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Temperature Monitoring of Heating System for Flexitank

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Abstract: This project was created to improve the quality of services and additionally to upgrade the functionality of Flexitank and its heating systems overall. Heating systems in Flexitank helps in maintaining the preferred temperature of the products from the time of transportation to the destination. Thus, A prototype temperature monitoring system was developed to test its proper functionality using hot water. In this way, the workers of Flexitank can notice the increased temperature of the steam and can control its flow by adjusting the temperature. There were several software and hardware equipment were used to build this system, mainly based on Arduino as NodeMCU ESP32, Arduino IDE, and Blynk app to perform tasks of the monitoring system. The NodeMCU ESP32 was interfaced with the respective Type K Temperature Sensor with the installed Blynk app. In a nutshell, it is crucial for building a useful steam temperature monitoring system to obtain greater benefits through the advanced technology of the internet of things (IoT).

Keywords: Temperature Monitoring System, Heating Pad, Flexitank

1. Introduction

Flexitanks are known for their secure, most innovative, productive which transports bulk liquid items from one place to another in a profitable way. It helps to preserve the unity of the non-hazardous liquids and products that are being transported. In addition, installing heating pads helps in maintaining the preferred temperature from the time of transportation to the destination. The heater pads commonly have a constant HDP or value flex hose. The purpose of having these hoses is to ensure the steam flow through freely to heat the product inside the Flexitank. There are a few benefits obtained from using heating pads mainly, it helps to preserve the desired temperature at the start of the load right until it has to be unloaded at the

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desired location. Besides, heater pads are used for liquids that can be easily solidified thus the load can be carried out more rapidly. Also, heater pads are reusable and they don't need to get rid of after one uses them. Therefore, in this project, the steam temperature monitoring system has been introduced to reduce the rate of damage to the heating pad. This is because the monitoring system will help to indicate the temperature that passes through the heating pad. Eventually, implementing a temperature monitoring system can produce heating pads with better operation without having unnecessary leakage on them. The damaged heating pads need to be replaced with new ones which can be costly sometimes.

2. Materials and Methods

This project is about improving the heating pad that is the heating system of the Flexitank by implementing a temperature monitoring system in it. Moreover, this project involved the use of NodeMCU as the brain for the temperature monitoring system which helps to obtain data through the support of other components such as the thermocouple, found in the system. Besides, Arduino programming software acts as the medium which been used for coding purposes to instruct the temperature sensor and obtain the temperature data through the Blynk app. The temperature monitoring of the heating system for Flexitank was developed using NodeMCU ESP32, MAX6675 Thermocouple Type K, and Blynk using the WiFi connection. The purpose is to monitor the steam heat source temperature within the heating pad of the Flexitank. Besides, this monitoring system was built using Arduino programming known as Arduino IDE to instruct the function of the whole system especially the ESP32 and the Type K Thermocouple.

2.1 Methods

```
#include <WiFi.h>
#include <WiFiClient.h>
#include <BlynkSimpleEsp32.h>
#define BLYNK_PRINT Serial  // Comment this out to disable prints and save space
#include "max6675.h"

char auth[] = "-EWWdT9AIixbGt9VMZWOl2j2_SOKZtta";

// Your WiFi credentials.
// Set password to "" for open networks.
char ssid[] = "OnePlus 7T";
char pass[] = "aaaaaaaa";
int thermoSO = 27;
int thermoCS = 14;
int thermoSCK =12 ;
MAX6675thermocouple(thermoSCK, thermoCS, thermoSO);

void setup()
{
Serial.begin(9600);
Blynk.begin(auth, ssid, pass);
Serial.println("MAX6675 test");
// You can also specify server:
  //Blynk.begin(auth, ssid, pass, "blynk.cloud", 80);
  //Blynk.begin(auth, ssid, pass, IPAddress(192,168,1,100), 8080);

}
```

```
/**************************************************
 * Send Sensor data to Blynk
 **************************************************/
void loop()
{
// basic readout test, just print the current temp
Blynk.run();
Serial.print("C = ");
Serial.println(thermocouple.readCelsius());
Blynk.virtualWrite(V3,thermocouple.readCelsius()); //virtual pin V3
delay(1000);
}
```

Figure 1: Arduino Programming Coding of Temperature Monitoring for Heating System in Flexitank

As shown in Figure 1, the first step was to add the MAX6675, WiFi and ESP32Blynk libraries. Next, the three output pins of MAX6675 Type K Thermocouple were defined and connected to pins of 27, 14, and 12 of the NodeMCU ESP32. The Authentication, SSID and Password are required to create a project in the Blynk app as shown in the figure above. Moreover, a WiFi network was required and its SSID and Password were included to ensure the WiFi is connected between the Hardware and Blynk hence, this is important as the collected temperature values from the thermocouple will later on be projected through the Blynk app. The third step was taken by setting up the Blynk app on mobile by placing the gauge and super chart graph and referring to them as Temperature Reading. On the other hand, the readings were then set to virtual pin, V3 to observe the temperature readings through the gauge and graph chart. Lastly, the temperature was displayed in Degrees Celsius.

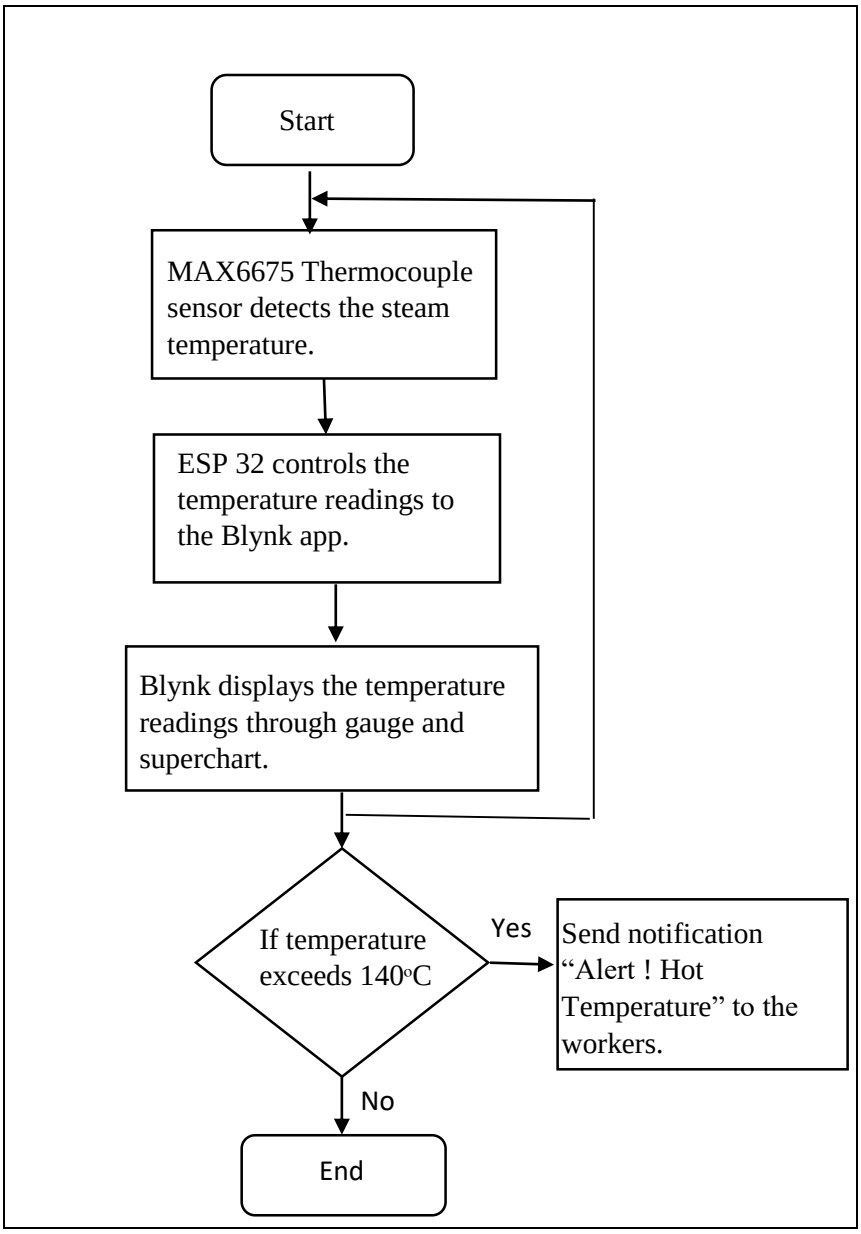

Figure 2: Flowchart of Temperature Monitoring of Heating System in Flexitank

Figure 2 shows a system flowchart of temperature monitoring of the heating system in the Flexitank respectively. The hoses were connected to the supply of steam-water hose that was to be used. When the steam is properly discharging from the outlet hoses and slowly increases the steam pressure into the heater pad. At this moment, the temperature monitoring system was activated such that the temperature sensors such that MAX6675 thermocouple type K will start to operate by detecting the temperature data of the steam from the steam generator. The process began in such a way, where these sensors collect the temperature data of the hot steam in each layer of the heating pad. All the data were received by the Blynk app were for observation and analysis purposes. This temperature observation is important to let them know that an adjustment should be made towards the heater supplier of the steam if there is an increase from the normal temperature. It is to ensure the proper functionality of Flexitank however the process of measuring the temperature from the heating pad operation will continue as shown in the figure diagram above.

3. Results and Discussion

The project assigned is entitled Temperature Monitoring System in Flexitank using IoT technology. For the simulation part, the software technique was considered initially before proceeding to hardware. This is to ensure that suitable types of electronic components to be selected to design the system for proper functionality. The software part used are Arduino IDE and Blynk. According to several studies, the `simulation results obtained through the developed Blynk from the temperature monitoring system can be studied when the temperature data obtained are transferred to excel format.

The temperature monitoring for the heating system of Flexitank was developed using NodeMCU ESP32, MAX6675 Thermocouple Type K, and Blynk using the WiFi connection. The purpose is for monitoring the temperature within the heating pad of the Flexitank. Besides, this monitoring system was built using Arduino programming also known as Arduino IDE to instruct the function of the whole system especially the ESP32 and other main components. Besides, the system ensures the temperature, is not exceed the maximum temperature of 140 ^{o}C which might cause internal damage to the heating pad and also, to the products kept above it. In this case, the temperature data will be monitored through the Blynk app on mobile.

However, the temperature monitoring system using the data logger was failed to be implemented in the heating pad. There were a few leakages that occurred on the heating pad which causes failure in proceeding with the implementation of the system on it. On the other hand, the temperature readings of the steam obtained were also shown errors when tested using the bolt thermocouple for this system, due to the bad condition of the heating pad. Therefore, the research was continued using hot water to replace the steam in the heating pad. The purpose was to test the functionality of the temperature monitoring system in general. Below shown the three sets of tests analyses were carried out using hot water for every second, replacing the steam in the heating pad, namely Result Analysis Test 1, Test 2, and Test 3. The results obtained were in three different conditions that are before the heating process, during the heating process, and cooling down process using hot water filled in a cup. Moreover, the results obtained for each test were considered for the first six seconds.

3.1 Temperature Monitoring System in Hot Water

Figure 3: Temperature Sensor (MAX6675) Interfaced with NodeMCU (ESP32)

Figure 4: Temperature Sensor (MAX6675) Interfaced with NodeMCU (ESP32)

The circuit diagram of the steam temperature monitoring system is shown in Figure 3 and Figure 4. From the diagram, we can observe the connection between the ESP32 Dev module and Thermocouple Type K sensor through jumper wires. As shown on the diagram where the SO pin of the thermocouple is connected to the D27 pin, CS pin to D14, and SCK pin to D12 of ESP32 while the Vcc pin and Ground pin of the sensors are connected to the respective 3 V3 pin and Ground pin of the ESP32 respectively. The MAX6675 temperature sensor can be powered through the VDD pin (normal mode), or it can derive its power from the data line (parasite mode). For this project, it is a normal mode circuit. The sensor was connected to ESP32 according to the right pins to ensure the proper functionality of the monitoring system.

3.2 Result Analysis

Test 1

Temperature Reading on Blynk App before Heating Process

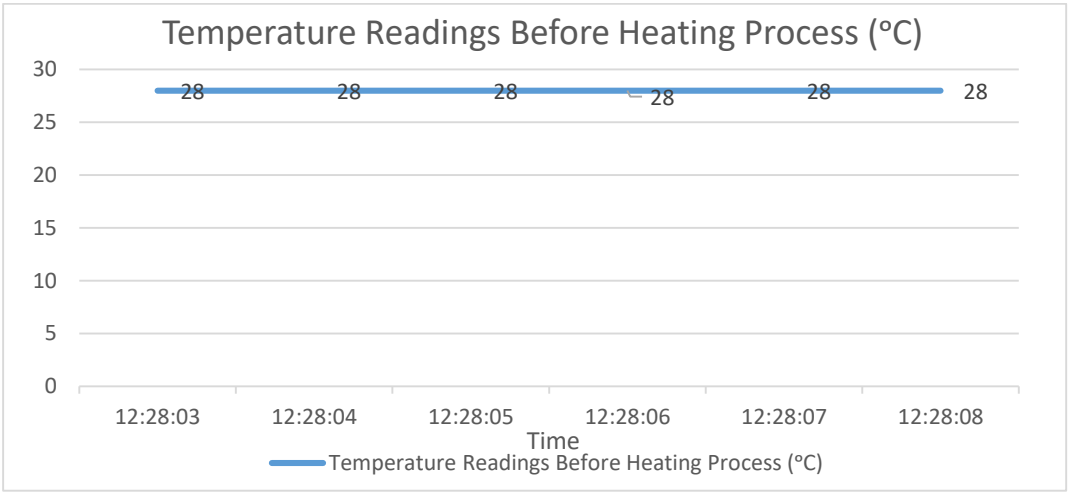

Figure 5: A graph of Temperature Reading obtained before Heating Process

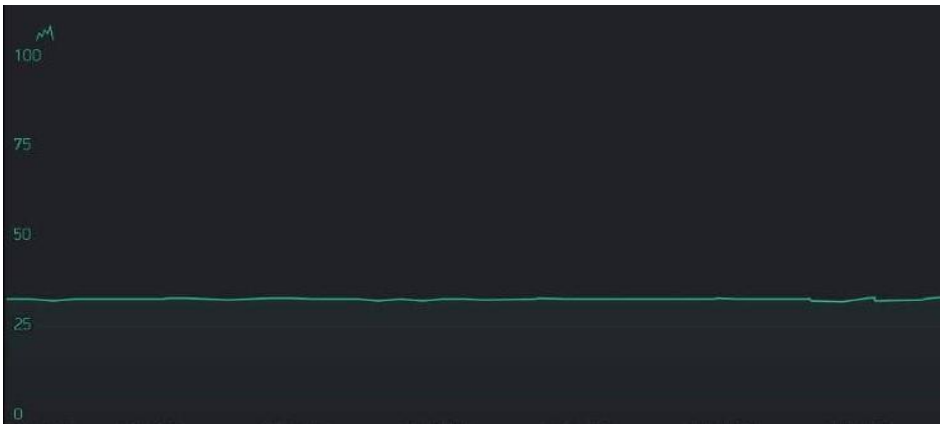

Figure 6: Temperature Graph on SuperChart of Blynk before Heating Process

The temperature reading before the heating process is shown above. These are the common room temperature recorded in the Blynk application. This result proves that the normal surrounding temperature used to be at 28 °C which is also known as room temperature. At this point, the thermocouple is said to be at a normal state which detects the surrounding temperature.

Test 2

Temperature Reading on Blynk App during Heating Process

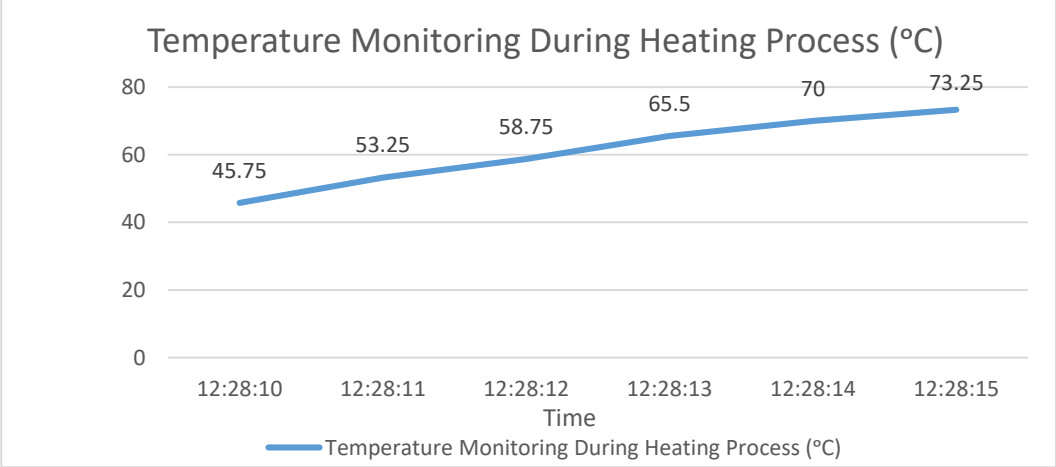

Figure 7: A Graph of Temperature Reading obtained during Heating Process

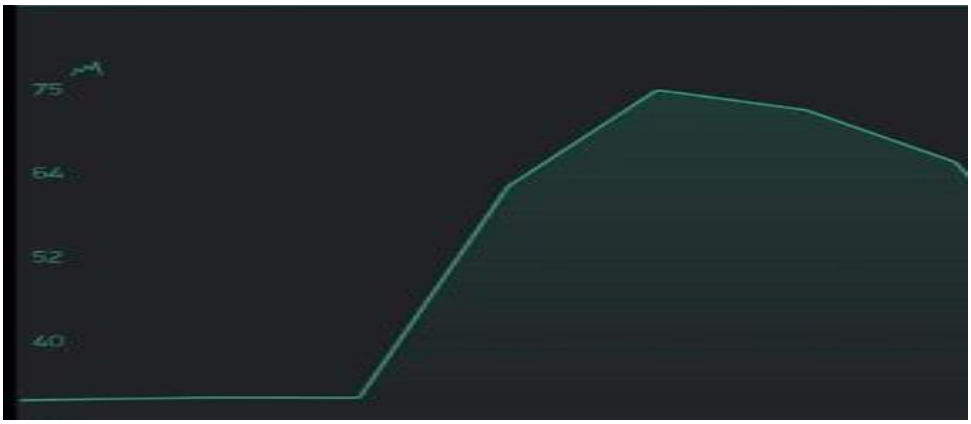

Figure 8: Temperature Graph on SuperChart of Blynk during Heating Process

As shown in Figures 7 and 8, The temperature started to rise gradually from the room temperature to above 40 °C. The MAX6675 thermocouple was used to detect the temperature reading of the hot water for this test. The capacity of type k thermocouple is above 150 °C which is quite high compared to other temperature sensors. During the heating process, the thermocouple receives the triggering from the hot temperature at its end. This well explained that the MAX6675 senses and corrects for the changes in the ambient temperature with cold-junction compensation. This device is responsible to convert the ambient temperature reading into a voltage using a temperature-sensing diode. To make the actual thermocouple temperature measurement, the MAX6675 measures the voltage from the thermocouple's output and the sensing diode.

Test 3

Temperature Reading on Blynk App during Cooling Down Process

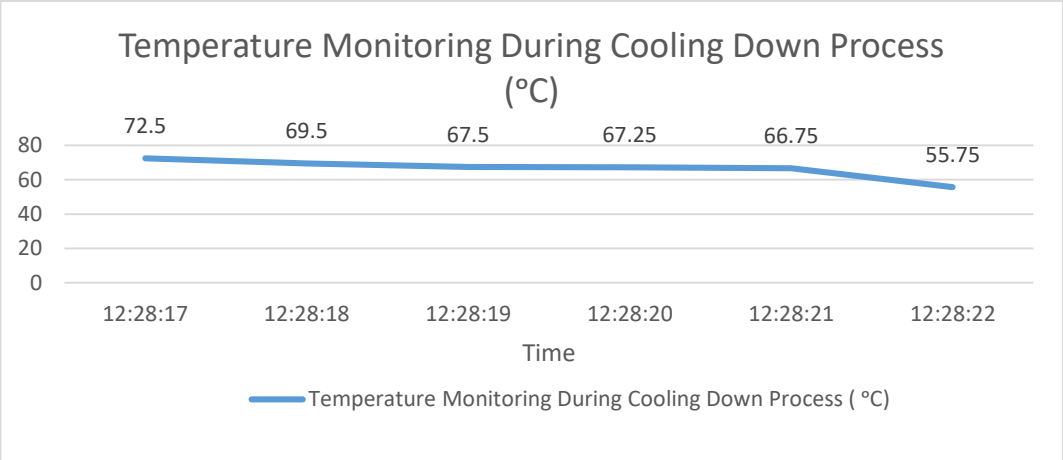

Figure 9: A Graph of Temperature Reading obtained during Cooling Down Process

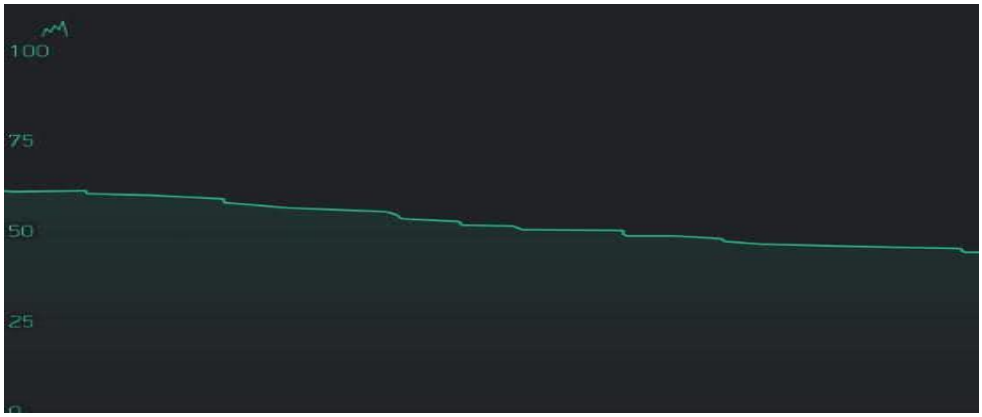

Figure 10: Temperature Graph on SuperChart of Blynk during Cooling Down Process

Based on Figures 9 and 10, shows that once the thermocouple sensor is removed from the heating of hot water, the temperature reading kept lowering and eventually back to normal room temperature. However, if hot water was replaced with a heating pad in Flexitank, at some point the steam temperature that flows within the heating pad lowers due to heat loss. Thus, the temperature reading also reduces as well.

4. Conclusion

The objective of the project has been achieved where, a prototype of Temperature Monitoring of Heating System for Flexitank is successfully built. This system is capable of

giving an accurate reading of the steam temperature in the heating pad. The project assigned is based on the improvement to be given towards the Flexitank. One of them will be the implementation of a temperature monitoring system in a heating pad also known as heating system. Somehow heating pads are playing a very important to make sure the products carried in the Flexitanks are kept safe and properly delivered to their destination. The operation of heating pads, upon the container arrival by spacing the right-hand door of the container needed to be untied of the rubber hoses that are attached to the bulkhead. Later on, adjust the hoses and connect one to the supply of steam hose that to be used. This way is to make sure the steam is properly released from outlet hoses and slowly increase the steam pressure into the heater pad. Next, it is important to check the melting temperature of the product and confirm that the products are not extremely heated. However, the discharge process will be initiated without removing the heat source once the product has been adequately melted. The heat source should be connected until 1/4 of the product remains and slowly begins to decrease the steam pressure. This process is vital to allow the heating system to be cool off before detaching all hoses and unloading the pads once the operation is ended. The typical products which require the application of a heating pad are such as Oils, Fats, Organic Compounds, and Sweeteners. Several recommendations have been suggested that will help to improve this study in the future such as various types of display such as Bluetooth display using a mobile phone or LCD for temperature, can be used for further study as it is eco-friendly and cost-effective material. The operation of the heating system in Flexitank should be upgraded by checking its safety and maintenance aspects to prevent damaged heating pads that can cause leakage and problems to give accurate temperature readings. The hoses connected from the steam generator contacting to the heating system or heater pad should have a medium surface area to ensure better steam and its pressure to be pumped into the heating pads.

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