# THE IMPLEMENTATION OF AN ANDON PRODUCTION MANAGEMENT SYSTEM TO IMPROVE THE EFFICENCY OF TRACKING OF OUTPUT SCORES

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## ABSTRACT

With the rapid ever changing technological advances, simple processes are easily changed from manual to automated. An automotive company struggled to keep track of their hourly target as well as the shift production scores. This was crucial to the production line management as this posed as a difficulty to determine the line overall efficiency as well as the possible factors of downtime. This paper is aimed to improve the tracking of hourly scores on a moving conveyor using an automated production management Andon system. Using the PDSA cycle, this automated system was implemented which made capturing of scores easier and more efficient. Once implemented, the daily downtime analysis report could be analyzed and factors affecting the production score were further investigated by the production line management. These contributors were then addressed with implemented countermeasures resulting in a high efficiency line as well as correctly tracked hourly scores.

**Keywords:** Automated, Andon, PDSA

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## 1 INTRODUCTION

Continuous improvement forms an integral part of a company which chooses to improve continuously. The world and methods of technology are rapidly improving as new systems are being integrated. Once what needed manual labor in a process can be easily made automated and robotic. There is vast knowledge and literature on improving man and machine related processes as well as methodologies to enhance manufacturing processes. These methodologies focus greatly on standardized work and kaizen. Many companies opt for this method and this is greatly carried out by Industrial engineers, process and production engineers. However, many of the companies do not investigate other technological improvements that can assist a process in increasing productivity. A perfect example of a methodology that consists of improving and adding technological processes is the Toyota Production systems and its 14 principles.

A production assembly line was selected for this investigation and improvement. This production process struggled to keep up with recording their hourly target. Their line management which consists of a senior group leader as well as a team leader was in charge of this process and the hourly tracking of production scores. A sewing line was selected for this improvement. The main struggle was having two separate sewing assembly lines, with one group leader and one team leader whom also have other functions to do during a day of shift. This was a problem as management of the line could not understand why hourly scores were made or not achieved. They were also unable to understand exactly what was the reason for scores not being met. The aim of this paper is to develop a system that records the hourly target as well as to investigate characteristics of other factors that could assist production in reducing their downtime. This paper will also focus on the use of the PDSA cycle of implementation of the Andon system as well as the root-cause analysis to assist the line in reducing the amount of downtime.

## 2 LITERATURE REVIEW

Technology can be integrated into a lean manufacturing system as long as it supports lean principles and adds value to the manufacturing process. According to Hirvonen [14] Lean manufacturing originates from Toyota Production Systems (TPS). This production system was developed for the need to manufacture more with less. Digitalization of production can be defined as using technology to automate data handling and to optimize processes. It is more especially related to autonomous data collection and analysis as well as interconnectivity between products, processes and people. With the use of advanced enterprise software, this can enable a real time view of the production process and has a positive association with operational performance [13].

According to Dekier [5], The TPS systems can date back to the twentieth century in Toyota. The father of the system was Sakichi Toyoda, a manufacturing engineer. Sakichi Toyoda [8] first invented a motor driven loom which he incorporated a specialized mechanism that stopped in the case of the thread breaking off. This mechanism later became one of the pillars of the TPS house, known as Jidoka (automatization with human manufacturing). The TPS principle is shown below in Figure 1 which is also broken up into the 14 principles.


**Figure 1: The Toyota way model [5]**

Part of the 14 principles there are 2 principles that support the use of production processes to be visual as well as technological. Principle 7 and 8, describes and contributes to the use of technological use in TPS and processes. Principle 7 which is known for visual management has been effectively employed in some manufacturing and service industries. It is not considered an essential element of the lean production system [2]. This tool is unique to a manufacturing process as it incorporates the entirety of the manufacturing process to promote transparency throughout the company [10]. Visual controls tools and communication goes beyond production management in shop floors as it can be successfully adopted by commercial educational, healthcare, government and other fields as stated in literature [2]. Visual tools need to be integrated and openly exposed in the work environment for being easy to reach and easy to see.

Principle 8 refers to using reliable and proven technology in processes. Technological innovations and changes in business environments affect both firms' short-term performance and long-term sustainability. When future directions and options in technology are obscure and uncertain, firms need to formulate an appropriate technology strategy to support their planning for interacting with upcoming future technological developments such as Industry 4.0 [11].

According to Merino [13], there are currently few industries and companies that is aware of the andon systems and their benefits of implementation. Overall Equipment Effectiveness (OEE) is a powerful lean manufacturing tool to measure the effectiveness of a machine or a process line by integrating factors related to availability, quality, and performance [9]. An OEE is also described as an andon system. An Andon systems allow you to visualize the status of different workstations simultaneously. This creates awareness based on visual information to improve efficiency of the manufacturing processes and business as a whole [15]. Visual systems also reduce the waste by saving the supervisors time by directing the attention to where it is required. Importantly visual systems add additional transparency to production as this is one of the visual tools of lean [12].

Although there are multiple models offering frameworks for change, this article focuses on the PDSA cycle. PDSA is a process of Plan, Do, Study and Act, similar to the PDCA cycle. The use of the word 'study' in the third phase of the cycle emphasizes that the purpose of this phase is to build new knowledge. The PDSA model can be applied to the improvement of processes, products and services in any organization. The PDSA model attempts to carefully study a process or activity being implemented before taking further action [3]. The benefits of using the PDSA cycle is that this process enables one to test changes on a small scale. This allows individuals implementing an activity to test cycles in a structured way before doing any further implementation. This basically guarantees success and if a project fails, one can always go back and restudy and re-implement the changes. Through this, the process of change and implementation is safer and less disruptive for patients and staff [14].

The fishbone diagram, also known as the Ishikawa diagram, has become a key diagnostic tool for analyzing and illustrating problems through root cause analysis. This is also a useful diagnostic tool for improvement [6]. Fishbone analysis begins with a problem. This diagram provides a template to separate and categorize the causes of the major problems in a process [11]. The article [9] further goes on to state that because this method allows problems to be analyzed, if it is used with colleagues, it gives everybody an insight into the problem so that solutions can be developed collaboratively. This tool can also assist groups or individuals to identify the root causes of problems to understand the reasons behind the failures, and to determine a progression of actions and consequences to prevent another failure from occurring [1].

## 3 RESEARCH APPROACH

For this activity the PDSA cycle was adapted to follow through the implementation of a proposed andon system to improve the tracking of score keeping of the production assembly line. The PDSA cycle is a four step model with the first step being the plan or the planning stage. During this stage it is vital to develop a plan in which predictions of outcomes are clearly stated. This is the step where the who, what, when and where is decided. The planning stage of any improvement plays a vital part as this decides the direction of the project. If much emphasis is done during the planning stage, the remaining stages of the PDSA cycle becomes easier to accomplish and plan out. Here the requirements needed for easy visibility of line control are brainstormed collectively with production management and other relevant departments before carrying out any implementation. The second step which is the do stage, consists of the changes or activities identified to be implemented or roll out preferably with a timing plan or schedule (depending on environment). Here the andon is implemented and trialed at production. The study stage known as the third stage, requires the leader in charge of the activity to study the implementation. This was trialed for a week and the data was presented to be analysed. From these findings, additional requirements for the andon were discussed to improve the project as a whole. In this aspect, this refers to the andon and to monitor the workability of the Andon with production. In this stage if any further changes are required, it is further investigated and implemented. The final stage of the process is the act phase. This step incorporates any modifications that are deemed necessary from the study stage that may lead to an improvement. Here, full implementation is also carried out to ensure the end users (the quality and production) fully understand how the system works to enable an easier working environment. The PDSA cycle is shown below in figure 2.

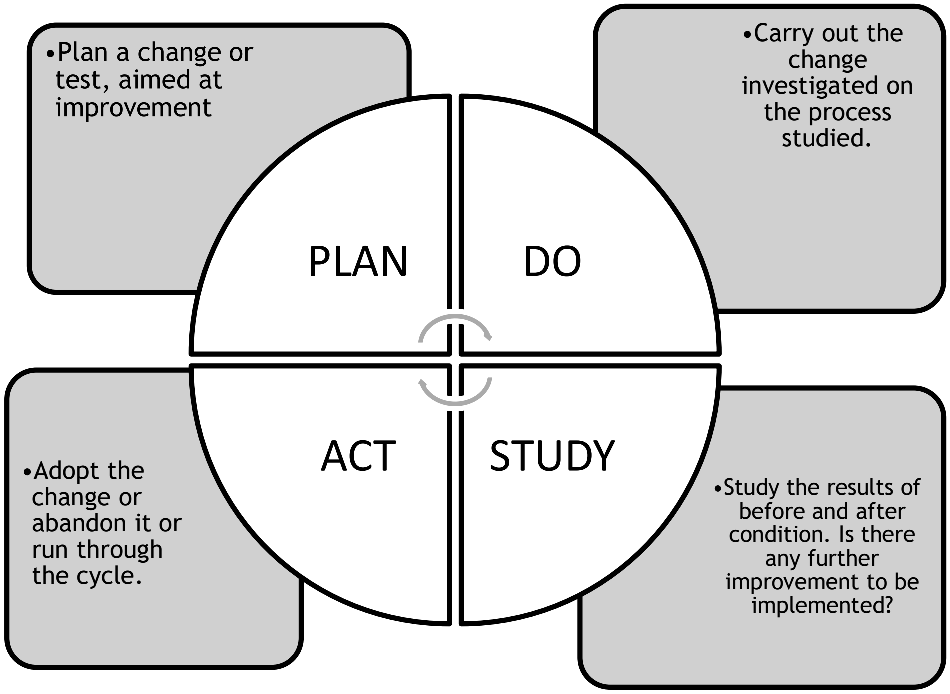


**Figure 2: The PDSA Cycle (Authors own)**

## 4 DEFINITION OF PROBLEM AND IMPLEMENTATION OF SOLUTIONS

### 4.1 Problem identification

An automotive assembly supplier based in South Africa, manufacturers components for one of the market leading car manufacturers in the country. At the sewing production assembly line, it was found that the production output of scores were not be recorded hourly or correctly by the line management. This showed a struggle in analysing the hourly scores as line management. Line management could not determine the struggles being faced hourly by the production line. Production scores was not being met and this posed a difficulty in determining the factors in determining what was wrong.

### 4.2 Process description

There are two assembly conveyor processes known as the cushion cover assembly and the back cover assembly. Both processes are run by conveyors at a speed of the volume requested by the customer. Each conveyor has eight work stations on the conveyor. Each workstation has one person stationed at it. Once each line completes the assembly of a cover, this cover then goes to the final point on the cover which is the quality inspection. At the quality inspection process (QCI), the cover is checked before going to the finished goods storage. At the finished goods storage, the goods are then taken by the next process when needed. Figure 3 below shows the process flow of the line.

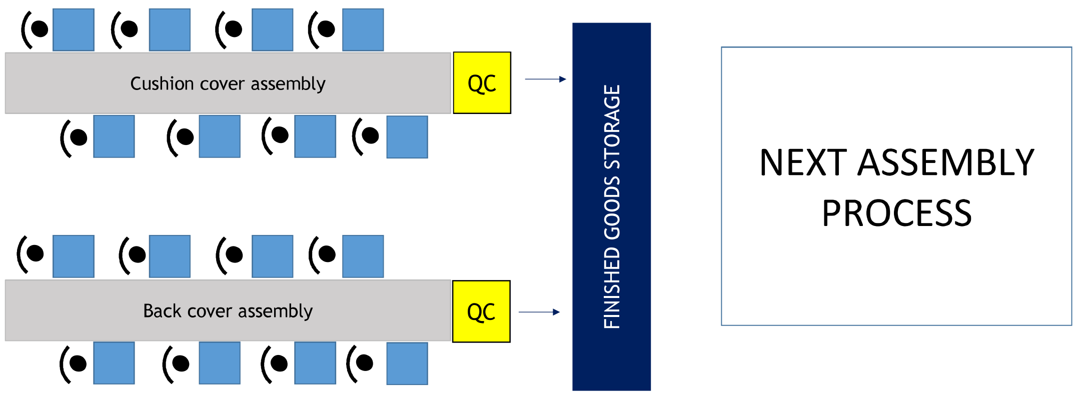


Figure 3: Production line shown diagrammatically

### 4.3 Potential cause of scores unable to be recorded

Each line has production sheets which hourly information needs to be recorded. This assists management to determine if the production requirement is being met at any part of the day. Unfortunately, this was found as a difficulty by the line team leader and group leader as there was many other tasks required of them. This was difficult to prioritize hourly due to line performance and abnormality on certain days.

The requirement and production standard of the company is that production records scores of output hourly as well as the quality inspection department. Quality inspection records how may covers have been checked for a day. Production requirement a day is of 240 pieces. Data was requested from the quality department of the number of scores recorded daily for the month of November 2022. These scores were then compared to the recorded production scores by production. The compared scores per department is shown below in Figure 4. The blue scores indicate the scores recorded by production, the orange bars indicate the scores recorded by quality and the red line graph indicates the target required by the line to produce.

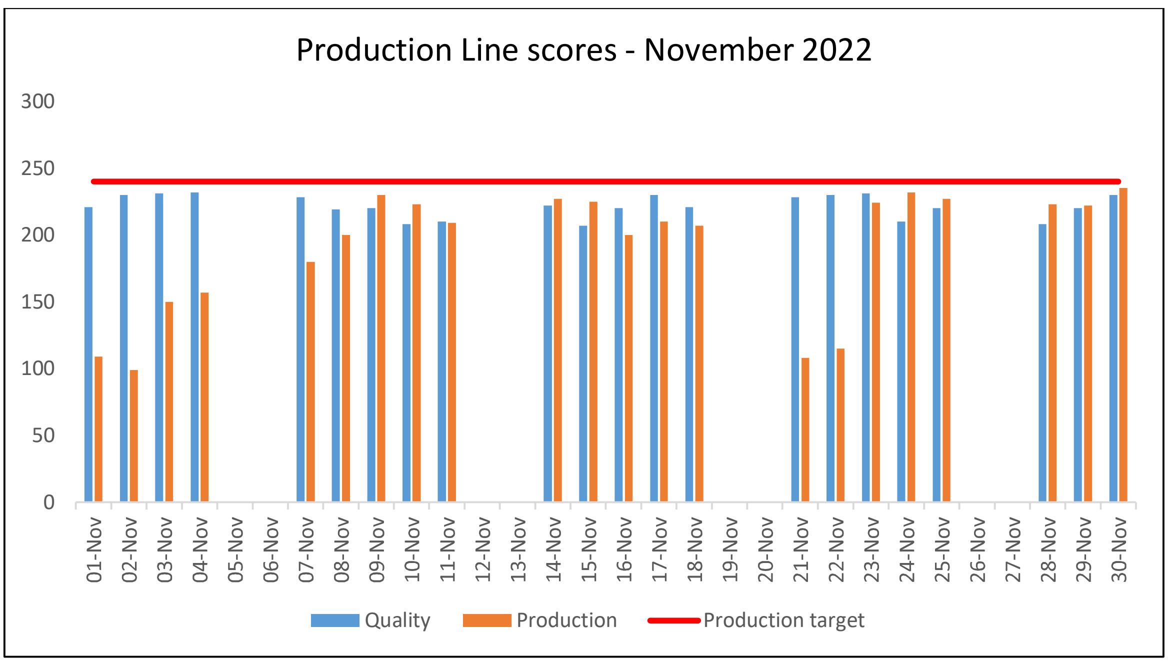


Figure 4: Bar graph showing the different scores captured by the quality and production department against the line requirement

As visible, scores were not aligned and not a true reflection of production pieces being produced. There were days were production scores are higher and days were the scores captured by quality was higher. Actual scores could not be presented to management as true reflection of scores could not be recorded. Downtime analysis was difficult to do as real data of what prevented the hourly score from not being achieved could not be determined.

A fishbone diagram assists in determining root causes of issues of line constraints and finding possible solutions to the problem areas. A fishbone diagram is broken up into six categories, man, method, material, machine, measurement and environment. The Fishbone or Ishikawa diagram in figure 5 shows factors that affected the production line in not being able to record and track the hourly scores

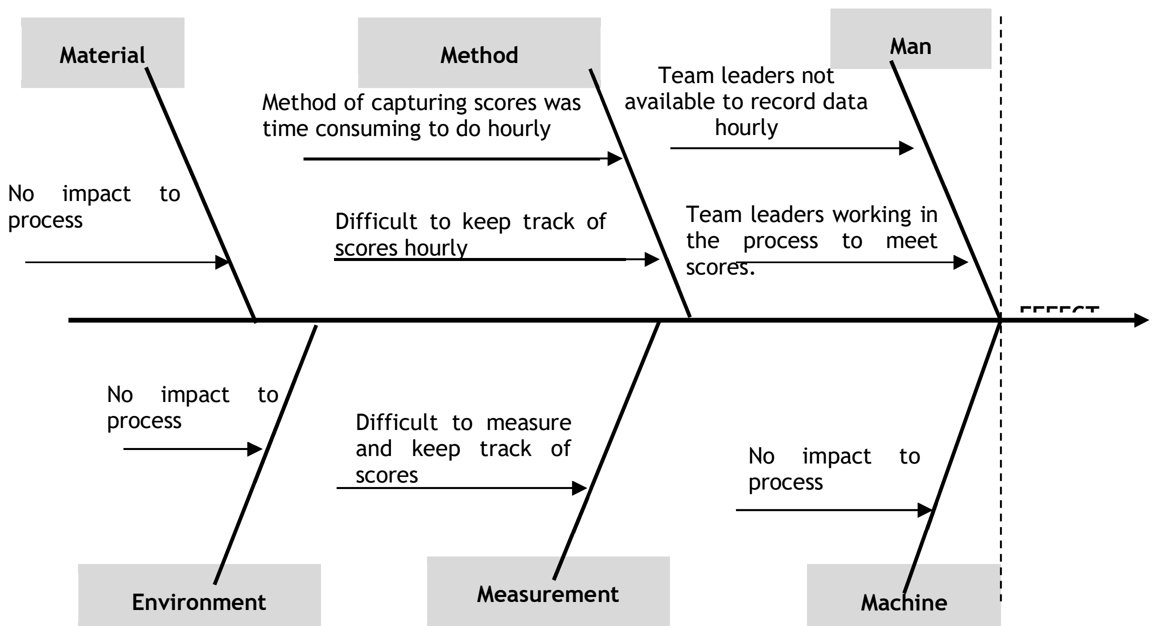


**Figure 5: Fishbone diagram of what prevented team leaders and group leaders in capturing scores.**

From the fishbone diagram we can see that are factors under the method, man and measurement category in which scores could not be captured. Under man, we determined that the team leaders who are in charge of capturing the scores found it difficult to do as there are other tasks required of them. When there is high absenteeism of the line, they have to work at different work stations. This prevents them from capturing the scores. Under measurement, we found that there is no easy way of capturing scores, this took time and was difficult to do. This was also time consuming to keep track of.

### 4.4 Implementation of possible solutions

*Plan – Brainstorming with relevant departments*

When consolidated with manufacturing and the quality department, it was agreed that an easier and technological approach should be used as this would be an efficient and creative way of capturing scores as well as developing a system. With this research, this activity began with a draft of the system and what should be displayed. This was completed and the proposal was then discussed with the relevant departments. The approach used was installing an automatic production management andon system.

*Do – Installation of Andon.*

Once the requirements were verified and completed, this was shared with an external supplier to implement, install and program the andon system to the manufacturing line requirements. This is described below in detail of how implementation went about in Table 1. This activity was implemented in December 2022.

**Table 1: PDSA cycle used to install an andon system**

| Step | Description | Responsibility | Status |
|---|---|---|---|
| Plan | • Create a schedule of implementation<br>• Source a contractor to understand the activity | Industrial Engineer | Completed |
| Do | • Implement the Andon system at the sewing assembly line | Industrial Engineer | Completed |
| Study | • Study and observe that the push buttons are working | Industrial Engineer | Completed |
| Act | • Train production members on how to use process push buttons<br>• Monitor condition and screen display. | Production management and Industrial engineer | Completed |

## 4.5 Process set up of andon system

*Act – Workability of Andon at each workstation*

An andon cord or button is used to generate alerts to the line management. Here at each workstation, a push button for "CALL TEAM LEADER" and "WORK COMPLETE" was installed. The call team leader button is for the member to call the team leader without moving from their station if there is any abnormalities or breakdowns. The WORK COMPLETE button is pressed after each cycle done by a member. So every cycle of the calculated takt, ideally it should be pressed to confirm each member at each process has completed their work cycle. If this not the case, the work complete starts flashing to indicate to the member at the process that she is running behind. This is also displayed on the screen showing which process is now delaying the overall line. This screen is displayed at the end of the line or at any point that is visible to line management or management walking by. While this is being shown, a melody is also played for the line management to draw attention to the screen to visually see which processes are behind the schedule and takt time. Using the PDSA Cycle, this was followed through.

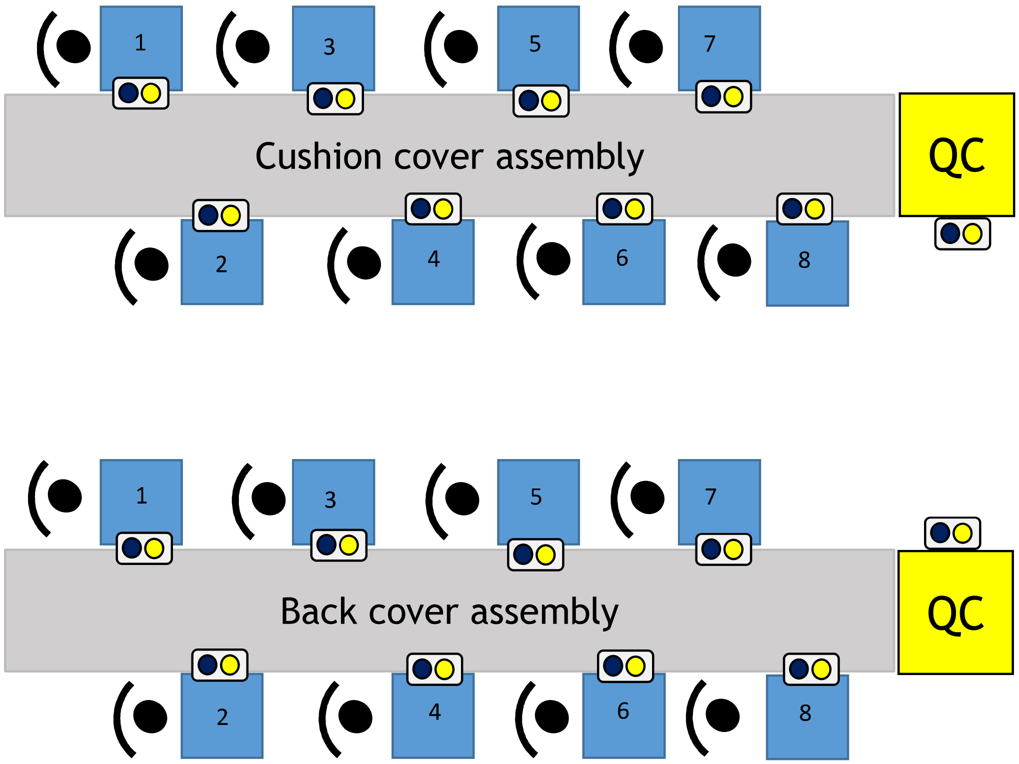


**Figure 6: Line set up with andon buttons at each process**

Each work station /process was set up with a set of andon buttons at each process. If there was an issue, the member at each process would press the yellow button - the call button. This was displayed on two LED screens situated at line side. There was one screen dedicated for the cushion cover assembly line and another screen dedicated for the back cover assembly process. After each member at each process was completed with each piece of sewing at their process, there were required to press the blue button to indicate a piece was complete. A set of andon buttons was also installed at the quality station as it also records each day's data and could easily be retrieved on any day as the system records the information automatically. This was required as manufacturing confirms how many units they produced and so does quality. The reason as to why this is separated and quality final counts are displayed on the andon is specifically because quality does the final count and are the last to touch the product before final shipment to the finished goods storage. For example, manufacturing can state that they manufactured 20 products and hour and quality only counts 18 units. The variance of the 2 components can either be rework or units scrap.

If there was an issue, any process would press the call button and it would display as shown below.

| Cushion | Process 1 | Process 2 | Process 3 | Process 4 | Process 5 | Process 6 | Process 7 | Process 8 |
|---|---|---|---|---|---|---|---|---|
| | - | TL CALL | - | TL CALL | - | - | - | - |

| Back | Process 1 | Process 2 | Process 3 | Process 4 | Process 5 | Process 6 | Process 7 | Process 8 |
|---|---|---|---|---|---|---|---|---|
| | - | - | - | TL CALL | TL CALL | - | TL CALL | - |

**Figure 7: Display for Call button**

The display of each process assembling a piece is also shown below in figure 8:

**OVERALL LINE PRODUCTION SCORES**

| | PROCESS | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|---|
| Cushion | TARGET | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 |
| | ACTUAL | 233 | 222 | 220 | 219 | 230 | 222 | 224 | 219 |

| | PROCESS | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|---|
| Back | TARGET | 240 | 240 | 240 | 240 | 240 | 240 | 240 | 240 |
| | ACTUAL | 234 | 236 | 230 | 222 | 231 | 217 | 220 | 222 |

**Figure 8: Production score tracking per process**

*Study - Study of the results*

The overall line andon display is shown below in figure 9. This made it extremely easy to track scores and improve line efficiency. This was easy to view by ay line management walking past.

CUSHION ASSEMBLY COVER DISPLAY SCREEN

| | Cushion Assembly | Back Assembly |
|---|---|---|
| Plan | 240 | 240 |
| Actual | 222 | 232 |
| Calculated OA | 93% | 97% |
| Takt time of the line | 1,89min | |

BACK ASSEMBLY COVER DISPLAY SCREEN

| | Cushion Assembly | Back Assembly |
|---|---|---|
| Plan | 240 | 240 |
| Actual | 222 | 232 |
| Calculated OA | 93% | 97% |
| Takt time of the line | 1,89min | |

Figure 9: Andon display screens at the process

## 5 RESULTS

Installing an automated andon system posed may benefits for the line management. Many of which are listed below:

- Assisted the managers in knowing real time data at any point in time.
- Data from the line is recorded on the system which is linked to the company drives. Each shifts data and downtime were recorded so at any point in time, it could be back tracked.
- Assisted management in determining the reasons for inefficiencies. With the downtime analysis reports, many of the work station delays were due to line stoppages of no parts or maintenance issues. This was resolved internally and addressed.
- Data and piece count was corrected and were now easy to keep track of.
- Each workstation was also evaluated to see which process was a bottleneck or which work station did not meet the scores required for the shift. With this process improvements were done to reduce the effects of bottleneck processes on the line.
- If a process did not press the work complete button, the conveyor would then stop to indicate work delay at that process.
- If there was a maintenance issue, the member at the process would then press the work call button and indicate on the andon that it was a maintenance breakdown that occurred and how much of downtime occurred.

Three months of data was captured and this gave a more realistic view of the actual production scores being captured. This shows the real time target and production scores being captured. The production scores captured by the Andon system were verified and compared with the quality department. This showed us that the record of production scores was correct.

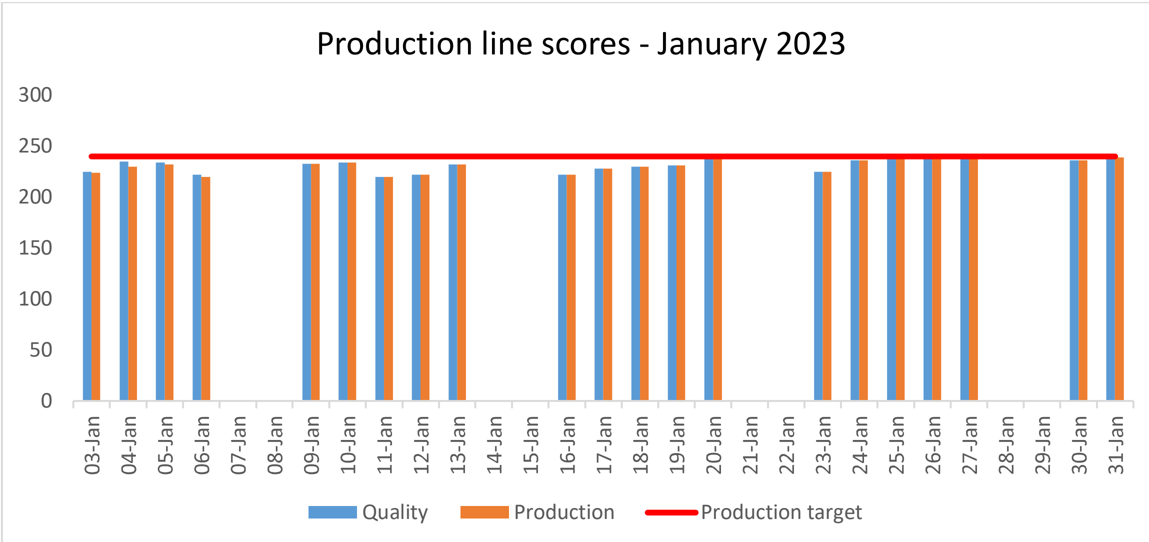


Figure 10: Production scores captured by the Andon in the month of January 2023

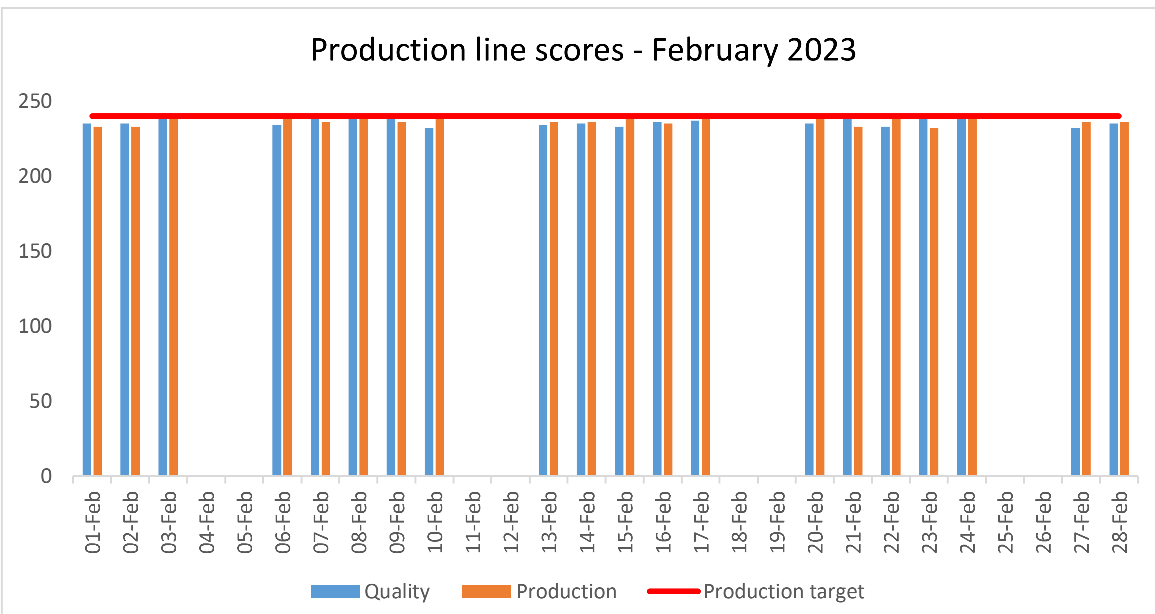


Figure 11: Production scores captured by the Andon in the month of February 2023

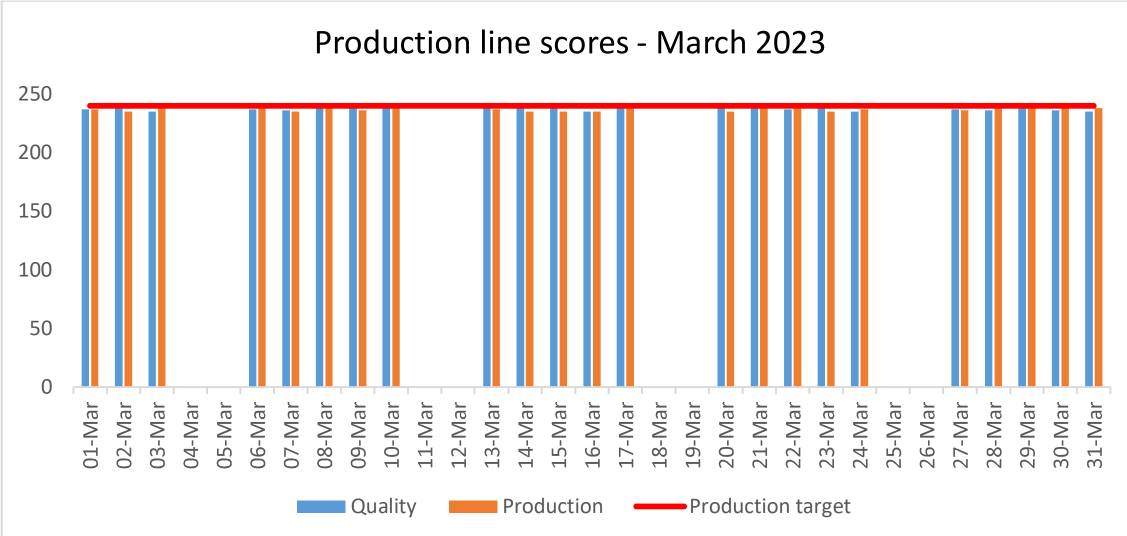


Figure 12: Production scores captured by the Andon in the month of March 2023

We could also see over that over a week of production, there were issues that prevented the production line from meeting their scores. The implementation of the andon assisted the manufacturing department in analyzing the data and putting in respective countermeasures in place. The data for a week is shown below in the pie chart figure 13 below. These issues were addressed and is shown in Table 2.

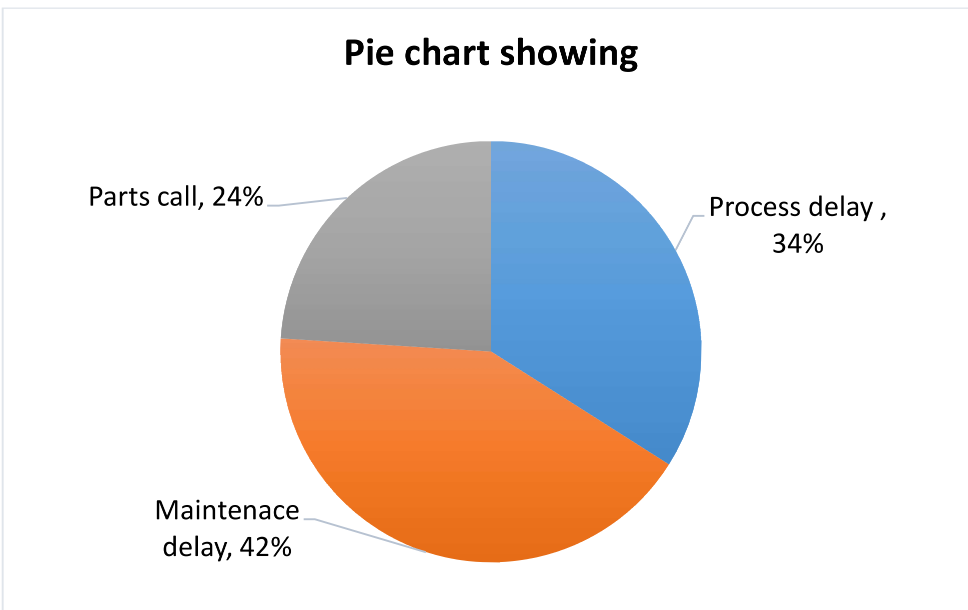


Figure 13: Pie chart showing issues at workstations for 1 week.

From the analysis reports, we could see that there were many issues affecting the line productivity. Each issues are listed below and the countermeasure of each item was also addressed. This is shown in table 2 below.

**Table 2: Downtime analysis and countermeasures**

| Downtime | Description | Countermeasure | Status |
|---|---|---|---|
| Maintenance | Poor lead time to break downs. No dedicated technician for the area | Hire a dedicated maintenance technician for this process to be dedicated to. This will enable a fast response to any breakdown of the line | Completed |
| Process delay | It was found that there were two process on each line (Cushion and back assembly) that were bottlenecks | Restudy and balance process to ensure there are no stoppages or processes falling behind. | Completed |

The reports from the andon were helpful in addressing issues that occurred and putting countermeasures to ensure an efficient process.

## 6 CONCLUSION AND RECOMMENDATIONS

Many companies are still very traditional when it comes to process planning as well as process improvements. Installing an Andon system at the end of the process as well as simple buttons to control the process at each stage makes it easier to control as well as to track and monitor hourly production efficiently. With this, this enables the production line management to easily deal with other tasks needed on a daily basis. Even though an andon system was implemented there are still many improvements that can be done. Some are listed below:

- Add on logistics call button at each process.
- Add on delay button at each process.
- Add on maintenance call button at each process.

By breaking it down further, we are even more able to distinguish the issues affecting productivity. The production visualization system or the Andon system was successfully implemented at the line side. This assisted greatly at responding to issues at each process to ensure the line runs efficiently.

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