Production Stock Monitoring System at PT Yamaha Indonesia Using the Scrum Method

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ABSTRACT

Digital transformation brings changes to the industrial sector to become Industry 4.0. PT Yamaha Indonesia is a piano-manufacturing company that also uses technology to help monitor the production of piano parts. Production stock monitoring is carried out in order to meet the company's production targets. As a result, the company's stock can meet customer demand, keeping inventory costs to a minimum. Furthermore, it has the potential to optimize operational production time. Previously, the production monitoring procedure was done manually. Recordings are made every few hours or so to keep track of the data. Due to the manual recording of each step of the piano's part-making process, productivity and the ability to perform other tasks are slowed down. To address these issues, PT Yamaha Indonesia, through this research, developed a production stock monitoring system. This system was built using the Scrum method and implements data visualization using chart.js to facilitate monitoring. The research contribution is analyzing user needs until the production stock monitoring system is built so that monitoring the manufacturing process can be simplified and more efficient, and it can be done in real-time.

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1. INTRODUCTION

Many industries have undergone a digital transformation [1, 2]. Technology encourages the 4th industrial revolution, also known as Industry 4.0 [3]. Technology not only digitalizes but also improves existing businesses [4]. Through digital transformation, executives are improving three critical aspects of their businesses: customer experience, operational procedures, and business models [5]. There are three distinct elements in each of these three pillars. Customer experience digital transformation is heavily reliant on three key components: customer understanding, customer touch points, and top-line growth. Companies are also benefiting significantly from modernizing their internal processes through process digitization, performance management, and employee enablement. Many businesses are redefining how their operations interact with one another and even altering their operational boundaries and activities, primarily through digital business modifications, the establishment of new digital businesses, and digital globalization [5].

Thanks to digital transformation, which has led to the Industrial 4.0 era. End-to-end digitization and integration of physical assets into digital ecosystems with value chain partners is a key focus of Industry 4.0. Another significant challenge is incorporating "digital" into the business model's DNA [6]. One sector that has benefited a lot from the industrial revolution is manufacturing [7]. Manufacturing firms have faced significant challenges in recent years due to the necessity of coordinating and connecting disruptive concepts such as communication and networking, embedded systems, cyber security, adaptive robotics, data analytics, artificial intelligence, and additive manufacturing. In the era of Industry 4.0, manufacturing is more scalable, competitive, and knowledgeable because of its integration with information and communication systems [8].

Yamaha Corporation is one of Indonesia's manufacturing companies. This business sells products such as musical instruments and motorcycles. PT Yamaha Indonesia is a manufacturing company that produces pianos and is a subsidiary of the Yamaha Corporation. In the piano manufacturing process at PT Yamaha Indonesia, a spray area must produce piano parts in a certain number to meet the company's target. The spray area will first wait for 2 hours at a temperature of 20°C to 30°C before entering the seasoning stage by heating for 2 hours at a temperature of 30°C to 40°C. The seasoning stage stabilizes the wood by preserving its dimensions and tone characteristics under certain environmental conditions. After two hours of seasoning, move on to the 16-hour seasoning stage to ensure the deodorization process is entirely perfect.

The spray area, which uses manual recording via Excel, is encountering challenges. Operators or the Person in Charge (PIC) are required to record data every few hours, which reduces productivity and the ability to perform other tasks. Therefore, a production stock monitoring system is required to assist PIC in optimizing operational time management and monitoring the amount of production to meet the company's targets.

Data visualization is included in the production stock monitoring system. This is meant to make the monitoring process easier. This is due to the fact that data visualization simplifies the presentation and analysis of data, particularly large amounts of data [9]. Visualizations help people get a quick look at a system or process and find important information that is hidden in the data [10]. Furthermore, data changes can be tracked in real-time. Changes in data can automatically alter the appearance of the chart on the dashboard. A Javascript plugin called chart.js is used to display visual charts. The benefit of chart.js is that it supports a large number of chart types, which are in line with the system's need to display chart types in the form of line charts, bar charts, and pie charts.

In this study, the Scrum methodology is used as a method for system development. The use of this method was chosen because it adapts to the needs of the production process, and the benefits of this scrum can be done in stages. Scrum is one of the methods that employ the Agile principle, which refers to team collaboration, incremental product development, and iterative processes to achieve goals [11]. Scrum is an agile methodology framework that allows for the control and management of requirements as well as the development of software. Using this model, a module of software can be developed incrementally in a defined manner, much like a small chunk of software can be developed iteratively [12]. The web-based production stock monitoring system was created with the PHP programming language and a MySQL database. The research contribution is to analyze user needs until the system is built so that the goal of this system, which is to make monitoring of the production stock at PT Yamaha Indonesia easier, can be accomplished.

2. METHOD

2.1. Qualitative Method

This study employs a qualitative approach in the form of observations and interviews. Interviews were conducted with experts in piano parts production at PT Yamaha Indonesia. Qualitative researchers examine issues in their natural settings, attempting to make sense of or interpret phenomena in terms of the meanings people assign to them [13]. In general, qualitative research is a type of research that produces results without the use of quantitative measurements or statistical analysis [14]. The most common starting point for qualitative research is an observation of the natural world, a broad background investigation, a search for the mechanisms and details of a problematic situation, or a presumptively incorrect assumption [15].

2.2. Scrum Methodology

Scrum was used to develop the system in this research. Most organizations use Scrum as their agile framework of choice [16]. Agile can assist businesses in responding to change. Agile allows for changes to be made in the middle of the development process. Scrum is a cost and time-efficient agile framework for developing and maintaining complex problems [17]. Despite the fact that manufacturing systems are constantly evolving, production control systems are a critical component of management toolkits that need to keep up with system changes [18].

The scrum methodology enables programmers to work collaboratively by breaking their work into small tasks that can be completed in fixed-duration cycles (sprints), monitoring progress, and re-planning in regular meetings in order to incrementally develop products [19]. This method was chosen because it is adaptable to changes and is consistent with the system's work, which is frequently modified in response to user needs. The stages are shown in Fig. 1 [20].

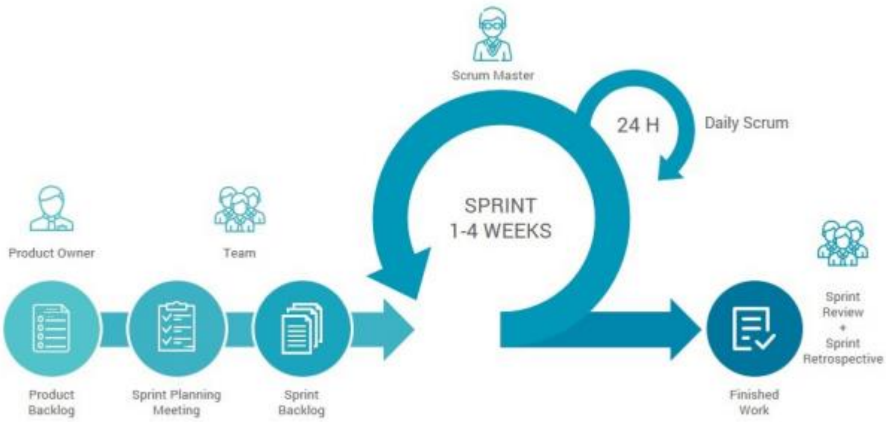

Fig. 1. Phases in a scrum with involved stakeholders

3. RESULTS AND DISCUSSION

3.1. Requirements Analysis

PT Yamaha Indonesia uses technology to overcome problems in the piano manufacturing process. There are four major issues to be addressed. The first issue is that production stock is still monitored manually using Excel. The primary goal of inventory control is to meet customer demand by stockpiling the right amount at the right time in order to keep inventory costs to a minimum [21]. The second issue is that data processing does not occur in real-time. The third issue is that a significant amount of time is wasted in entering stock monitoring reports because data entry time (manually) is done every few hours, reducing productivity and the ability to perform other tasks. The fourth issue is that data processing is prone to human error. Human error is defined as a decision or action that reduces or has the potential to reduce the system's effectiveness, safety, or overall performance [22].

The control system monitoring system is a web-based system designed to monitor production results in spray areas. There are four system users who have different roles:

a. PIC 1: responsible for preparing piano part reports.
b. PIC 2: in charge of planning reports that have reached the two and 16-hour seasoning stages.
c. PIC 3: establish daily and monthly objectives.
d. Guest User: view the spray process data results.

A use case diagram contains lexical information about actors and use cases [23]. Fig. 2 depicts a use case for the system.

Fig. 2. Use case diagram

3.2. Scrum Methodology

The following is an explanation of the steps in the Scrum method for developing this system.

A. Sprint Planning

The “Product Backlog” is a typical Scrum artifact that consists of an ordered and prioritized list of all the product specifications, with "user stories" being its most prominent elements [24]. User stories can be viewed in Table 1. The team prioritizes the Product Backlog elements to be implemented and transfers these Product Backlog elements to the Sprint Backlog, which is the list of features to be implemented [25]. The product backlog can be seen in Table 2.

Table 1. User Stories

As a/an	Description	Number	Priority	Story Points
PIC 1, 2, and 3	Log in to the system	1	4	1
PIC 1	Creating piano part reports	2	1	2
PIC 2	Scan out a slip at the 2-hours seasoning stage	3	2	4
PIC 2	Scan out slips at the 16-hours seasoning stage	4	3	3
PIC 3	Input target value	5	5	5
PIC 3	View the history of 16-hour seasoning productions	6	6	6
Guest Users, PIC 1, 2, and 3	View the summary of spray processing data results	7	8	7
Guest Users, PIC 1, 2, and 3	View the spray processing data visualization results (View Dashboard Monitor)	8	7	8

Table 2. Product Backlog

Number	Sprint Stage	Feature	Total Duration	Testing
1	Sprint 1	Log in to the system	1 week	1 day
2	Sprint 1	Creating piano part reports	1 week	
3	Sprint 2	Scan out a slip at the 2-hours seasoning stage	2 weeks	1 day
4	Sprint 2	Scan out a slip at the 16-hours seasoning stage	4 weeks	
5	Sprint 3	Input target value	1 week	1 day
6	Sprint 3	View the history of 16-hour seasoning productions	1 week	
7	Sprint 4	View the results of the summary of spray processing data	2 weeks	1 day
8	Sprint 5	View Dashboard Monitor	3 weeks	3 days

The "Priority" column in Table 1 represents the importance or value of the user's needs. This was determined as a result of discussions with PT Yamaha Indonesia's Production Engineering (PE) division. The higher the priority value, the more important its use is. For example, in the table, it can be seen that the value of "View the summary of spray processing data results" has a priority value of 8, indicating that this feature is truly needed/wanted by the user, whereas previously, the data was stored in an excel format document.

The "Story Points" column is obtained based on the difficulty of implementing the system. It can be seen that the value of 8 is obtained in "View the spray processing data visualization results (View Dashboard Monitor)" because the implementation requires the visualization of charts with the calculation of piano part data.

The Business Process Modeling Notation (BPMN) diagram of the system can be seen in Fig. 3. This BPMN serves to provide a clear picture of the process from start to finish in the production stock monitoring system. According to the BPMN in Fig. 3, PIC 1 is a production employee who creates reports that will enter the Slip table database. Then, select the item type and print the report (data is saved in the database table To_Ongoing_Slip). If it is longer than 2 hours, the item is stored in the 2-hour area, and PIC 2 (as a production employee) can decide whether or not to move it to the 16-hours area. If PIC 2 wants to move it, they can scan out item 2 hours, and all items in the database table To_Ongoing_Slip will be moved to Ongoing_Slip. If they refuse to move it, the item stays in the 2-hours area.

After the item has been stored in the 16-hours area, a decision must be made about whether or not it will be transferred to sanding buffing. If the item is moved to the sanding buffing area, a 16-hour scan out will be performed, and the item will be deleted from the Ongoing_Slip table database.

PIC 3 serves as the manager, with the ability to add target values. The value will be saved in a database in the "Target" table. This actor can also check the report history (taken from the Tracking table database). All PICs can view an item summary and export it to Excel or PDF. Furthermore, all PICs can view a dashboard in the form of a graph of items to monitor items in each process.

This system is worked on by three people in five sprint stages to develop eight features. System development took around four months in total, including front-end and back-end development, as well as testing. For testing, the black-box approach is used. This test is designed to detect errors in both the interface and system performance. This test is carried out through meetings, direct use of the system, and auditing with prospective system users, with a total testing time of one week.

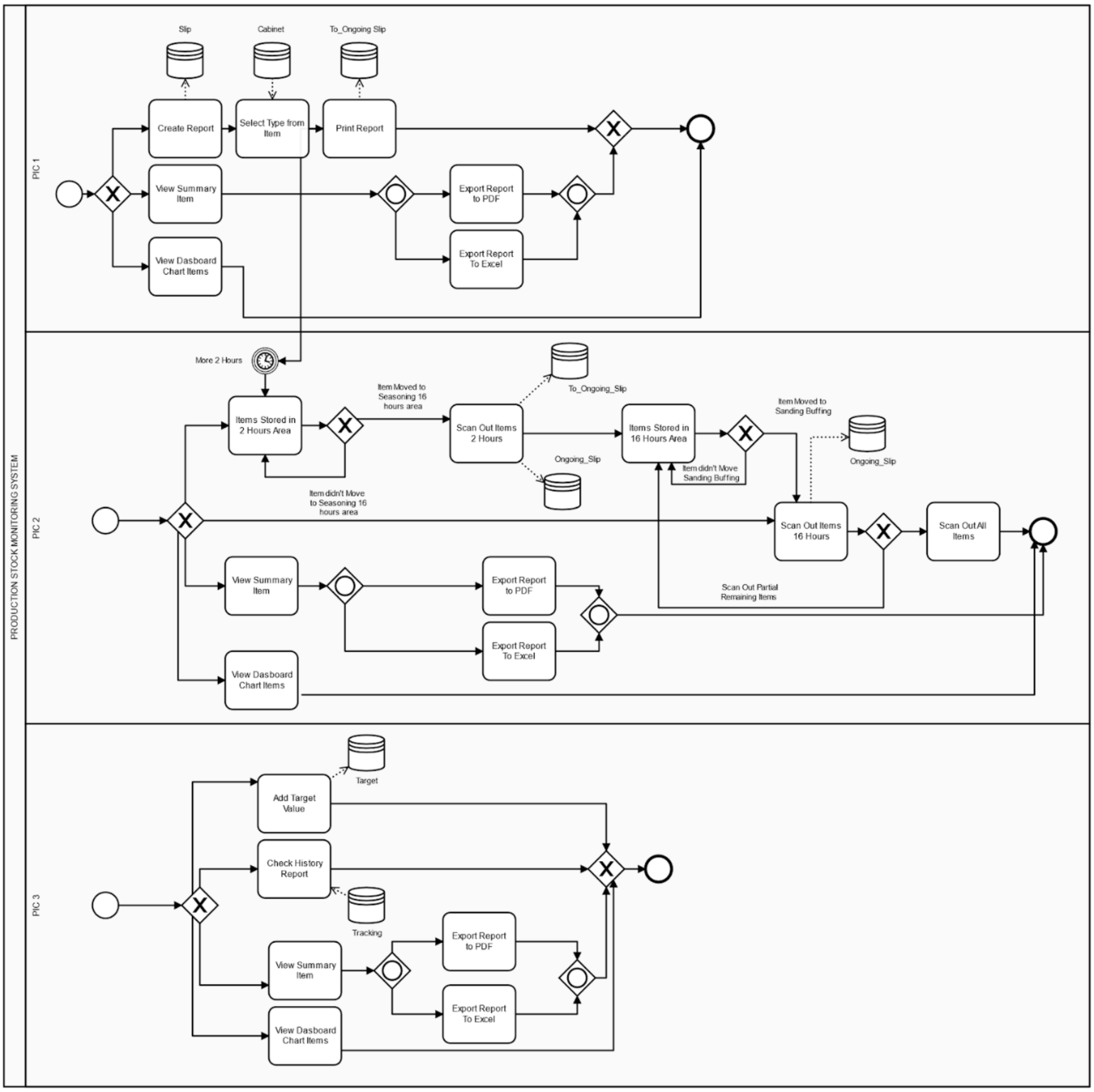

Fig. 1. BPMN diagram of Production Stock Monitoring System

B. Sprint Development Work

1) Sprint 1 (Login and Report Creation): In Sprint 1, the system was built with login pages for the Admin (PIC of data management) to log into the system. The session is used to restrict user access rights on the system. A username and password are used for authentication, which verifies the user during the session of login [26]. To facilitate visualization, the researcher used the Bootstrap framework to create the interface. Bootstrap is a library of pre-built javascript templates for forms, navigation, buttons, and a variety of other user interface components [27]. The login page interface can be seen in Fig. 4.

2) The "Create Report" page is used to record piano parts that are being worked on. This feature employs Ajax to automate report generation from incoming data. This page is depicted in Fig. 5.

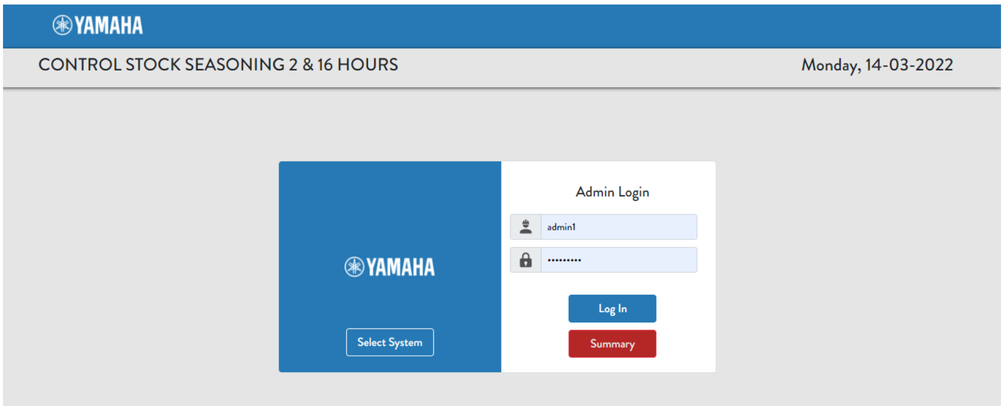

Fig. 4. Login page using session

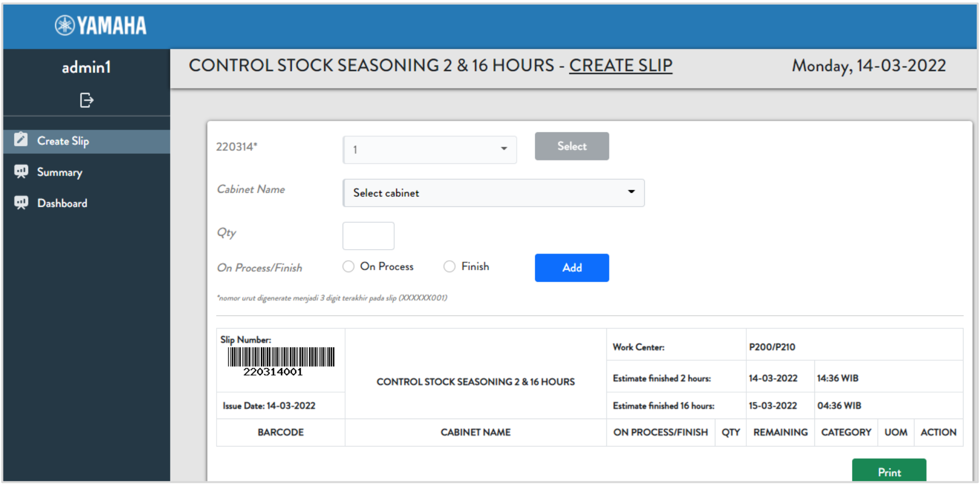

Fig. 5. Report creation page

3) Sprint 2 (Scan Out Seasoning 2 and 16 Hours): In Sprint 2, there is a scan-out seasoning of 2 and 16 hours. The page can be seen in Fig. 6 and Fig. 7 for scanning out in 2 hours and 16 hours, respectively. By entering the report number or scanning the barcode, the PIC will scan it out.

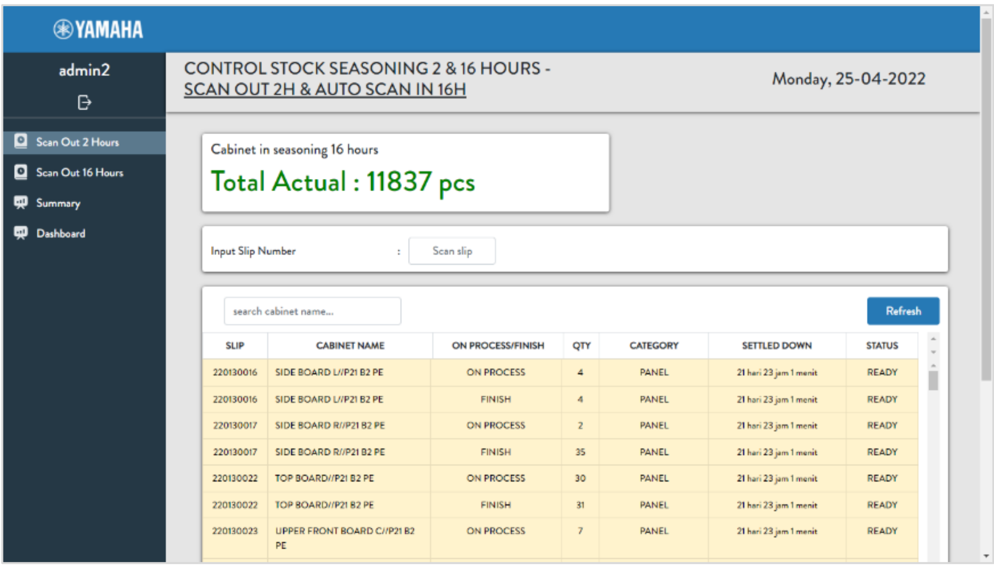

Fig. 6. Scan out 2-hour page

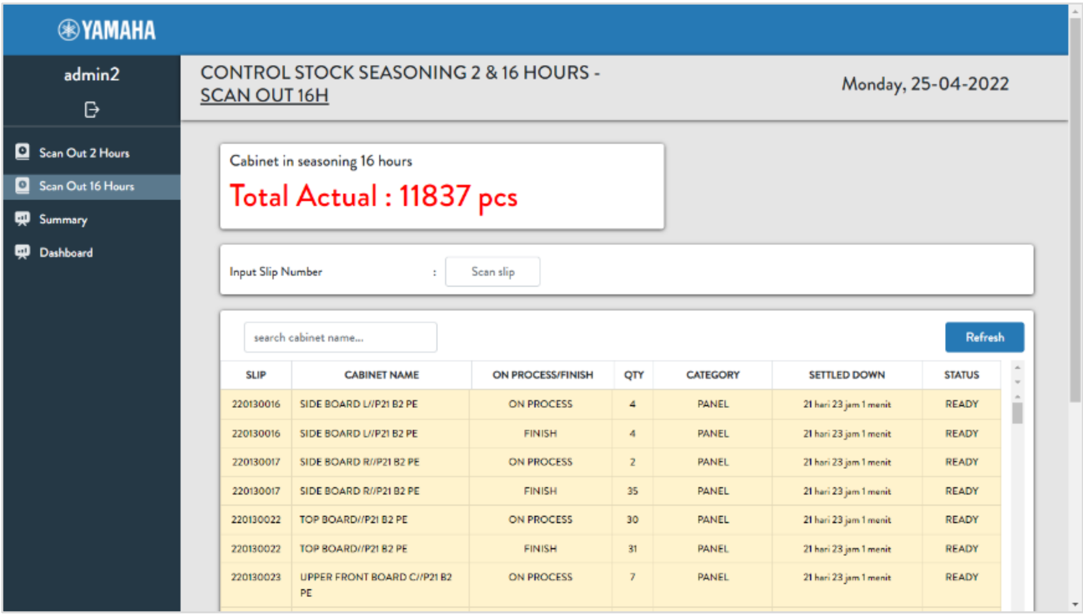

Fig. 7. Scan out the 16-hour page

4) Sprint 3 (Input Target Data and View History Report): In Sprint 3, PIC adds production target values using a target data input page. This data will be monitored with actual data. The history report page is used to view the production history report. Fig. 8 depicts the target input page, while Fig. 9 depicts the history report page.

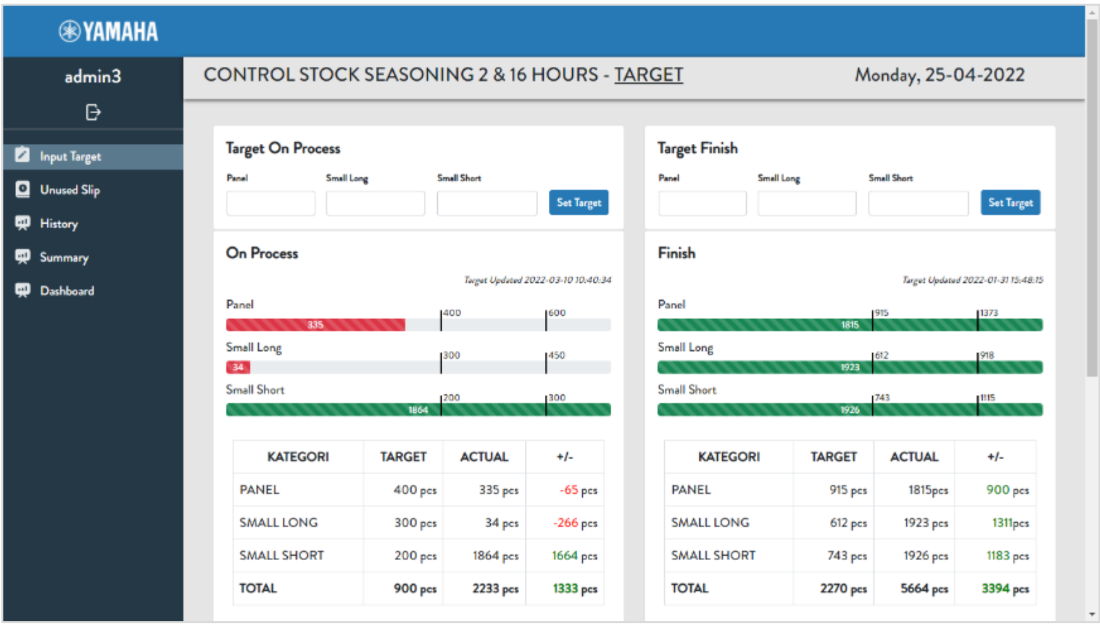

Fig. 8. Target input page

There are six columns on the target input page where PIC can fill in the monthly target based on the type and process. After entering the target, this value will be the minimum and maximum limits of its production, as indicated by a progress bar. Each type of piano part has its own progress bar. Colors on the progress bar indicate each status: red if production is less than the specified minimum target limit, green if production has exceeded the minimum target value.

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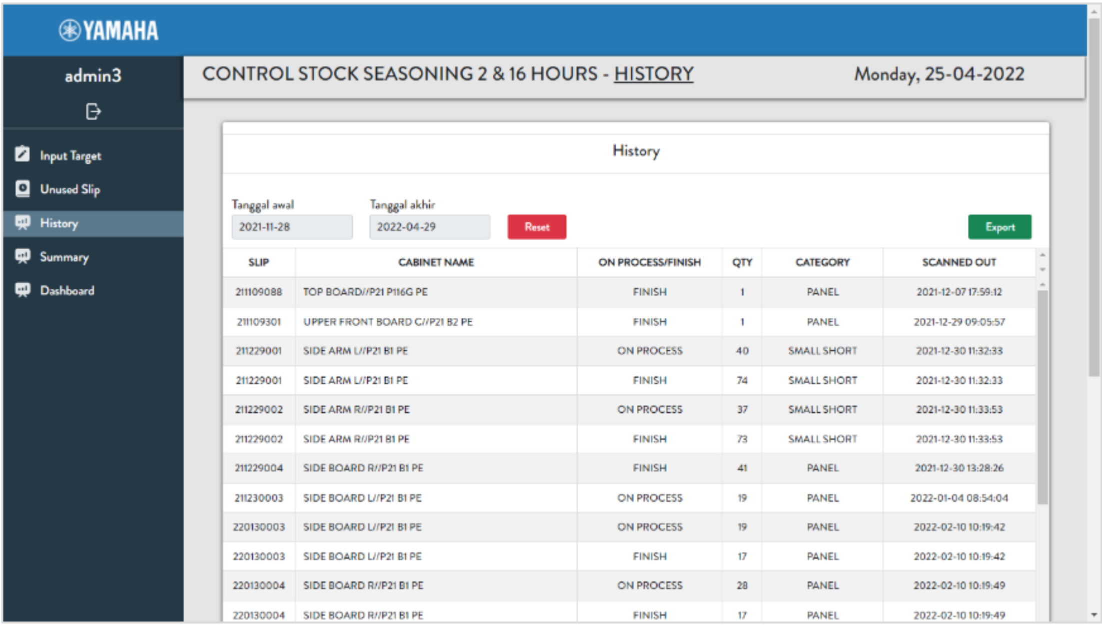

Fig. 9. History report page

5) Sprint 4 (Data Summary Report): In sprint 4, PIC and guest users view all summaries, a summary of the category (panel, small long, and small short), and a summary of production with the process or finish status. This summary is exportable to PDF and Excel. Fig. 10 depicts the summary report page.

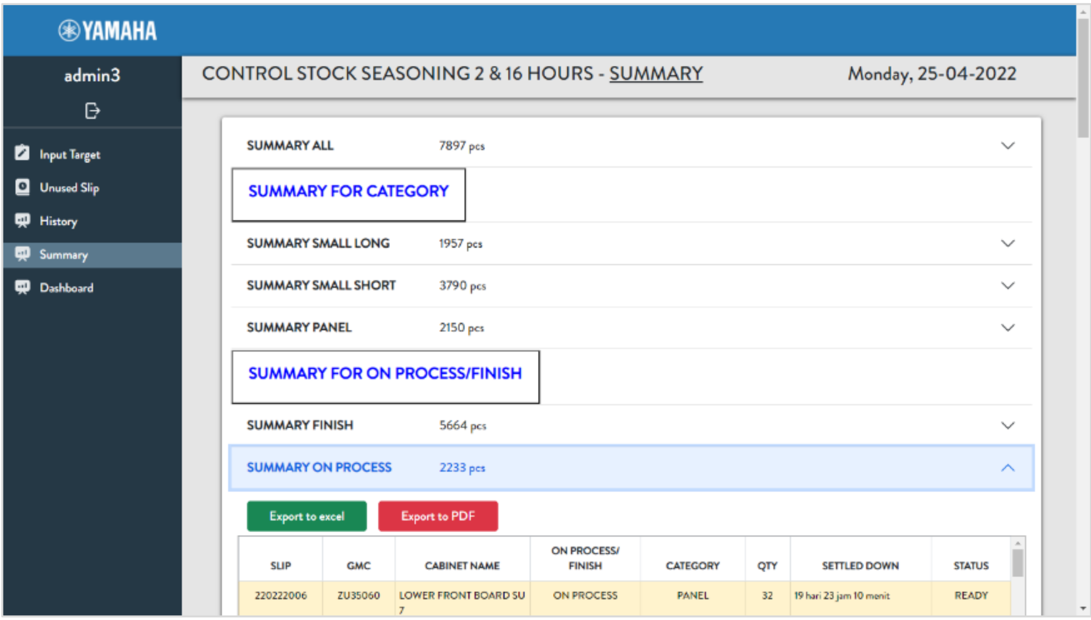

Fig. 10. Data summary report page

6) Sprint 5 (Data Chart Dashboard): In Sprint 5, PIC and guest users use a dashboard page to display data processing with chart visualization. Dashboards on the web have grown in popularity as a means of consolidating, organizing and displaying these visualizations [28]. The chart dashboard page can be seen in Fig. 11.

C. Sprint Review

After the sprint development work is completed, the results will be reviewed by all members. Each week, between 1 and 2 hours are allotted for inspection. Members will assess the task and, if necessary, develop a system. Following that, it concludes by explaining each development process in detail and offering a solution.

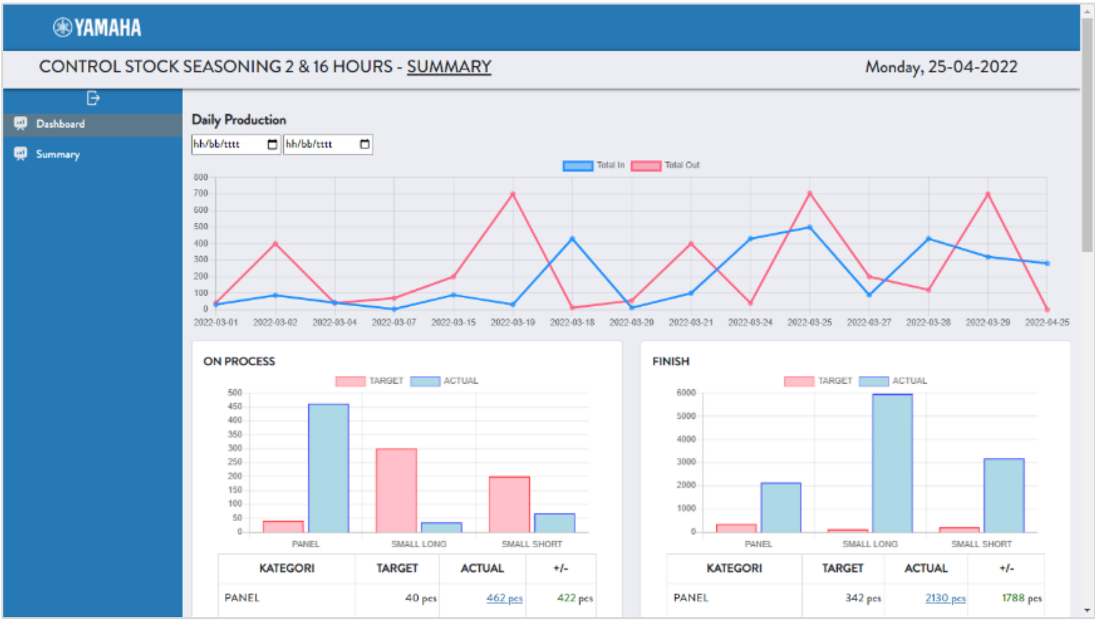

Fig. 11. Data chart dashboard page

D. Sprint Retrospective

Each team member will observe the processes and techniques used during sprint implementation and development, such as using bootstraps as visualization support and MySQL as the system's database. MySQL is a popular relational database server that supports the SQL (Structured Query Language) database language [29]. People still use SQL and relational databases to store and get to datasets in most commercial data management systems that are out there. SQL is frequently used by data scientists to retrieve and explore data [30]. PHP is a widely used programming language in web application development due to its high level of flexibility, ease of use, and ease of learning [31]. The system also uses Asynchronous JavaScript XML (Ajax), which is a way to make dynamic Web pages [32].

The implementation of Scrum in developing the production stock monitoring system was carried out by three people to build eight features. System development and testing took approximately four months. The system can handle the company's production stock monitoring issues. However, in its development, there are obstacles to system development, particularly because some features rely on online tools, and internet access on the company network is limited, causing the system to run slowly. Because of this, changes were made to offline tools, which made the system run smoothly.

According to previous studies, the Scrum method has also been successful in the development of a monitoring system in the retail sector [33]. Scrum has also been shown to be effective in the development of other systems such as point of sale [34], automatic course scheduling systems [35], and games [36]. Scrum is not only used as an agile method for developing software but it is also used as a framework for university teaching [37].

3.3. Data Visualization

Using concepts from the information visualization field enables users to create multiple coordinated views of data, referred to as charts, that depict the data from a variety of angles [38]. The system visualizes data in the form of visual charts by utilizing the chart.js Javascript plugin [39]. Chart.js is a free and open-source library that includes a variety of chart-drawing functions [40]. The use of charts.js is perfectly aligned with the system's requirements and makes it simple to modify the chart's visuals, such as type and color changes.

As shown in Fig. 12, the application of charts from the production stock monitoring system includes a bar chart to display the difference between target and actual data of piano parts with process time, including process and finish. The target data is highlighted in red, while the actual data is highlighted in blue. The chart is meant to be a reference comparison between the actual data results and the target data.

Then, as shown in Fig. 13, a pie chart is used to display piano parts with a seasoning time of 2 and 16 hours. The pie chart is probably the most frequently used method for visualizing proportions or the relationship between the size of one component and the size of other components and the whole [41]. Charts displayed with data by size type category include small long, small short, and panels. The color on the chart represents the processing time; red represents a piano part that is less than 16 hours, green represents a piano part that is more than 16 hours but less than three days, and yellow represents a piano part that is more than three days.

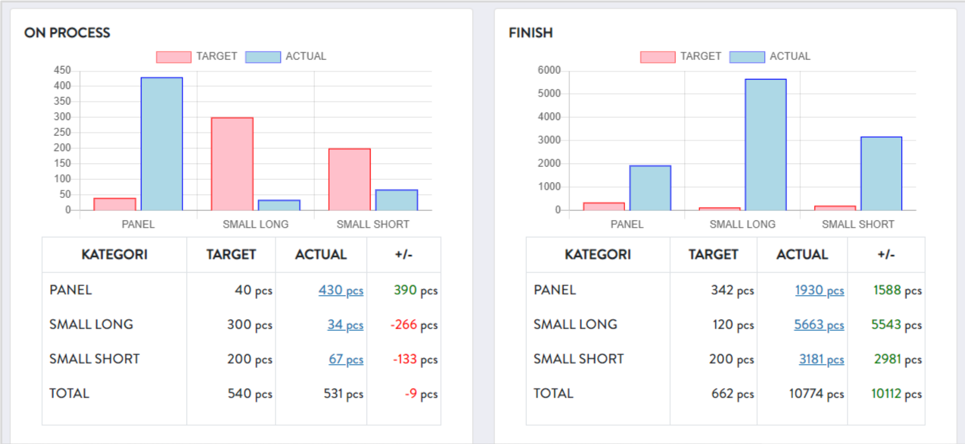

Fig. 12. Bar Chart

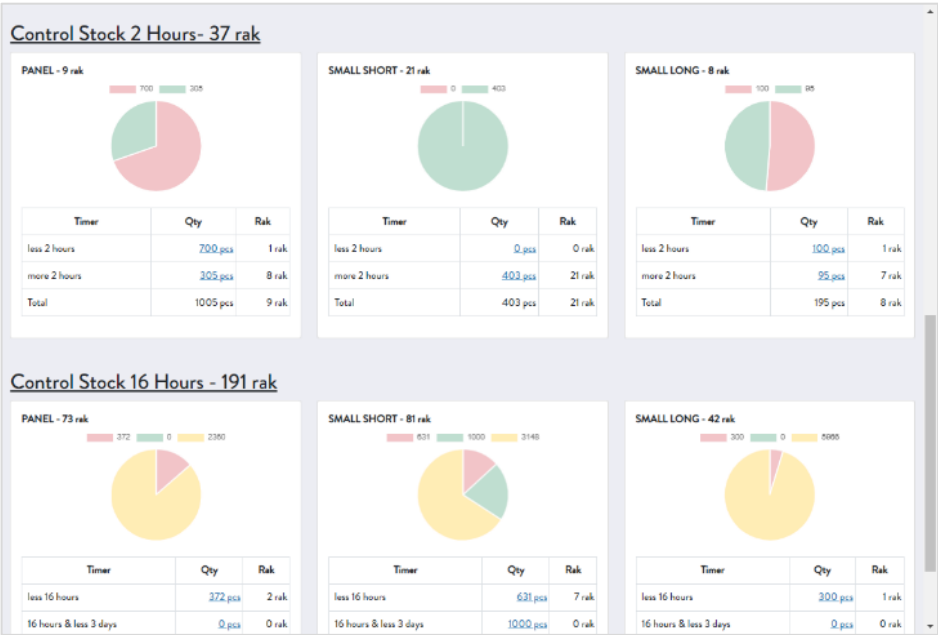

Fig. 13. Pie Chart

The production history of piano parts is displayed with the line chart type seen in Fig. 14. To display the visualization of data, PIC only needs to specify the start and end dates. The line chart has two colors: blue for production transactions and red for piano parts that have progressed to the next process.

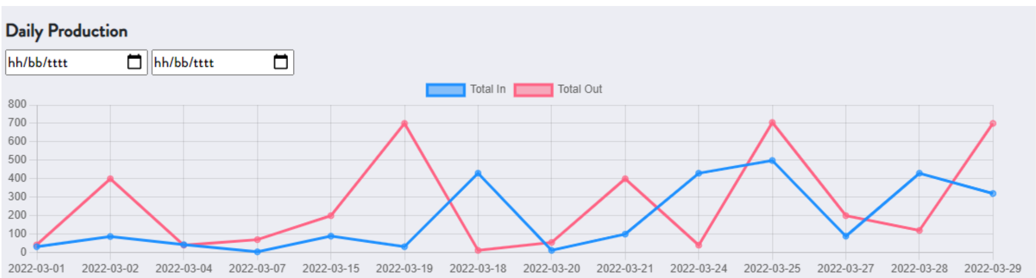

Fig. 14. Line Chart

Aside from overcoming production monitoring issues, the system's implementation also represents the company's application of Kaizen. The Kaizen philosophy has been widely applied to numerous operations and production processes in the manufacturing industry [42]. The Kaizen methodology is an effective tool for improving workflow, resource utilization, and efficiency [43]. One of the basic principles of Kaizen is making small changes to activity over and over again to make it more valuable and less wasteful, which can be measured and last for a long time [44].

4. CONCLUSION

The production monitoring system was developed using the Scrum method. Scrum assists companies in adapting to change and allows for mid-process changes. Charts.js was used to display a large amount of data for easy monitoring. Charts.js assists in the modification of charts as needed. The system was built in five sprint stages and includes eight features. System development and testing took about four months. Black-box testing is used, in which prospective system users use and test the system directly. Based on the tests performed, the system works as expected. The production stock monitoring system assists PT Yamaha Indonesia in real-time production monitoring and makes it easier for PICs to generate stock monitoring reports automatically, saving time. Furthermore, because production monitoring is done in real-time, it assists managers in making production decisions.

According to PT Yamaha Indonesia's production expertise, "The potential that occurs the process in the spray area is not fulfilled is a linear fault in the piano part after buffing. The linear fault refers to the condition of piano parts that have been painted on the surface, with horizontal and vertical lines measuring 5-10 cm. Then, if over-seasoning for 16 hours, the paint on the piano part will harden. It requires new action: the abrasive grid process of roughness level 240, which will increase the time of piano part production while addressing the issue of developing a stock control system that can guarantee quality at a nominal cost savings of Rp 110,058,881/year". Cost savings enable cities to grow economically, resulting in the development of other sectors [45]. In the company, the production stock monitoring system was implemented beginning in 2022. The system, in addition to solving the problems presented in the "Introduction" and "Requirements Analysis" sections, can save production costs, according to PT Yamaha Indonesia's production expertise statement.

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