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# Development of Automatic Real Time Inventory Monitoring System using RFID Technology in Warehouse

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***Abstract*— RFID technology is one of the technologies in logistics as an important application in logistics operations and supply chain management. The application of RFID technology can be applied to the inventory control monitoring system in real-time. The inventory monitoring information system can replace the manual system with a computerized system so that the processing of monitoring data is more efficient, effective, and can be controlled directly and accurately. This study presents a case study of a real stock monitoring system based on RFID technology. The design of a real-time stock monitoring system is transitioning from manual to technology by involving computerization in its implementation. This study aims to design an RFID-based real-time stock monitoring system and integrate warehousing systems in the company. The real-time inventory stock monitoring system is still developing, so a simulation is carried out to compare the existing data with the data from the RFID system. We used the existing warehouse layout to try the efficiency of the RFID stock monitoring. Based on the research results, the RFID system increases the efficiency and effectiveness of inventory control. In further research, it is necessary to integrate the inventory optimization model with real-time inventory control with RFID. The integration of real-time monitoring technology can be used as input to the inventory optimization model to be more accurate in providing purchasing policies.**

***Keywords*— RFID; real-time stock monitoring; inventory monitoring system application.**

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## I. INTRODUCTION

Monitoring can be described as being aware of what one wants to know; a high level of monitoring is done to make measurements over time that show movement towards a goal or away from it. Monitoring activities can be interpreted as an activity to monitor or supervise all activities carried out by someone [1]. Monitoring can be done directly by reviewing incoming goods, outgoing goods, and so on. Meanwhile, indirect monitoring is carried out through reviewing written reports, observing oral reports, or interviewing one of several people involved in an activity. The advantage of the company having a monitoring system, especially the inventory monitoring system, is information about the availability of inventory and the process of making inventory reports quickly so that they can make quick decisions. The inventory monitoring system could be maximized if the company supports providing technology and presenting information in real-time. Logistics service providers can improve their performance by involving innovations in logistics services that can be implemented through technology, knowledge, and relationship networks [2]. Radio Frequency Identification (RFID) is one of the technologies in logistics as an important application in logistics operations and supply chain management [3]. The inventory monitoring information system can replace the existing system from manual to computerized so that the processing of monitoring data is more efficient and can be controlled directly, and the information obtained is better and more accurate.

PT Tanjung Jaya is a company engaged in the automotive industry that manufactures and exports vehicles, engines, components, dies, and jigs. PT Tanjung Jaya has five factories spread across Sunter and Cikampek areas, West Java, Indonesia. The factory in the Sunter area produces car engines to be sent to the Cikampek factory. PT Tanjung Jaya Plant Sunter 1 is a factory that carries out internal B2B with Plant Sunter 2 and Plant Cikampek 3 as the manufacturers of TR-1, TR-2, and TR-KAI engines. PT Tanjung Jaya Plant Sunter 1 has a large supply of parts from various suppliers. PT Tanjung

Jaya Plant Sunter 1 requires a warehouse that can store the required inventory optimally.

The problems that arise at PT Tanjung Jaya are in the logistics sector, which is experiencing delays in controlling inventory which causes the material stock to not be available at the right time. Work processes are carried out manually without the involvement of technology that helps integrate the system in real-time [4]. The use of information systems in the form of RFID as a solution to the problem of monitoring inventory logistics for proper inventory control, so that inventory is carried out in real-time, not excessive and not lacking, and can produce information for making decisions [5]. The system development carried out with integrated data produces useful reports for the company. Based on the results of the research conducted and the problems faced, the author's goal is to build an inventory data monitoring information system for PT Tanjung Jaya.

## II. Materials and Method

### A. Materials

#### 1) Inventory management

Inventory management is an important element in making all decisions in a company to give the excellent treatment for inventory items, such as activities to be carried out, inventory management policies, and procedures to handle the inventory to guarantee the quantity of each item when stored in the warehouse all the time [6]. Inventory management is controlling and monitoring inventory levels and assuring sufficient replenishment to meet customer demand. Inventory management ensures a company's resources are always maintained and available [7]. With good inventory management, it is expected not to have any shortage of stock, and delivery will be on time.

#### 2) Inventory control

Inventory control is important in saving the cost of a company [4]. Inventory control is one of the most noteworthy techniques in various companies to control the relationship between production, purchasing, marketing, and financial policies. Inventory control is carried out so that the company can balance quality and raw materials needed with minimal costs. Inventory control has three functions, such as [8]:

- Maintaining stock to make a company's production or sales activities can continue to run.
- Maintaining inventory from being too large so it does not cost a lot.
- Guarantee that there are no repeat purchases during the production. Therefore, the ordering cost will not become high.

#### 3) RFID technology

Radio Frequency Identification (RFID) Technology is based on information communication technology (ICT) which has been used recently for technology development. This technology improves service quality and lessens delivery time problems [9]. RFID is a wireless radio communication technology to identify people or assets uniquely and allows tracking of an item.

RFID is an automatic system that utilizes wireless technology for identifying and tracking marked objects in a unique serial number. RFID systems have four constituents: FID tags, readers, antennas, and a central node computer system that houses management software and a database server [10].

Transponders in RFID are objects that can be installed, embedded, inserted, and placed in products such as animals, plants, and even humans as identification using electromagnetic radio frequencies. Identification uses a magnetic field that emits a certain number of codes when asked or called by the Reader, so Reader does not need to make direct contact with the attached RFID label on the object [11].

#### 4) Model and simulation

Management often uses modeling and simulation tools to study or analyze the work behavior of a system or process [12]. Models are useful and efficient tools for analyzing and designing systems, and models can show how the operation works and stimulate the user to think about improving or fixing it. A model is a logical description of how the system works or how the components interact. Making models from a system will make it easier to analyze [13].

Simulation is a technique of imitation operations or processes that occur in a system with help from computer equipment. Simulation is based on certain assumptions so that the system can be studied scientifically, and simulation is used to imitate the behavior of real systems or certain realities. The simulation aims for training, studying system behavior, entertainment, or games [14].

#### 5) Verification and validation

Data verification is a process of determining whether the simulation model created properly reflects the conceptual model. Data validation is a process of determining whether the conceptual model properly reflects the real system model. Data verification and validation are needed to reduce errors in the system. Verification consists of a separate set of activities to ensure that the model is correct. Validation ensures that the model is meaningful to the systems' users [15].

Verification usually identifies and eliminates errors in the model by comparing analytical and numerical solutions. The result of the verification is a properly constructed model or a warning on the structure and behavior of the model if there is an error. Validation focuses on calculating the model's accuracy by comparing numerical solutions to the experimental data. Validation allows the detection of errors that can interfere with real systems[16].

#### 6) Use case diagram

The first step of modeling a system is to identify the system's entities and analyze the system's functional requirements using a use case diagram. Using a case diagram is a diagram model for the behavior of an information system to be made. Use case diagram is used to find out what functions are in an information system and who should use these functions. Use case diagram represents an interaction between actors and the system [17]. There are three types of relationships in the use case diagram, namely:

- Association between use case and actor.
- Generalization of use case and actor.
- Form and extend the relationship between two uses.

*7) Activity diagram*

An activity diagram illustrates the workflow or activities of a system or business process. Activity diagrams are dynamic, and it is a special state diagram, where most of the states are actions, and most of the transitions are triggered by the completion of a previous state or internal processing. Thus, activity diagrams rather describe the processes and activity paths from the highest level in general.

*8) Sequence diagram*

The sequence diagram illustrates objects' behavior by describing the object's lifetime and sent and received messages between objects. A sequence diagram is commonly used to describe a series of steps taken in response to events that produce a certain output. Starting from what triggers the activity, what processes and changes occur internally, and what outputs are produced.

*B. Method*

*1) Conceptual model*

A conceptual model is a thought concept that describes how the author formulates a problem-solving framework and helps in formulating solutions to problems. The conceptual model aimed to solve the problem is as follows:

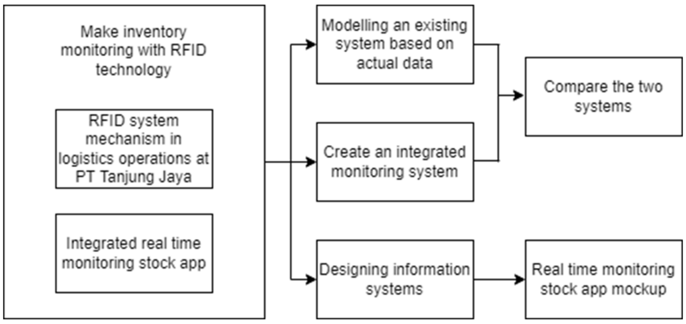


Fig. 1 Conceptual Model

This research aims to design a real-time stock monitoring system based on RFID technology at PT Tanjung Jaya. A stock monitoring system, especially a system that provides information about stock in real time, is expected to facilitate the inventory control work process. We design an RFID system mechanism in logistics operation at PT Tanjung Jaya and an information system from a real-time stock monitoring system. We make a comparison between the two systems. We also design an information stock system to produce output as a mock-up of the real system monitoring application.

*2) Systematic problem solving*

Systematic problem solving defines steps to solve problems. The systematic problem-solving in this research is as follows:

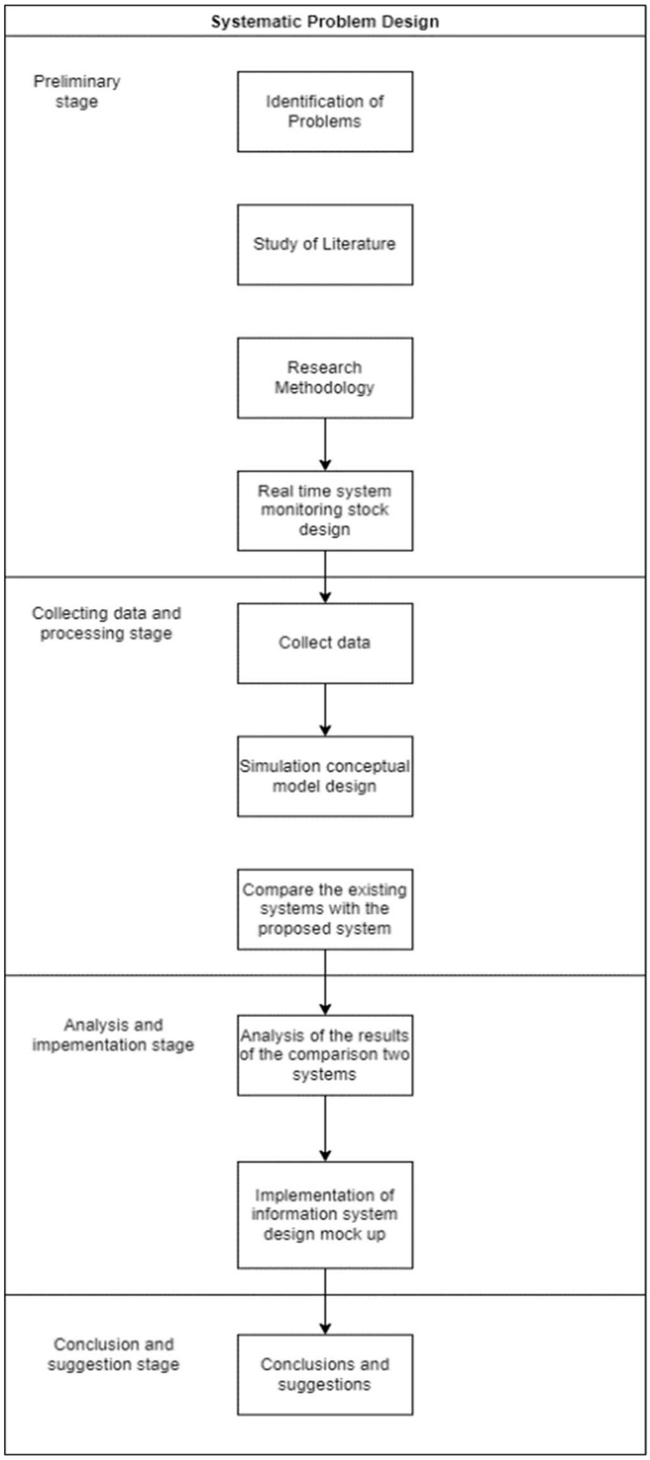


Fig. 2 Systematic Problem Solving

*3) Preliminary stage*

This research begins with a preliminary stage to introduce the problem. We identify the problem by conducting a literature study and direct observation in the field. Direct observation is carried out to understand the existing problems in the company to help them formulate the problems properly. A literature study was conducted to make understanding the topic and background problem easier. After formulating the problem, we set goals as a solution for the formulated problem.

*4) Real-time stock monitoring system*

In this stage, we model the initial business process simulation that has been verified and validated. After modeling, we overview the layout of the RFID system mechanism at PT Tanjung Jaya. Then, we describe the scenario of the proposed business process improvement, namely the inventory control business process after using RFID technology. The improvement scenario was re-stimulated to control loading time inventory after RFID was introduced. We design a real-time stock monitoring application to provide better stock visualization.

*5) Data collection and processing stage*

We collect the data needed to perform data processing at the data collection stage. The data needed for this research are:

- Existing logistics business process data at PT Tanjung Jaya.
- Inventory control business process data at PT Tanjung Jaya.
- Observation data for loading time inventory control at PT Tanjung Jaya.

When the required data has been collected, we move to the next stage, which is the data processing stage. After collecting data, the next stage is the data processing stage to find the distribution pattern of the observation data, which will later be input when conducting the simulation. After looking for the data distribution pattern, we need to determine the parameters to make a conceptual model of the simulation. When the design of the simulation model has been carried out, we will verify and validate the simulation model. The verification process ensures whether the simulation model created can represent the actual simulation conceptual model. This stage is done by testing the simulation model to determine whether there are errors or not in making the model [18]. The validation process is to ensure whether the model built is correct and whether the model can represent the actual system accurately. The comparison process between the simulation model and the real system is carried out by testing the hypothesis based on the paired-t statistical test. After the simulation model is valid, the simulation model is run based on experiments designed to produce several recommendations for solving problems.

*6) Analysis and implementation*

We analyze the initial business process of inventory control before RFID. After that, we analyze the simulation model that has been verified and validated. Then, we analyze the proposed business process that has been simulated and tested with a pair t-test [19]. We analyzed the load time inventory control before there is RFID and after there is RFID based on the simulation result. Last, we implemented the information systems design in the form of an application interface design.

*7) Conclusion and recommendation*

This contains the conclusion from all the stages that have been done, including analysis and implementation. Advice should be given to the company so the proposed system can be implemented and even be better in the future.

## III. Results and Discussion

To prove that RFID reduces the process of checking inventory in the warehouse, we experimented by designing a simulation model in a warehouse. The inventory control process begins with the operator preparing an inventory check sheet. Then the operator manually calculates the inventory stock in the racking bay. After finishing calculating the inventory stock in the racking bay, proceed with manually calculating the inventory stock. After completing the stock calculation, the operator must input the results of the inventory calculation data into the order tool for later calculations and order adjustments. After that, the operator makes an inventory report and makes reporting.

### A. Process Flow

Figure 3 is an inventory control business process currently running at PT Tanjung Jaya. The standard total loading time required to carry out the inventory control process is 410 minutes/shift. The inventory control process begins with the operator preparing an inventory check sheet. Then the operator manually calculates the inventory stock in the racking bay. After completing the stock calculation, the operator must input the results of the inventory calculation data into the order tool for later calculations and order adjustments. After that, the operator makes an inventory report and makes reporting.

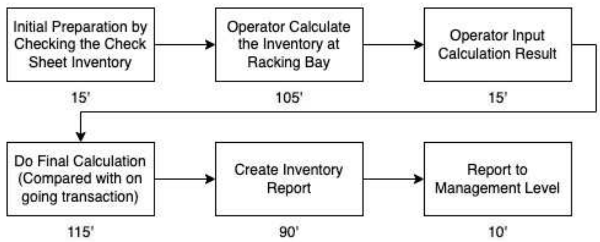


Fig. 3 Process Flow

### B. Scenario Design

Figure 4 illustrates the mechanism of using RFID technology in PT Tanjung Jaya's warehouse operations to support the proposed real-time stock monitoring system design. At each shelf entering and leaving the racking bay, an RFID reader and an RFID antenna were installed so that every movement of goods entering and leaving will be read by the RFID system so that information about the amount of stock in the racking bay will be obtained quickly in real-time [20]. Inventory control operators do not need to do stock calculations directly to the racking bay manually, so inventory control operators only input the results of inventory calculations into the order tool and perform calculations and order adjustments. Inventory control operators can also quickly generate reports [21].

In this study, we use several assumptions and limitations in developing scenarios:

- Each product that enters the warehouse will be affixed with an RFID Writer sticker.
- RFID Reader uses Long RFID type with a range of 8m.
- Not considering the electronic wiring and placement of the RFID Reader.
- Only focusing on reducing processing time for stock take, not focusing on investment costs.

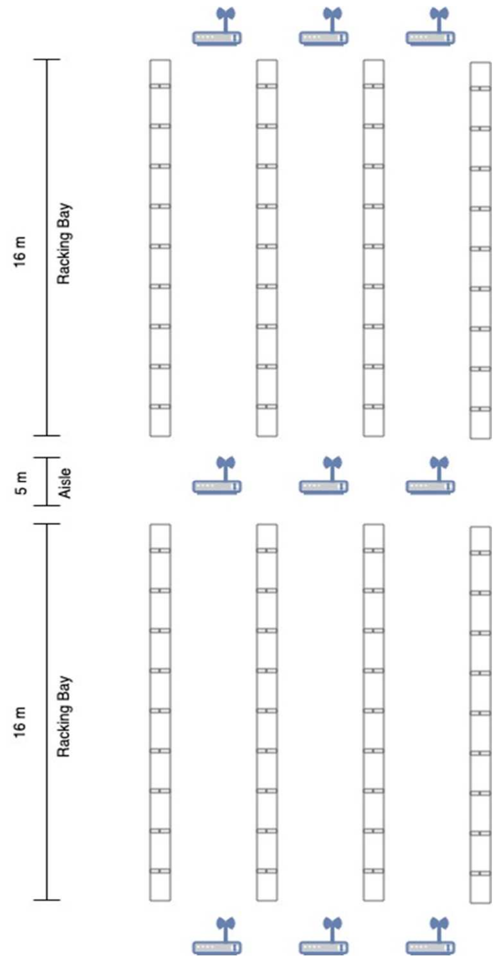


Fig. 4 Mechanism of Using RFID Technology

## C. *Information System Design*

To design a stock monitoring system, it is necessary to identify the processes related to the monitoring system, as illustrated in the following use case diagram [22]. From the use case diagram, it can be seen that the managers and staff of the PPC and logistics divisions can log in to the system, and managers can access real-time stock monitoring. Meanwhile, PPC and Logistics division staff can also access real-time monitoring stock but can only manage parts, either adding, subtracting or adjusting the number of parts.

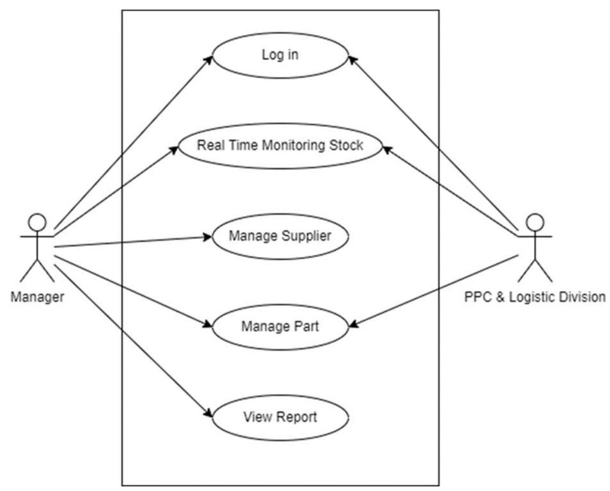


Fig. 5 Use Case Diagram Monitoring Stock

The activity of the relationship between the user and the system can be seen in the activity diagram as shown in Fig. 6 below.

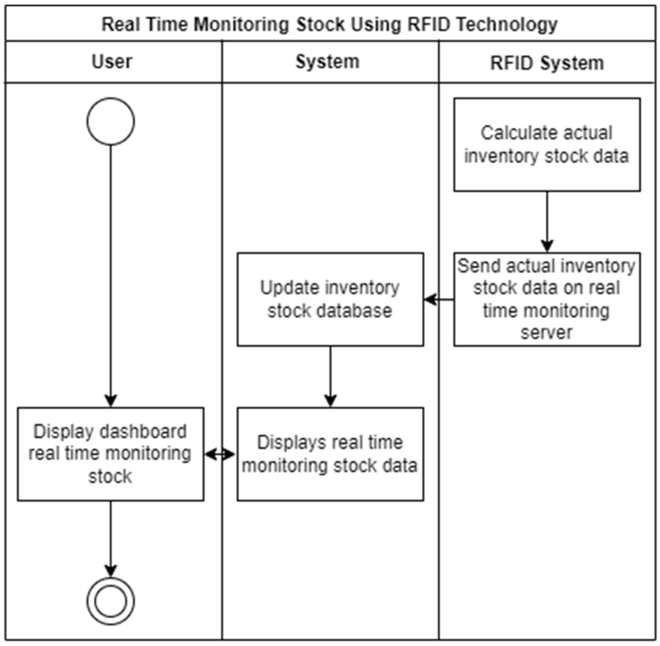


Fig. 6 Activity Diagram Real-Time Monitoring Stock

Real-time stock monitoring using RFID technology begins with calculating the actual physical stock by the RFID system [23]. Then, the RFID system sends the actual physical stock calculation results to the monitoring server. Then the inventory database is updated and displayed by the system. Then, users who have successfully entered the system and clicked on the real-time stock monitoring page can immediately see the interface of the real-time stock monitoring. The sequence diagram of the real-time monitoring stock process is as follows.

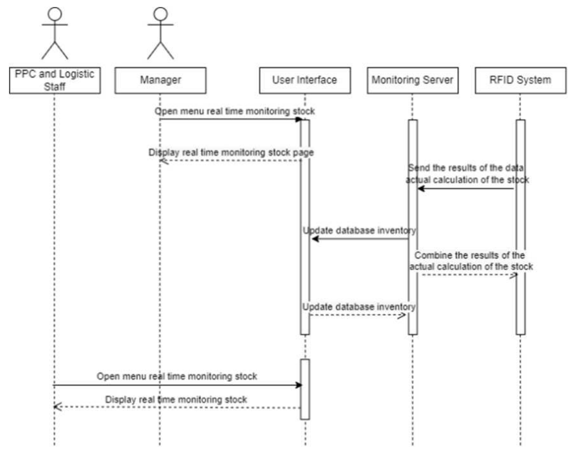


Fig. 7 Sequence Diagram Real-Time Monitoring Stock

## D. *Design of Login Page and Dashboard Design*

The login page is the initial page that appears when the application is started [24]. The login page is the gateway to enter the home page. On the login page, the user is required to enter a username and password to be able to enter and use the application. With a suitable username and password, the user can directly enter the application homepage.

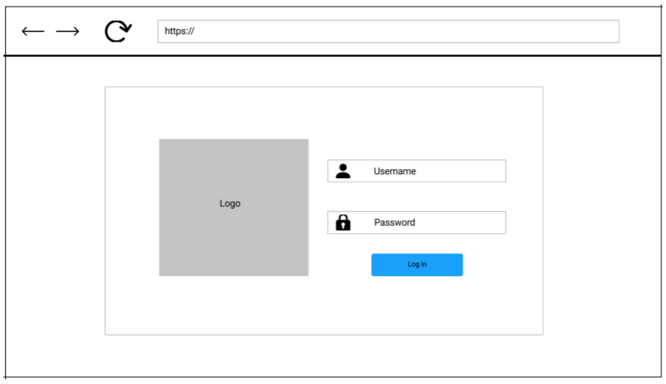


Fig. 8 Login Page Design

After the user successfully logs in, the user was immediately taken to the main view of the application, namely the dashboard, which displays a visualization of the latest status data and certain metrics. In this case, certain metrics in question are the operator on duty today, the schedule for the arrival of goods from the supplier, the machine's production capacity today, the level of accuracy of inventory records from the RFID system, as well as the status of incoming and outgoing stock on the progress lane and SPS racks. The dashboard interface proposed in the application is shown in the following figure.


Fig. 9 Dashboard Page Design

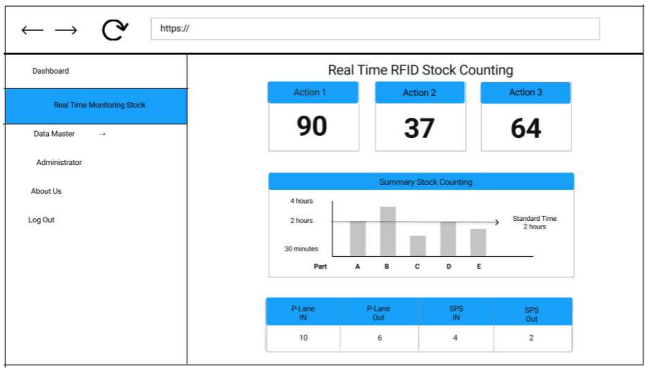


Fig. 10 Design Page Real-Time Monitoring Stock

When the user selects the real-time stock monitoring menu, the user gets information about the exact quantity of each part. This page also displays a summary of the number of parts in the standard hours set by the company. If there are parts that are less in number within the standard period, the company can immediately find out that there is a stockout problem so that decisions are made to address the problem immediately. The system also displays the number of parts on the progress lane and SPS shelves.

## *E. Design Master Data Page Design*

The first master data is the supplier master data. In this menu, the user can see a list of suppliers from PT Tanjung Jaya Plant Sunter 1. The supplier master data consists of supplier ID, supplier name, supplier address, address, telephone number, mobile number, email, and action. In the action options, the user can edit and delete suppliers. On this page also, the user can add a new supplier. The interface page of the master data supplier is depicted in the image below.

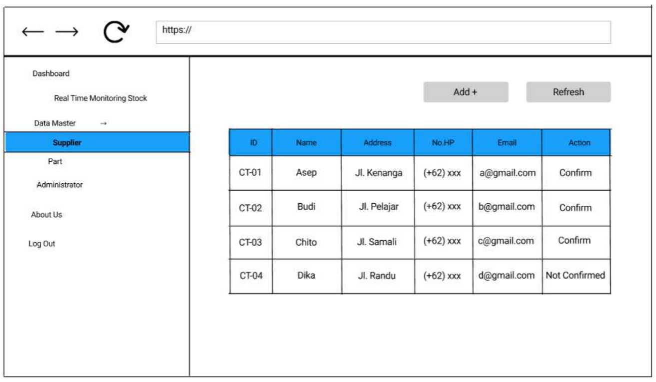


Fig. 11 Design Page Master Data Supplier

The second master data in this application is the part master data. In this menu, the user can see a list of parts in PT Tanjung Jaya Plant Sunter 1. In this master data, each item has information such as part name, part number, and RFID tag. The RFID tag contains detailed information on each part to the item's location on the shelf.

## *F. Part Design Page*

The second master data in this application is the part master data. In this menu, the user can see a list of parts in PT Tanjung Jaya Plant Sunter 1. In this master data, each item has information such as part name, part number, and RFID tag. The RFID tag contains detailed information on each part to the item's location on the shelf.

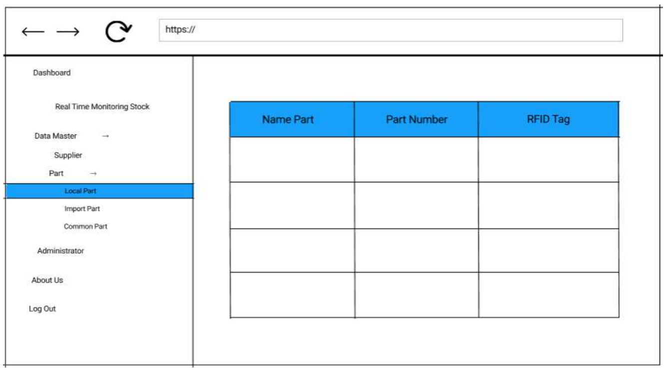


Fig. 12 Design Page Master Data Part

# IV. Conclusion

The use of RFID technology in the warehouse operating system at PT. Tanjung Jaya, especially as a technology to support the stock monitoring system, can provide convenience in monitoring the existing stock in the progress lane and SPS because the information is obtained in real-time and provides improvements in how to speed up the inventory control process because the operator no longer must calculate the stock to the progress lane and SPS. It is hoped that the company can have a more efficient warehousing system by having a real-time stock monitoring system using RFID technology and a real-time stock application. It eliminates manual processes, can keep track of the movement of goods, know the amount of inventory stock in real-time anytime and anywhere, and can reduce labor costs. Designing real-time stock monitoring applications based on RFID technology can provide good visibility and get real-time information, making it easier for the company to make decisions regarding related problems and improve.

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