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Motor Maintenance on Cooling Tower Using Predictive Maintenance Method

Firman Maulana, Sumardi

Department of Electrical Engineering, Department of Electrical Engineering, Diponegoro University
Jl. Prof. Sudharto, SH, UNDIP Tembalang Campus, Semarang 50275, Indonesia
E-mail : firmanmaulanaa870@gmail.com

Abstract: *Cooling towers play an important role in geothermal power generation systems. The motors in these towers are vital for ensuring proper water circulation and heat rejection. Unexpected motor failures can lead to costly downtime and repairs. Predictive maintenance strategies can help identify potential motor problems before they cause outages, reducing costs and improving system reliability. this paper will discuss various techniques for predictive maintenance of cooling tower motors, including vibration analysis, motor current signature analysis (MCSA), and thermography. The benefits and limitations of each technique will be explored. Additionally, the paper will outline a general framework for implementing a predictive maintenance program for cooling tower motors. by implementing a predictive maintenance program, Cooling tower operators can benefit from reducing downtime and associated costs, increasing system reliability, extending motor life and optimizing maintenance scheduling.*

Keywords: ***predictive maintenance, vibration, thermography, motor current signature analysis, cooling tower.***

1. INTRODUCTION

Power Plant is a company that is built as a provider of electrical energy by converting energy, energy conversion is generally carried out from mechanical energy to electrical energy. There are quite a lot of power plants in Indonesia, ranging from renewable energy and non-renewable energy. Geothermal Power Plant uses geothermal energy as fuel to produce steam, then by passing through several stages the steam will be used to drive the turbine, the movement of the turbine is used by the generator to convert from mechanical energy to electrical energy.

To ensure the operational efficiency and reliability of the cooling system. The cooling tower plays an important role in lowering the temperature of the liquid fluid produced from the vacuum process in the condenser, so that the fluid can release heat to the outside air and be reused in the condenser vacuum process. This helps to increase the condenser vacuum which has an impact on optimizing the power output on the turbine. Good maintenance of the cooling tower motor will prevent unexpected failures and ensure smooth and efficient operation. The specific purpose of this maintenance is to optimize maintenance techniques, the maintenance in question is to use predictive maintenance methods, to identify and overcome damage before it causes significant operational disruptions.

2. THEORITICAL BASIS

2.1 GEOTHERMAL POWER PLANTS

Geothermal power plants are a type of power plant that uses hot steam to drive turbines. This steam is obtained from geothermal sources found in reservoirs in the earth. If there is steam in the wellhead, the steam will be directly flowed to the turbine, which will later drive the generator to convert kinetic energy into electrical energy. However, if the fluid in the wellhead is a mixture of two phases, namely the steam phase and the liquid phase, then the separation process will be carried out first on the fluid.[1]

The use of geothermal power is considered a renewable energy source because the heat extraction process is much lower than the geothermal charge. The reason for this is due to the quality of the steam, where about 60% is water and 40% is dry steam separated by the separator. The separated water will be injected back into the earth in a still hot state through injection wells located around the power house area. Meanwhile, some of the water will be used to cool the system that has previously been cooled by the Cooling Tower.[2]

2.2 PREDICTIVE MAINTENANCE

Predictive maintenance is a maintenance that is carried out to anticipate failure before complete damage occurs. Predictive maintenance This will predict when damage to certain components on the machine will occur by analyzing the behavior trend of the machine/work equipment. Predictive Maintenance more emphasis on testing the condition of the engine (Condition Based).[3]

The benefits of predictive maintenance are cost savings, increased lifetime and reduced risk of workplace accidents. In predictive maintenance , there are several methods that are carried out, which are as follows.

3. ANALYSIS AND DISCUSION

3.1 Monitoring Vibration

Vibration measurements are carried out on the motor whether the motor needs maintenance. Visually, vibration is the back and forth movement of a machine, which can be felt or felt by the human body, or commonly known as vibration. Vibration is measured using a vibration meter.

Vibration analysis is one of the methods that can be used to reduce and eliminate problems in the engine. The greater the vibration in the engine, the more problems the engine has, if left unchecked, the vibration will propagate to other parts of the engine, and will harm other parts of the engine. Mechanical vibration parameters are distinguished in three categories, namely vibration distance, vibration speed, and vibration acceleration.

In the figure below is the most recent ISO standard, ISO 10816-3.

Fig. 1. *Vibration standards*

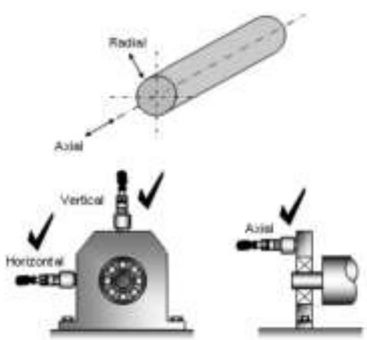

Fig. 2. *Precise Vibration Measurement Horizontal, Vertical and Axial*

Table 1: Vertical measurement

Motor	January 2024					
	15	16	22	23	29	30
AN	2.62				1.91	
AS	1.1		1.93		2.52	
BN	2.65		2.94		1.5	
BS	1.64		2.35		1.79	
CN	0.92				0.92	
CS	1.12		1.15		1.24	
DN		1.04		1.31		1.5
DS		1.85		1.59		1.74
EN		2.71		2.31		2.52
ES		2.07		1.91		1.99
FN		1.9		2.17		3.32
FS		2.6		2.18		2.36
GN		2.16		2.04		
GS		1.87		2.23		
HN						
HS						
JN						1.91
JS						2.52

Table 2: Horizontal measurement

Motor	January 2024					
	15	16	22	23	29	30
AN	1.88				1.92	
AS	1.06		1.19		2.43	
BN	1.95		1.84		1.55	
BS	1.39		1.17		1.62	
CN	0.94				1	
CS	1.42		1.5		1.68	
DN		1.31		1.47		1.64
DS		1.79		1.55		1.87
EN		1.56		1.16		1.69
ES		2.29		1.57		2.19
FN		1.02		1.01		1.58
FS		2.58		1.83		2.54
GN		2.52		2.18		
GS		3.41		3.61		
HN						
HS						
JN						1.81
JS						1.18

Table 3: Axial measurement

Motor	January 2024					
	15	16	22	23	29	30
AN	1.27		0.84		1.32	
AS	0.97		0.93		1.91	
BN	2.49		1.66		0.81	
BS	0.94		0.94		0.08	
CN	0.71		0.66		0.54	
CS	1.06		0.87		1.02	
DN		1.01		0.75		0.68
DS		1.36		1.13		1.24
EN		1.06		0.93		0.75
ES		1.29		1.21		0.96
FN		1.03		1		0.89
FS		0.88		0.99		1
GN		1.04		1.18		
GS		1.97		2.53		
HN						
HS						
JN						0.75
JS						0.8

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From the vibration measurement table data, the average is then taken on each motor and displayed as the following bar graph, an empty table indicates that the motor is not operating.

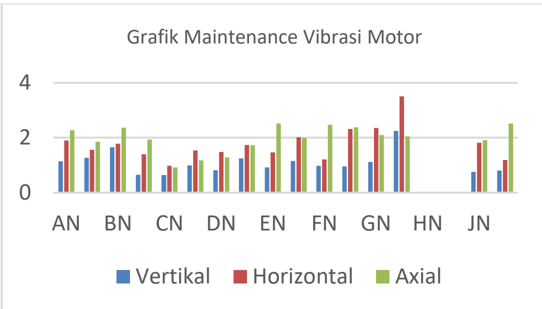

Fig. 3. *Motor Vibration Maintenance Graph*

Based on vibration measurement data taken in January 2024, it can be seen that vibration measurements on cooling tower motors have good results. The average vibration values for axial, horizontal, and vertical were 1.96 mm/s, 1.76 mm/s, and 1.08 mm/s, respectively, which is still far below the standard maximum of 7.1 mm/s. Based on ISO 10816-3.

3.2 Thermography infrared

Infrared thermography is an imaging technique that utilizes the infrared energy produced by an object. Infrared is a radiant of heat that is a function of the temperature and emmitance of an object's material. The hotter an object is, the greater the energy emitted and the brighter the color of the object. Conversely, the darker the color of the object the less radiation is emitted (black has emmitance = 1). Infrared thermography that takes advantage of temperature changes is easy to apply to the power grid that is in operation. By allowing the current to flow through a component, the measured temperature is the change in heat that occurs due to the current flowing at a load that follows Ohm's law. The greater the current flowing, the greater the power applied, so the greater the heat dissipated. Inspection using an infrared camera on the cooling tower motor that is in operation produces a temperature pattern. On the motor, the temperature is measured on the front, back, and body.

Table 4: Temperature bearing front

Motor	**January 2024**					
	15	**16**	**22**	**23**	**29**	**30**
AN	45		45		43	
AS	47		42		48	
BN	45.1		46		45	
BS	46		46		55	
CN	51		49		50	
CS	52		49		52	
DN		41		43		44
DS		60		54		57
EN		45		44		47
ES		46		42		47
FN		47		46		48
FS		46		44		47
GN		51		48		
GS		52		44		
HN						
HS						
JN						51
JS						58

Table 5: Temperature bearing rear

Motor	**January 2024**					
	15	**16**	**22**	**23**	**29**	**30**
AN	36		33		33	
AS	34		35		31	
BN	32		35		37	
BS	35		32		38	
CN	34		35		32	
CS	44		35		36	
DN		35		31		36
DS		42		39		41
EN		35		31		33
ES		36		31		34
FN		36		37		39
FS		35		32		35
GN		38		32		
GS		37		33		
HN						
HS						
JN						37
JS						42

Table 6: Temperature bearing body

Motor	**January 2024**					
	15	**16**	**22**	**23**	**29**	**30**
AN	45		45		45	
AS	45		42		47	
BN	49		46		48	
BS	49		46		51	
CN	52		49		51	
CS	51		49		52	
DN		45		43		48
DS		55		54		56
EN		47		44		49
ES		48		42		48
FN		50		46		49
FS		48		44		48
GN		52		48		
GS		49		44		
HN						
HS						
JN						53
JS						55

From the temperature measurement data above, it is then processed into an average bar graph on each motor as follows, an empty table indicates that the motor is not operating.

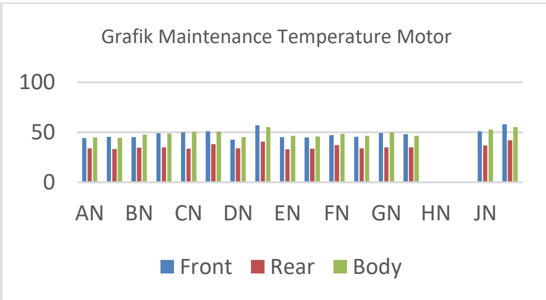

Fig. 4. *Graphs Maintenance temperature motor*

Based on temperature measurement data taken in January 2024, it can be seen that the temperature measurements taken on the cooling tower motor are relatively good, because they produce average temperature values for the rear, front and body are 35.66°C, 48.4°C, 48.7°C, respectively, where these values are still far from the maximum number according to the standard, which is 45°C-50°C + ambient, where the ambient in the surrounding environment is 19°C. Based on IEC 60034-1.

3.3 Motor Current Signature Analysis (MCSA)

Motor current signature analysis (MCSA) is a method to detect damage to a motor by analyzing its frequency spectrum and stator current. In a damaged motor, the harmonization spectrum in the stator current is different from the harmonization spectrum in a healthy motor, so that by using the Motor Current Signature Analysis (MCSA) method, several damages that occur in a motor can be detected. Among others: Air imbalance, rotor bar damage, bearing damage and stator damage. Which damages are conditions that often occur on a motor. Early detection of damage to the motor is very necessary, so that at any time if there are symptoms of damage, repair steps can be taken immediately.

Table 7: Motor Current Signature Analysis

Equipment Tag	Date	Noise Motor	Visual Motor	Operation Status	current
CT_F_AN	1/29/2024	Usual	Good	Operate	89
CT_F_AS	1/29/2024	Usual	Good	Operate	89
CT_F_BN	1/29/2024	Usual	Good	Operate	90
CT_F_BS	1/29/2024	Usual	Good	Operate	93
CT_F_CN	1/29/2024	Usual	Good	Operate	94
CT_F_CS	1/29/2024	Usual	Good	Operate	96
CT_F_DN	1/30/2024	Usual	Good	Operate	86
CT_F_DS	1/30/2024	Usual	Good	Operate	98
CT_F_EN	1/30/2024	Usual	Good	Operate	87
CT_F_ES	1/30/2024	Usual	Good	Operate	92
CT_F_FN	1/30/2024	Usual	Good	Operate	87
CT_F_FS	1/30/2024	Usual	Good	Operate	88
CT_F_GN	1/30/2024	Off	Good	Not Operate	
CT_F_GS	1/30/2024	Off	Good	Not Operate	
CT_F_HN	1/30/2024	Off	Good	Not Operate	
CT_F_HS	1/30/2024	Off	Good	Not Operate	
CT_F_JN	1/30/2024	Off	Good	Not Operate	
CT_F_JS	1/30/2024	Off	Good	Not Operate	

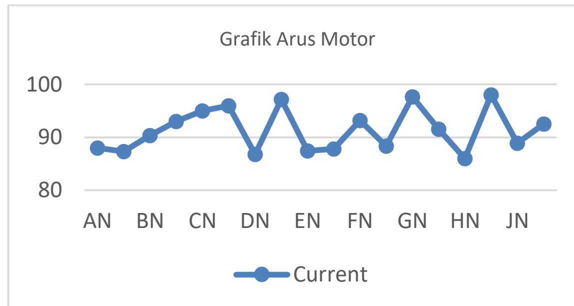

Fig. 5. *Motor Current Graph Cooling Tower*

From the current measurement data taken in January 2024, it can be seen that the current measurement on the cooling tower motor shows good results. The average current value produced is between 86-98 which is still far below the maximum number according to the standard, which is 106A. Measurement using a multimeter measuring device or amperage pliers on the motor breaker panel , if the working current of the motor is still below the nominal current listed on the name plate, the motor is still in good condition. An empty table indicates that the motor is not operating

4. Conclusion and Suggestion

4.1 Conclusion

- The measured current value on the motor is in accordance with the standard on the motor name plate, which is a maximum of 106 A. On the current consumption graph, the more steam that must be cooled, the more motor cooling fans will also turn on so that current consumption will also be high.

- The average vibration values for axial, horizontal, and vertical were 1.88 m/s, 1.9 m/s, and 1.1 m/s, respectively, which is still far below the standard maximum of 7.1 m/s. Based on ISO 2372-1974.

- The temperature measurement is relatively good, because it produces the average temperature values for the rear, front and body are 33.8°C, 47.5°C, 48.2°C, respectively, where these values are still far from the maximum number according to the standard, which is 45°C-50°C + ambient, where the ambient is 19°C. Based on IEC 60034-1.

4.2 Suggestion

The suggestions that I can give to the selected topic are as follows:

- Record maintenance records in detail and review the design to make sure the components are as needed. With these simple steps, it is expected to ensure optimal performance and prevent unwanted damage.
- The data recap using lookerstudio is good, making it easier to monitor the results of checks and making it easier to find damage that occurs.
- For a recap of vibration measurements, it would be better if the recording was also done through lookerstudio, because the excel recap was a bit confusing for the reader.
- The benefits of predictive maintenance are cost savings, increased lifetime and reduced risk of workplace accidents.

5. References

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