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Design And Implementation Of Temperature Measuring Device Using Max6675 And Thermocouple On Wet Cooling Tower

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ABSTRACT
Cooling Tower or cooling tower is a technology used in the industrial world, cooling tower works to cool water fluid by using wind power that comes from a fan or blower, how the cooling tower works is basically hot water coming from the machine is flowed to the cooling tower then water through the fill-fills that are in the cooling tower and in direct contact with the air, the cooling tower is focused on reducing the temperature of the inlet water until it leaves it, while the water temperature reading uses a thermocouple sensor. A thermocouple is a temperature sensor capable of reading temperatures from -200 ℃ to 1200 ℃. This cooling tower uses arduino mega circuit, PCB board, MAX6675 module and thermocouple. How to read the temperature on the cooling tower using a computer or laptop with Microsoft Excel that is already connected to the PLX-DAQ software. The data that has been obtained is then tested using SPSS (Statiscal Product and Service Solutions) software, testing using 3 types, namely normal distribution, standard deviation, and reliability. The overall results of the thermocouple sensor on the Wet Cooling Tower show normal performance according to statistical testing, including normal distribution, standard deviation, and reliability. All data and values obtained have met the established standards

Keywords: *Thermocouple sensor, Arduino mega, temperature*

INTRODUCTION

A cooling tower is familiar in factories, shopping centres, and other extensive facilities. Its primary function is to cool hot water from machinery by direct contact with air forced by fans. This process involves heat transfer and partial evaporation of water, resulting in a decrease in water temperature. Cooling towers are essential for managing temperatures in industrial and commercial systems, maintaining optimal performance, and preventing equipment overheating. Challenges in cooling tower design and operation include resistance to weather changes throughout the year [1]. The tower characteristics increase with cold air velocity, and the wave fill arrangement gives the best results[2]. In industry, cooling water is used as a medium for heat exchange between hot fluid and cold water in a heat exchanger or cooler. This heat exchange causes the temperature of the cooling water to rise because it absorbs heat from the hot fluid[3]. Cooling towers are critical to various industries. They employ a process of cooling hot water to reuse it, reducing environmental pollution. Wet cooling towers utilise heat release and transfer principles to move heat from water to air [4]. The ability of the fill to effectively cool the water, as shown by the effectiveness of the range, increases as the air velocity increases. [5]. Most cooling towers working on air conditioning systems use centrifugal pumps to move water vertically upwards across the tower. Cooling tower performance is usually expressed in range and approach [6]. The approach is the difference between the cooling tower exit chilled water temperature and the ambient wet bulb temperature. When the approach condition is low, the cooling tower performance is better. Range and approach are still monitored, and "approach" is a better indicator of cooling tower performance.[7]. Some factors that affect the performance of the cooling tower are the conditions of the distribution of water and airflow in the cooling tower. The more even the flow of air and water, the better the performance of the cooling tower [8]. To determine the effect mechanism of the air duct, the air velocity distribution and water temperature at several representative sections of the tower were analysed under no wind and cross-wind conditions [9]. The airflow can enter the leeward tower from the wind tower and even flow out from the air inlet of the leeward tower under cross-wind

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conditions. The airflow distribution becomes more uniform in the tower group[10] Excessive heat transfer in the cooling tower causes significant evaporation loss and diffuse rain mist, which causes the problem of diffuse bacteria and environmental pollution. A cooling tower uses a multi-unit combined heat exchange strategy and heat exchanger packing [11]. It can be obtained that in the presence of ambient natural wind, the proposed deflector can prolong the positive effect of natural wind, leading to a decrease in the outlet temperature of circulating water and the back pressure of the turbine [12]. . At present, digital sensors have developed in the world of instrumentation. It also created the Internet of Things (IoT), a wireless system of real-time data updates [13]. Temperature is one of the critical parameters in every aspect of life, so accurate temperature measurement is needed. Researchers use temperature acquisition data using K-type thermocouples and MAX6675 modules because of their low price and availability in the market [14]. A thermocouple is a device for measuring temperature with an output as an electric current, allowing digital conversion. Seebeck (1821) discovered that thermocouples work based on the thermoelectric effect, in which a difference in heat produces an electric voltage in a conductor[15]. Thermocouples are temperature sensors that convert temperature differences into voltage changes due to the difference in density possessed by each metal, which depends on the thickness of the metal [16]. Thermocouples are temperature sensors that convert temperature differences into voltage changes caused by the difference in density possessed by each metal, which depends on the thickness of the metal. Similar to the thermocouple sensor, besides being able to read temperature changes, it can also act as an analogue input to a control system [17]. Connecting all thermocouples with a thermocouple reader [18]. Type K thermocouples are used in this research because they have a temperature reading limitation in the temperature range of -200°C to 1200°C. In addition, type K thermocouples are the most popular thermocouples, are often used for general purposes, have lower prices, and are readily available in Indonesia compared to other thermocouples[19]. Arduino Mega is a microcontroller board based on Atmega 2560. It has 54 digital input and output pins, 15 of which can be used as PWM outputs and 16 analogue input pins, a 16 MHz crystal oscillator, a USB connection, a power jack, an ISCSP header, and a reset button. It is enough to support the microcontroller to connect the Arduino Uno Board to a computer using a USB cable or electricity with AC to a DC adapter or battery to run it SPSS software is widely used in various marketing research, court and quality improvement, and scientific research [21]. Although cooling towers play an essential role in ensuring optimal performance and preventing equipment overheating in industrial and commercial systems, there still needs to be substantial gaps in research. Prior research indicates that using digital sensors and data-collecting technology for monitoring cooling tower temperatures has yet to be extensively investigated. Although type-K thermocouple sensors and MAX6675 modules are frequently utilised because of their widespread availability and cost-effectiveness, additional investigation is needed to improve the efficiency and accuracy of integrating real-time temperature monitoring systems with environmental meteorological conditions. Hence, continuous research is necessary to tackle operational obstacles, minimise environmental consequences, and use digital technology and data collecting to enhance cooling tower systems' performance and efficiency. The unique aspect of this study is incorporating real-time temperature and weather condition monitoring systems into cooling towers, an area that has not been extensively investigated before. This integration aims to enhance operating efficiency and precision. The project aims to develop precise temperature and weather-measuring devices to improve the efficiency and accuracy of monitoring cooling tower performance in different operational situations..

RESEARCH METHOD

The research implementation of making temperature measurement instruments on a wet cooling tower was carried out at the Mechanical Engineering Laboratory of Universitas Muhammadiyah Sumatera Utara (UMSU) Jl. Kapten Muchtar Basri No.3 Medan.

Material

The tools used for making temperature measurement instruments on wet cooling towers are as follows:

a) PCB board

PCB board is a thermocouple circuit board with Arduino; this PCB board is used to connect Arduino to the MAX6675 module with the designed layout path. The PCB board uses a copper layer to be printed into the sensor circuit layout path. This chemical solution is to dissolve the PCB layout to dissolve unused copper on the PCB board; the solvent uses a mixture of chemicals, namely a mixture of Ferric Chloride (FeC13), ferric chloride, or iron (III) is a chemical compound, when dissolved in water, chloride undergoes hydrolysis which is an exothermic reaction (generates heat). This hydrolysis produces a brown, acidic, and corrosive solution used as an etcher for copper-based metals on PCB printed circuits.

a) **Arduino Mega**
Arduino is a microcontroller board. To support the microcontroller, it is enough just to connect the Arduino Uno Board to a computer using a USB cable or electricity with an AC to DC adapter or battery to run it. This can be seen in Figure 3.4.

b) **MAX6775 Module**
The MAX6675 module converts voltage into digital data with an ADC of 12 bits. The data sent from MAX6675 is in the form of digital data with communication similar to SPI communication. The MAX6675 module is installed on the header pin that is already installed on the PCB board, as can be seen in Figure 3.7.

c) **Type K Thermocouple**
Type K thermocouples are used in the wet cooling tower sensor circuit. These thermocouples can read temperatures from -200 to 1200 °C. The thermocouples come in several sizes: 3 meters, 2 meters, and 40 cm.

Research Design

The arrangement of the tools that have been assembled can be seen in Figure .1

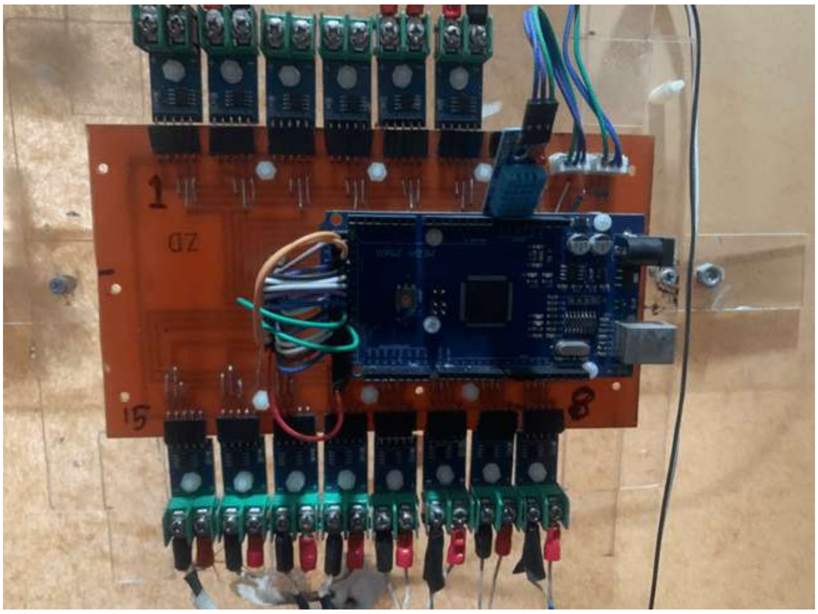

Fig.1. Sensor circuit

Procedure for Making Research Tools

The procedure for making a Temperature Measurement Instrument is as follows:

Prepare tools and materials in the form of PCB board, PCB board solvent, PCB board circuit that has been printed and photocopied, acetone liquid, bucket, sand paper, Arduino mega, male to male jumper cable thermocouple, pin header, MAX6675 module, USB cable, solder, solder tin, Y skin, cutting pliers, heat gun, pliers press skin, cable pliers, acrylic, acrylic cutting knife, ruler. Creating a thermocouple sensor layout on a PCB board using Proteus 8 software. Apply the printed circuit to the PCB board using acetone liquid. Dissolve the circuit ink and PCB lead in a hot water container using PCB solvent. Perforate the PCB board according to the circuit, and for the Arduino holder, use the header pin. Install and solder the header pins for the MAX6675 module and the

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Arduino. Install the Arduino and secure it using plastic bolts. Attach the MAX6675 module to the header pins. Attach the jumper cables from the header pins to the Arduino according to the pins. Attach the thermocouple sensor Y skin to the MAX6675 module. Cut the acrylic to make the sensor circuit housing. Glue the acrylic using glue in a box shape. Lubricate the acrylic to tighten it and attach it to the Wet Cooling Tower so that the sensor circuit Fig.1 can be used..

RESULTS

Results of Making Temperature Measurement Instrument on Wet Cooling Tower
Sensor Installation to Wet Cooling Tower

The sensor is placed and tied using cable ties in the fill end holes according to the water drop as shown in Figure 2.

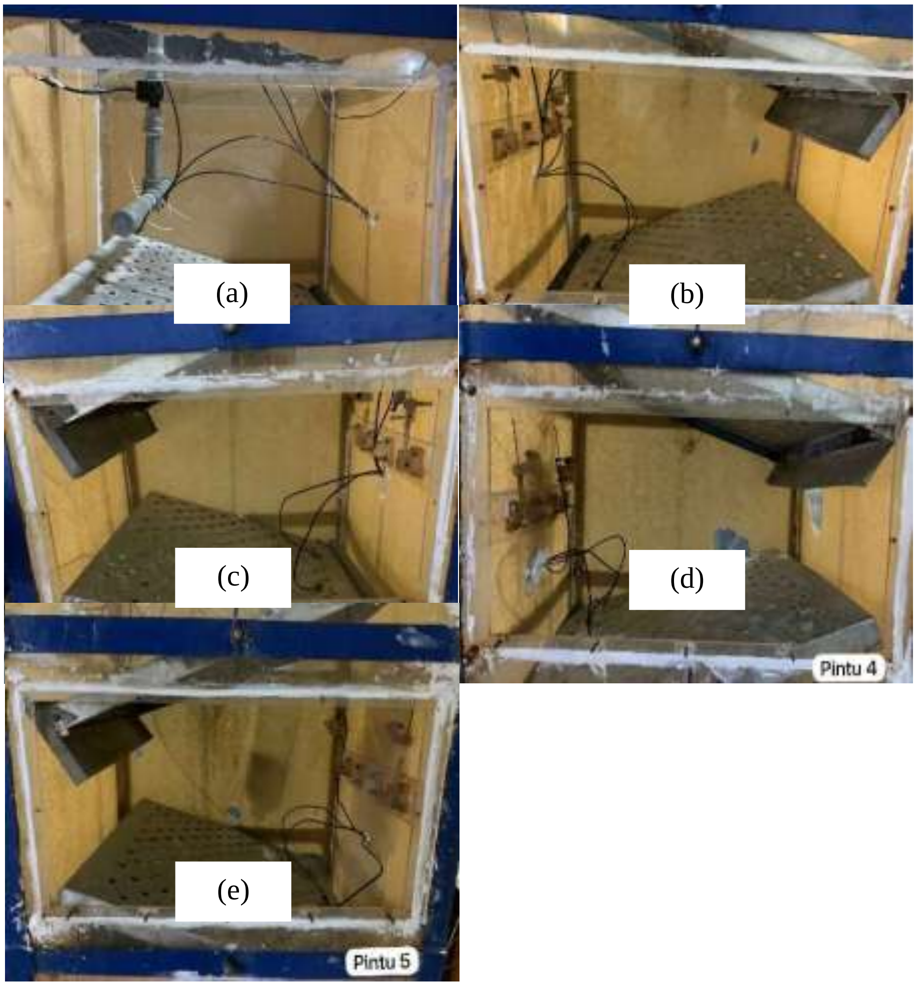

Figure 2 Sensor location (a level one, (b) level two, (c) level three, (d) level four, (d) level four

The sensor is installed in the incoming water pipe and at the ends of the fill by punching holes in the Wet Cooling Tower wall using a 5 mm drill to insert the thermocouple into the Wet Cooling Tower and then tie it using cable ties. The water entry sensor tries to hit the water in full so that when the temperature reading is obtained, the temperature is read perfectly; there are 2 metres for the middle of the wet cooling tower and 40 cm for the bottom of the wet cooling tower. The temperature measurement instrument is formed from a series of thermocouple sensors connected to the MAX6675 module and Arduino mega, then read through Arduino. Sensors are installed at specific points, from the entry of water to the exit of water, and data collection using a laptop or computer using Microsoft Excel software linked to PLX-DAQ. Temperature data has been taken and statistically tested using SPSS software. Testing is carried out in several types, such as normal distribution, standard deviation, and reliability.

Testing Results
Figure 3 shows the data obtained from the results of collecting acquisition data with 15 thermocouple sensors. Data collected as many as 149 pieces of data each data collected within 3 seconds

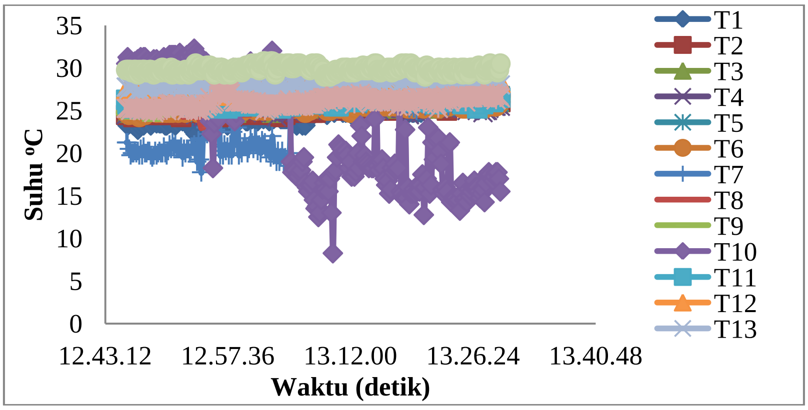

Fig.3 Data collection results of 15 thermocouple sensors

Normal Distribution
Table 1 shows the results of normal distribution tested using the SPSS application, the results of data taken from 4 types: calibration, round fill, square fill, and triangular fill. The data seen is Asymp. Sig (2-tailed), if the sig value> 0.050, then the data is declared customarily distributed; if the sig value <0.050, then the data is declared not normally distributed [22]. The analysis results in Table 1 are obtained for the Asymp. The sig value on round fill, square fill, triangular fill, and calibration is 0.200. Because the value of Asymp. If the sig value is more significant than 0.050, it can be concluded that the data is usually distributed. Can be seen in Table 1. The results of the One-Sample Kolmogorov-Smirnov Test for the AVERAGE variable show that the sample consists of 149 data (N=149). The mean value is 0.0000000 with a standard deviation (Std. Deviation) of 0.45674705. The most extreme difference between the sample cumulative distribution and the expected normal cumulative distribution is shown by the Absolute value of 0.043, with a maximum positive value of 0.043 and a maximum negative value of -0.031. The test statistic is 0.043. This value indicates the extent to which the distribution of the sample data differs from the expected normal distribution The low value of the test statistic indicates that the data distribution is close to a normal distribution, but further interpretation requires checking the significance value (p-value) not presented in this table.

Table 1 Normal Distribution

One-Sample Kolmogorov-Smirnov Test		
		RATA-RATA
N		149
Normal Parameters[a,b]	Mean	.0000000
	Std. Deviation	.45674705
Most Extreme Differences	Absolute	.043
	Positive	.043
	Negative	-.031
Test Statistic		.043

Standar Devisiasi
Table 2 shows the standard deviation value data in determining how the distribution is to determine how the data is distributed in the sample and how close the individual data points are to the mean or average sample value[23]. The data results were taken 4 times during data calibration. If the standard deviation is smaller than the mean, the data spreads not far from the average because the standard deviation describes a high deviation[24]. Descriptive statistics tables provide an

overview of the distribution and characteristics of the variables under study, VAR00002. Data was collected from 149 respondents (N=149). This variable has a minimum value of 50.00 and a maximum value of 54.00. The mean of this variable is 51.9111, indicating the central tendency of the data is around this value. The standard deviation (Std. Deviation) of 0.76509 shows the distribution or variation of data values around the average. The relatively close minimum and maximum values indicate that the VAR00002 data tends to be homogeneous, with slight variation among respondents. The mean in the middle range of minimum and maximum values indicates a relatively symmetrical data distribution. The slight standard deviation indicates that most data does not deviate much from the mean. The number of valid samples is 149, indicating all the data in this analysis. This data provides a solid basis for further analysis and a more in-depth interpretation of the variables under study.

Table 2 Standard Deviation

	N	Minimum	Maximum	Mean	Std. Deviation
VAR00002	149	50.00	54.00	51.9111	.76509
Valid N (listwise)	149				

Reliability

Table 3 shows the results of reliability data taken using SPSS software. The results of the data taken Data are said to be reliable if the Cronbach alpha value> 0.6 [25]. From the results of the calculation of the reliability test of the Cronbach alpha method, it can be seen in the Cronbach alpha column on round fill, namely 0.857 square fill 0.676, triangular fill 0.836, and calibration data is 0.141 with N of items indicating that the number of items or the number calculated is 10.

Tabel 3 Reliabilitas

Cronbach's Alpha	N of Items
.857	149

Cronbach's Alpha is a coefficient that shows the internal consistency of a research instrument. In this study, the Cronbach's Alpha value of 0.857 indicates a very high level of reliability. This means that the instrument is consistent in measuring the same concept. An Alpha value close to 1 indicates that the items in the instrument correlate well with each other so that the results obtained can be trusted and relied upon. Thus, this instrument can be used for further research with the confidence that the items consistently measure the variables under study.

CONCLUSION

From this research, temperature measurement instruments for the wet cooling tower were successfully manufactured. The data can be concluded by Making temperature measurement instruments on the wet cooling tower using Arduino-based thermocouples. Asymp. The sig value of calibration, round fill, is 0.200, which means it is generally distributed because if the sig value> 0.050, the data is declared normally distributed.

- In the calibration value, the standard deviation is 0.24341, and the mean value is 34.2542. In the round fill value, the standard deviation is 0.76509, and the mean value is 51.9111. If the standard deviation is smaller than the mean, it means that the data is not far from the average because the standard deviation describes a high deviation.
- Data is reliable if the Cronbach alpha value is> 0.6. The Cronbach alpha data on calibration is 0.141, which means that all the data tested is said to be reliable.
- The overall results of the thermocouple sensor on this Wet Cooling Tower have worked normally according to the statistics tested in SPSS. The tests carried out are normal distribution, standard deviation, and reliability. All data and values meet the standards.

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