Design and Implementation of Productivity Monitoring System in Rubber Injection Molding Machine in Real Time Based on Visual Studio and Android Application

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Abstract. The molding machine is used to rubber material cooking process. The one type of molding machine is an injection molding machine. The productivity monitoring process of injection molding machines can be said to still use conventional methods. This is caused by data collection using paper and takes 2 days to be displayed to the computer database. In order to solve this problem, we conduct research by designing real time productivity monitoring system applications on injection molding machines. The monitoring system designed in the form of desktop and mobile applications. Desktop application is used to manage production plans, monitor production and know the results of production data. This test has two stages, the first is to ensure that the counter point in Programmable Logic Controller (PLC) has the same value as desktop and mobile applications and other stages ensure the application can display productivity conformance indicators. Test conducted show that monitoring systems with desktop and mobile applications can provide productivity information on injection molding machines in real time, provide indicators of productivity conformance with predefined standards and reduce paper usage. Keywords: injection molding machine, productivity, real time monitoring system, paperless.

1. Introduction

Manufacturing industries such as rubber processing currently can not be separated from technology. In the process of processing, expected to produce optimal productivity accompanied by maximum product. One of the machines used is a molding machine for the process of cooking rubber material which is planned to be fully automatic [1]. The process of productivity monitoring conducted on the molding machine still uses conventional methods. The obstacles experienced are relying on the delivery of information by workers. Observations have been made to prove that the processing time of data into daily reports of molding machine production to computers takes 2 days. If the administrator in charge of processing the data can not be present, then the data processing is pending.

The need for fast, precise and accurate information is essential in every aspect of activity in the manufacturing industry. One of the technological innovations in the manufacturing industry is the application of monitoring systems that can be automated remotely by computer-based applications [2] and [3]. The use of information technology is expected to meet all information needs in the
manufacturing industry, thereby facilitating the processing, analyzing, and communicating of relevant information in order to efficiently manage resources in the manufacturing industry. The monitoring system ever developed by LIPI is accessible via the web [4]. Monitoring systems can also be applied via smartphones due to the development of significant mobile applications [5]. Currently researchers propose solutions in the form of real time productivity monitoring system on injection molding machine. The system is a desktop and mobile application synchronized with Programmable Logic Controller (PLC) on injection molding machine to increase productivity.

2. Research methods
The research begins by identifying the data used in measuring the productivity of the injection molding machine. Furthermore, programming on PLC is a factor in monitoring productivity. Data generated from PLC are then processed and stored in the database as performed in monitoring system using XAMPP [6]. The type of database used in the study using the local database.

The design of desktop applications is done using Microsoft Visual Studio. Chen once did so on an intelligent vehicle so that it could be proved for the research of the monitoring system being developed [7]. Desktop application created in the form of the main page, the entry page that can be accessed through two types of account that is admin and user, production monitoring page which is the main purpose of this research, the production item page that function to determine the items to be produced, and the production report page as a means of information and printing of production activity data.

Mobile apps created on Android Mobile. This is caused by most developments like [8] and [9] use Android Studio and Android OS-based smartphones. The mobile app loads the login page as a user access security and the main page. The main page contains production monitoring that shows productivity in real time based on desktop application data. The synergy of Visual Studio and Android has been successfully performed for monitoring system [10].

After all system support has been successfully created, the design is connected. The architectural monitoring system is designed as follows.

![Architectural monitoring system diagram](image)

**Figure 1.** Architectural monitoring system
Architecture in this research is conducted to know the productivity of injection molding machine through application from 2 different device. The devices used are PC servers and Android smartphones. The application on the PC server is capable of monitoring and entering the data you want to produce and storing it into the database. Applications on Android smartphones can be used to monitor the productivity of injection molding machines when connected in the same network as PC servers.

Testing is done by comparing the counter value of PLC (in the form of shoot) with desktop and mobile applications, both of which have the same value. This test is done at the same time to test the concept of real time monitoring. The next test against the indicator that will appear to know the suitability of productivity standards. The calculation formula included in the application program code is as follows:

\[
\text{Standard production value per hour} = \frac{e^m}{s c ti} \quad (1) \\
\text{Actual production value per hour} = \frac{e^m}{a c ti} \quad (2)
\]

The next test displays the results of production activity reports in the desktop application so that the authorized leadership can know the results of production in real time. In addition, it can also find out the data report results each month and every year.

3. Result and discussion

3.1. Real time monitoring system test
Testing is done by ensuring that exchange rates on PLC, desktop apps, and mobile apps have the same value at the same time. Figure 2 and Figure 3, it can be seen that PLC values, desktop apps, and mobile apps are capable of displaying the same counter value with 8 shooting values at the same time of 15:57.

![Figure 2. Validity of PLC and desktop application](image)
3.2. The standard of suitability productivity
This test is to determine the suitability of productivity standards. When simulated on a PLC counter by giving the cycle time suitable to the specified standard in Figure 4, Figure 5 shows that the application is capable of displaying a green indicator. However, if a certain time cycle exceeds the specified standard, Figure 6 shows that the app is capable of displaying a red indicator. This means that the application is designed to be able to tell when something is not in accordance with the standard set.

Figure 3. Validity of mobile application

Figure 4. Standard of productivity
Figure 5. Productivity of counter suitable standard

Figure 6. Productivity of counter unsuitable standard

The processing result of the above application can be proven by comparing it with manual calculation. If the standard 15 minutes cycle time is known, then the calculation is as follows:

Counter PLC = \frac{60 \text{ minutes}}{15 \text{ minutes}} = 4 \text{ shoot}

Actual productivity value per hour = \frac{60 \text{ minutes}}{\text{actual cycle time}}

= \frac{60 \text{ minutes}}{15 \text{ minutes}} = 4 \text{ shoot}
Standard productivity value per hour = \frac{60 \text{ minutes}}{\text{standard cycle time}} = \frac{60 \text{ minutes}}{15 \text{ minutes}} = 4 \text{ shoot}

Estimation of total production = Actual productivity value per hour x 7 working hours
= 4 x 7
= 28 shoot

The results of manual calculations show the same value with the desktop application that is the production value per hour which value of 4 shoot and the estimated value of 28 shoot. Here the data of other calculations by using the actual assumption of different cycle time.

| Max. standard value of cycle time (minute) | Cycle time of PLC counter (minute) | Min. standard value of product in each hour (shoot) | Product actual value in each hour (shoot) | Indicator |
|-----------------------------------------|-----------------------------------|---------------------------------|---------------------------------|----------|
| 15                                      | 8                                 | 4                              | 7.5                             | Green    |
| 15                                      | 10                                | 4                              | 6                               | Green    |
| 15                                      | 13                                | 4                              | 4.615384615                     | Green    |
| 15                                      | 15                                | 4                              | 4                               | Green    |
| 15                                      | 17                                | 4                              | 3.529411765                     | Red      |
| 15                                      | 20                                | 4                              | 3                               | Red      |
| 15                                      | 22                                | 4                              | 2.727272727                     | Red      |
| 15                                      | 25                                | 4                              | 2.4                             | Red      |
| 15                                      | 27                                | 4                              | 2.222222222                     | Red      |
| 15                                      | 30                                | 4                              | 2                               | Red      |

Based on Table 1, the indicator on the monitoring system will show the suitability of productivity by the established production standard. If the actual production value per hour \geq 4 shoot, then the productivity exceeds or equal to the standard set, so the indicator will be green. Whereas if the actual value of production per hour < 4 shoot, then the indicator will be red.

3.3. Testing of production activity report
The test strengthens the monitoring system in production activities to be the most important part, especially in the reporting of production activities. As shown in Figure 7, the monitoring system can be used to determine the amount of production activity based on the production report data.
Figure 7. Report of production activity

The report data in the form of monthly and annual reports can be used as an evaluation of company performance. Thus, the digital data report can be hinted at as a reduction in paper usage and increase the productivity of work [11]. In addition, in accordance with [12] that the industry is willing to use information systems.

4. Conclusion
Productivity monitoring systems designed and implemented for rubber injection molding machines can be integrated with Programmable Logic Controller (PLC) as the input of production data on injection molding machine and can provide productivity of injection molding machine production in real time. The applied desktop and mobile applications can provide productivity conformance indicators with predefined color indicator standards. If the actual production value per hour ≥ 4 shoot, then the indicator is green. Applies otherwise, then the indicator will be red. The monitoring system can also report monthly and annual production activities that can reduce paper usage.

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