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Original Research Article

Design of Ideal Air Condition Control Inside 20 kV Cubicle for Lokomboro Micro Hydro Power Plant in Sumba Indonesia

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Abstract: Corona, which is a phenomenon that occurs when the air around the conductor is ionized can occur in a 20 kV cubicle and damage the equipment. To prevent this occurrence, the air condition inside the cubicle need to be controlled at a safe level. In this study, we maintain an ideal air condition with Arduino-based humidity and temperature control system using ATMEGA328 microcontroller. This system was installed in the 20 kV cubicle at Lokomboro Micro Hydro Power Plant and then tested for performance. From the test result it was found that the system was able to control the humidity and temperature inside the cubicle at 45 % and 26 ^{0}C, respectively. By controlling humidity and temperature values at ideal condition, the corona appearance that damage the equipment has been prevented. This installation showed operational, financial, and company image benefit for PT. PLN since it has prevented loss due to damage of equipment and also maintained electrical power reliability.

Keywords: Cubicle, Corona, Humidity, Temperature, Microcontroller.

1. INTRODUCTION

PT. PLN (Perusahaan Listrik Negara) plays a critical role in ensuring a stable supply of electricity in Indonesia [1]. As the state-owned electricity company, PT. PLN is responsible for generating, transmitting, and distributing electricity throughout the country. The company's ability to meet the increasing demand for electricity has a significant impact on Indonesia's overall stability and development. PT. PLN's investment in renewable energy sources, such as geothermal, hydro, and solar power, helps to reduce the country's dependence on fossil fuels and promote a more sustainable future [2, 3].

Figure 1: Flashover causing damage to Disconnect Switch and Load Balancing Switch as indicated by red circle. The picture was taken from the 20 kV cubicle at Lokomboro Micro Hydro Power Plant in Sumba, Indonesia (*Photo by: The Author*)

The Lokomboro Micro Hydro Power Plant in Sumba is an excellent example of PT. PLN's commitment to promoting sustainable development in Indonesia [4]. The plant, with total capacity of 2.7 MW, provides access to modern amenities such as lighting and refrigeration for households in the area. Before its construction, the community relied on expensive and unreliable diesel generators for electricity. The Lokomboro Micro Hydro Power Plant not only provides affordable and reliable electricity but also helps to reduce the community's dependence on fossil fuels. The plant's use of the natural flow of water to generate electricity and its lack of greenhouse gas emissions make it an environmentally friendly energy source.However, PT. PLN also faces challenges in maintaining the reliability and safety of its medium voltage distribution system, which uses a 20 kV system [5]. One of the most crucial components of the system is the cubicle, which acts as a switching, dividing, and protective device. To prevent moisture from affecting the system's performance, the cubicle contains a humidity regulator component called a heater. However, in conditions of rising temperature due to a large load or current, the heater can release heat that increases the level of saturated water vapor in the air in the cubicle. This condition can cause corona and failure of air insulation, potentially leading to short circuits and damage to the distribution system. Addressing these challenges is crucial to maintaining the reliability and safety of PT. PLN's distribution system and ensuring uninterrupted access to electricity for consumers. By investing in infrastructure and technology, PT PLN can continue to provide reliable and sustainable electricity to support Indonesia's long-term growth and prosperity.

To address the issue of humidity regulation in cubicles, PT. PLN can explore the possibility of implementing low-cost technologies such as an Arduino-based humidity and temperature control system. This system uses sensors to measure the humidity and temperature inside the cubicle and automatically adjusts the heater's power to maintain optimal conditions [6],[7]. Arduino is an open-source electronics platform that is affordable and widely available, making it an accessible solution for PT. PLN to implement. By adopting this technology, PT. PLN can improve the reliability and safety of its electricity distribution system while also reducing maintenance costs associated with traditional humidity regulation systems. Additionally, implementing such low-cost technologies demonstrates PT. PLN's commitment to leveraging innovation to improve its operations and reduce its environmental impact.

2. MATERIALS AND METHODS

In this study, design of humidity and temperature control for 20 kV cubicle were made following the block diagram in Figure 2. The humidity and temperature value inside the cubicle will be recorded by DHT11 sensor [8]. The data was read by Arduino Uno module with ATMEGA328 microcontroller and then compared with the set point of temperature and humidity value intended by user. Arduino Uno based humidity control system design has also been reported to be viable solution at industry level [9]. Comparing the measured and set value, the relay fan and relay heater will be activated accordingly. If the humidity and temperature were too high, the relay fan and relay heater will be on until the desired condition is met. The status of relay fan and relay heater as well as the value of humidity and temperature will be displayed on the LCD screen.

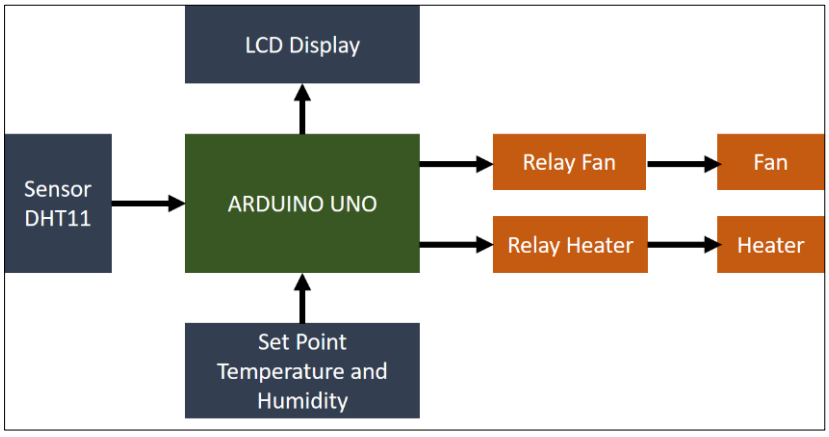

Figure 2: Block diagram of humidity and temperature control system

The wiring diagram of humidity and temperature control system were shown in Figure 3. The red line is the V_{CC} of 5V DC power for the equipment. The black line is the GND ground wire of the electrical circuit. The brown line is DHT11 data wire connected to digital input D2 of Arduino Uno. The purple line is the relay data wire for the heater setting which is connected to the digital output D4. The blue line is the relay data wire for the fan setting which is connected to the digital output D5. The green line and yellow line are the SDA and SCL data wires of the LCD display that are connected to the digital output D6 and D7, respectively. The fan relay will control a blower fan of 220 VAC 40 Watt and the heater relay will control a heating element of 220 VAC 100 Watt.

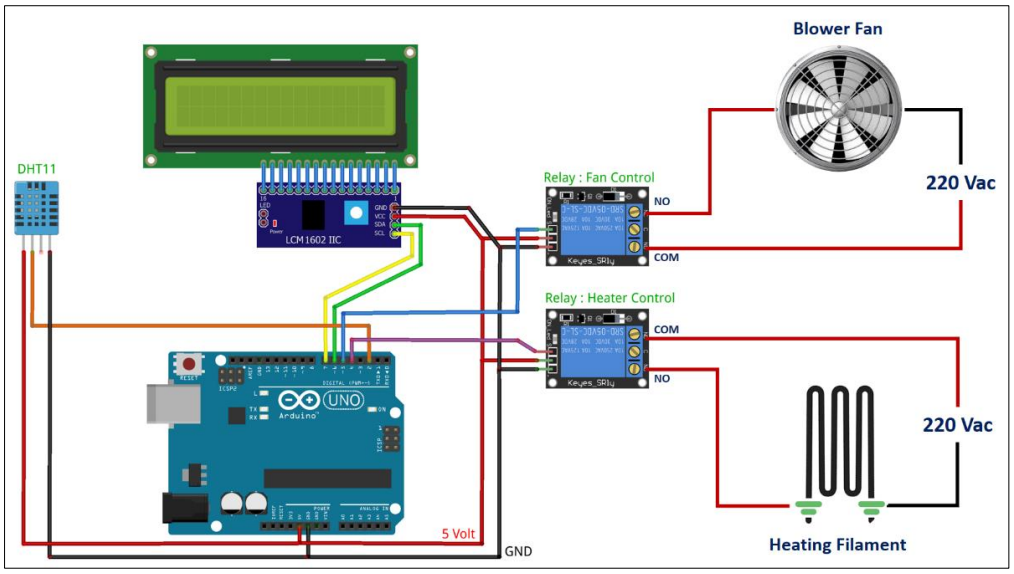

Figure 3: Wiring diagram of the prototype humidity and temperature control system

To test the working of sensor, all components were assembled in breadboard according to wire diagram in Figure 3. The software was programmed in Arduino IDE and uploaded into the microcontroller. To test the temperature sensor, heat source was used to increase the temperature value and check whether the relay fan was activated. To test the humidity sensor, mist source was used and check whether the relay heater was activated. All the measured temperature and humidity sensor were displayed in LCD as well as the fan status.

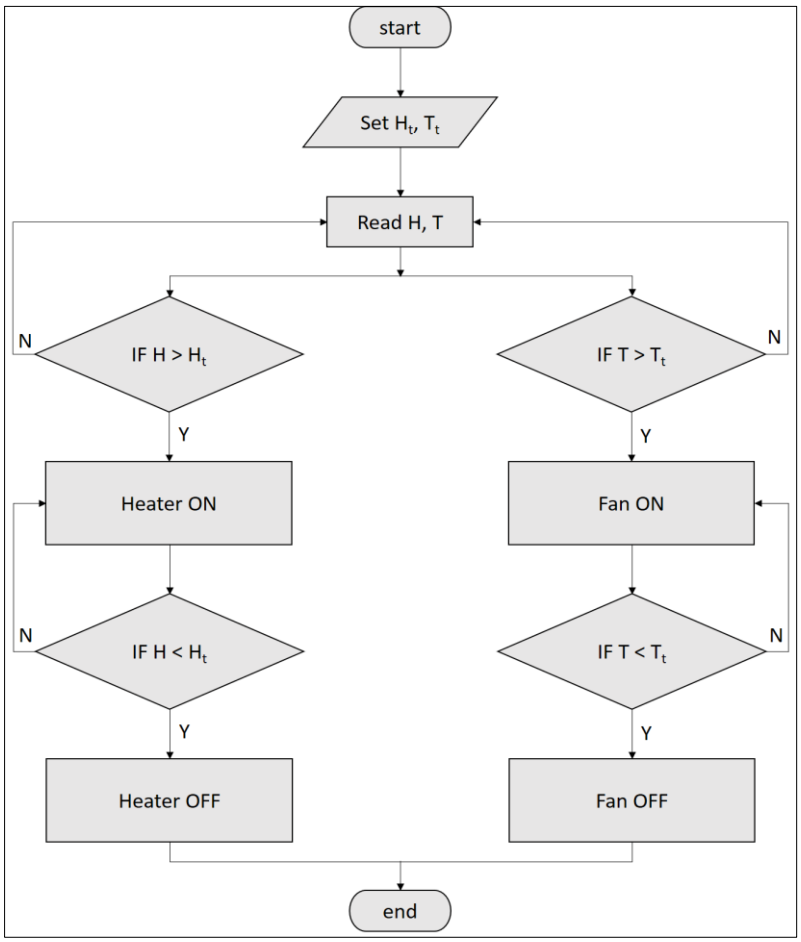

Figure 4: Flowchart of software for humidity and temperature control system

In order for the hardware to work according to requirement, a software program was designed and uploaded into the microcontroller. The flowchart of the working mechanism for the software was shown in Figure 4. Initially, input value of $\mathbf{H_t}$ and $\mathbf{T_t}$ were provided as the ideal humidity and temperature values inside the cubicle. And then the measured values from the DHT11 sensor were compared with the input values. If the humidity measured was higher than the set values then the heater will be activated. Also, if the temperature measured was higher than the set value then the fan will be activated. This process will be kept until the desired humidity and temperature were reached.

After the prototype control system were assembled and tested successfully, next the installation process will be carried out at the cubicle. The outline processes are as the following steps. It started by making holes and mounts on the rear body of the cubicle using a grinder. After that, it followed by installing the fan in the prepared holes and mounts, installing the microcontroller on the stand made on the side body of the cubicle, installing the DHT11 sensor on the inside or back of the Disconnect Switch cubicle. Next, cut off the fan and heater voltage source cable and install it on the relay. Install the LCD display on the stand in the cubicle. Lastly, connect the power cable of the appliance with the cubicle installation cable and connect it to the circuit board for low voltage at the substation.

For analysis, the temperature dan humidity data before and after the installation of the control system will be taken accordingly. After collecting data from this temperature and humidity control system, then the next steps were to analyze the temperature and humidity data as comparison study as well as to analyze the system main benefit for PT. PLN as electricity company.

3. RESULTS AND DISCUSSIONS

3.1 Hardware Installation

The control system was installed, tested and implemented in the cubicle at Lokomboro Micro Hydro Power Plant Sumba, Indonesia. The installation of an Arduino-based humidity and temperature control system in a cubicle involves several essential components such as a fan blower, a heater, a DHT11 sensor, and an LCD display, as shown in Figure 5. The fan blower ensures proper air circulation by drawing in fresh air from outside and pushing out moist air to maintain optimal conditions. The heater is responsible for maintaining a suitable temperature inside the cubicle to prevent moisture buildup, working in tandem with the fan blower to create a steady airflow and keep the temperature and humidity levels within the optimal range. The DHT11 sensor measures the humidity and temperature inside the cubicle and sends the data to the Arduino microcontroller. The microcontroller uses this data to regulate the heater's power and the fan blower's speed to maintain optimal conditions. The LCD display provides real-time data on the conditions inside the cubicle, allowing the operator to monitor and adjust the system as necessary.

The Arduino-based humidity and temperature control system is an accessible and cost-effective solution that offers significant benefits for the power distribution system in the cubicle. The use of readily available components makes the system easy to install and maintain. The DHT11 sensor ensures accurate and reliable measurements of the temperature and humidity, which are continuously fed to the microcontroller to automatically adjust the system's settings. The LCD display provides real-time data that allows the operator to monitor and make any necessary adjustments. Implementing this system can significantly improve the reliability and safety of the electricity distribution system in the cubicle by reducing the risk of electrical shorts, corrosion, and other issues. Furthermore, the low-cost nature of the system makes it a practical solution that can be scaled up and implemented throughout the entire distribution network.

However, it's important to note that there are potential drawbacks to using a low-cost Arduino-based control system. One potential drawback is that the system may not be as robust or durable as more expensive commercial solutions. The components used in the system may have a shorter lifespan or be more susceptible to damage from environmental factors such as moisture, heat, or dust. Additionally, the system may not have as many advanced features or capabilities as more expensive solutions, which could limit its functionality in certain situations. Finally, while the system itself may be low-cost, there may be additional costs associated with installation, maintenance, and training that could add to the overall cost of implementation. Despite these potential drawbacks, however, the benefits of using a low-cost control system such as the Arduino-based system are significant and should be considered in the context of the specific needs and requirements of the PT. PLN distribution network.

Figure 5: Installation of humidity and temperature control system component such as fan blower, heater, DHT11 sensor and LCD display
(*Photo by: The Author*)

3.2 Performance of Control System

The installation of an Arduino-based humidity and temperature control system can significantly improve the stability of the conditions inside the cubicle. Before the activation of the system, the humidity and temperature inside the cubicle were too high, with humidity around 65% and temperature around 30 ^{0}C from day 1 to day 5 as shown in Figure 6. These conditions are not ideal for the electrical equipment inside the cubicle and can lead to issues such as electrical shorts and corrosion[10].

However, after the activation of the control system, the humidity and temperature inside the cubicle were stabilized and maintained within a good range from day 6 to day 8 as shown in Figure 6. The humidity level dropped around 45%, and the temperature was around 26 ^{0}C. These conditions are optimal for the electrical equipment inside the cubicle and can significantly reduce the risk of issues such as corrosion and electrical shorts.

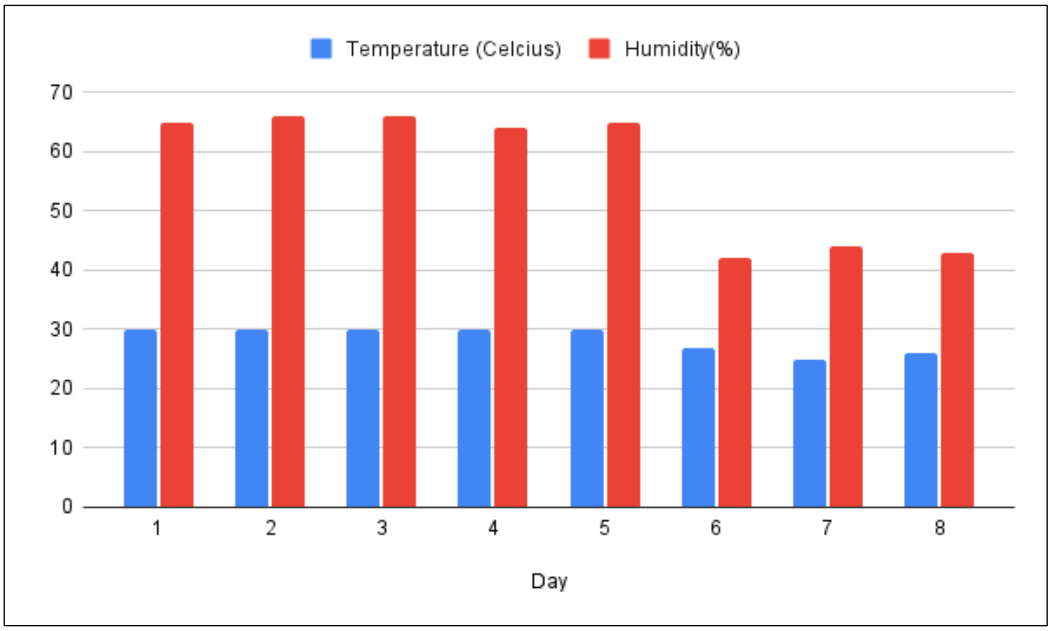

Figure 6: Performance of humidity and temperature control system

The performance of the control system in maintaining stable conditions inside the cubicle is achieved through the use of the DHT11 sensor, which measures the humidity and temperature inside the cubicle. This data is continuously fed to the Arduino microcontroller, which adjusts the fan blower and heater to maintain optimal conditions. The automated nature of the system ensures that conditions are continuously regulated without the need for manual intervention, providing reliable and stable performance.

Overall, the performance of the control system in maintaining good stable humidity and temperature range inside the cubicle is essential for the reliability and safety of the electrical equipment inside. The system provides significant benefits by reducing the risk of issues such as corrosion and electrical shorts, leading to a more efficient and reliable distribution system.

3.3 Benefit for Company

The improvement in the humidity and temperature control system installation in the cubicle can bring significant benefits to PT. PLN in terms of operational, financial, and company image aspects. In terms of operation, the control system ensures the stability and reliability of the power distribution system in the cubicle. The optimal humidity and temperature levels can prevent equipment malfunction due to moisture buildup, reducing the risk of electrical shorts and other issues. This, in turn, can improve the uptime of the distribution system and reduce maintenance costs. In terms of financial aspects, the improved stability and reliability of the distribution system can lead to cost savings. The reduced risk of equipment failure and downtime can lead to increased productivity and revenue generation. Additionally, the low-cost nature of the control system can provide cost savings in terms of installation, maintenance, and energy consumption. In terms of company image, PT. PLN can benefit from the installation of a sustainable and innovative control system that demonstrates the company's commitment to efficient and reliable power distribution. This can improve the company's reputation and attract more customers who value sustainability and innovation. Overall, the installation of the humidity and temperature control system in the cubicle can bring multiple benefits to PT. PLN in terms of operation, finance, and company image.

4. CONCLUSION

In conclusion, the installation of a low-cost humidity and temperature control system based on Arduino technology can significantly improve the safety, reliability, and efficiency of power distribution systems, such as those used by PT. PLN. By maintaining optimal conditions inside cubicles, the risk of electrical shorts, corrosion, and other issues can be reduced. Moreover, the low-cost nature of the system makes it a practical solution that can be implemented on a large scale, ensuring that the benefits of the system can be realized throughout the entire distribution network. The performance of the control system in maintaining good stable humidity and temperature ranges of 45 % and 26 ^{0}C inside the cubicle was shown to be effective, with significant improvements before and after installation. PT. PLN can benefit from the installation of such a system in terms of improved operation, reduced maintenance costs, and a positive company image. Therefore, the installation of a low-cost humidity and temperature control system based on Arduino technology is a viable solution for improving the safety, reliability, and efficiency of power distribution systems.

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