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Mekanika: Majalah Ilmiah Mekanika

Implementation of Automatic Dust Detector on Dust Suppression System on Transfer Tower 0 In Paiton 9 Power Plants

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Abstract

The operation of dust suppressor and dust collector was operating semi-manually by pressing the power button on the local panel during the initial unloading of coal material from the barge or stockpile, where local operators manage several large areas. This research is carried out on the implementation of Automatic Dust Detector for Dust Suppression operational at Paiton Unit 9 power plants with the aim of increasing the efficiency of operator and equipment performance. We use House of Quality (HOQ) as a determinant of the priority scale for technical response to be implemented, namely the addition of an Automatic Dust Detector. The results obtained showed a decrease in the calculation of the dust suppression operating time, i.e. from 5 hour 54 minutes to 5 hour 6 minutes, from 1005.36 L/barge to 869.04 L/barge for water consumption, and 1 L/barge to 0.86 L/barge for chemical use. Furthermore, the implementation of the Automatic Dust Detector can significantly increase efficiency at least 15% from operating time difference.

1 Introduction

The application of the Hi-Pressure Fog Spray Dust Suppression System can control the dust formed during the coal handling process. This is proven by the reduction of dust levels in the air from 50.14 mg/m^3 to 1.35 mg/m^3.This is correspond to the standard of 10 mg/m^3 and that one of the programs that support Operation Excellent, especially Coal Handling Safety because dust control can minimize the incidence of fire and environmental pollution. can reduce maintenance costs, especially in the scope of cleaning [1]. In the operation of the dust suppressor and dust collector operators should be operate semi-manually by pressing the power button on a local panel when the initial unloading of coal from the barge or stockpile is started. From the condition above, we proposed the implementation of automatic dust detector to dust suppression system. This is aimed to reduce the operating time and water consumption and to improve the efficiency of dust suppression system operational.

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2 Experimental Methods

2.1 Data collection

In this research, we use three data resources, which are:

1. Observation data is data taken from samples in the field and then summarized in descriptive sentences and tables.
2. Operational data is any operating activities recorded in the logbook forms, excel sheets and reported via email.
3. The simulation data is data obtained from the process of designing and experimental tools to get the final result.

2.2 Experiment and simulation methods

Raw data from the data collection process are processed into operating data to define operating limits for the basis of tool design and simulation. We use HOQ as a reference for innovation where the greatest weight is applied to the existing system. After the implementation stage, an evaluation of the operator's assessment is carried out to improve the efficiency of the operational process.

2.3 Research flowchart

The following is the sequence process of data collection and data processing so that the final result for the design of the tool can be seen in Figure 1 [2].

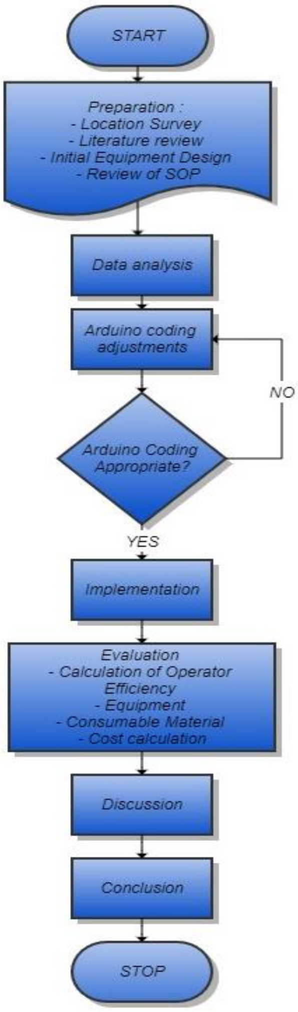


Figure 1. Research flowchart

2.4 House of Quality (HOQ) product

House of Quality (HOQ) is part of Quality Function Development (QFD) which identifies the needs or product features from the costumers/users. Identification is done in the field of design, sub-system characteristics, manufacturing processes, production activities, and also quality assurance. The HOQ takes the form of a matrix of development and planning through the process of comparing the characteristics of critical components and key operations in production [3].

3 Results and Discussion

3.1 Initial technical assessment

In the preliminary research, a technical study was carried out on the operation of the equipment system before implementation. The use of material consumption during the operation of the dust suppression system can be seen in Table 1.

Table 1. Technical assessment TB. MEGA POWER 26 / BG. FINACIA 101 before implementation

TB. MEGA POWER 26/BG. FINACIA 101 / 11,933.939 MT / 19h35min / ±22% dust		
No	**Operational**	**Technical calculation**
1	Main pump motor	5 hr 54 min
2	Main control of the dust suppression system	5 hr 54 min
3	Operator travel time	1 hr 36 min
4	Water consumption	1005.36 L
5	Chemical consumption	1 L

3.2 Automatic dust detector tool design

Main components used in the design of an automatic dust detector is a dust sensor on Figure 2 and a microcontroller on Figure 3 [4,5]:

Figure 2. Sensor sharp GP2Y1010AU0F

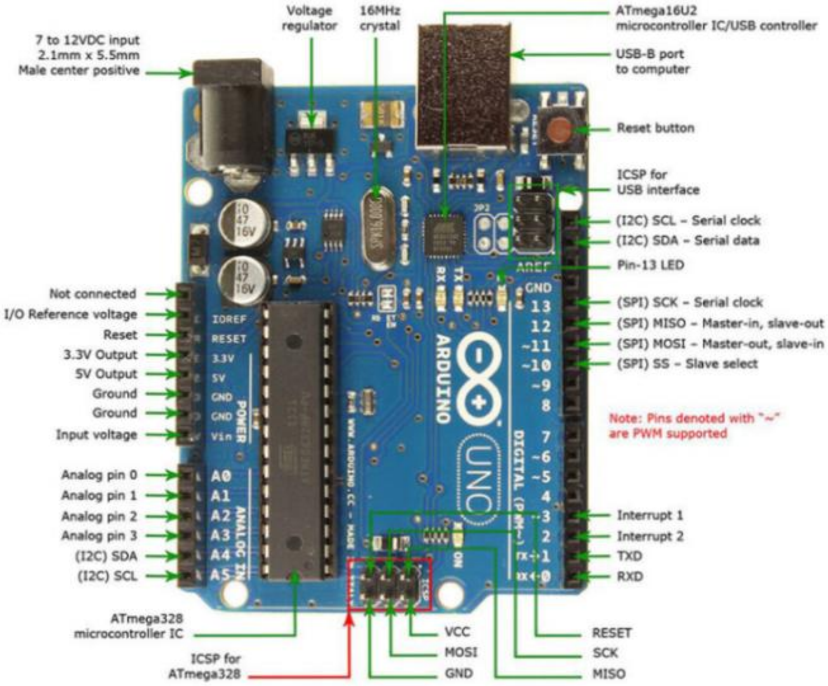


Figure 3. Layout arduino UNO

The design of the equipment has been converted in the form of block diagram to explain briefly some groups of components that will be compiled in a single prototype. The following illustration on the

Figure **4** is the tool design presented in the block diagram:

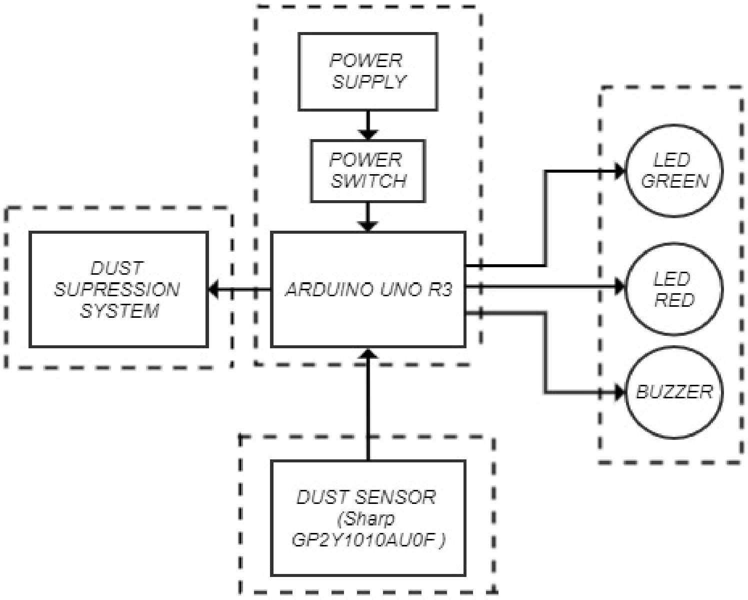


Figure 4. Block diagram automatic dust detector

The next step is to design a programming language on a prototype that has been adjusted to the results of observational data collection and operational data. The following is a series of commands that have been programmed as follows [4,5]:

Insert pin setting

```
int measurePin = A5;
int ledPower = 12;
int redLED = 10;
int greenLED = 9;
int buzzer = 8;
int DSSrelay = 6;
```

Insert sampling setting

```
unsigned int samplingTime = 280;
unsigned int deltaTime = 40;
unsigned int sleepTime = 9680;
```

Insert calculated variable

```
float voMeasured = 0;
float calcVoltage = 0;
float dustDensity = 0;
```

Set pin as input or output

```
void setup(){
 Serial.begin(9600);
 pinMode(ledPower,OUTPUT);
 pinMode(redLED, OUTPUT);
 pinMode(greenLED, OUTPUT);
 pinMode(buzzer, OUTPUT);
 pinMode(DSSrelay, OUTPUT);
```

Insert logic command for sampling

```
void loop(){
 digitalWrite(ledPower,LOW);
 delayMicroseconds(samplingTime);sw
 voMeasured = analogRead(measurePin);
 delayMicroseconds(deltaTime);
 digitalWrite(ledPower,HIGH);
 delayMicroseconds(sleepTime);
```

Insert equation measurement

```
calcVoltage = voMeasured*(5.0/1024);
dustDensity = 0.17*calcVoltage-0.1;
```

Insert code for calibrating 0 point

```
if ( dustDensity < 0)
{
 dustDensity = 0.00; // dust density still 0
}
```

Insert code for detection dust density level "High"

```
if ( dustDensity >= 0.46)
{
digitalWrite(10, HIGH); // indicator redLED ON
digitalWrite(9, LOW); //_indicator greenLED OFF
digitalWrite(6, HIGH); // DSSrelay ON
}
```

Else insert code for detection dust density level "Normal"

```
else if ( dustDensity < 0.46)
{
digitalWrite(10, LOW); // indicator redLED OFF
digitalWrite(9, HIGH); // indicator greenLED ON
digitalWrite(6, LOW); // DSSrelay OFF
}
```

Insert code for buzzer at dust density level "Alarm"

```
if ( dustDensity>0.53)
{
digitalWrite(8, HIGH); // buzzer ON 100ms
delay(100);
digitalWrite(8, LOW); // buzzer OFF 100ms
delay(100);
}
```

Insert code for buzzer at dust density level not "Alarm"

```
else if( dustDensity<0.53)
{
digitalWrite(8, LOW); // buzzer OFF
}
Serial.println("Raw Signal Value (0-1024):");
Serial.println(voMeasured); // set name for monitoring
Serial.println("Voltage:");
Serial.println(calcVoltage); // set name for monitoring
Serial.println("Dust Density:");
Serial.println(dustDensity); // set name for monitoring
delay(1000); // set time for each sample
}
```

3.3 Tool work system

Equipment that has been designed and assembled has several types of programming commands as follows:

1. When the dust density variable is at a value < 0.46 then the green Light Emitting Diode (LED) (standby indicator) on, red LED (indicator running) off, yellow LED (dust suppression systems) off.
2. When the dust density variable is at a value >= 0.46 then the green LED (standby indicator) is off, the red LED (running indicator) on, yellow LED (dust suppression systems) on.
3. When the dust density variable is at a value > 0.53 then the buzzer (alarm indicator) on up with the rhythm on and off 0.1 seconds.
4. When the dust density variable is at a value < 0.53 then the buzzer (alarm indicator) off.

The results of the prototype experimental simulation by being triggered using a random sample of coal dust 3 times are shown in the following Figure 5.

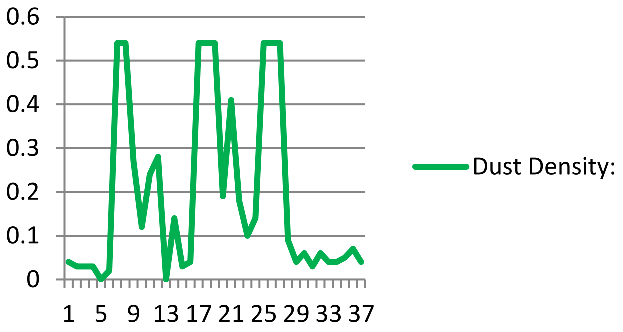


Figure 5. Dust density chart

The layout from Figure 6 is a description of the block diagram that has been designed before and the coding is programmed to make a prototype of the applied layout function as designed. In the simulation process, it is stated that the equipment functions in accordance with the coding that has been programmed on the prototype and with the success of the simulation of the equipment, the calculation of operational efficiency can be carried out. The following is the calculation of efficiency after implementation which is presented in table form. After the implementation of the tool, the results obtained can be seen in the comparison in Table there is a decrease between working hours, operator travel time and water and chemical consumption.

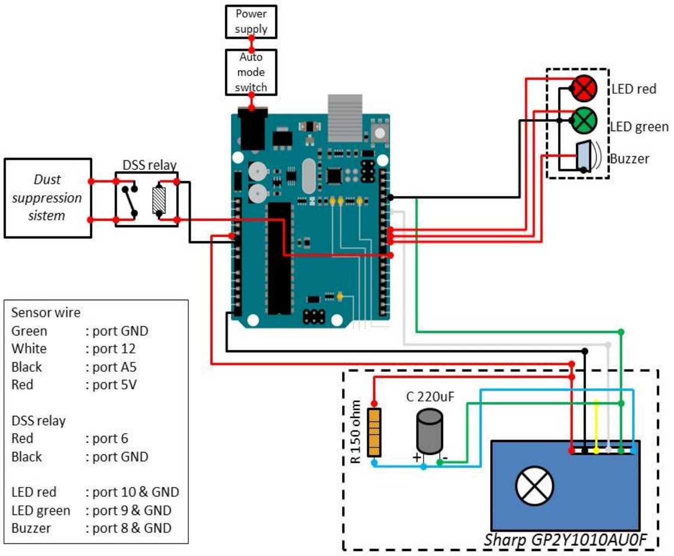


Figure 6. Automatic dust detector wiring diagram

Table 3. Technical assessment TB. MEGA POWER26 / BG. FINACIA 101 after implementation

TB. MEGA POWER 26/BG. FINACIA 101 / 11,933.939 MT / 19h35m / ±22% dust

No	Operational	Technical calculations before	Technical calculations after	Difference
1.	Main pump motor	5 hr 54 min	5 hr 6 min	≥ 48 min
2.	Main control of the dust suppression system	5 hr 54 min	5 hr 6 min	≥ 48 min
3.	Operator travel time	1 hr 36 min	(empty)	≥ 1 hour 36 min
4.	Water consumption	1005.36 L	869.04 L	≥ 136.32 L
5.	Chemical consumption	1 L	0.86 L	≥ 0.14 L

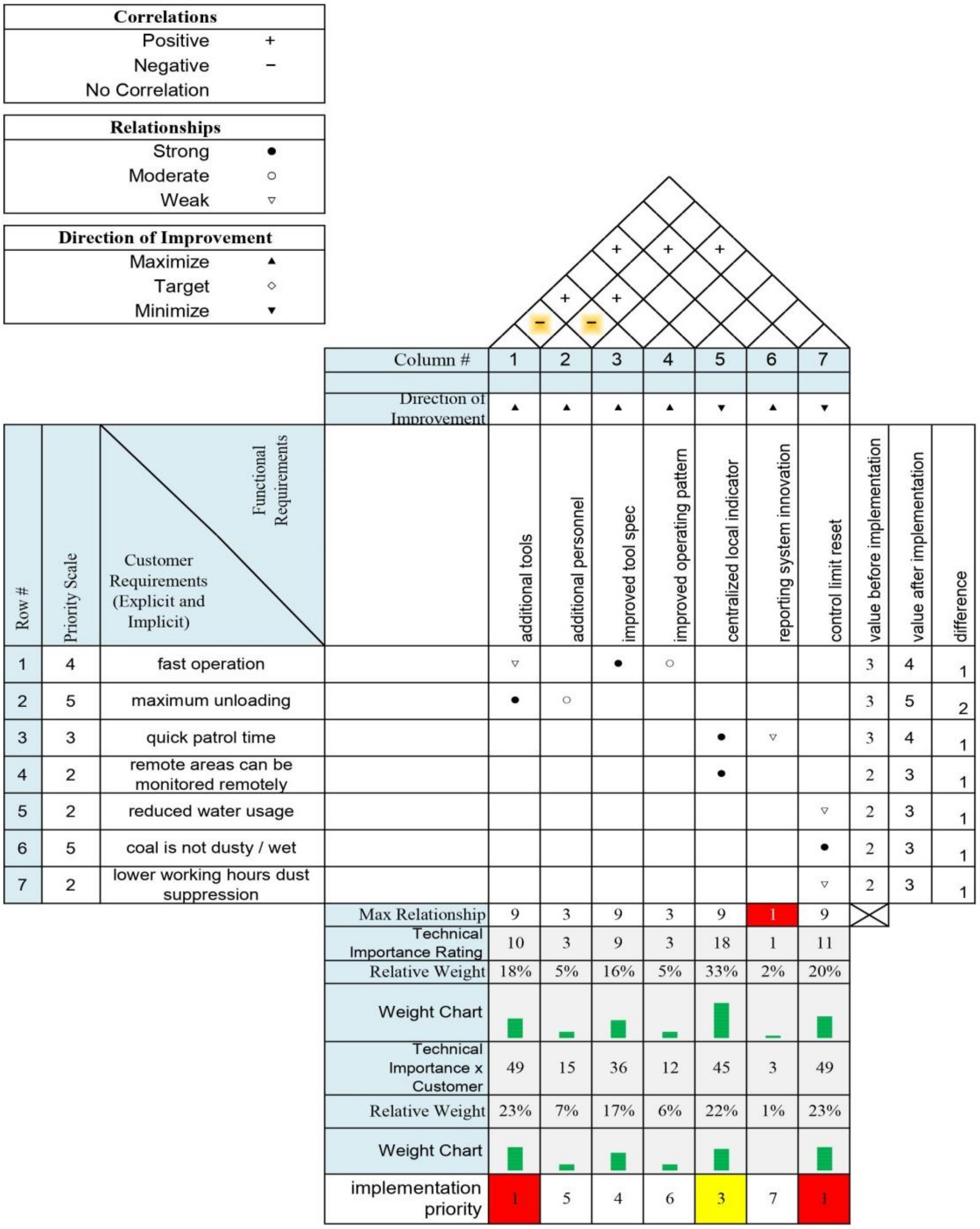
3.4 Research HOQ

HOQ research is determined by calculating the priority scale shown by a ranking system for the selection of innovations to be produced and there is a comparative survey between the systems before and after the implementation of the tool which can be seen in

Figure **7** [2].

Determining the priority scale of the customer requirements, namely operator requests and functional requirements or technical responses [6] generates basic ideas for designing an automatic dust detector device and after the implementation process there is an increase in the value of the author's survey for each operator's request so that it is stated that the implementation of automatic dust detector equipment can increase work efficiency [7] and improve the performance of the dust suppression system equipment and the performance of the operator in operational activities.

In rate data retrieval importance and level of satisfaction (perception) using a Likert scale namely (1) very insignificant, (2) not important, (3) quite important, (4) important and (5) very important. Meanwhile data for the level of satisfaction (perception) service is (1) very bad, (2) bad, (3) bad enough, (4) good and (5) very good. Testing data in this questionnaire is conducted through validity and reliability test [8]. QFD is widely used in product development and production fields [9]. The Quality Function Deployment (QFD) framework is used to understand the product requirements defined by the user [10]. QFD focuses on transforming customer needs into engineering product characteristics. House of Quality (HOQ) is the tool used at QFD [11].



Correlations	
Positive	+
Negative	−
No Correlation	

Relationships	
Strong	●
Moderate	○
Weak	▽

Direction of Improvement	
Maximize	▲
Target	◇
Minimize	▼

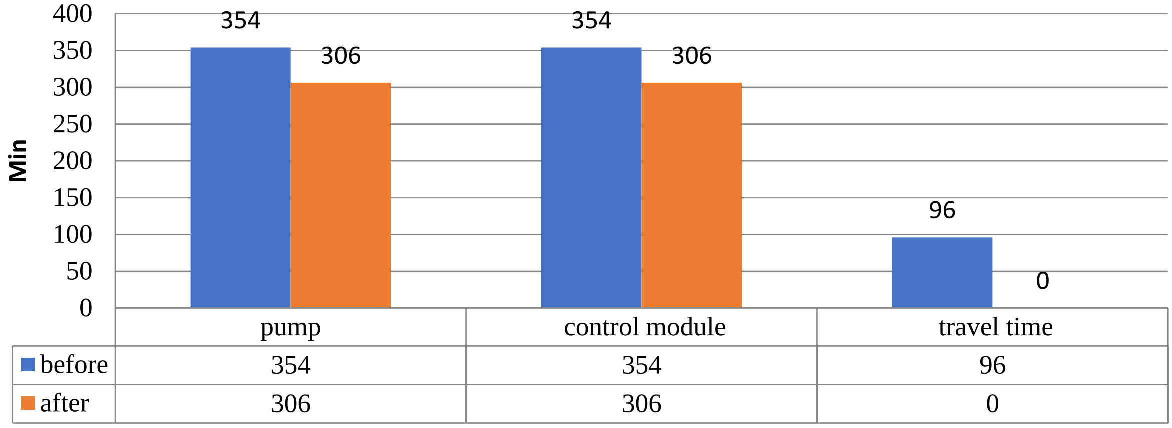
		Column #	1	2	3	4	5	6	7			
		Direction of Improvement	▲	▲	▲	▲	▼	▲	▼			
Row #	Priority Scale	Functional Requirements Customer Requirements (Explicit and Implicit)	additional tools	additional personnel	improved tool spec	improved operating pattern	centralized local indicator	reporting system innovation	control limit reset	value before implementation	value after implementation	difference
1	4	fast operation	▽		●	○				3	4	1
2	5	maximum unloading	●	○						3	5	2
3	3	quick patrol time					●	▽		3	4	1
4	2	remote areas can be monitored remotely					●			2	3	1
5	2	reduced water usage							▽	2	3	1
6	5	coal is not dusty / wet							●	2	3	1
7	2	lower working hours dust suppression							▽	2	3	1
		Max Relationship	9	3	9	3	9	1	9	☒		
		Technical Importance Rating	10	3	9	3	18	1	11			
		Relative Weight	18%	5%	16%	5%	33%	2%	20%			
		Weight Chart										
		Technical Importance x Customer	49	15	36	12	45	3	49			
		Relative Weight	23%	7%	17%	6%	22%	1%	23%			
		Weight Chart										
		implementation priority	1	5	4	6	3	7	1			

Figure 7. HOQ table before and after implementation

3.5 Discussion

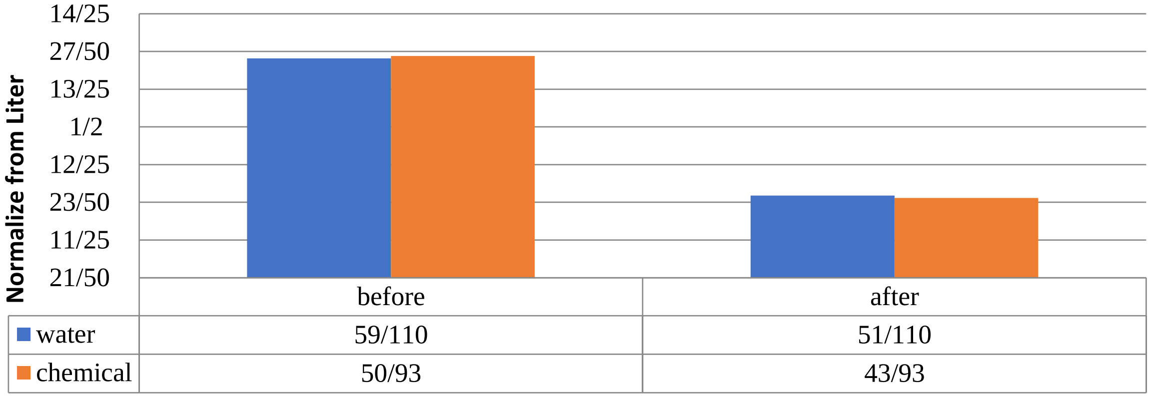
The results obtained from the implementation of automatic dust detector is decrease the time for the shortest travel time operator for 1 hour 36 minutes per barge cause operator no longer need to travel form patrol post building to transfer tower 0 building for activating dust suppressor.

The decrease of the time dust suppression systems operational for a minimum of 48 minutes/barge, water consumption of at least 136.2 L/barge and chemical consumption of at least 0.14 L/barge cause operational of dust suppressor was cut off for no longer waiting the operator operate dust suppressor semi manually. Chart of comparison can be seen on Figure 8 and Figure **9**.



	pump	control module	travel time
■ before	354	354	96
■ after	306	306	0

Figure 8. Comparison of running hour



	before	after
■ water	59/110	51/110
■ chemical	50/93	43/93

Figure 9. Comparison water and chemical usage

4 Conclusions

The final result of designing an automatic dust detector fulfils the objectives of the preparation of the proposal, namely minimizing the work of the dust suppression system equipment and operators and increasing the performance of the entire system operation. The result of automatic dust detector modification can be developed with a more complete design in the Coal Handling System area of the Paiton 9 power plant and can be reviewed for implementation in other coal power plant units according to field conditions. The system can be developed also in industries that have concerns about the handling of dust to reduce the risk generated by the dust that can be generated industry with high performance and environmentally friendly.

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