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Article

IS4AC (Intelligence System for Air Controller) Application for Air Quality Control of Tobacco Storage Warehouse PT. Mangli Djaya Raya

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Abstract: Warehouse Quality Monitoring Information System (IS4AC) was developed to improve the monitoring of storage environmental conditions, especially related to temperature, humidity, and PH_3 levels, which have an impact on product quality. This study includes the collection of initial data from partners used for system design and modeling, followed by the development of a sensor-based application that allows real-time monitoring. The research methodology includes data collection, system design, application development, and testing and implementation in the laboratory and partner warehouse locations. The results of the study show that IS4AC is able to provide accurate and timely information, improve operational efficiency, and reduce the risk of product damage due to unmonitored environmental conditions. With this system, users can make better decisions in storage quality management. In conclusion, this study shows the significant potential of an automated monitoring system in improving warehouse management, as well as contributing to the development of adaptive technology in various industrial sectors.

Keywords: Information System; Quality Monitoring; Sensor; Warehouse

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1. Introduction

PT Mangli Djaya Raya (PT MDR) is a multinational company engaged in the tobacco production industry, especially cigars, with export markets covering countries such as Germany, England, and several other countries in Europe and America. Since its establishment in 1960 in Jember, PT MDR has grown into one of the main exporters in the tobacco industry, with an increasing international sales scale [1] [2].

However, PT MDR faces challenges in managing a tobacco storage warehouse measuring ±40 mx 60 m. The warehouse is not yet equipped with an automatic control system that is able to monitor and regulate temperature, humidity, and phosphine gas (PH3) levels in real time. An uncontrolled warehouse environment can have a negative impact on the quality of tobacco leaves that are easily exposed to mold, as well as increasing safety risks due to the very dangerous phosphine gas.[3]

Phosphine (PH3) is a colorless, flammable gas that is highly toxic at low concentrations [4]. It has a boiling point of -126°F and a freezing point of -209°F, and can explode if exposed to excessive heat [5]. Currently, PT MDR only has a monitoring system for temperature and humidity, but does not have an automatic control mechanism for phosphine gas, which can endanger the health of workers and reduce the quality of tobacco products.

In this study, the Jember State Polytechnic team developed an intelligent system called SI4AC (Intelligence System for Air Controller) to control air conditions in PT MDR's storage warehouse. This system uses temperature, humidity, and phosphine gas sensors integrated with a Raspberry Pico W-based microcontroller. The collected data is processed using an artificial intelligence method based on Fuzzy Logic, which will automatically control the exhaust fan according to warehouse conditions, so as to ensure a safe, efficient, and quality standard storage environment.

2. Materials and Methods

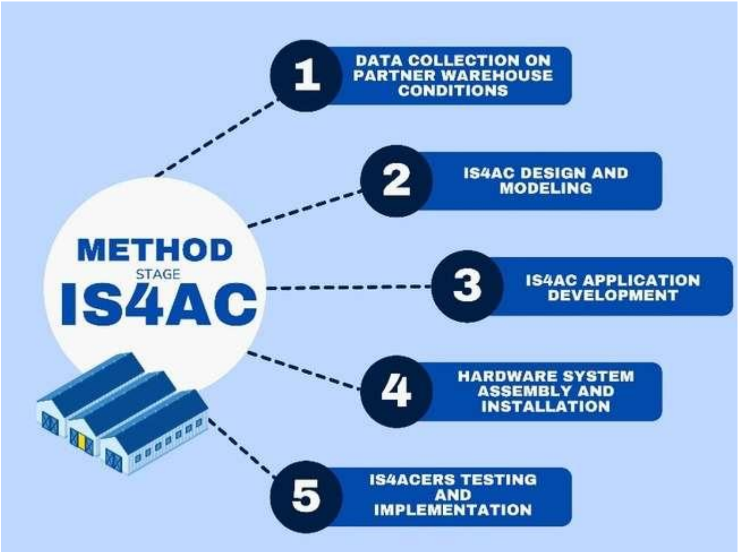

Figure 1. Method

The IS4AC development stages are carried out through several strategic steps that are systematically designed to ensure the success of the system implementation. The following are the stages taken in the development of IS4AC:

1. Partner Warehouse Condition Data Collection

The initial data collection process was carried out in the partner's storage warehouse to measure temperature, humidity, and PH_3 levels. The data obtained was used as the basis for developing the IS4AC system. Measurements were made using calibrated sensors, and the results were presented in tables and graphs for further analysis [6].

2. IS4AC Design and Modeling

The IS4AC system design and modeling are developed as a comprehensive implementation blueprint, meticulously crafted to achieve seamless integration between hardware and software components. This process encompasses several key phases, including circuit design to define the physical and electronic structure of the system, system modeling to represent the overall functionality and interactions within the system, and the creation of essential visual aids such as UML diagrams, wireframes, and database diagrams. The UML diagrams outline the software architecture, showcasing class structures, interactions, and behaviors, while wireframes provide a visual representation of the user interface for enhanced usability [7]. Database diagrams define the data structure to ensure efficient data storage and retrieval [8]. By combining these elements, the design establishes a solid foundation for developing a robust, efficient, and well-integrated system, addressing both functional requirements and user needs effectively.IS4AC Application Development.

The IS4AC application is developed to read inputs from temperature, humidity, and PH_3 sensors. The output of this application is used for monitoring environmental conditions in the storage warehouse. The coding process is carried out by utilizing a suitable development platform and followed by testing to ensure accurate functionality.

3. Hardware System Assembly and Installation

The hardware assembly and installation phase of the IS4AC system involves integrating sensors and microcontrollers with the application to ensure seamless communication and functionality. This process includes securely connecting components, calibrating sensors for accurate data capture, and programming microcontrollers to process and transmit data effectively. Rigorous micro-scale testing is conducted to verify system connectivity, data flow, and performance, ensuring all components operate harmoniously. This trial phase ensures the system functions reliably and meets design specifications before deployment in a real-world environment, reducing potential errors and ensuring a smooth implementation.

4. IS4AC Testing and Implementation

IS4AC prototype testing was conducted in the laboratory and continued with implementation in partner warehouses. This process includes tool assembly, data collection from sensors, and system analysis and updates based on test results. This implementation is expected to improve the supervision of storage environmental conditions, with a focus on product quality.

3. Results and Discussion

3.1. Collecting Data on Partner Warehouse Conditions

Data collection was carried out using sensors to measure temperature, humidity, and PH_3 levels in the partner's storage warehouse [9]. This data was obtained over a certain period to ensure consistency and accuracy. The measurement results showed a temperature variation between 30°C to 35°C, humidity ranging from 60% to 70%, and the detected PH_3 levels were within the safe range. Figure 1 presents the data, which serves as the basis for the development of the IS4AC system.

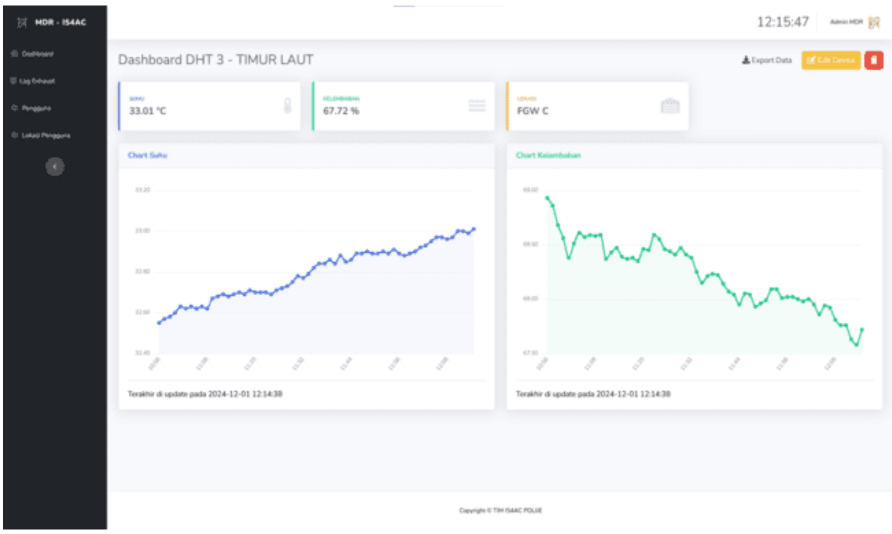

Figure 2. Temperature and Humidity graphs

The image shows a monitoring dashboard called "MDR - IS4AC" showing temperature and humidity data from a DHT 3 device at the "Northeast" location. The dashboard has two graphs: one for temperature shown as a blue line with degrees Celsius, and one for humidity shown as a green line with percentages. At the top, you can see the current temperature (33.01°C), humidity (67.72%), and location (FGW C). There are buttons for "Export Data," "Edit Device," and "Delete." Based on the graph above, it is shown that humidity decreases with an increase in temperature. This has a bad impact on the quality of tobacco plants, so with this IS4AC tool, temperature and humidity are controlled automatically so that the quality of tobacco leaves is well maintained. [10]

Figure 3. gas chart Ph3

The figure shows the "MDR - IS4AC" monitoring dashboard for the "PH3 East" device. The dashboard displays Phosphine (PH3) level data with a value of 0.70 ppm at the "FGW C" location. The graph at the bottom shows the fluctuation of PH3 levels with varying patterns, shown in blue lines that illustrate the trend of the data over a period of time. At the top, there are "Export Data," "Edit Device," and "Delete" buttons for data management. The last updated time of the data is displayed at the bottom of the graph as "2024-12-01 12:16:34," providing users with up-to-date information on the status of the device. In the graph above, the humidity, temperature and phosphine conditions are shown in the FGW C Warehouse. If the phospine condition is high, or the temperature and softness exceed the desired conditions, the IS4AC will automatically turn on the exhaust to flow clean air so that the air remains safe for humans. In addition, the humidity state is controlled, not too humid and cold, which causes mold growth.

3.2 IS4AC Design and Modeling

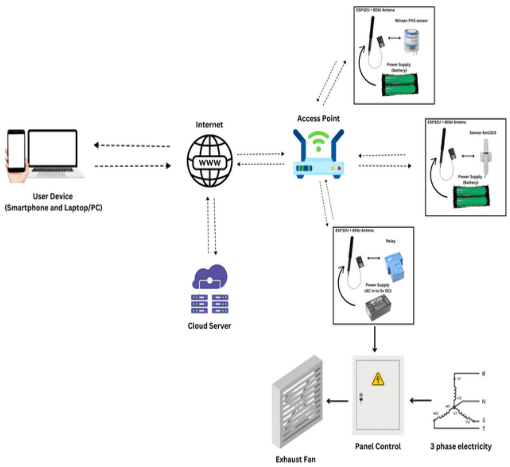

Figure 4. System Design

The figure explains that data from the condition of the storage warehouse room is acquired by the ME3-PH3 and DHT 22 sensors which are processed using a Raspberry Pico W-based microcontroller. Data from the Raspberry is forwarded to the Raspberry Pi 5 to be combined before being sent to the IoT server, MySQL Database Server, and Apache Web Server. On this web server, data processing is carried out using the AI method based on Fuzzy Logic to control the 1 channel 24V power relay. This relay will turn the current on and off at the exhaust. Thus, the use of the Exhaust is more efficient, and real-time according to field conditions [11].

In this system, room temperature and humidity data and phosphine are acquired from high-accuracy sensors specifically used on an industrial scale, namely ME3-PH3 and DHT 22, which are then sent via the Raspberry Pico module installed at 6 observation points, to be sent to Raspi 4. In the next process, the data is processed using the Fuzzy Logic-based Artificial Intelligence method to activate the relay to turn the exhaust off and on. The fuzzy logic system also functions to control the fan rotation (RPM) so that the air continues to flow effectively [12]. The monitored data is presented in statistical tabulation and graphics presented on the dashboard screen.

The following is the external design of the IS4AC physical system.

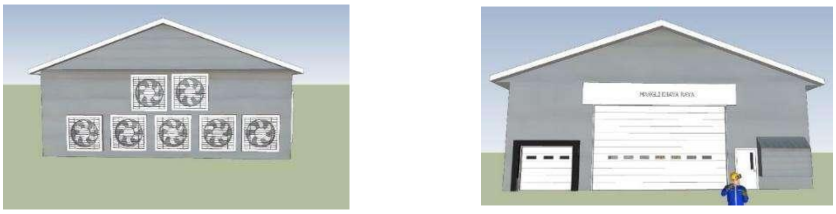

Figure 5. Exterior Design

3.3 IS4AC Application Development

The IS4AC application was developed using a suitable programming language, and is designed to accept input from the attached sensors. The development process involved creating functions to read data from the sensors, process that data, and produce output that is easy for the user to read. Initial testing of the application showed that the application is able to process data quickly and accurately, with an average response time of less than 2 seconds. The following are the features of the IS4AC Application

3.3.1. Splash Screen Feature

Figure 6. Splash Screen Feature

This feature displays the initial display of the application that will display the logo or name of the application to be run. After pressing the SplashScreen section, the Login Display will appear. The image is as below.

3.3.2. Login Features

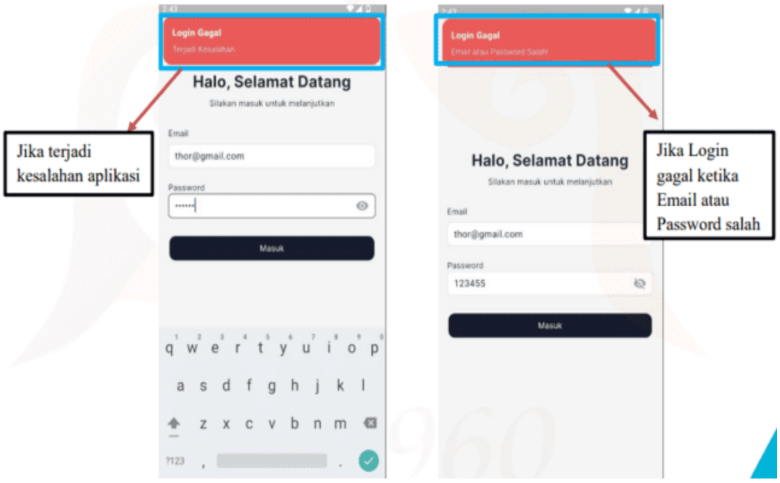

Figure 7. Login Features

In the login feature, users must enter an email or phone number along with a registered password. Users enter their email and password in the space provided, and after ensuring all information is correct, they can press the "Login" button to access the application's Dashboard menu. If an error occurs when logging in, such as an incorrect email or password, a notification pop-up will appear reminding users to recheck the email and password used, ensuring that both match those registered in the application.

3.3.3. Dashboard Features

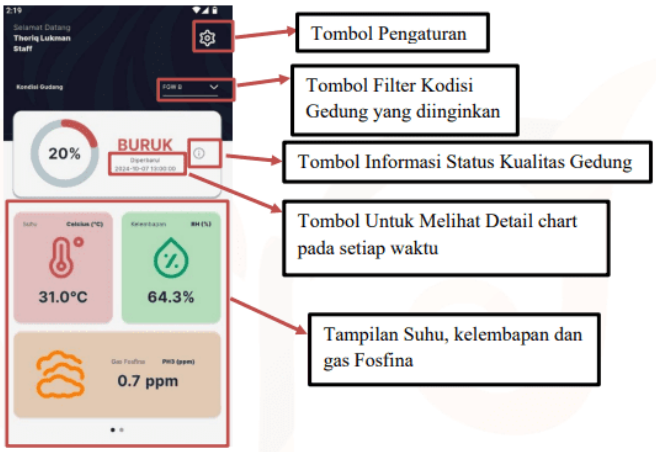

Figure 8. Dashboard Features

On the IS4AC mobile-based application Dashboard feature, users will see real-time basic data, including temperature, humidity, and phosphine gas levels, which are displayed based on the desired building condition selection. The dashboard also provides settings for users to manage accounts, such as changing passwords and editing account information. In addition, there is information on building quality status and detailed charts that show data over time. On the second page of the dashboard, users can access charts that show real-time data by selecting filters for temperature, humidity, and phosphine gas conditions, making it easier for users to monitor building environmental conditions.

3.3.4. Warehouse Quality Status Information Feature

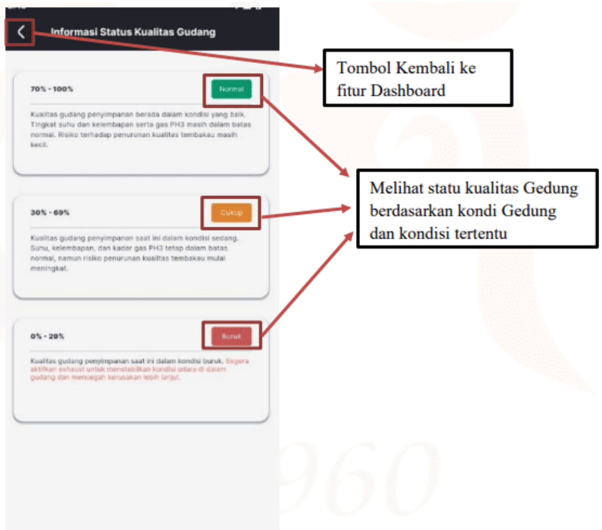

Figure 9. Warehouse Quality Status Information Feature

In this Building Quality Status Information Feature, it only displays the conditions that occur. If the condition of the Building is 70% to 100%, then the condition of the Building is included in the normal category and the risk of decreasing tobacco quality is still small. The condition of the Building is 30% to 69%, then the condition is included in the sufficient category and the risk of decreasing tobacco quality is starting to increase. Meanwhile, if the condition of the Building is 0% to 29%, then the condition of the Building is included in the bad category and immediately activate the exhaust to stabilize the air conditions in the Building and prevent further damage. The Building Quality Status Information feature also has a Return to the dashboard button with that button.

3.3.5. Chart Detail Features

Figure 10. Chart Detail Features

This detailed chart feature only displays time details for real-time situations regarding the condition of the building at that time.

3.3.6. Settings Features

Figure 11. Dashboard Features

In this settings feature, there is application user account data that can be viewed. Features are provided to edit accounts and also change passwords to new ones. There is a logout feature if you press the feature, you will be offered to exit the application or not. The about application feature provides a brief explanation of the IS4AC mobile-based application and social media information used by the company. The settings feature also has a Back to dashboard button.

3.3.7. Logout Feature

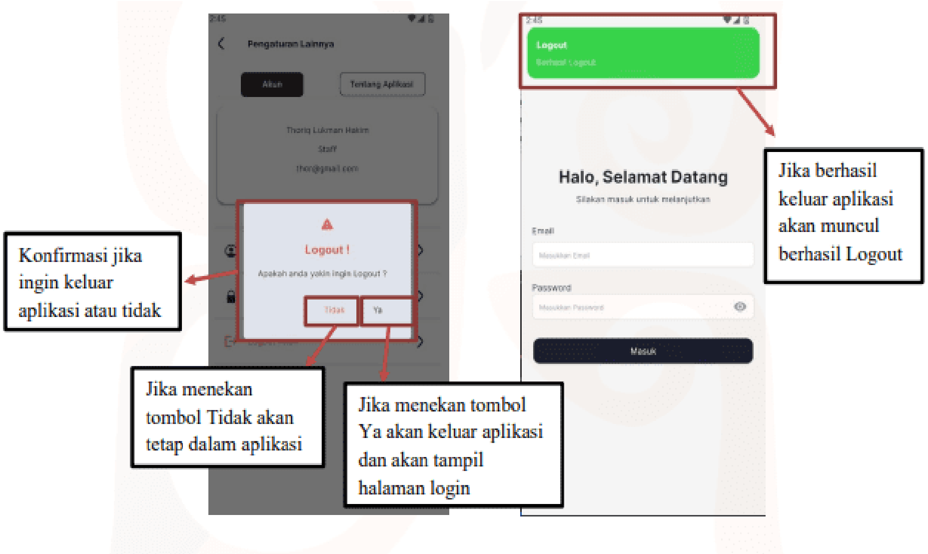

Figure 12. Logout Features

Logout feature in the IS4AC application, users need to access the account settings to log out of the application. After opening the settings, users can press the Logout button. This logout process will display a confirmation to ensure whether the user wants to log out of the application or not. If the user chooses no, they will remain in the application. However, if the user confirms to log out, they will be redirected back to the login page, which displays a success message as an indication that the process of logging out of the application has been successful. This feature is designed to provide a safe and comfortable experience for users when managing user sessions.

3.4 Hardware System Assembly and Installation

The hardware system assembly was done by integrating temperature, humidity, and PH_3 sensors into the microcontroller. Initial testing showed good connectivity between components, with all sensors functioning according to specifications. The system testing results showed that the system can operate well on a micro scale, and the data obtained from the sensors is integrated with the monitoring application without any lag.

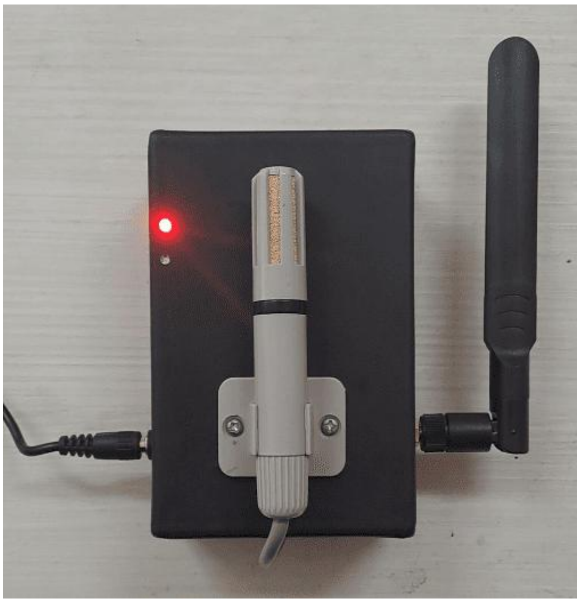

Figure 13. temperature and humidity tools

Figure 14. Gas ph3 tools

3.5 IS4AC Testing and Implementation

The implementation process includes tool assembly, data collection, and analysis of monitoring results. Field testing results show that the system is able to provide real-time information on warehouse environmental conditions, which improves the ability to monitor product storage quality. Regular data collection allows early detection of potential problems, so that corrective actions can be taken immediately.

Table 1. Data on temperature, humidity, ph3 location 3

No	Normal Temper ature	Temper ature with exhaust	Normal Humidity	Humidity with exhaust	Normal propane gas	Propane gas with exhaust
1	32.95	31.79	63.83	67.81	0.5	0.5
2	33	31.8	63	67.88	0.5	0.5
3	33.07	31.85	62.92	67.62	0.5	0.5
4	33.3	32.05	62.07	66.74	0.5	0.5
5	33.3	32.08	60.3	66.14	0.5	0.5
6	33.25	32.11	61.58	66.21	0.5	0.5
7	33.23	32.05	60.89	65.94	0.5	0.5
8	33.22	31.97	62.16	66.05	0.5	0.5
9	33.29	31.89	61.4		0.5	0
10	33.3		61.15	66.08	0.5	0
Aver age	**32.95**	**31.79**	**63.83**	**67.81**	**0.5**	**0.4**

Data at location 3 (East) shows a comparison of temperature, humidity, and propane gas conditions in two conditions: normal and using exhaust. The results show that the use of exhaust tends to lower the average temperature, increase the average humidity, and slightly reduce the concentration of propane gas. This indicates that exhaust is effective in regulating environmental parameters at the location, especially in increasing humidity and reducing propane gas levels, although its impact on temperature is relatively small.[10]

Table 2. Data on temperature, humidity, ph3 location 4

No	Normal Temper ature	Temper ature with exhaust	Normal Humidity	Humidity with exhaust	Normal propane gas	Propane gas with exhaust
1	32.58	31.79	64.25	67.81	0	0
2	32.62	31.8	64.12	67.88	0	0
3	32.76	31.85	63.81	67.62	0	0
4	32.83	32.05	63.64	66.74	0	0
5	32.89	32.08	63.51	66.14	0	0
6	32.99	32.11	63.32	66.21	0	0
7	33.04	32.05	62.97	65.94	0	0
8	33.11	31.97	62.87	66.05	0	0
9	33.2	31.89	62.42	66.08	0	0
10	33.23	31.83	62.34	66.81	0	0
Aver age	**32.925**	**31,942**	**63,325**	**66,728**	**0**	**0**

At location 4, based on observations, there are parameters involving temperature, humidity, and propane gas in two conditions, namely normal and with the use of exhaust. The changes that occur at this location reflect how exhaust affects these environmental parameters. This analysis is important to understand the impact of the tool on the efficiency of environmental control, especially related to temperature and humidity, without any indication of the presence of propane gas in both conditions. This shows the effectiveness of exhaust in managing temperature and humidity without changing the levels of propane gas.

4. Conclusions

The developed Warehouse Quality Monitoring Information System (IS4AC) shows significant potential in improving the monitoring of storage warehouse environmental conditions. Through a systematic data collection process and the use of sophisticated sensors, IS4AC is able to provide real-time information on temperature, humidity, and PH_3 levels. The results of the system implementation in the field show that the application can operate well and provide ease in monitoring, as well as early detection of potential risks that can affect the quality of stored products.

With the development and implementation of IS4AC, partners can more effectively manage their storage conditions. This system not only provides convenience in data collection and analysis, but also increases responsiveness to environmental changes that can impact the quality of goods. The success of this project opens up opportunities for further development and similar applications in other industries, as well as becoming a foundation for research in the field of automatic monitoring and sensor-based information systems.

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