A3 Problem Solving: A Case of Assembly Line Downtime

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Abstract
A3 problem solving is an improvement process that applies lean thinking to present report in a structured manner. This process improvement methodology identifies and eliminates waste to satisfy organization's potential goals such as improving productivity, satisfy customers, reduce the operation costs, and support the decision-making. The problem solving is a key ability in manufacturing environment. An ineffective decision making can affect productivity, the lead time and manufacturing costs. This paper used case study to present A3 thinking approach by developing a very simple and structured report for improvement process. The results of case study show the developed A3 report, which goes from the identification of the problem, determination of current situation of the process, identification cause of the problem, determine how to tackle the problem, evaluation of improvement and determination of the effectiveness of the process. The result has also showed that the cycle time of line reduced from 180 minutes to 172 minutes and 25 seconds. The reduction was due to identification and elimination of non-added values**.** Application of A3 problem solving process has demonstrated the applicability and paybacks of the methodology in manufacturing industry.

Keywords
A3, Lean thinking, Cycle Time, Downtime, Waste

1 Introduction
Recently, the pressure to find ways to manage operations more efficiently and effectively is increasing rapidly in manufacturing industry. Organizations are realizing that they must improve their entire workforce in order to help their organizations achieve their goals or objectives. Keeping customer satisfied is among most vital functions of any company (Jones and Sasser, 1995). A company should ensure the continuous delivery of its service standards to customers to preserve customer satisfaction. Customers have higher expectations, and manufacturers must meet these expectations by increasing product's quality, reducing delivery time, and minimizing costs (George, 2002). With business support tools in place, companies can ensure to meet consistently meeting customer expectations. Many companies have lost opportunities due to shortfall of the products or services due to the incapacity of production lines, courtesy of the resource's management. Constant late delivery to the customer results in unsatisfied customer and the loss of market share.

In production and manufacturing, businesses use cycle time as a benchmark of their productivity. Less cycle time means less lead time to present a product in the market quicker. Organization will produce more units in reduced time and use resources of organization at best level; it also increases customer satisfaction and organization's productivity. As such, in the long run, most companies wish to decrease their cycle times to improve productivity and thereby reduce costs. For this reason, it is very important to implement process to identify and help to eliminate waste, which is the major cause of any system inefficiency.

This paper aims to apply A3 problem solving tool developed by Toyota to find out the biggest problem that contribute to the downtime in production line and eliminate it. The information arrangement is vital to guide through the investigation of the current problem. The investigation will lead to identify value and non-value-added activities and eliminating non-value added based on verified information. To achieve the above aim, the specific objectives are: Identify the problem and eliminate it, improve operational speed and improve effectiveness. Shook (2008) defines A3 as a structured problem-solving method, the elements of the A3-method as well as the visualization of outcomes during the improvement are helpful in re-arranging the project activities. The author explained that the approach is a useful tool that supports communication and leads to effective countermeasures based on facts and works as both a problem-solving tool and as a designed process for creating problem-solvers.

1.1 Lean thinking

The term Lean thinking is a concept built on Toyota Production System (TPS) automotive company. According to Womack and Jones (1997), the concept means using less, in term of all inputs, to create the same outputs. According to Radnor and Walley (2008), Lean concept emphasize on strategic and operational levels. At a strategic level it focuses on the principles, and at an operational level it focuses on the tools and techniques. Lean concept is also a business philosophy that carries different names: excellent manufacturing, agile manufacturing, just-in-time manufacturing, synchronous manufacturing, and continuous flow. These words are all similar with Lean Manufacturing. The first goal of the approach is to improve productivity as well as to decrease the cost by eliminating waste or non-value-added activities (Rohani and Zahraee, 2015). The figure 1 describes the objective of Lean. This approach forces company to ask question if someone would pay for the item's actual value, if the answer is no, then it is a waste.

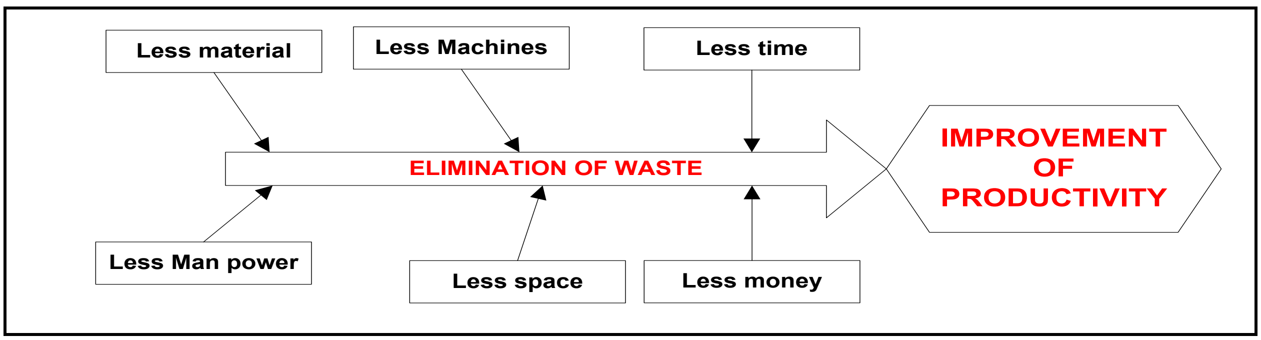

Figure 1. Lean objective

Productivity improvement through Lean Manufacturing (LM) can mean optimizing the input resources to minimize the waste (Junior, C.C.F. and Pinto, L.T., 2020). It is difficult to eliminate waste if it cannot be identified. Once waste has been identified, it can then be eliminated. This includes wasted time, wasted products, wasted space, and wasted services. To identify waste, lean manufacturing uses different type of tools, one of them is A3 problem solving which provides a simple and strict procedure.

1.2 The A3 problem solving

The word A3 refers to international standard name for the paper size 11″x17″. It is an overview or sheet paper that contains an amount of direct information. From the problem to the solution, the A3 allows the writer to include detailed information in one hand, while on the other hand it forces the author to select and process the information carefully. A3 shows more of how thoughts are moved from the issue to the recommendation, rather than just the data. When the thinking process is clear, you can reach arrangement faster.

The idea of this approach was created by Toyota as part of Toyota Production System (TPS) to describe the process of getting report-writing down to one page. For Toyota, this was just a format for structuring a report so that it could be clearly and consistently communicated on one page of paper, reducing the waste of report writing and report reading. The A3 method is an effective tool since it contains not only text, but also pictures, tables, diagrams, and charts to enrich and clarify the data, Chakravorty (2009). Since Toyota was always applying lean thinking, A3 reports made that thinking visible to start perceiving it to help others to think lean. For that reason, Flinchbaugh (2017) explains that Lean success at companies today is not delayed by a lack of tools, nor the capability of the tools they have. It means that what is really behind companies that succeed at sustained lean implementation is the level of thinking driven by lean principles and rules. Thinking is powerful in changing an organization. "*Thinking drives behaviors, behaviors drive action, action drives results. No tool can fix poor thinking*" (Flinchbaugh, 2017).

The benefits of the A3 process include organization focusing on objectives, it forces the A3 report writer to be concise and stick to what is truly critical. Jimmerson (2007) explained that A3 process is a way to look with "new eyes" at a specific problem identified by direct observation or experience. It has roots in the PDCA (Plan-Do-Check-Act) cycle (Prashar, 2017).

2 Literature Review

Several concepts have been introduced to address the issue of productivity improvement in lean manufacturing included is A3, but this last has received little attention. Companies had the models and knowledges of the problem-solving tools, but most of them are not the better problem solvers. The motive is that when most organizations start their lean implementation, they go straight to using the lean tools not bearing in mind that lean implementation has four components: lean planning, lean concepts, lean tools and lean culture. These components must be implemented in matching. The lean tools are hopeless without the support of a developing lean culture (Rubrich, 2017). The author explained that lean culture consists of bringing it all together, Leadership, communication, empowerment, and teamwork. A3 is a structured and very useful problem-solving template that brings all these components together.

There are many materials in relation to establishing A3 lean problem solving in different industries globally. Anderson (2011) in sector of education, described the results of a short survey among 22 students who used A3-reporting in a case analysis. The aim in this survey was to train students to structure problem-solving, to improve communication of the students with their tutor and company supervisor, and to stimulate the learning attitude of the students. Therefore, to make them better problem-solvers. The study showed that most students were pleased with using the A3-report and needed the same time or less to prepare the A3-report, compared with traditional reporting. The author argues that the key features of A3 reporting, appreciated by these students, were the need to be concise and the encouragement for collaboration (Anderson, 2011). Students appreciated the A3-problem solving method structure, which helped them to scientifically describe, analyze and solve problems and force them to think deeper. Students also emphasized the value of the A3-method in the communication with the promoters. The restricted space of an A3 pushed them to be concise and clear. This is one of the main learning points for the students. By using the A3-method, they learnt to develop a good improvement story.

Jimmerson was founder and president of Lean Healthcare West, adapted the A3 problem-solving report for use by hospital staff to improve the organizational processes (Jimmerson, 2007). He explained that the A3 problem solving is an essential tool from Toyota Production System (TPS), which is an extension of work identified with the well-known Value Stream Map. His study was initiated in health care system due to the labor shortage in many areas (Sobek, 2004). The author argued that the health care administrators were very conscious of increase in costs, waste, and inefficiency, therefore the evidence of continuous improvement is high in the priorities of health care accreditation agencies.

Pollenscak and Muller (2011) presented the study to identify factors that contribute to the process of designing and implementing new technology into a specific manufacturing cell within the factory of GKN Aerospace Norge AS (GAN), by observing, analyzing and evaluating different factors during creation, usage, and after use of several A3 overviews. GAN was a Norwegian manufacturing firm that manufactures jet engine components (shafts, vanes, turbine cases and rear exhaust frames) for commercial and military customers. Manufacturing processes of parts consisted of milling, turning, drilling, de-burring, grinding, welding, heat and chemical treatment, and accurate measurements for quality control. The concern was to optimize the utilization of the machines as well as making the operations more reliable and predictable. The study showed that the A3 method has not developed the way the author and group work at GAN, but it was encouraging in a way to make participants more harmonized, aware, and efficient. The author explains that the response from GAN investors confirm that utilizing A3s in different sessions, both planned and unplanned in the factory has made discussions more focused and inclusive, identifying new questions and concerns, as well as serving as a great tool to distribute relevant information. The outcome got from members of the A3 forum shows that there might be a need for basic training and understanding of the A3 process before starting to adapt the tool as a means to support communication and documentation.

Based on different studies above, one can confirm that A3 is a crucial tool used for process improvement and can be used in different environments including manufacturing. Its success depends on careful attention given to it. The common ground found in different environment studied here resides in the support of communication and documentation in different problem solving. The challenge is that issues such as limited human managing abilities and lack of structured of organizational work methods lead to inexact and unclear discussions, that causes the plan team to waste valuable time. It is also time-consuming and difficult to select, sort and organize the information needed for a coherent A3. Therefore, the flow of right information to the right path is critical to ensure the improvement. The crucial part of this information flow is the process of communicating and documenting numerous sides of the system.

The difference found by this study among applications of A3 in manufacturing and A3 used in other environment is that A3 summaries within manufacturing are used as practical ways to report and solve various problems, while in development, these summaries often include more planning and design based information to drive the additional development further.

3 The Methodology

The methodology used in this study is A3 problem solving that is considered as an improvement process that applies lean thinking. Created in Japan by Toyota as part of the Toyota Production System (TPS) to present a report in a simple and structured way. This methodology provides a simple, logical way to solve a problem and to communicate about the problem to the team in a structure that begins by always defining the issue through the eyes of the customer. In this study, the problem is the production downtime found in the assembly line for period of three months. The different elements that constitute A3 problem solving are enumerated below, each element delivering specific function in process of solving problem (Shook, 2008).

- Identify the problem / Issue
- Understand the current situation / state
- Set Goal/Target
- The roots cause
- Brainstorm/determine countermeasures
- Create a countermeasures implementation plan
- Check results – confirm the effect
- Update standard work

The figure 2 describes the different elements of A3 structure used for this case study.

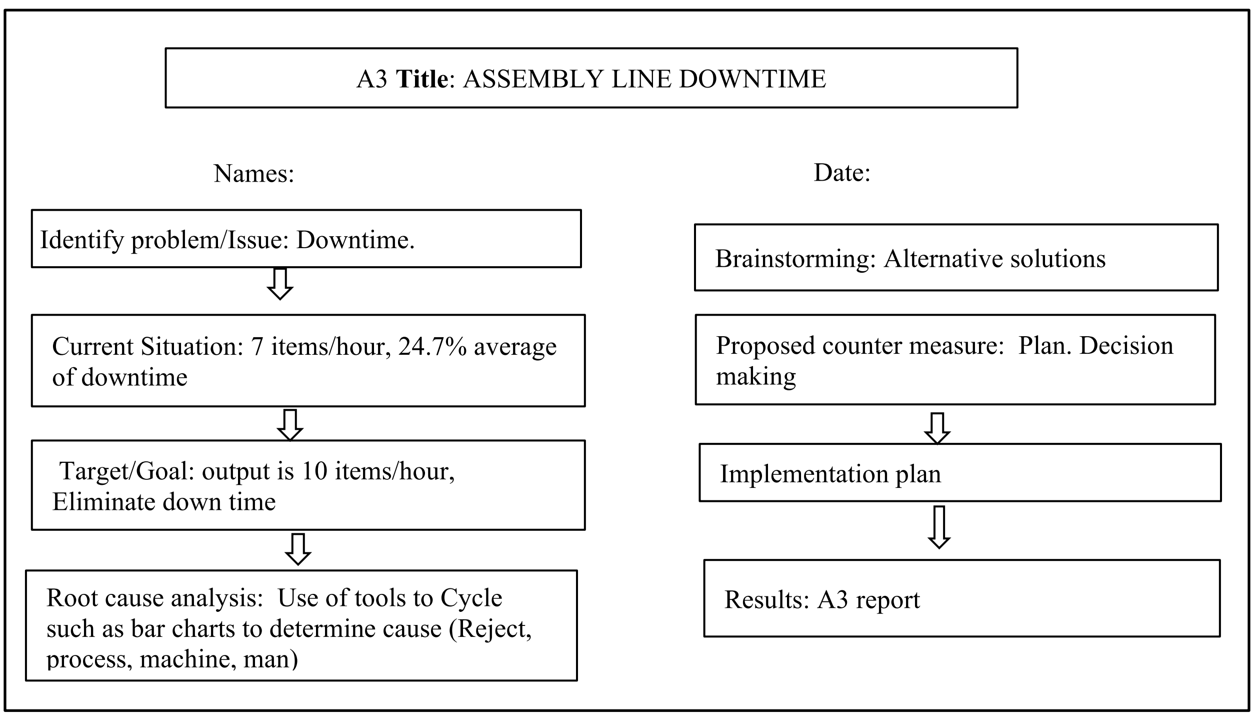

Figure 2: A3 report structure

4 Case Study

4.1 Identify the issue or problem / Background.

The automotive manufacturing company in New Germany, South Africa, is using lean thinking technique to manufacture aluminium and steel car parts for large local and international customers. For past three months, one of its main production lines recorded a significant down time and found itself in shortfall of parts to reach the target and unable to satisfy its customer in time. The company strategy on a manufacturing excellence wants to find out the cause of the production downtime that created incapacity to reach the production target.

The assembly line was targeted for 10 items per hour from each operator. And the line has two operators, both operators are not capable of hitting the target. It means that they could not even reach 80% of the target. This has created a big delay in delivery to customers. The objective of the study was to eliminate waste, improve operational speed, and improving effectiveness. The procedure was to conduct time study to understand downtime losses and identify areas of focus for improvement.

4.2 Current Condition

The data collected from time and method study for last three months revealed that the downtime of the assembly line was so significant. The average downtime for last three months was 27% for June, 30% for July and 32% for August. The average for all three months was 29.7%. The current condition should be observed directly, and an observation worksheet be used to record the different activities in the process. Validate the current condition by getting staff input on the sketch. The ideal situation of the downtime for organization was set to 5%, but the calculated average was 29,7%. Now the real problem of downtime is 29.7% - 5% = 24.7%

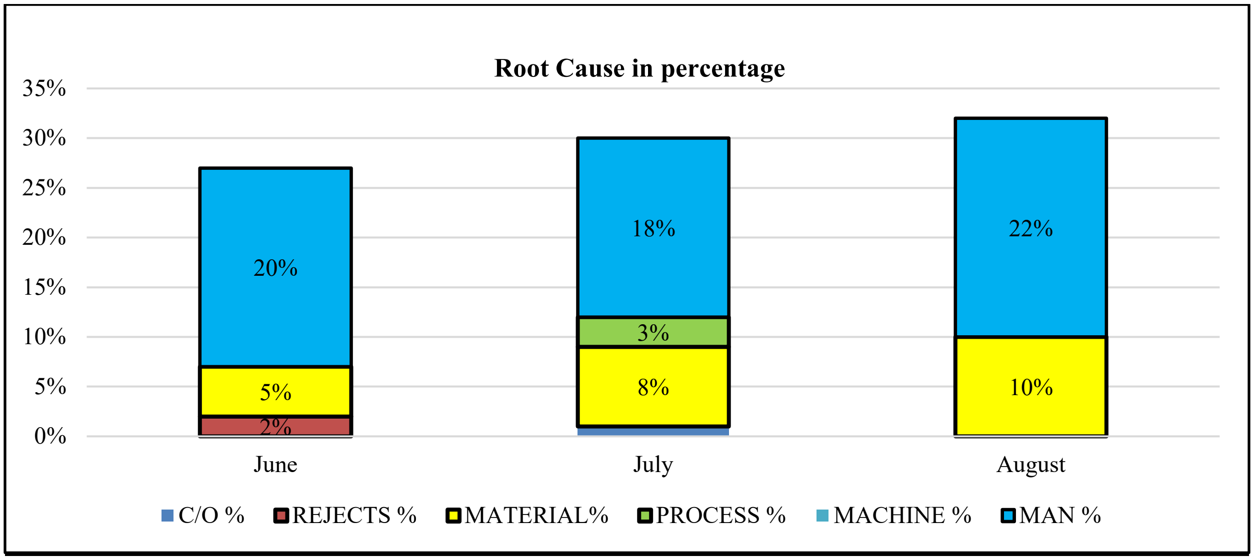

Figure 3: Current situation

The figure 4 describes the assembly workstation where two operators perform the job. In current conditions, operator 1 on right side assembling the right-hand product online number 2 (RH2) and operator 2 on left side assembling the left-hand product on the line number 2 (LH2). Both one and two are assembling same type of product but different because one is right-hand and other is left-hand. The tools found online are screws, electrical head screwdrivers, knifes for trimming, screw beads to perform assembling and the containers of work-in-process (WIP) parts at "Input" and finished goods are also in assembly line at "Output" of line. The activities on assembly line consisted of:

- Collecting part from container, check quality. If good, put on table and assembly. If not reject or fix.
- Assembling three different type of sub-parts on main part using five different type of screws
- Spray and polish of parts
- Walk to the finished goods container leaves the part.
- Greasing

The target output is 10 items per hour, 180 seconds per product. Shift is 7.25 hours.
The table1describes two types of product as main parts to be assembled. Each has the production rate of ninety five percent (95%) as target with allowance 5% for waste. But the line delivers only 70% of output.

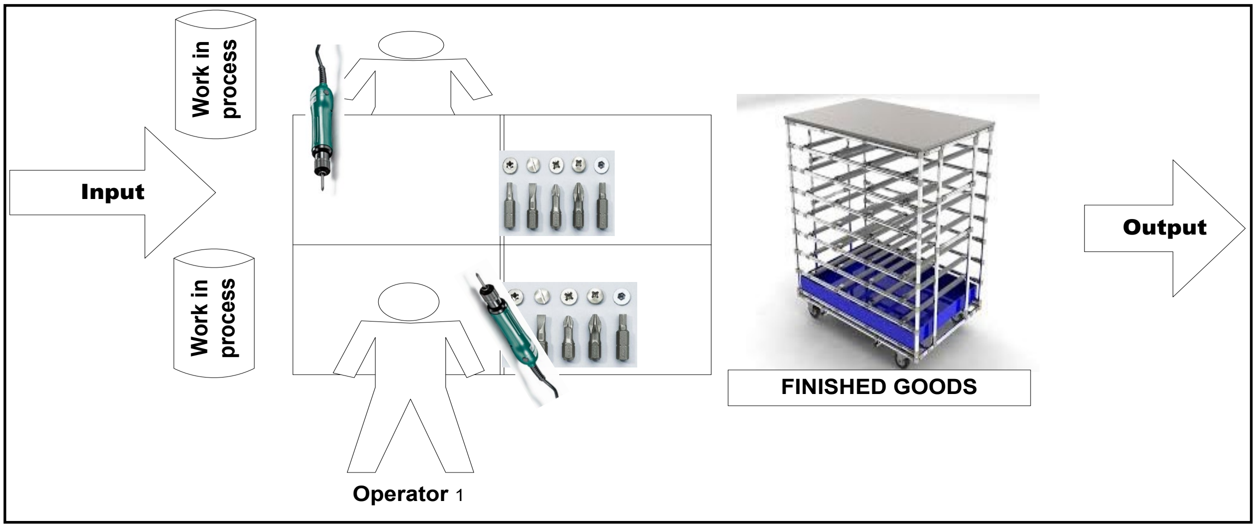

Figure 4: Assembly workstation

The table 1 gives the details of packaging quantity.

Table1: Packaging quantity

PRODUCTS	TARGET OPR	ACTUAL OPR
RH	95%	70%
LH	95%	70%

4.3 Target

The table 2 describes the assembly line with hourly target, the work hour per shift for each operator and the cycle time to assemble a product.

Table 2. Production information

MACHINE TYPE	***PRODUCT***	***HOURLY TARGET***	***SHIFT (HR)***	***CYCLE TIME***	***N0. OF OPERATOR***
Assy 2	RH2	10	7.25	180	1
Assy2	LH2	10	7.25	180	1

4.4 Root-cause analyses

Based on figure 3, there is 20% of the time wasted in June was caused by the "man" (man pace and man away from the line), July was 18% and August was 22%. In June 5% of time was wasted due to the material, 8% in July and 10% in August. For "Process", 3% of time was wasted in July. The 2% of time was wasted in June for reject and 2% of time wasted was due to the machine stopping in July. And 1% was due to the machine

The direct time study was performed with the agreement of management to find out the real cause of the downtime on assembly line caused by man which contributed the highest part of downtime and the failure to reach the target. The results from figure 4 have shown that the main root cause of the downtime is the “Man”, followed by “Material”. The further examination was done to find more causes of downtime for the man. The time study was initiated one line to evaluate all assembly activities.

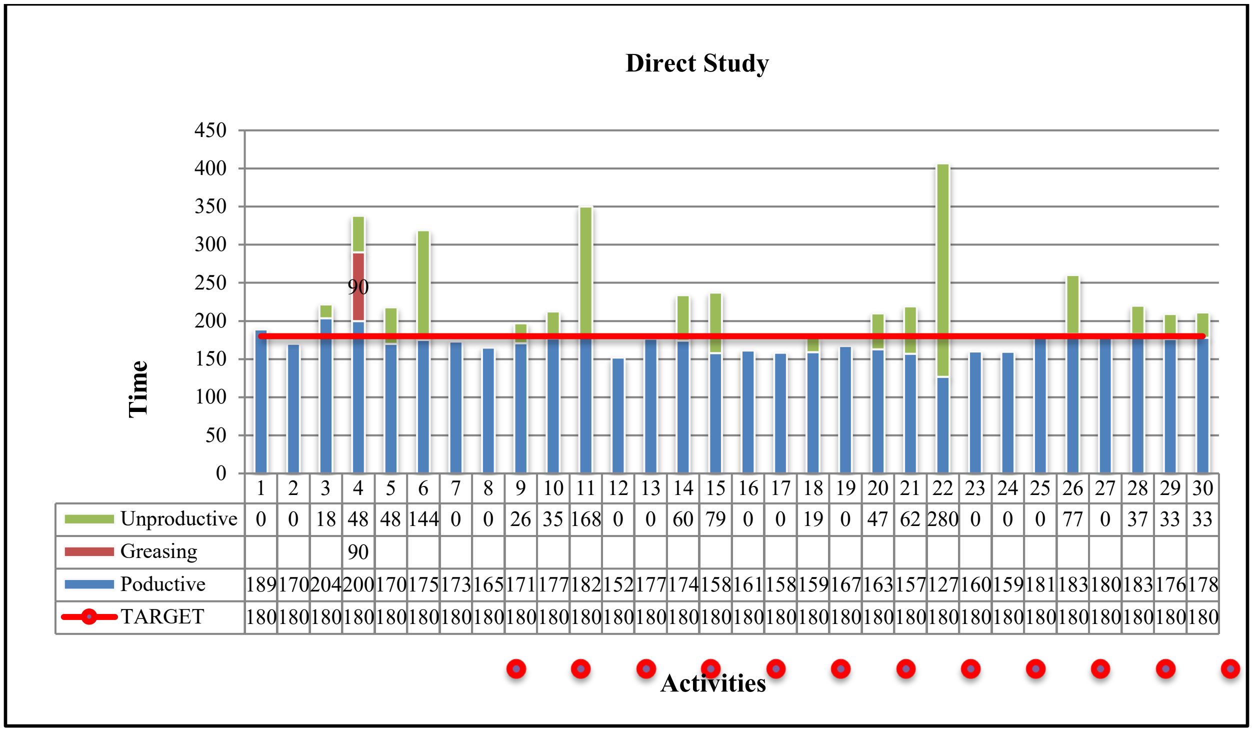

Figure 5. Direct study

The figure 5 has given the result of study done by observer on assembly line. It shows that the number of observations was 30 cycles, the set standard cycle time by organisation was 180 seconds, but the total measured cycle time (productive and unproductive time) by observer was 256 seconds. The cycle time of productive work was only 171 seconds and the unproductive work was 85 seconds. The summary of figure 5 is given in table 3.

Table 3: Result of observation on the assembly line

RESULT OF TIME OBSERVED ON ASSEMBLY (SECONDS)	
Standard cycle time	180
Measured cycle time	256
Number of cycles	30
Productive time	171
Unproductive time	85

Based on observation given above, the figure 6 describes the measured cycle time against standard time.

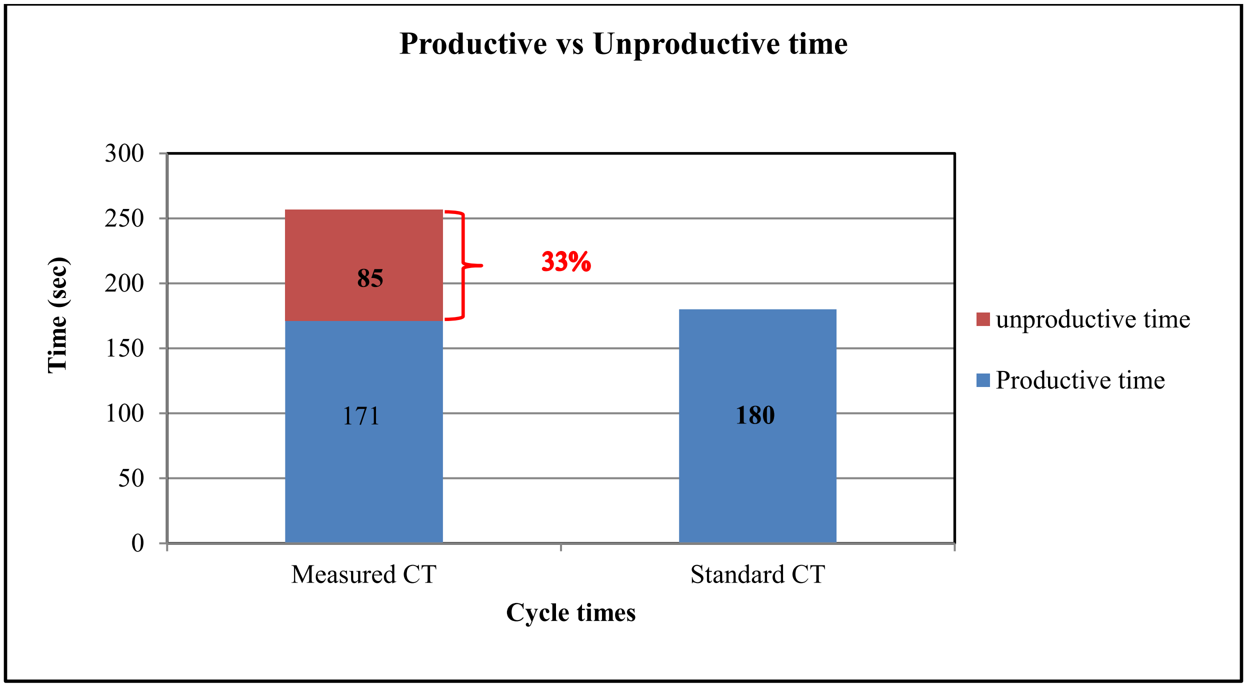

Figure 6. Production versus Unproduction time

Based on figure 6, the unproductive time is 85 seconds which represents 33% of the total measured cycle on the production line. And below is the figure of all categories of down time.

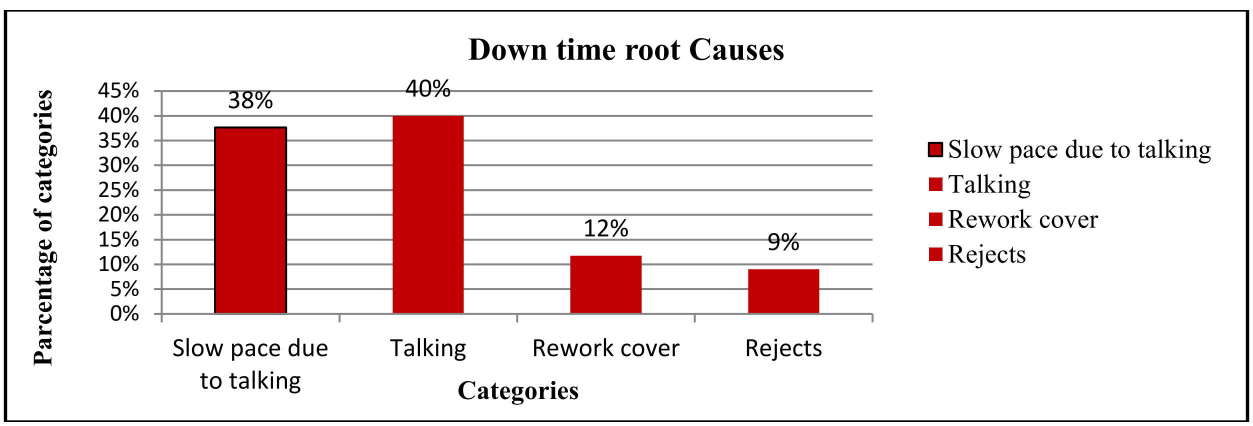

Figure 7. Category of problems

Based on figure 7, the problems are categorized as follows:

- Slow pace due to talking: Here the operator works and talks. The time is evaluated according to the standard time of the activity performed. The time to accomplish the job minus the standard time set to accomplish the same job.
- Talking: The operator stops working and starts talking to each other. This also is considered as pace.
- Rework: This category consists of checking quality of product on assembly line such as trim of unnecessary parts, polishing the parts.
- Reject: This consists of rechecking quality and taking decision of rejection.

The categories of slow pace due to talking constitute 78% of downtime. But do not require operator skills. The last two categories constitute 22% of downtime.

Greasing was neglected because it is a part of the process.

4.5 Brainstorm/determine countermeasures: Decision Making

This step consisted of resolving the issues such as time wasted to talking online by operator, time wasted for quality issues (rejects) and other material issues. The problems could be out of control of the operator and needing advice or the problem could be the ignorance of operator and needing reminder. The best way to solve this was to call up the meeting with team leader first to communicate with the operator. This problem did not need training, but communication only. Second was awareness of the operator about the goals of organization towards commitment to the customers. The consequences will have the negative impacts to the organization such as losing customer in long run, as said in section one that delivery made on time to the customers keeps customers happy.

The section 3 demonstrated that the average downtime for three months (June, July and August) was 29.7%, and the ideal downtime for the organization was set at 5%, then real problem or the downtime eliminated was 24.7% (29.7%-5%). During evaluation of work breakdown, it was found that 71% was man's problem, 26% was machine problem and 3% was material problem. Then the improvement was be focused first on man. By narrowing the data continuously, in 71 % man's problem, it was found that 81% was due to the pace of the operator, 11% due to the man away from the production line and 8% due to other reasons. For 81% due to the pace, RH2 had downtime of 52% and LH2 had downtime of 48%. Because the difference of downtime of RH2 and LH2 is not significant, the focus of improvement will be in both RH2 and LH2. To calculate the improvement target, focus will be on current situation, man, and the pace, (0.297 x 0.71x 0.8) = 0.1708 or 17%. For this section, please see the A3 final report (Figure 8). The problem experienced to be targeted are talking, rework, man away and rejects. Based on the results in figure 6, the measured cycle time (171) is less than standard cycle time (180 seconds). This means that the line can reach the target and satisfy customer demand without interruption or without delay. It is now important to eliminate waste in production line which is due to the pace of operator. The meeting was set after this step between management and area supervisor to deal with situation by letting operators know result and what company expect from them.

4.6 Implementation plan

As this study showed that the cycle of 171 seconds was achievable, create a plan that includes all steps necessary to implement the countermeasure knowing who is responsible for each task and when it should be completed.

4.7 Effectiveness

The follow up was made on implementation of new plan of 171 seconds of cycle and elimination of wasted time. The results of effectiveness showed that there is improvement because the percentage of wasted time have dropped gradually, 19% of wasted time included quality issues was recorded at the beginning of October, at the end of the same month the wasted time dropped to 2%. The average percentage for wasted time for the first week was 13.6 %, for second week, it dropped to 9.4 %, for third week it dropped to 6.2 % and fourth week it went to 4.4%.

5. Results

The results are described in the summary of A3 problem solving report in figure 8 below.

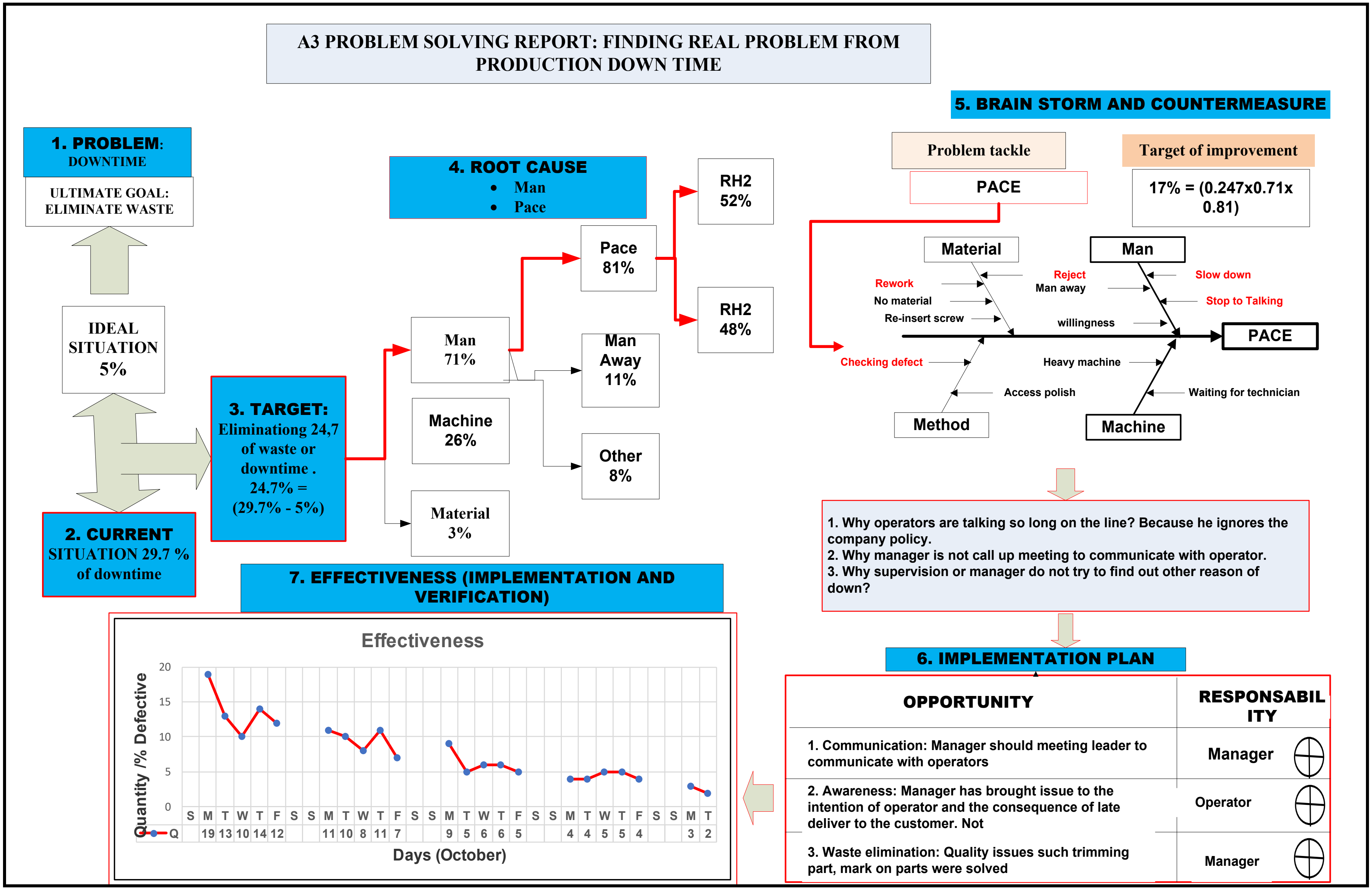

Figure 8. A3 report

6. Conclusion

The lean tool A3 problem solving report has been implemented successfully through the results of the process. From this case study, the A3 problem solving has shown that it is a tool that promotes lean thinking. Through the process, it allowed the identification of specific activities (slow pace and quality issues) that negatively influenced the productivity of the assembly line and to eliminate the waste and satisfy customers. It also promotes communication among different functional department in organization such as production department and quality department to work for common goal.

The study has shown that in A3 structured report, the assembly line was effective during the month October (after campaign). The output for the line was increased from 7 parts to 9.6 parts, that means the productivity improvement was achieved. The downtime dropped from 32.7% in August to 8.4% in October.

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