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Implementation OEE in Integrating Siemens S7-1200 Data with Odoo ERP

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ABSTRACT

The integration of Operational Technology (OT) and Information Technology (IT) is crucial for enterprise-level decision-making regarding company effectiveness and productivity. This integration is achieved by developing an API service that facilitates the connection between Programmable Logic Controllers (PLCs) and Odoo Enterprise Resource Planning (ERP). This allows IT systems to synergize with OT systems, processing data obtained from industrial machine performance. The Overall Equipment Effectiveness (OEE) method was employed to monitor production outcomes. A prototype sorting system with PLC control was created as an OEE implementation. The API service acquires data from the plant and performs preliminary analysis in Odoo ERP. This analysis is conducted through the development of a manufacturing module in Odoo ERP, applying OEE method calculations to monitor effectiveness and efficiency of production process. Calculated results are monitored in real-time on Grafana. This research provided insights into the design and implementation of an integration system for the bottle sorting process, ensuring real-time monitoring through Odoo ERP and Grafana. The OEE analysis was validated against manual calculations, showing a 0% discrepancy, thereby ensuring its accuracy. Overall Equipment Effectiveness of bottle sorting machine reached 85.7%, with the three main indicators being: Availability at 96.67%, Performance at 92.53%, and Quality at 95.7%, indicating a world-class category. This research enables the production process to be optimized and provides significant benefits to the company. The findings serve as an evaluation tool at the enterprise level regarding the effectiveness and efficiency of machinery, highlighting areas for improvement and ensuring optimal production performance.

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1. INTRODUCTION

The industrial automation system has rapidly evolved since the early 20th century, which required companies to enhance their production effectiveness and efficiency to keep pace with the development of the industrial era 4.0. Digital transformation has become crucial in the industry, allowing the integration of digital technologies into all of company operations in order to generate accurate and punctual data reports[1]. Nevertheless, the continued practice of manually reporting data of production results carries the potential for human error and data inconsistency between departments[2]. A decrease

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machine performance over time can lead to reduction in productivity and product quality. Hence, a monitoring system based on the Overall Equipment Effectiveness (OEE) method is required to monitor machine performance in industrial automation systems[3]. To overcome these challenges, a novel integration approach is proposed that combines between Operational Technology (OT) and Information Technology (IT). OT is responsible for managing production devices such as SCADA, PLC, sensors, and induction motors, while IT oversees systems like ERP, Grafana, and other supporting applications. This integration allows direct data integration from OT to IT, eliminating the necessity for manual input thereby enhancing efficiency and productivity[4]. The implementation of OT and IT integration is facilitated through an API service that connects data from the PLC to Odoo ERP[5]. To validate the systems, a prototype was designed for bottle sorting system to monitor the volume of bottle liquid and analyze machine operation time[6]. Data from the prototype is transmitted to Odoo ERP for examination using the OEE method and subsequently monitored on Grafana, enabling companies to make more effective and efficient decisions to improve both the quality and quantity of its production[7]. The integration of OT and IT represents an effective solution for enhancing production monitoring, which has previously been conducted manually. By this integration, companies can ensure optimal production quality and quantity in the industrial era 4.0.

2. RESEARCH METHOD

In this research, the Overall Equipment Effectiveness (OEE) method is implemented on a bottle sorting plant that has been established. Subsequently, the data results from the bottle sorting plant will be transmitted through an API service by integrating data from the Programmable Logic Controller (PLC) with the Odoo Enterprise Resource Planning (ERP) system. Once the OEE calculation indicators is obtained, users can automatically determine the category of machine effectiveness and efficiency based on the OEE assessment standards[8].

2.1. The Overall System Design

In general, this research consists of four components: hardware, API Service, Odoo ERP, and Grafana. The hardware includes a bottle sorting plant and a control panel containing PLC and Arduino. Figure 1 illustrates the data input and output originating from sensors and actuators integrated into a bottle sorting plant, which is controlled by a Siemens PLC. Subsequently, data from the plant is acquired by the API Service and transmitted to the ERP Odoo. After the data has been processed, the results are displayed on Grafana.

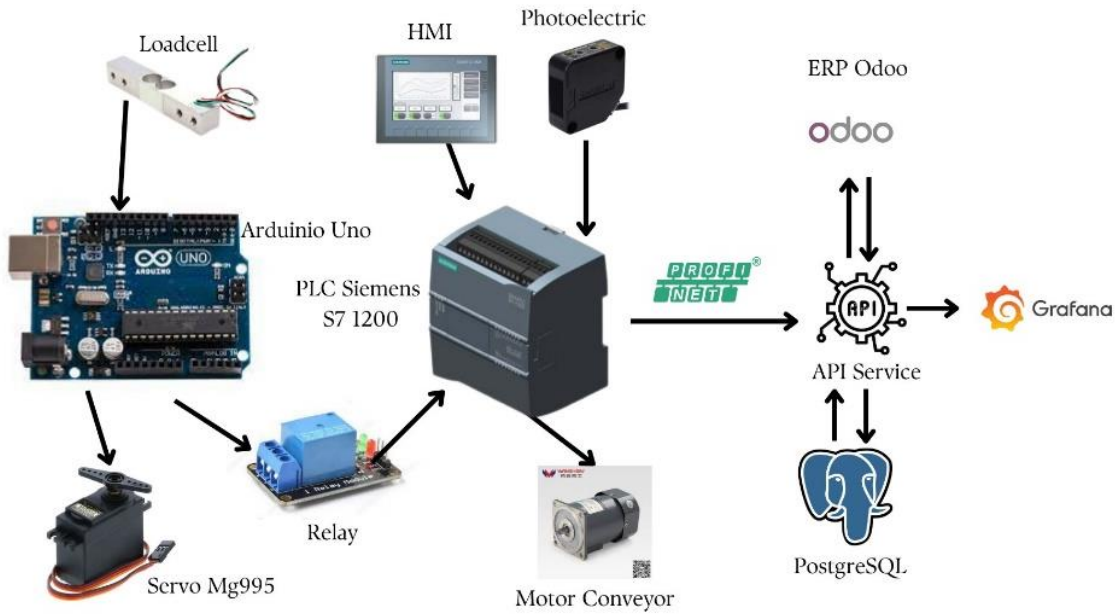

Figure 1. Block Diagram System

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2.2. Overall Equipment Effectiveness

Overall Equipment Effectiveness (OEE) is a method used to assess the extent to which equipment or machines are effectively utilized. OEE is calculated based on three elements Availability, Performance, and Quality Rate[9]. The systematic formula for OEE can be expressed as follows:

$$\text{Availability (\%)} = \frac{Operating\ Time}{Loading\ Time} \text{ x } 100\% \quad (1)$$

$$\text{Performance (\%)} = \frac{Cycle\ Time\ x\ Actual\ Output}{Operating\ Time} \text{ x } 100\% \quad (2)$$

$$\text{Quality (\%)} = \frac{Good\ Product}{Actual\ Output} \text{ x } 100\% \quad (3)$$

From the calculation of these three elements, a formula for overall equipment effectiveness is obtained:

(Overall Equipment Effectiveness (OEE) = Availability x Performance x Quality x 100%)

Overall Equipment Effectiveness (OEE) indicators in a company can be categorized into several assessment standards which can be seen in the Table 1 [10].

Table 1. Overall Equipment Effectiveness Category

Value OEE	Category
40% - 59%	Low
60% - 84%	Currently
85% - 99%	World Class
100%	Perfect

2.3. Hardware Design

The hardware in this study consists of a bottle sorting plant and a controller panel as depicted in Figures 2 and 3. The bottle sorting plant is comprised of two controllers: a PLC and an Arduino. On the PLC side, a photoelectric sensor is responsible to trigger the conveyor stop, calculate the time cycle, and determine the total number of products. Meanwhile, on the Arduino side, a load cell sensor is used to distinguish the weight of good and bad products, along with an MG995 servo actuator to reject bad products. Data transmission for good and bad products data, a relay is used, which is connected to the PLC's digital input pins. The plant is also equipped with an HMI to control the conveyor's operation and monitor the value read by the sensors. Bottles with a volume of 150ml are indicated as good products, while bottles with a volume less than 100ml are classified as bad products[11]. The workflow of the bottle sorting plant is depicted in Figure 3.

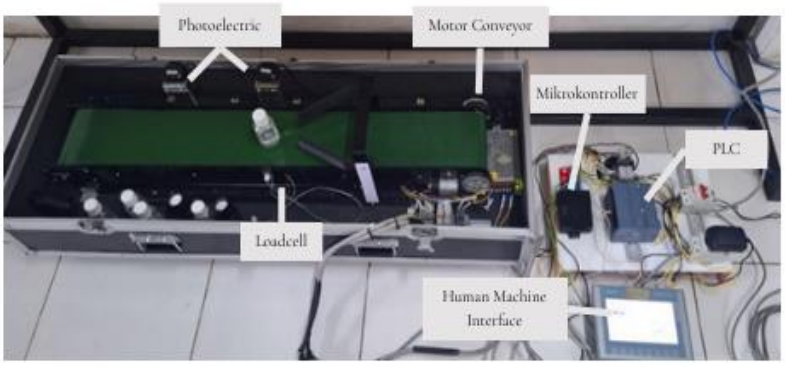

Figure 2. Bottle Sorting Plant and Control Panel

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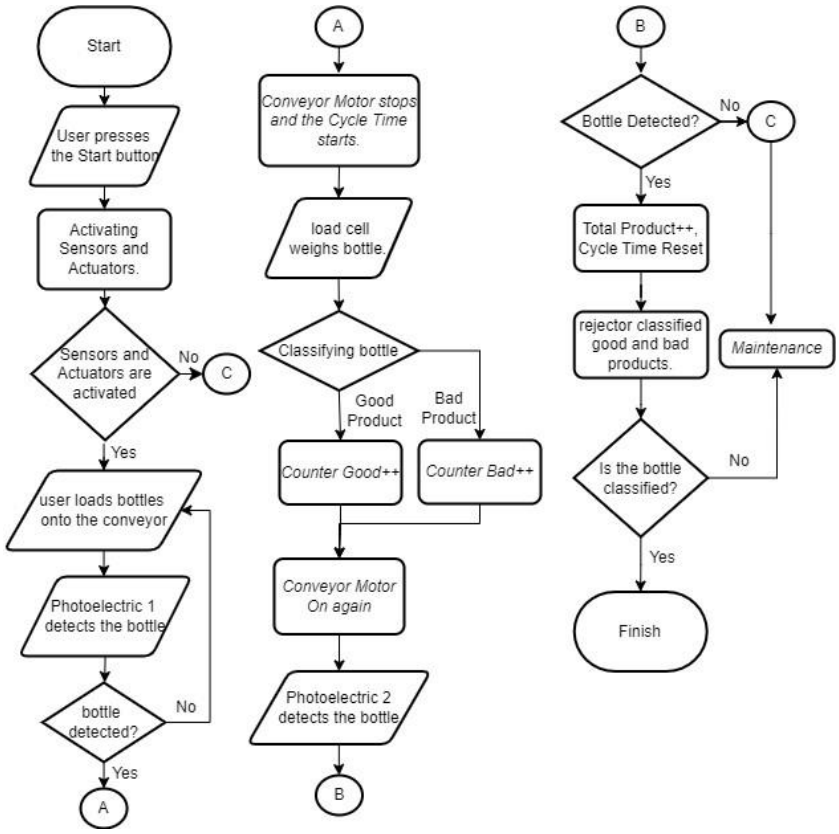

Figure 3. Workflow of the bottle sorting plant

2.4. Software Design

In this research, there are three main components of the software: API Service, ERP Odoo, and Grafana. The API service was developed using the VS Code as debugger and the Node.js programming language to acquire values from the Siemens PLC using the Profinet protocol. The acquired values are then sent to PostgreSQL as the database for ERP Odoo. In ERP Odoo, an analysis of the bottle production results is performed using the OEE method[12]. To enable monitoring, data from PostgreSQL is sent to Grafana for visualization using graphs, bar charts, and pie charts, displaying the three main OEE assessment indicators: Availability Ratio, Performance Rate, and Rate of Quality[13].

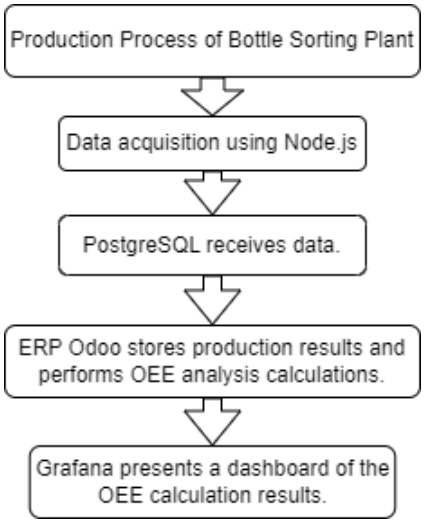

Figure 4. Use Case Software Process

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3. RESULTS AND DISCUSSION

This chapter will discuss the results of the research and testing that has been conducted. The testing includes hardware, API Service, ERP Odoo and Grafana.

3.1. Hardware Testing

The hardware testing was carried out to assess the success of integrating the PLC, Arduino, and the bottle sorting plant. The Arduino was programmed to process reading the data from photoelectric and load cell sensors to detect incoming products and activate an actuators to dispose any defect items. The sensor data readings by Arduino was transmitted using relays through the digital inputs available on the PLC. The success of this integration was confirmed by the bottle status readings displayed on the HMI, as shown in Figure 5.

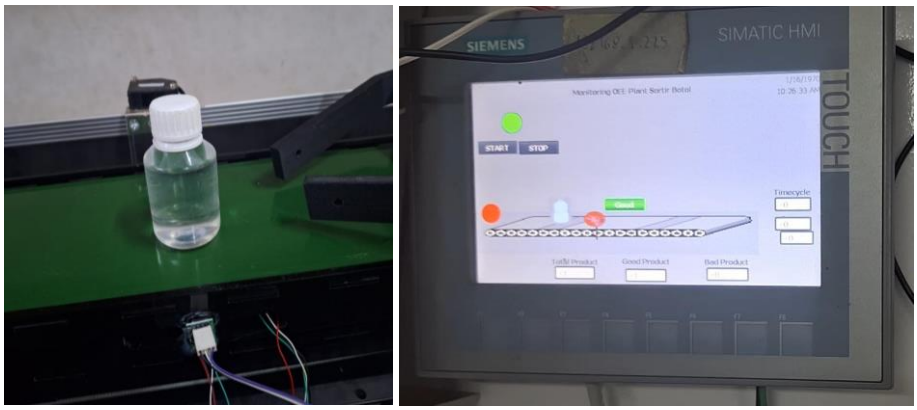

Figure 5. Integration of PLC, Arduino, and bottle sorting plant

In the bottle sorting plant, there are several sensors to support the acquisition of values needed for OEE analysis. The following table shows the relationship between components with their functions and purposes:

Table 2. Relationship between components and their functions

No.	Sensor	Pembacaan
1.	Photoelectric Sensor	Cycle time dan total produksi
2.	Loadcell Sensor	*Bad product* atau *good product*
3.	Button on HMI	Downtime

Once the contributions of each sensor has been established, the PLC address that will be used can be determined. A list of PLC addresses to will be used can be found in the following table:

Table 3. I/O List PLC Siemens

No.	PLC	Hardware	Address
1	DI 0	Sensor Photoelectric belakang	%I0.0
2	DI 1	Sensor Photoelectric depan	%I0.1
3	DI 2	Relay Good Product	%I0.2
4	DI 3	Relay Bad Product	%I0.3
5	DO 0	Motor Conveyor	%Q0.0
6	DO 1	Lampu ON	%Q0.1
7	DO 3	Lampu OFF	%Q0.3

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Table 4. Memory List PLC Siemens

No.	Memory Address	Explanation
1.	%M0.5	Clock 1 Hz
2.	%M1.4	Stop
3.	%M1.7	Start

Table 5. Data Block Memory PLC Siemens

No.	Address	Explanation
1.	%DB1	Count Total Product
2.	%DB3	Count Bad Product
3.	%DB4	Count Good Product
4.	%DB12	Timer Get Quality
5.	%DB9	Timer Motor Conveyor Stop
6.	%DB5	Time Cycle Second
7.	%DB7	Time Cycle Minute

3.2. API Service Testing

The testing of the API Service software involves embedding the node.js logic into an executable (.exe) file. During the acquisition process, configuration of the PLC's IP Address, port, rack and slot used in the Profinet protocol is required. The .exe file will execute its logic by retrieving values from the PLC. Parameters that are read on the PLC including the actual output, good product, bad product, planned time, and downtime are used for OEE analysis. The acquired values will then be stored in a PostgreSQL database and processed through ERP Odoo. The following is display of the PLC data acquisition. In addition, it is necessary to configure the data transmission trigger, which can be based on time intervals or sent when only there is incoming data[14].

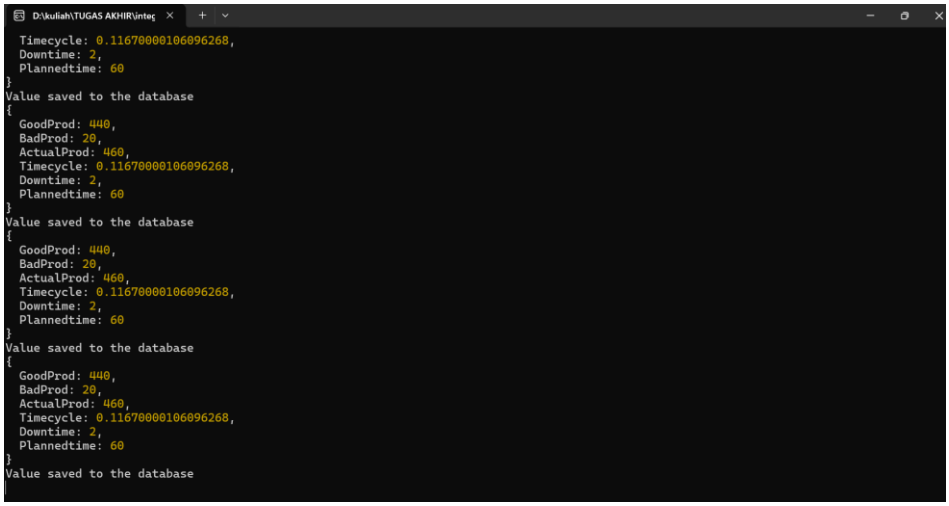

Figure 6. Value of Data Acquisition API Service using node.js

3.3 ERP Odoo Testing

The ERP Odoo, OEE analysis will be performed on the bottle sorting plant. The testing process is conducted by accessing the database utilized by Odoo itself, namely PostgreSQL. The data sent from the Siemens PLC will be obtained by the API Service. After that, the data will be stored in the database. Furthermore, it will be processed in the Odoo backend using the OEE calculation formula. This backend data will then be displayed in Grafana in the form of tables and charts.

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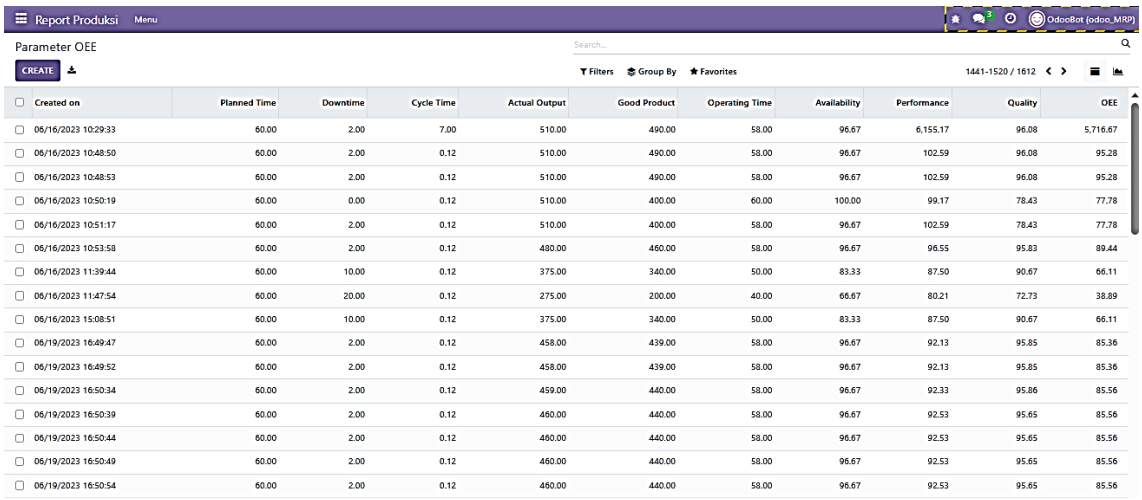

Report Produksi Menu — OdooBot (odoo_MRP)

Parameter OEE

CREATE — Filters — Group By — Favorites — 1441-1520 / 1612

Created on	Planned Time	Downtime	Cycle Time	Actual Output	Good Product	Operating Time	Availability	Performance	Quality	OEE
06/16/2023 10:29:33	60.00	2.00	7.00	510.00	490.00	58.00	96.67	6,155.17	96.08	5,716.67
06/16/2023 10:48:50	60.00	2.00	0.12	510.00	490.00	58.00	96.67	102.59	96.08	95.28
06/16/2023 10:48:53	60.00	2.00	0.12	510.00	490.00	58.00	96.67	102.59	96.08	95.28
06/16/2023 10:50:19	60.00	0.00	0.12	510.00	400.00	60.00	100.00	99.17	78.43	77.78
06/16/2023 10:51:17	60.00	2.00	0.12	510.00	400.00	58.00	96.67	102.59	78.43	77.78
06/16/2023 10:53:58	60.00	2.00	0.12	480.00	460.00	58.00	96.67	96.55	95.83	89.44
06/16/2023 11:39:44	60.00	10.00	0.12	375.00	340.00	50.00	83.33	87.50	90.67	66.11
06/16/2023 11:47:54	60.00	20.00	0.12	275.00	200.00	40.00	66.67	80.21	72.73	38.89
06/16/2023 15:08:51	60.00	10.00	0.12	375.00	340.00	50.00	83.33	87.50	90.67	66.11
06/19/2023 16:49:47	60.00	2.00	0.12	458.00	439.00	58.00	96.67	92.13	95.85	85.36
06/19/2023 16:49:52	60.00	2.00	0.12	458.00	439.00	58.00	96.67	92.13	95.85	85.36
06/19/2023 16:50:34	60.00	2.00	0.12	459.00	440.00	58.00	96.67	92.33	95.86	85.56
06/19/2023 16:50:39	60.00	2.00	0.12	460.00	440.00	58.00	96.67	92.53	95.65	85.56
06/19/2023 16:50:44	60.00	2.00	0.12	460.00	440.00	58.00	96.67	92.53	95.65	85.56
06/19/2023 16:50:49	60.00	2.00	0.12	460.00	440.00	58.00	96.67	92.53	95.65	85.56
06/19/2023 16:50:54	60.00	2.00	0.12	460.00	440.00	58.00	96.67	92.53	95.65	85.56

Figure 7. results of OEE analysis calculations

The image above shows the Odoo interface displaying real-time production data, including planned time, downtime, actual output, good product, and cycle time. Moreover, the results of the OEE analysis will be displayed, based on the data that has been received. These OEE data include Availability, Performance, Quality, and the total OEE.

3.4 Grafana Testing

In order to facilitate the process of monitoring the OEE analysis results, a dashboard is created as shown in the image. The dashboard displayed a gauge chart and a bar chart of the OEE calculation results, making it easier to monitor OEE based on real-time data and shift data.

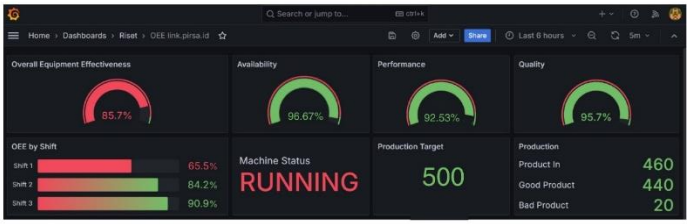

Figure 8. OEE dashboard results on Grafana

3.5 Result of OEE analysis

Data collection from the bottle sorting plant is carried out every 1 hour, which represents data collection in the industry periodically every shift. The collected data from the plant includes the number of good products produced, the number of bad products, the downtime duration, the loading time, and the cycle time. Production results can be seen in the table 5[15].

Table 6. Production Outcome Data for OEE Calculation

No.	Data				
	Loading Time (Menit)	**Cycle Time (Menit)**	**Downtime (Menit)**	**Good Product**	**Actual Output**
1	60	0,116666667	2	440	460

Here are the manual calculation results of the production outcomes presented in Table 6.

$$\text{Availability (\%)} = \frac{Operating\ Timw}{Loading\ Time} \text{ x } 100\ \%$$

$$= \frac{60-2}{60} \text{ x } 100\ \%$$

$$= 96{,}67\%$$

$$\text{Performance (\%)} = \frac{\text{Cycle Time x Actual Output}}{Operating\ Time} \text{ x } 100\ \%$$

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$$= \frac{0{,}116666667 \text{ x } 460}{60-2} \text{ x } 100\ \%$$
$$= 92{,}53\ \%$$

$$\text{Quality (\%)} = \frac{\text{Good Product}}{Actual\ Output} \text{ x } 100\ \%$$
$$= \frac{440}{460} \text{ x } 100\ \%$$
$$= 95{,}65\ \%$$

Once the final results for the three OEE variables, Availability, Performance, and Quality, are known, the OEE value based on this data is:

OEE (%) = Availability x Performance x Quality
= 0,9667 x 0,9253 x 0,9565
= 0,8556
= 85,56 %

3.6 Comparison of Manual OEE Analysis ~~dan~~ and ERP Odoo

In order to demonstrate the successful integration of the system, a comparison is made between the OEE analysis results in the Odoo ERP, as shown in Figure 7 and the manual calculations performed. The results of this comparison are presented in Table 7.

Table 7. Comparison Results of Manual OEE with ERP Odoo

No	OEE (Manual) (%)	OEE (ERP Odoo) (%)	Error (%)
1	85,56 %	85,56%	0%

The results of the comparison in Table 6 demonstrate that the overall OEE calculations in the Odoo ERP are accurate and function well. This is evidenced by the fact that the percentage error obtained from the overall OEE calculation comparison between the manual calculation and the system calculation is only 0%.

4. CONCLUSION

Based on the results of the testing conducted, it can be concluded that:

1. The integration system between IT (Information Technology) and OT (Operational Technology) is achieved through the development of a bottle sorting prototype controlled by a Siemens PLC using the Profinet protocol. The production results from this prototype are acquired by the API Service, sent to the ERP Odoo for OEE analysis, and displayed on the Grafana dashboard. Furthermore, the results of OEE can be displayed in the form of graphs and dashboards. The real-time data transmission from the PLC to ERP Odoo will facilitate improvements in efficiency and productivity, ensuring that production runs smoothly and product quality is maintained. To ascertain the efficacy of the API Service in acquiring data from the Siemens PLC and performing OEE analysis, a comparison was conducted with manual calculations. The absence of any discrepancy between the manual calculations and those performed by ERP Odoo, with a 0% error rate, indicates that the integration system between IT and OT has been successfully implemented.
2. Data acquisition from the PLC to the API Service is done by inputting the IP address and Port configuration of the PLC. Subsequently, it is necessary to configure the addresses from which data will be acquired and the PostgreSQL database configuration to which the data will be sent. In this study, the API Service successfully acquired data from the Siemens PLC using the Profinet protocol.

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