.

3.1 Case Study

To study the current condition of beverage production for a case study factory with operations and manufacturing process in particular the process by collecting of the statistical data problems for analysis to root cause of problems in the next step.

3.2 Classify and to analyze

To study and to analyze in production lines by using the process flows diagram for analysis all systems. In the step of brainstorming, to clarify cause and affect defects uses cause and effect diagram and evaluation the potentials the defections with first priority amendment by FMEA for chosen the defections into the topics of meeting to find the solutions.

3.3 Improve and solve the problems

The purpose that this solution is for better implementation in brief;

1. Using AM implementation for efficiency maintenance of machine working.

2. Raising proper management of spare parts for repairing machine.

3. Reconsidering to coordinate in between involved group of operation workers for delay reduction.

3.4 Evaluate and Compare

Evaluation and comparison the results by collecting the data before and after improvement implementations for summary by consideration the value of OPI that presents totally efficient production line. After improvement according to the planed solutions between Jul - Aug and collect the data between Sep -Nov for research summary.

3.5 Summarize the implementation

Summary of implementing research with changing OPI score during Sep – Nov 2017 that bring to compare with managements of the OPI goal-setting by 80% correlate with the significant causes of machine downtime to improve that is it better to solving the problems or not in order to be the improvement implementations of the similar types of defects.

To study and to implement research are shown in Figure 2.

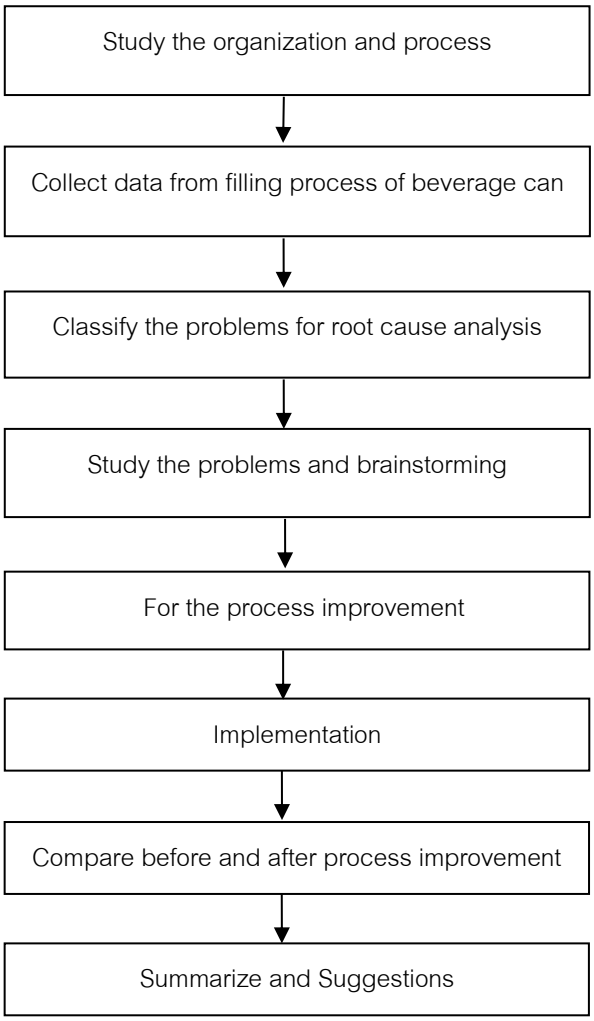


Figure 2. Flowchart of research method

4. Implementation

4.1 Case Study

The case study factory is a beverage factory that distributed its product in domestic and overseas. Beverage products were contained into aluminum cans, bottle glasses and tanks. The types of packaging are divided into primary and secondary packaging. The primary packaging that is container materials to hold the product for food contact directly. The secondary packaging that is to protect the

product to prepare products for shipment, selling and creating the interesting remark. The packaging materials are being used in domestic and imported from the overseas.

This research will focus to study and to analyze for waste reduction, especially in filling lines of packaging in beverage cans. Currently, operation's work days from Monday to Saturday was separated into 3 shifts with 5 employees in every shift.

4.2 The current problems of the case study

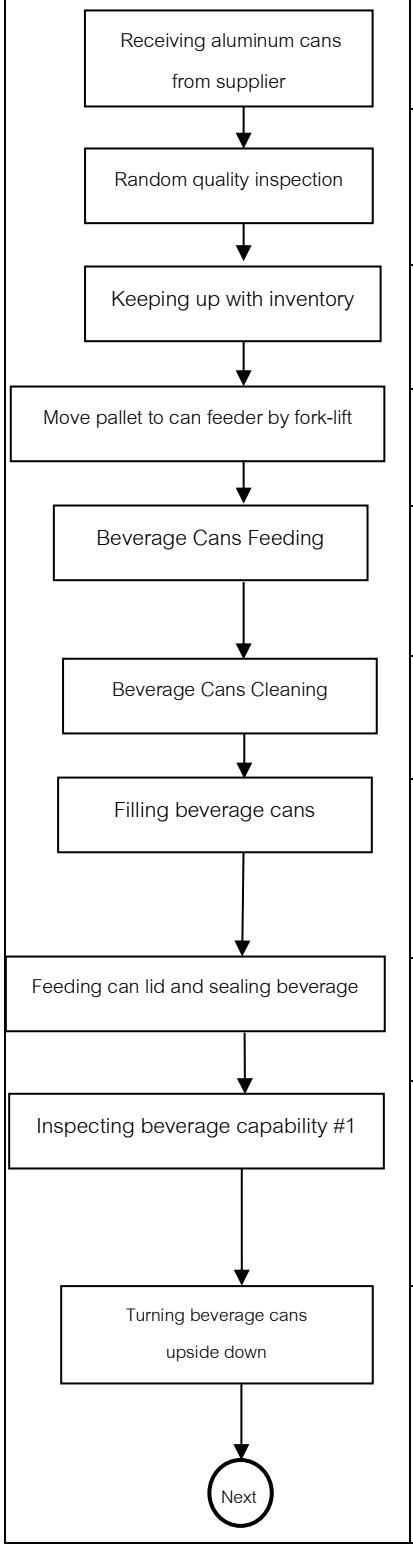
According to OPI score since Jan - Jun 2017 as shown in Table 1, the OPI score is 76.21% by data classification. That is, there are capacity filling machine, products of quantity, and the amount of time available for manufacturing process to be done. It had been realized that the available time is less than the performance and product of quantity affecting the lower OPI score.

The main thing that has caused the available time is that machine downtime was divided to internal factor namely; breakdown maintenance machine must repair for over 10 minutes and minor stop during production process, cleaning, changing type of beverage filling, reaching the due date of machine checklists by maintenance department, operating of human defects and etc. The machine downtime for external factor namely; changing production plan immediately by electricity plan department and blackout in the electricity causes to beverage production lines cannot produce or send to the next process for filling production lines and etc.

To analysis the problems of inline beverage filling downtime; for this reason, to arrange the meeting with relevant workers namely; beverage filling department, quality assurance department, beverage manufacturing department, engineering & maintenance department and inventory warehouse department brainstorm to find the factors and causes of the problems to get the solutions to cope with. Starting with analysis improper occurred in each of the process by the flowchart of beverage cans filling lines shown in Table 2.

Refer to the information of maintenance department that was collected problems and defects when beverage filling machine stopped working of beverage filling lines to solve the problems with spending more than 10 minutes (Breakdown) or to stop the machine in short (Minor Stop) frequently getting through running of machine since Jan-Jun 2017 with comparing to the types of defect per time per minute shown in Table 3.

Table 2. Problems and defects in each of the process of beverage cans filling lines.

The flowchart of beverage cans filling lines	Problems and Defects
	Defective beverage cans Improper beverage cans in shape, coloring and pattern label Damaged beverage cans from transferring pallets Minor bump by a forklift truck occurred the distorted cans Faulty machine ,Overturned beverage cans feel uncomfortable conveying not enough water pressure to flush beverage cans Faulty & leaky machine and improper filling function Incomplete covering and undistributed can lid with leaky machine Incorrect capacity measuring, not separate loss occurs, separate the perfect to defective product Beverage cans obstruction made the distorted cans

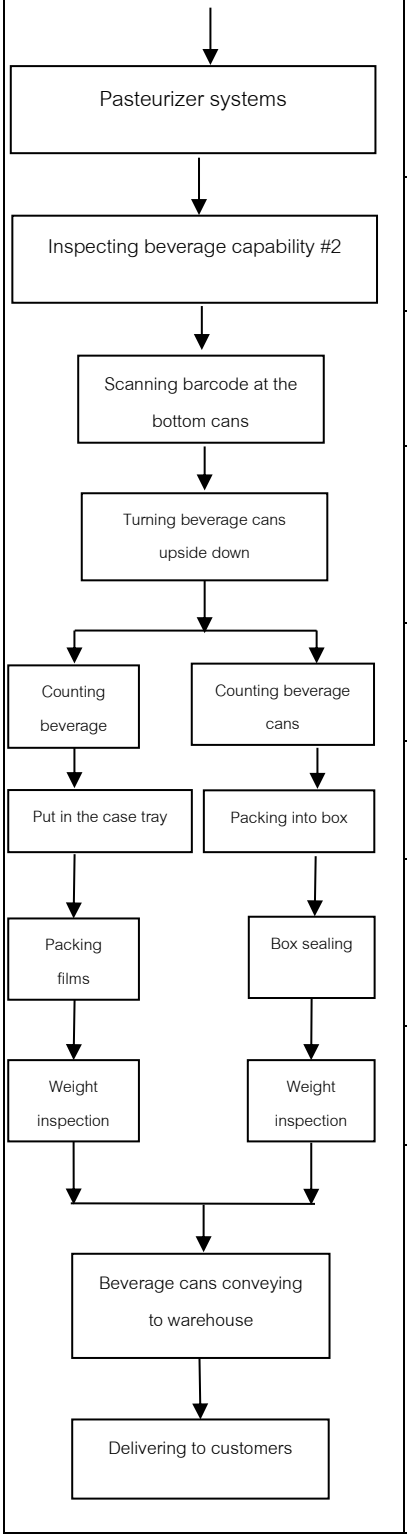
The flowchart of beverage cans filling lines	Problems and Defects
	not enough water pressure/quantity, incomplete temperature, faulty machine/in the belt conveyor Incorrect capacity measuring, not separate loss occurs, separate the perfect to defective product Faulty machine, not obvious barcode and keying wrong in product barcode Beverage cans obstruction made the distorted cans Incomplete, overturned beverage cans Faulty machine, not feeding tray/ corrugated box or incomplete case tray covering Stuck packing film, Not working of hot blow packing film, Incomplete adhesive on box/grime adhesive ,Distorted box Incorrect in weight measurement Belt conveyors in failure mode

Table 3. Quantity of minor stop compared with available time and OPI during Jan- Jun 2017.

Month	Breakdown		Minor Stop		Available time (%)	OPI (%)
	Q'ty of stop (Times)	Total Time stop (Min)	Q'ty of stop (Times)	Total Time stop (Min)		
Jan	8	747	18	360	81.00	74.73
Feb	5	862	15	250	82.00	76.66
Mar	6	649	18	425	83.00	78.53
Apr	7	1,012	22	352	80.00	73.16
May	8	1,240	24	431	82.00	76.69
Jun	6	835	19	225	83.00	77.47
Total	40	5,345	116	2,043		
Average					83.83	74.73

Due to faulty machine for 40 times, that causes the total waste of production time is 5,345 minute and the total minor stop of machine for 116 times, that causes the waste of production time is 2,043 minute. As the quantity of minor stop and breakdown in each machine in particular the filling beverage machines in case study factory using OPI score appearance the defect that is the first one to resolve.

The second one is beverage can feeder in lines to minor stop and breakdown. As the information mentioned above, the researcher and team worker in relevant department have the same opinion that finding solutions to problems and improve to the main of in both machine to prepare more efficiently. That is, there are beverage filling machines and beverage can feeders.

Summarize the defects of beverage filling machine and beverage can feeder as follows;

1. Defects that cause breakdown and minor stop of beverage filling machine consist in 28 defects as follows;

- 10 Defects cause by worker/person
- 6 Defects cause by machine
- 8 Defects cause by methods
- 4 Defects cause by raw materials

2. Defects that cause breakdown and minor stop of beverage can feeder consist in 32 defects as follows;

- 12 Defects cause by worker/person
- 6 Defects cause by machine
- 8 Defects cause by methods
- 6 Defects cause by raw materials

According to all defects and mistakes, the same types of defects during gathering information and priority sorting the data found that 34 defects topics by using FMEA technique.

4.3 Evaluation of defects and priority problems

The evaluation of priority problems with calculating the RPN in descending order as the Table 4. For gathering the causes of problems with 100 score or more to establish the priority implementations.

Table 4. Descending order of priority number (RPN)

Topics	Defects	RPN
1	Irregular cleaning, inspection and lubricating engine	370
2	Workers lack of sense of ownership	354
3	Workers and technicians lack of analysis skill of cause faulty machine	354
4	Workers found abnormality and not informed to supervisor or technician	345
5	No specify the check point	318
6	Workers lack of knowledge of operations	282
7	Workers did not notice the defects appearance	282
8	Workers did not inform to relevant workers when machine must be resolved	282
9	Machine parts become loose	275
10	Dirty machine	275
11	No standards for inspection machines	275
12	Lack of analysis skill to preventive maintenance	275
13	Long waiting for machine parts	240
14	Communications between manufacturing department and PM department is not quite well	240
15	Workers did not interactive each other between supervisors and technicians	230
16	No have spare parts in the inventory stock	230
17	Technicians did not have enough information to fix it	230
18	Technicians lack of repairing skills and fixing literacy	200
19	Workers lack of knowledge in inspection quality	200
20	Not lubricated machine where necessary	200
21	Beverage cans was distorted in the pallet	200
22	No procedure to determine informing the relevant workers when occurred faulty machine	200
23	Not following up after repairing machine	200
24	Not updated with the changed machine parts	180
25	No workers control machine at all time	180
26	Improvident workers	180
27	Improvident technicians	165
28	Parts and equipment machine lack of reconsidering lifespan	165
29	Distorted beverage cans through in the lines	165
30	Old age machines and lack of overhauling	75
31	Improper machine lubrication	75
32	Wood pallets of beverage cans turn bad	75
33	Forklift truck crush the beverage cans with damage	75
34	No beverage for containing into the cans	50

From Table 4 this study research found that RPN with more than 100 score for 29 topics from total 34 topics. The evaluation results are used for the rules for the priority selected defects to improve. If the priory problems are well-resolved, the subtopics of problems may also be affected to cope with. Hence, to arrange the meeting is to establish the solutions in the next step.

5. Guideline improvement and application

For cause analysis and priority sorting the problems, therefore, to arrange the meeting was discussed in the current problems with their supervisor involving department to create solutions to problems with focusing on the problems of beverage filling machine and beverage can feeder as follows;

5.1 Creating solutions to problems

From grouping the defects and mistakes for creating solutions to problems distinctly and fit to the objectives of revision in primary amendment in each of defects by applying Why-Why analysis technique for amendment. From Table 5. is the example of making why-why analysis to define correct answers, for instance, dirty machine has been asked with the why-question. The 1st why-question of answer key is that the workers did not clean of machines. The 2nd why-question for the details of answer key is

that the workers cannot finish cleaning machines and dirt always generate during manufacturing process even though the engines have been cleaned. The 3rd why-question for deeper answer key is that the workers did not know where all the elements in dirt on machine part come form and found that the machines is difficult to clean. The 4th why-question answer key is enough to establish the standard is that cleaning practices did not have standards for control, the workers did not have enough knowledge to understand machine and machine is not improved for easy cleaning. For why-why analysis as the mentioned above, to arrange the meeting participants is to establish the standard to cope with all the problems each other. That is focusing on the required cooperation for the sake of Autonomous Maintenances (Autonomous Maintenances: AM).

The all problems was analyzed by Why-Why Analysis for establishing standard and solutions as a results in conclusion as shown in the Table 6.

Table 5. Why-Why Analysis (Example)

Problems	Why? 1	Why? 2	Why? 3	Why? 4	Solutions
Dirty Machines	Workers did not clean of them	Workers did not complete cleaning	Workers did not know where they have to clean the dirt area and they did not recognize how important is sanitation	Not have standards for cleaning control	Autonomous Maintenances Focusing on the required cooperation for the sake of Autonomous Maintenances (Autonomous Maintenances)
		Dirt always generate during manufacturing process	Workers did not know where the dirt sourcing come from	workers did not have enough knowledge to understand machine	
			Difficult to clean the dirt area	Not improved machine for easy cleaning	

From Table 6. The topic is divided into 5 solutions as follows;

1. To improve educate quality of operations process for staffs.

2. To increase worker cooperative in machine maintenance.

3. To improve analysis skills to solve the problems when the defects occurred.

4. To reconsider spare parts inventory control.

5. To improve effectively and suitably the internal communications for workers in their relative department.

Table 6. Defects and Solutions

Topics	Defects	Solutions
1	No Standards for cleaning inspection and lubricating of machine	Established standards of cleaning practices to maintenance machine by machine controller
2	Workers lack of sense of ownership	Autonomous Maintenances Focusing on the required cooperation for the sake of Autonomous Maintenances
3	Workers and technicians lack of analysis skill of cause faulty machine	To attend the training of Why-Why Analysis for operational workers and technicians each other
4	Workers found abnormality and not informed to supervisor or technician	Autonomous Maintenances Focusing on the required cooperation for the sake of Autonomous Maintenances
5	No specify the check point	
6	Workers lack of knowledge of operations	
7	Workers did not notice the defects appearance	
8	Workers did not inform to relevant workers when machine must be resolved	Autonomous Maintenances Focusing on the required cooperation for the sake of Autonomous Maintenances
9	Machine parts become loose	
10	Dirty machine	
11	No standards to inspection machines	
12	Lack of analysis skill to preventive maintenance	
13	Long waiting for machine parts	To reconsider spare parts inventory control and purchasing
14	Communications between manufacturing department and PM department is not quite well	To arrange the agenda topics and meeting summary
15	Workers did not interactive each other between supervisors and technicians	Autonomous Maintenances Supervisor walk-through survey by AM board
Topics	Defects	Solutions
16	No have spare parts in the inventory stock	To reconsider spare parts inventory control and purchasing with optimizing storage data
17	Technicians did not have enough information to fix it	To attend the training of Why-Why Analysis for operational workers and technicians each other
18	Technicians lack of repairing skills and fixing literacy	Reconsidering by attending a training courses
19	Workers lack of knowledge in inspection quality	
20	Not lubricated machine where necessary	Established standards of cleaning practices to maintenance machine by machine controller
21	Beverage cans was distorted during in the pallet	Analysis the problems with technicians for revision
22	No procedure to determine informing the relevant workers when occurred faulty machine	Designed rules and Instruction for technicians and workers
23	Not following up with after repairing machine	Focusing on the required cooperation for the sake of Autonomous Maintenances
24	Not updated with the changed machine parts	
25	No workers control machine at all time	Installing sensors while end process of machine
26	Improvident workers	Designed rules and Instruction for technicians and workers
27	Improvident technicians	
28	Parts and equipment machine lack of reconsidering lifespan	To reconsider spare parts inventory control and purchasing with optimizing storage data
29	Distorted beverage can through in the lines	Analysis the problems with technicians for revision

5.2 Implement the solutions to problems

From the implement the solutions to problems, to bring improvement by cooperation in their relevant worker department that has the details as follows;

5.2.1 Implement Autonomous Maintenance

Implement AM in this research study that mentioned to AM at level 1. Shown in Table 7.

Table 7. Results of implement AM in level 1 and 2 between Sep - Nov 2017.

AM level	Topics	the results of implement AM			
		Beverage filling machine		Beverage can feeder	
		Target	Results	Target	Results
Level 1	Tag	100	165	50	75
	Revision Tag > 90%	90	85	45	60
	Number of OPL (Topics)	20	23	15	18
	Cleaning score	90	95	90	94
Level 2	Revision Tag > 90%	60	55	20	21
	Number of OPL (Topics)	15	15	15	15
	Resolving all sourcing dirt	30	30	40	40
	Reduction time of cleaning > 50 %	120 Minute	55 Minute	120 Minute	50 Minute

5.2.2 Implementation in spare parts management

In part of spare parts inventory management, to arrange for consideration the important of part lifespan harmonize with machine in the current by meeting between engineering and maintenance department to discuss with filling beverage department. After the meeting, to create the methods and to reconsider in spare part and machine parts management that effective on every procedure within August 2017 as follows;

1. Spare part inspection in the inventory stock for updating all parts items of quantities.

2. Inspection methods for all purchasing parts and machine parts solutions in pricing, delivering time and number of parts correctly for correction ordering with convenience.

3. To do the questionnaire with all machine controllers for weak and easy to damage parts or short life cycle parts in conclusion to spare parts for suitable quantities in the current situation information by preventive maintenance supervisor.

4. Sourcing domestic parts alternative to overseas that compared with raw materials and qualities is a must.

5.2.3. Implementation improvements to internal communications

In case of machine downtime due to occur some abnormality that machine controllers will try basically to resolve the problems in the primary in order to turn back of machine work. If the machine cannot fix the defects, the machine controllers will inform supervisor technicians or

technicians to resolve. If so the internal communications went delays causing the extended machine downtime of filling beverage lines and impacted to OPI. The procedure in communications between filling beverage department, technicians and management, when faulty machine occur, if can fix it within 5 minutes. The workers will record to be a minor stop. If machine downtime more than 5 minutes, the workers must inform shift technicians to inspect. When fixing machine can work within 30 minutes, the workers must inform production supervisor for transferring information during changing shift. If the fixing spends more than 30 minutes, the machine is still not working normally. The shift technicians must inform production supervisor and own supervisor for reporting situation and requiring the suggestions in case of supervisor technicians absence. Shift supervisor must inspect the situation report from shift technicians. If the fixing spends more than 60 minutes shift technicians must inform to shift production supervisor again. Shift production supervisor must inform to filling beverage manager requesting for help or any additional supporting namely; technicians from the seller machine and etc. If the fixing can be done within 2 hours, shift technicians or repairer machine must report abnormality directly to his shift supervisor in details for transferring the information and meeting each other in the next morning and if the fixing cannot be done within 2 hours, shift technicians and shift supervisor production must inform to their manager department for reporting to the factory manager for waiting for the solutions to solving in the next step. The OPI results after improvement by implementation AM, implementation maintenance in sparing parts inventory management and implementation internal communications in the relevant workers in case of faulty machine as shown in the Table 8.

Table 8. OPI between Jan -Jun 2017.

Month	Performance (%)	Quality (%)	Available time (%)	OPI (%)
Sep	95.00	99.60	87.00	82.32
Oct	96.00	99.60	88.00	84.14
Nov	95.00	99.40	88.50	83.57
Avg.			87.50	83.34

6. Conclusions, recommendations, and future research

6.1 Conclusions

With the problem of inefficiency machines working that caused to OPI score of filling beverage lines missing organizational target at 80%. According to process analysis found that the most of defections often occur the downtime with beverage filling machine and beverage can feeder.

With cause analysis of defects problem by brainstorming and using fish bone flowchart found that the 28 defects of beverage filling machine as shown in fish bone flowchart consists of 6 defects cause by operational workers, 4 defects cause by beverage filling machine and 8 defects cause by raw materials.

For the 32 defects by beverage can feeder consists of 12 defects cause by operational workers, 6 defects cause by machine, 6 defects cause by materials and 8 defects cause by operational methods. The defects in both machines are to conclude that in total 34 defects. After that, using FMEA technique for evaluation the defects and effects on that consider with RPN by the relevant workers to arrange in descending order found that 29 defects reach more than 100 RPN score. Hence, the defects that mentioned above bring to consider and find out the improvement into 5 implementation solutions as follows;

1. Knowledge and skills of operations improvement in both machine controllers and technicians.

2. Participation improvement in machine maintenance.

3. Analysis skills improvement to preventive maintenance and to resolving the problem in machine defects.

4. Spare parts management improvement in machine lifespan and parts sourcing in domestic for quickly replacement and order.

5. Internal communications improvement efficiency between the relevant workers in their department.

Implementing the solution in the 1st – 3rd steps uses the AM tools for improvement to resolve the problem that based on AM activities on the purpose that is the workers feel a sense of ownership by getting knowledge and activating expression of working with machine in maintenance strategies and approaches by cleaning with inspection machine.

Implementing the solution in the 4th steps by sparing parts inspection with accurately stock, reconsidering the channel of parts purchasing and delivery lead-time. Assignment to machine controllers survey the parts that easy to damage or often changing including sourcing parts in domestic and overseas by comparing with materials and quality for replacement.

Implementing the solution in the 5th steps is to optimize and efficiency internal communications improvement between the relevant workers in their department by brainstorming for setting a procedure in internal communications in case of machine downtime.

Implementation results during 3 months between Sep-Nov 2017 the OPI score was increased from 76.21% to 83.34% that calculated to efficient growth by 7.13%. With the OPI growth from the solutions caused to achieve the target that planned by the management and impacting on available time growth from 81.83% to 87.50% that calculated percentage increasing by 5.67% also.

6.2 Suggestions

For implementation solutions to solving the problems by Autonomous Maintenance (AM) due to limitations in terms of time collecting the data after improvement so that to educate operators to use AM in level 1 and 2 only. Later, if the operators were developed using AM in advance level supposed to rise up scoring OPI accordingly. For implementations maintenance by maintenance department in spare parts management found that the problems in collaboration in relevant departments for to purchasing and procurement for machine parts and sparing parts including increasingly higher cost.

Due to limit the period of time to research, these methods to improvement for solving the problems may not measure concrete workability. However, in primary of implementations research is sufficiency to apply for common machine for the guidelines increasingly OPI improvement.

6.3 Future research

As the results of the research study, that found the defects correction by implementing AM in level 1 and level 2 to rise up OPI score. Therefore in the future research study should study the topics about the affect AM in high level to OPI score. Another interesting research study to do in the future is to find out the methodology to cope with the spare parts inventory problems and implement solutions with them. And if the implementation solutions bring to the practices should be study about the affect to OPI score. In additional, the research is extension of time for collecting data after improvement implementation so that the research results are validity and reliability.

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