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Production Monitoring System Using Overall Equipment Effectiveness (OEE) Method to Improve Stamping Machine Performance

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Abstract

One of the factors that support success in the manufacturing industry is the smoothness of the production process. There are six factors that affect engine performance, known as the Six Big Loss. Six significant losses are the cause of production equipment not operating normally, namely: start-up loss, set up or adjustment loss, cycle time losses, speed loss, breakdown loss and defect loss. Downtime that often occurs results in decreased productivity, and production results do not reach the target. Production machine downtime is often not known by some parties, especially superiors positions such as managers, section heads and maintenance division. The goal to be achieved in this research is to design and realize a performance monitoring system for a stamping machine based on the internet of things (IOT) to increase the effectiveness of the machine with the optimal amount of production. The method used to determine machine performance is Overall Equipment Effectiveness (OEE). OEE is one of the methods available in TPM or Total Productive Maintenance. The study results show that machine downtime notifications are informed quickly uses an alarm system.

Keywords:
production monitoring, alarm, OEE, MTBF, MTTR.

1 Introduction

In the modern era like today, competition in the business world almost occurs in all fields, not least in the manufacturing sector where they have to adapt to technology so that production can still survive, one of which is the stamping machine. A stamping machine is a pneumatic, hydraulic or mechanical powered machine used to stamp an object and produce a new object with a denser volume. In the industrial world, a company needs a reliable production monitoring system. A production Monitoring System is essential to realize industrial automation with a high-efficiency level. Maintenance and monitoring activities do not require expensive and complicated costs to obtain reliable data [1, 2]. Generally, the information that needs to be monitored in the industry is the type of part made, the number of parts that have been produced, Gross Stroke Per hour, lifetime parts, and machine lifetime. From the information obtained, calculations can be made to determine Availability, performance, Quality, and Overall Equipment, Effectiveness [3].

One factor that supports success in the manufacturing industry is the smooth production process. If the production process is smooth, the machine will produce the amount of production according to the target [4, 5], such as quality products, the right time to complete the manufacture of products, and low production costs. The smoothness of the production process depends on the condition of the resources used, such as machines, workers or other supporting facilities [6]. Factors that affect the performance of production machines are called the six significant losses. Six significant losses cause the machine not to operate normally, consisting of star-up loss, set up or adjustment loss, cycle time losses, speed loss, breakdown loss and defect loss [7, 8]. Downtime often causes productivity to decrease, and production results are not on target. If the production process stops while operating, it will affect the production volume. Downtime is the time when equipment cannot operate smoothly due to a problem [9, 10]. Notification of problems with production machines requires fast information so that it can be followed up immediately [11]. When the machine breaks down, the operator will ask for approval from the supervisor for repair, which takes 30 ~ 45 minutes [12, 13], so approval takes longer than the machine repair carried out [4, 10]. The performance of a machine can be calculated with Overall Equipment Effectiveness (OEE), which is a measurement of total performance related to the availability of productivity processes and product quality levels. Related research that has been carried out is an increase in Overall Equipment Effectiveness (OEE) on Manual Tapping Machines by Minimizing Six Big Loss. Where in this research, there is a measured machine OEE value of 55.192%, where this value is still the ideal OEE standard value of 84%. One of the main causes is minor idle and 33.101% stoppage. The high value of minor idle and stoppage is caused by poor engine performance, which hampers the production rate [14].

Previous research has shown that the OEE value of stamping machines can be monitored using the mobile app. The loading times are obtained according to the on-off switch of the machine operation. Still, they have not been simulated in the OEE values for categories of machine downtime such as planned downtime, startup-shutdown losses, minor stops, and failures [6, 15, 16]. The stamping machine has never been made for its security system. This is very dangerous because it can injure the operator [17]. Based on the background of these problems, it is necessary to create a production machine monitoring system that can be monitored remotely can be accessed anytime and anywhere by optimizing the OEE value of the machine so that it can find out the cause of the stamping machine not operating optimally. And also make a security system for the machine. So we propose research to design and realize a performance monitoring system for a stamping machine based on the internet of things (IOT) to increase the effectiveness of the machine with the optimal amount of production. The method used in this research is Overall Equipment Effectiveness (OEE). OEE is one of the methods available in TPM or Total Productive Maintenance. The results of the study show that machine downtime notifications are informed quickly using an alarm system. Based on calculations with programs and tests that have been carried out, the OEE value error is 0.056%, the downtime loss error value is 0.09%, the performance loss error is 0.93%, and the defect loss error is 0%.

2 Method

2.1 Overview System

Fig.. 1. Shows information about the condition of the Stamping Machine, which can be accessed via an Android-based smartphone, where the stamping machine used is an air-powered pneumatic cylinder that is used as the main power of the engine. To control the air source so that the given tread is stable, we need a valve to regulate the air output channeled to the pneumatic cylinder [18].

For the air supply on the stamping machine to be monitored, a sensor/transmitter is needed to measure the air pressure value and be a feedback for the valve so that the air pressure can be controlled according to the desired value.

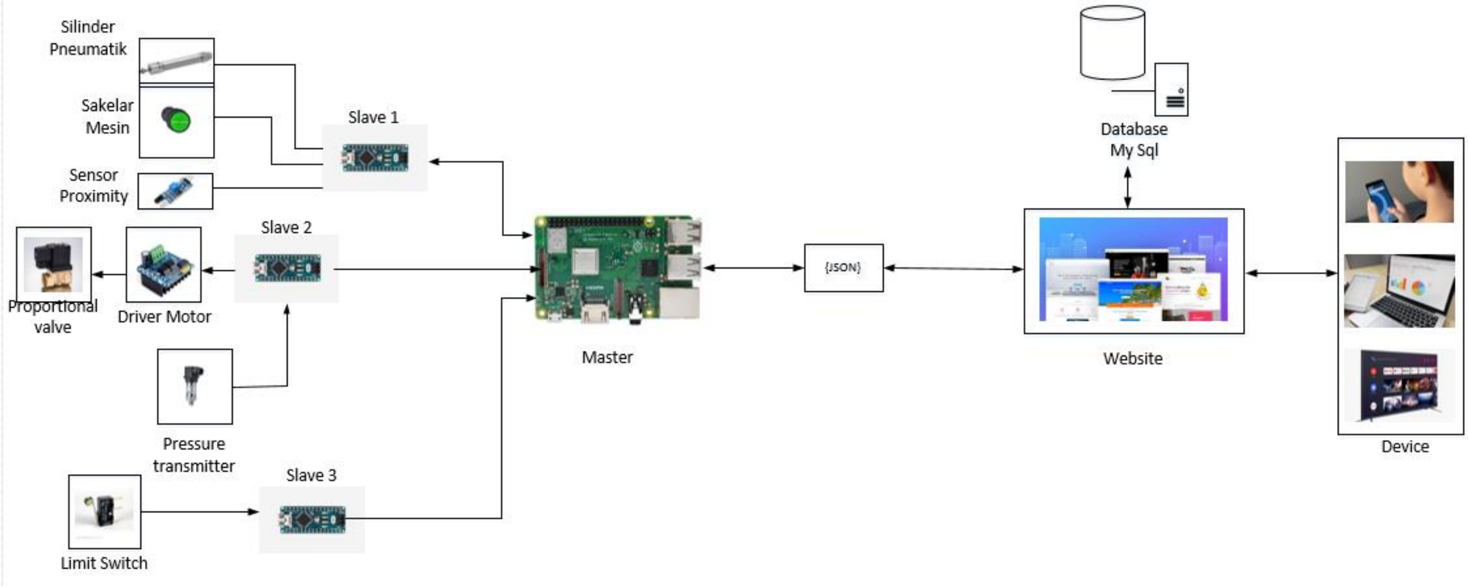

Fig. 1. Overview of the system

In addition, information that must be displayed on the Production Monitoring system is the type of part that has been made, the number of parts that have been produced, and the lifetime of the machine. From the information obtained, calculations can be made to determine Availability, Performance, Quality, and Overall Equipment Effectiveness (OEE) [19, 20]. Therefore, we need a sensor to detect the number of products from each stamping machine so that the calculation can be done automatically. To integrate this Production Monitoring System through the Internet of Things [21, 13, 22], the data is stored in the cloud database in real-time so that all information can be accessed and displayed on the user interface.

2.2 Flow of Research stages:

1. Literature study

At this stage, materials are collected from various sources related to the system to be created. These materials are studied and used as basic references for making the system.

2. System design and modelling

Prototype system design of production Monitoring System for stamping machines includes mechanical design, electrical design, programming algorithm design and modeling. This stage is intended to facilitate research implementation and reduce the error rate when carrying out research.

3. Work on the mechanical system

After the design is complete, manufacture mechanics for the stamping machine prototype. This stage includes the provision of materials and components used in the research. Then, these materials and components are built into a prototype mechanical Production Monitoring System stamping machine.

4. Pneumatic circuit work

After completing the mechanical work for the machine prototype, this stage includes providing materials and components used in the research. Furthermore, the materials and components will be assembled according to the pneumatic circuit drawing that has been made.

5. Work on the electrical circuit system

After the mechanical manufacture of the magnetic delivery system is complete, the next step is the assembly of the electrical circuit of the magnetic delivery system according to the drawing of the electric circuit that was made at the design stage of the magnetic delivery system.

6. Development of a control program

At this stage, a prototype stamping machine is programmed. Then, programming is carried out according to the algorithm that has been designed at the design stage of the stamping machine prototype system. After the program is completed, the program is also tested and analyzed. If successful, then proceed to the stage of making the interface program for monitoring the weir prototype system, if not then return to the stage of making the control program.

7. Making interface program

At this stage, interface programming is carried out to monitor the control system of the prototype Production Monitoring System stamping machine. Programming is carried out according to the algorithm that has been designed at the design stage. After the program is completed, the program is tested and analyzed. If successful, proceed to the integration stage and overall system testing; if not, return to the control program creation stage.

8. System integration and testing

At this stage, the overall system is combined, both mechanical, and electrical systems, as well as control programs and interfaces into a prototype. Then, the testing system is assembled into a prototype. The expected results from this test are GSPH, life-time, type of part, mean to repair, and the actual number of stamping machine production can be monitored in real-time without being anywhere so that the data can be used by management for machine preventives or can provide decisions quickly if an accident occurs. The problem can be monitored using a cellphone, LED TV, Laptop, or Smartphone connected to the internet.

9. Analysis

At this stage, the results of system testing will be analyzed and concluded, then compiled into a systematic report.

2.3 Specific Domain Design

This specific domain design is a description of the particular system design of each domain.

1. Mechanical Domain Design

The mechanical system applied to this system is designed to support any hardware used in the stamping machine. This mechanical system comprises aluminium profile material, aluminium plate, and acrylic. In addition, the mechanical system on this stamping machine is divided into two, namely the upper and lower parts.

2. Electrical Domain Design

This electrical domain design describes the stamping machine prototype electric system. The design of this electrical system includes the design of a power source circuit, master unit, the slave device, relay to the solenoid valve, light indicator, and a pneumatic cylinder circuit. The design of this electrical system is designed to support the function of the Process Control System on an effective stamping machine prototype.

3. Informatics Domain Design

In this informatics domain design, the information system in the Process Control System is described. The design of this informatics system includes a flow chart of the stamping Fig. 2. shows that the first Slave gets the machine operating switch input and receives key data from the master. When the accepted key value on the first slave is 1, the switch on the stamping machine panel can be accessed. When the machine switch is on, the machine is operating and when the machine switch is off, the machine is not operating; the status of the machine switch is in the form of string data and then sent to the master by serial communication. The string data is in and converted into a json data type. The second slave gets the air stampingure value input from the stampingure transmitter sensor; then, the float data is sent to the master by serial communication. The air stampingure data is processed and then sent to a database with json data

4. Machine Work Process and Information System

The following is a flowchart display of the Process Control System on a stamping machine prototype based on a mobile application. (Fig. 2)

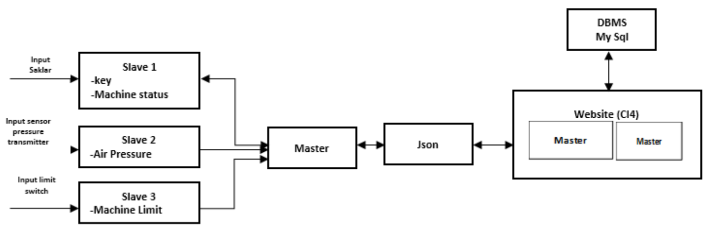

Fig. 2. Stamping process flowchart

The third slave gets input from the status limit switch, which is used to calculate the number of products processed. String data in the form of a limit switch on status is sent by serial communication to the master. Data in the form of strings are processed in the master with a product calculation counter system. After the data is processed, the master is then sent to the database with the json data type. The master, in addition to processing data from each slave, namely validating the key to access the push button on the stamping machine, calculating the Overall Equipment Effectiveness (OEE), machine lifetime, MTBF and MTTR [23]. Then the data is created in json form to be sent to the database.

2.4 OEE Value

Fig. 3. is the schema of the relational database design of the system

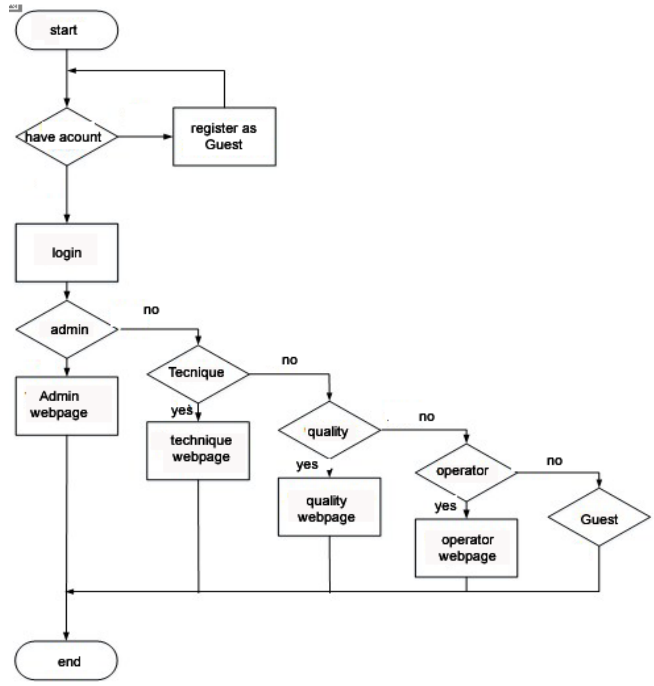

Fig. 3. Database relation schema

2.5 Value of MTBF and MTTR

Fig. 4 is a flowchart of the value of the MTBF and MTTR of the system.

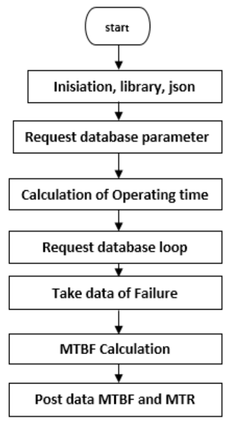

Fig. 4. MTBF and MTTR value flowchart of the system

3 Results and Discussion

3.1 Prototype of Stamping Machine

Fig. 5 shows that the stamping machine prototype is divided into two units, namely the control unit in the form of a table where four cylinders are stored which is a prototype of 4 stamping machines.

Fig. 5. Prototype of stamping machine

They are assembled using an aluminum profile and filament as a connection, connected to a limit switch sensor, air pressure gauge sensor, infrared proportional valve and solenoid valve.

3.2 Login System Test

1. Super Admin User

The super admin user has all the features on the website that can be accessed, such as dashboards, monitoring per machine, setting OEE input parameters, and checking trouble history. The features are displayed on the sidebar. Fig. 6. is a sidebar view of the website. Based on the design that has been made, the login system consists of 5 types of account roles, namely super admin, technical, quality, operator and guest. Each account has different features. Testing is done by logging in to each account and comparing the design and realization of each feature that is appropriate. Fig. 6 shows the main display (dashboard).

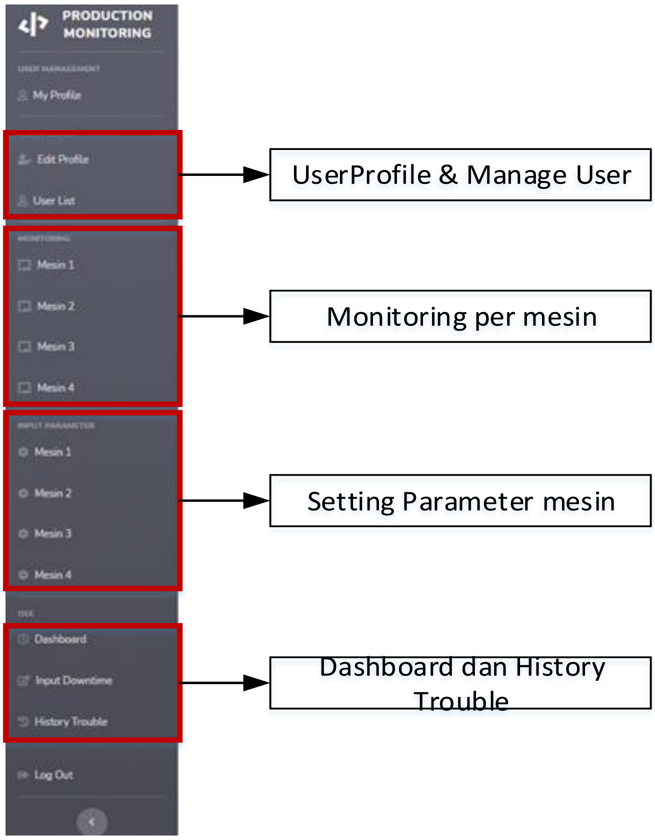

Fig. 6. Super admin sidebar view

which functions to monitor the four machines in an outline such as machine lifetime, machine status, key access buttons, air stampingure charts, graphs of the number of products produced and historical ack. Fig. 7 is the dashboard display.

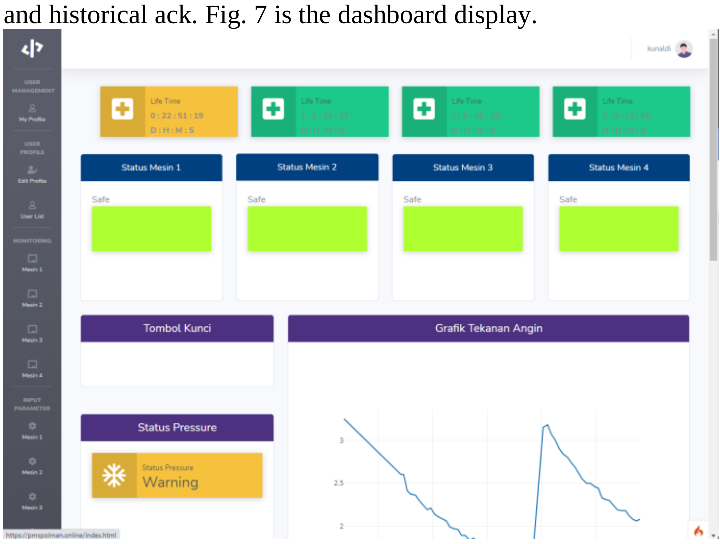

Fig. 7. Dashboard display engine indicator

Fig. 7 shows the manage user section. There is a feature to view the user list owned by the website, and the super admin also has a feature to delete users. Fig. 7 is a manage user feature. Super admin, which can be used to monitor all machines. There are value results for OEE, MTBF, MTTR and graphs of production results. Fig. 8 is the monitoring view per machine.

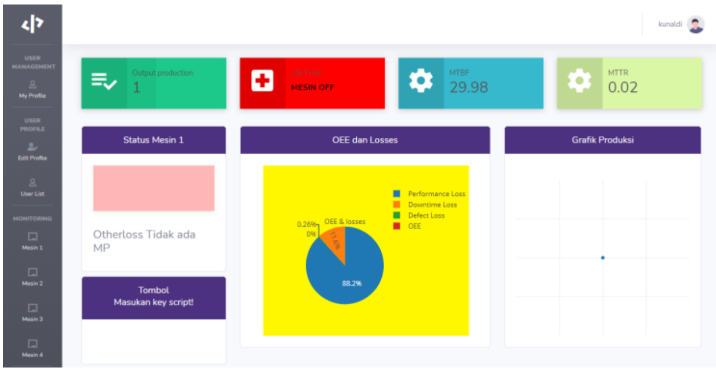

Fig. 8. Monitoring display per machine

The three parts of setting OEE parameters are total availability, planned downtime, setup loss, set adjustment and shutdown loss. Then the performance parameter is the ideal cycle time, and in the quality section, there is a defect loss parameter. Fig. 9 is a display of the features for setting OEE parameters.

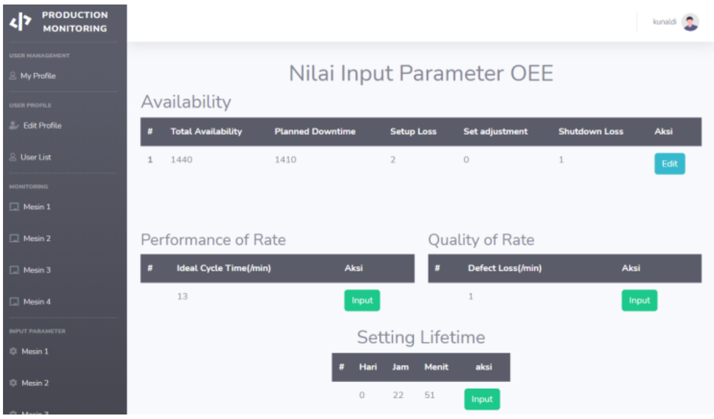

Fig. 9. Display of the features of setting the technical OEE user parameters

2. Engineering users

Engineering users have limited features on the website. The difference between super admin and technique is managing user and input OEE parameters. The technique cannot edit the OEE parameters of the availability and quality of rate sections. Fig. 10 is the input part of the OEE parameter with the technical user, it can be seen that the technique cannot replace the availability and quality of rate parameters.

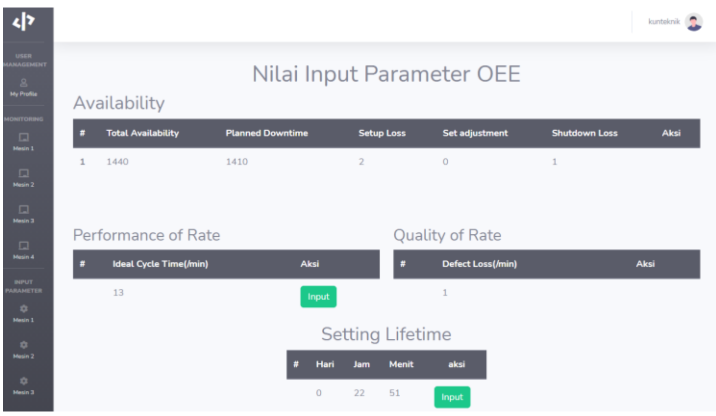

Fig. 10. User technique

Fig.. 11 shows the history of trouble, the technique cannot edit and delete downtime recorded by the system. And the fig.. is history of the engineering user trouble section.

Fig. 11. Record of trouble

User operators only access keys, view input OEE parameters and trouble history. Fig. 11 above is a login user operator in the input parameter section.

3. Lifetime Testing

Testing the lifetime of the stamping machine using the machine in on and safe conditions, then compared the travel time on the website with a timer. The test was carried out two times on each machine, with the first experiment of 5 minutes and the second experiment of 10 minutes. The following Tables 3, 4,5, and 6 are the result of the lifetime testing of each machine. Based on the lifetime testing that has been carried out, there are several trial errors of 2%. These trials and errors happened because the program created uses delay so that it does not simultaneously request.

3.3 Validation of OEE Value

OEE data testing is a test of the data generated from the results of processing programs contained on the website. Testing is done by comparing the calculated value and the value calculated by the program. Fig. 12 is a set of OEE parameters created on the website. The parameter set is set with total availability of 1 day (1440 minutes), planned downtime of 1425 minutes, setup loss of 2 minutes, and shutdown loss of 1 minute. The trial process is carried out five times in one minute. The average production rate obtained is ten products/minute. Fig.. 12 shows the results displayed on the website for the value of OEE and losses. Losses consist of 3 categories: downtime loss, performance loss and defect loss.

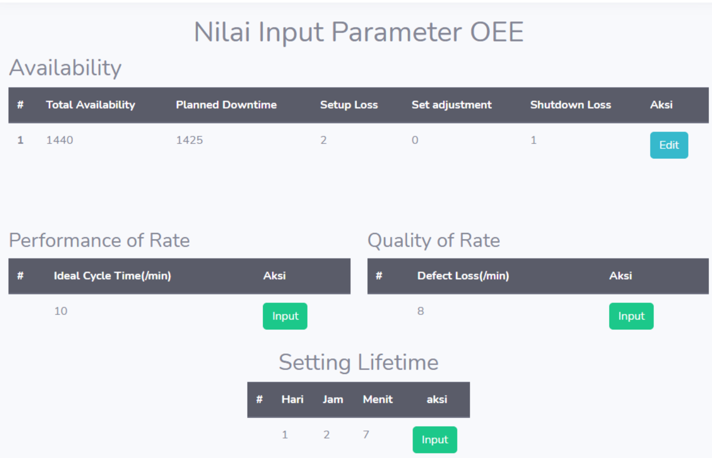

Fig.. 12. Set OEE parameters on the website

After getting the OEE and losses values, downtime data also occurs. Fig. 13 shows the system's downtime data displayed on the website

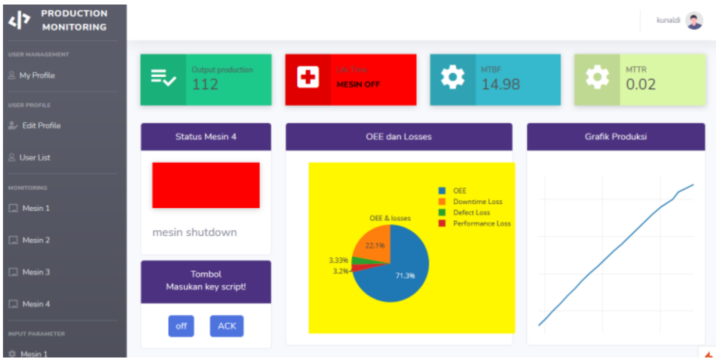

Fig. 13. OEE and losses value results

After obtaining the OEE value and losses through the website with three trials, the test is carried out by comparing the results of calculations. The elaboration of the analysis being tested is the first experiment consisting of 3 parts. The first part is the value of availability, the second part is the performance of rate, and the third part is the quality of rate.

1. Availability

The availability value consists of several parameters that are calculated, such as loading time, operating time, and downtime loss.

Loading time = total availability – planned downtime (1)

= 1440 – 1425 = 15 minutes

Downtime Loss = setup + set adjustment + shutdown + failure + otherloss (2)

= 2 + 0 + 1 + 0.3 + 0.016 = 3.316 minutes

Operating Time = Loading time–downtime loss

= 15 – 3,316 = 11,684 minutes

Availability = Operating time/Loading time x 100% (3)

= (11,684)/15 x 100% = 77,89

Based on the results of Availability using direct calculations, the error value between value and programs is 0.013%.

2. Performance of Rate

The value of the rate performance consists of several calculated parameters such as theoretical cycle time, net operating time, the performance of rate, speed loss, and performance loss. The following is the result of calculating the performance of the rate. Theoretical cycle time = ideal cycle time x operating time = 10 products/minutes x 11,684 minutes

3. Validation of MTBF and MTTR Value

Table 1 is the result of the calculated value of MTBF and MTTR with the program displayed on the website. Tests are carried out by comparing the results of value with the program. The data used is recorded on the website = 116.84 products.

Net Operating time = (process amount)/ideal cycle time (4)

=112/10=11,2 product/minutes

Minor stops = 0.016 minutes

Speed Loss = operating time – net operating time – minor stop

= 11.684 – 11.2 – 0.016 = 0.468 minutes

Performance loss = minor stop + speed loss (5)

= 0.016 + 0.468 = 0.484 minutes

Performance = (Process amount)/Theorical cycle time x 100% (6)
= 112/(116,84) x 100% = 95,86 %

Based on the rate's direct calculation performance, the error value between the calculation process and the program is 0,04%.

4. Quality of Rate
Value of rate quality consists of several calculated parameters such as : good product, value operating time (VOT), and defect loss.

Good product = process amount – defect (7)
= 112 – 5 = 107 products

VOT = Good product/(process amount) x net operating time (8)
= 107/112 x 11.2=10.7 minutes

Quality of rate = VOT/Net Operating Time x 100% (9)
= (10.7)/(11.2) x 100% = 95.5%

Defect Loss = defect/(ideal cycle time) 5/10 (10)
= 0.5 minutes.

Based on the results value of the quality of the rate value, the results are displayed on the website.

5. Value of OEE and Losses
After getting the value of availability, the performance of rate and the quality of rate, the next step is to determine the OEE value and lose value. is the OEE value and the loss value obtained:

OEE = Availability x Performance of Rate x Quality of Rate (11)
= 77.89% x 95.86% x95.54 % = 71.34%

Following is a value of the losses parameters. Parameter lossesconsist of 3 parts: downtime loss, performance loss, and defect loss. These losses are related to 6 significant losses.
Downtime loss = (3.316)/15 x 100% = 22.12%
Performance loss = (0.484)/15 x 100%=3.23%
Defect loss = (0.5)/15 x 100% = 3.33%

Based on the results of the program and tests that have been carried out, the OEE error value is 0.056%, the downtime loss error value is 0.09%, the performance loss error is 0.93% and the defect loss error is 0%. (Fig.. 14).

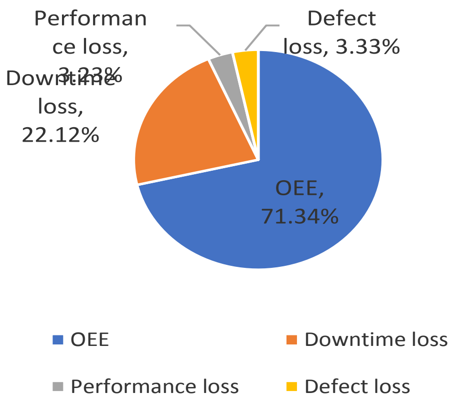

Fig. 14. OEE pie chart and losses

Table 1. Experimental results of MTBF and MTTR values

Parameter	Testing 1	Testing 2	Testing 3
MTBF (minute/times)	12,53	12,5	11,48
MTTR (minute/times)	2,47	2,5	2,52

Then the data for failure time and failure frequency is obtained in the trouble history section according to the table. Table 2 shows the data recorded by the website, which is needed for the value of MTBF and MTTR. Table 2 is a test that has been carried out.

Table 2. Parameters for MTBF and MTTR

Parameter	Testing 1	Testing 2	Testing 3
Total availability (minute)	1440	1440	1440
Planned downtime (minute)	1425	1425	1425
Frequency of breakdown	1	1	1
Breakdown time (minute)	2,46	2,5	2,52

The following is the result of the MTBF value from several pre-calculated parameters, such as loading time and operating time:

Loading time = Total availability – Planned downtime (12)
= 1440 – 1425 = 15 minutes

Total Operating Time = Loading time – breakdown time (13)
= 15 – 2, 46 = 12.54 minutes

MTBF =(Total operating time)/(Breakdown frequency) (14)
=(12.54)/1 = 12.54 minutes/times

6. MTTR Value
The required parameter values to calculate MTTR are breakdown time and breakdown frequency. The following is the result of the MTTR value: Breakdown time = 2.46 minutes and Breakdown frequency = 1 time

MTTR = (Breakdown time)/(Breakdown frequency) (15)
= (2,46)/1 = 2,46 minutes/times

4 Conclusion

Based on the system's test, the engine indicator has five conditions. First, the startup condition is a condition when the machine setup is lost; the indicator on the machine will blink red. The second condition is where the engine operates with air stampingure > 1.5 bar and PB on. The third condition is when no other loss of manpower occurs when the air stampingure is > 1.5 bar, and the PB is off. The fourth conditions are no air source loss occurs when the air stampingure is 1.5 bar and the PB is off. Finally, the fifth condition is the engine breakdown. Based on calculations with programs and tests carried out, the OEE value error is 0.056%, the downtime loss error value is 0.09%, the performance loss error is 0.93%, and the defect loss error is 0%. Production monitoring system using Overall Equipment Effectiveness (OEE) method is an effective and efficient monitoring system used in industry.

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