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Original Research Article

Design and Construction of Temperature Control Water Tank for Cassava Fermentation at 35^0c

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Abstract: This work aims to provide an alternative source of raising the temperature of water used in soaking cassava to a level that is normal for fermentation process to start and maintain it for the period of four days. Test was carried out to determine the effect of the environmental temperature on cassava fermentation process. Two set of tanks were used to soak the cassava, one was under control (temperature controlled water tank) and the other not controlled for a period of four and six days respectively. The maximum environmental temperature and process temperature for the controlled experiment was found to be 28^oc and 34^oc respectively while for the uncontrolled experiment, the maximum environmental and process temperature was found to be was found to be 28^oc and 32^oc respectively. The electrical parameters of the completed water tank was measured and it was found that the output voltage of the zener diode used to clean up the output of the voltage comparator was 5.2V instead of the rated 5.6, while the output of the set point temperature to voltage converter circuit was 8.34 volt instead of the calculated 8.39volts.

Keywords: Cassava, Fermentation, Temperature, Solar energy, Voltage, Circuit.

1. INTRODUCTION

The challenge of temperature measurement and control has been in existence for over 120 years and has experienced series of modifications. The possibility of temperature measurement and control is a product of an experiment of 1821 conducted by the German physicist Thomas Johann Seebeck, where he discovered the possibility of generating electrical signal from two dissimilar metals of different thermal conductivity with both edges making a common junction Enn Velmre (2007). Agriculture is all about the growing of crops and rearing of animals for mans use. One of the factors affecting agricultural production, preservation and processing is the availability of heat in the form of solar energy for either processing or preservation of crops.. It is important to note that plants which occupy the position of “primary producers” in the ecosystem depend on solar energy (ie sunshine) to achieve production through the process of photosynthesis. The growing demand for food and the unstable price of fossil fuels has led to the search for environmentally friendly sources of energy (Yuliana 2019) A combination of the relentlessly rising world population and the industrialization of developing nations drive a dramatic increase in overall energy demand. Several researchers have focused to provide a sufficient amount of food by using alternative technology with a different energy source (Yuliana 2019). Most agricultural products like rice cannot be consumed immediately after harvest while crops like corn, pepper, melon, beans, etc. need to be dried properly for the purpose of preservation. All these crops require solar energy for the purpose of preservation and processing. Where solar energy is absent due to change in weather conditions, an alternative method of generating heat equivalent to solar energy becomes imperative. The utilization of solar PV and solar thermal devices is suitable in areas which are endowed with abundant solar radiation with more than 325 clear sunny days (Surendra *et al*. 2018). Energy is the largest overhead cost in the production of agricultural greenhouse crops in temperate climates. Moreover the initial cost of fossil fuels and traditional energy are dramatically increasing (Reda H *et al*. 2016).

2. LITERATURE REVIEW

A conducive temperature environment is indispensable in the preservation of various products in the manufacturing and industrial sectors. The agricultural sector is not excluded, as it is important also to monitor the level of temperature of various Plants and food products. Places such as morgues, hospitals, aircrafts, living rooms, etc, also need to

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ensure that optimum thermal condition is maintained so as to achieve utility. Thermal comfort is generally defined as that condition of mind or functionality which expresses satisfaction with the thermal environment (Ogu *et al.* 2011). Energy is one of the major parameters for establishing growth and progress of the country, rather the standard of living depends directly upon the per capital energy consumption. Most of energy on the earth is received from the sun (Ali S.M *et al*. 2012). In agricultural systems, energy is available from different sources as human, animal, sun, wind, biomass, coal, fertilizer, seed, agro-chemicals, petroleum products, electricity etc. Energy sources that release available energy directly to the system are classified as direct energy sources. Renewable energy and farming are a winning combination. Wind, solar, and biomass energy can be harvested forever, providing farmers with a long-term source of income. Water tank systems are being used to illustrate both traditional and advanced multivariable control strategies. Aturo *et al.* (2009) developed a design procedure of a MIMO PID (Multi-Input-Multi-Output Proportional–Integral–Derivative) control system for controlling level and temperature in a water tank plant. The study considered a water tank system described by interconnected nonlinear differential equations. The objective control consist in stabilize level and temperature of the water tank simultaneously employing a MIMO PID controller. **(**Varalakshmi *et al*. 2014) defined the performance of water tank level control system for the PID controller and Fuzzy Logic Controllers (FLC). FLC was implemented using a smaller rule set and PID Controller is tuned. For the tuning of PID controller and the calculation of PID parameters Ziegler Nichols second method (process reaction curve method) was used. The study was conducted using the help of MATLAB Simulink Software. In many industrial processes, control of liquid level is required. Water level control is highly important in industrial applications such as boilers in nuclear power plants. A number of controlling techniques has been proposed to control the processes in order to get the better efficiency. PID controllers are the most commonly used approach which is effective in the temperature control process.

3. METHODOLOGY AND MATERIALS

The design of some vital components of the temperature control water tank is presented below;

3.1 Design of heater temperature to voltage converter circuit

The circuit diagram for the heater temperature to voltage converter circuit is shown in fig 3.1 below. It consists of a thermistor R_T, resistor R_1 and an amplifier.

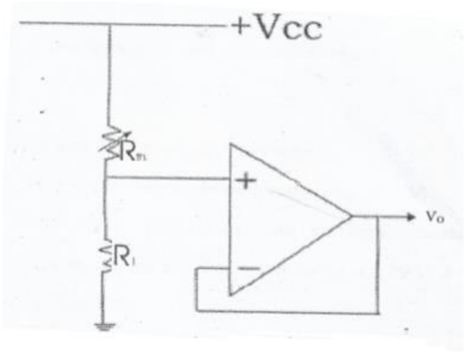

Fig-3.1: Heater Temperature to voltage Converter Circuit

The negative temperature coefficient (NTC) data is presented below.

NTC MF51 – A was selected because of its temperature range which is -20^{0}C to +250^{0}C which is suitable for the working environment temperature (35^{0}C).

By measuring the resistance of the NTC thermistor and the temperature of water, table 3.1 was obtained.

Table-3.1: NTC thermistor resistance vs temperature measurement.

S/N	Temperature ^{0}C	NTC resistance (Ω)
1	29^{0}C	5.1
2	35^{0}C	4.53

From the voltage divider network in fig 3.1

$V_i = \frac{R_c V_{cc}}{R_1 R_T}$ ……………………………………….3.1

Where R_T = resistance of thermistor

V_{CC} = 12V (since the switching relay is 12V)

Let R_1 = 10Ω (since the minimum and maximum resistance of the NTC thermistor at 29^{0}C and 35^{0}C is below 10Ω)

At 29^{0}C, Let V_i = V_{ia} and R_T = 5.1Ω (from measurement).

That is, $V_{ia} = \frac{10}{10+5.1} \times 12 = 7.95V$

At 35^{0}C, Let V_1 = Vib and R_T = 4.53Ω, That is; $Vib = \frac{10}{10+4.53} \times 12 = 8.26V$

At 35^{0}C, Hence 8.26V becomes the max reference voltage (at 35^{0}C).

3.2 Design of the reference voltage circuit

The circuit diagram for the reference voltage circuit is shown in fig 3.2 below. The reference voltage circuit consists of R_2, R_3, R_4 and LD, (indicator LED).

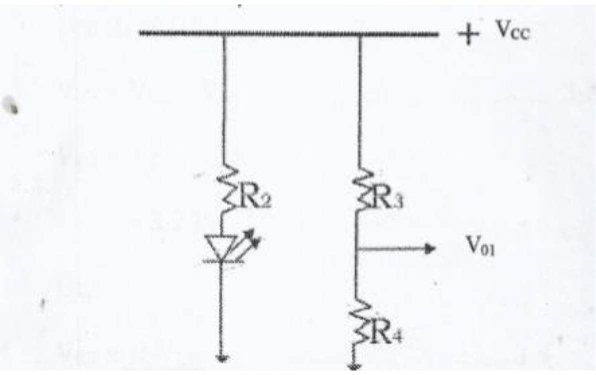

Fig-3.2: Reference voltage circuit.

3.3 Design of 35^0c temperature indicator led

The circuit diagram for the 35^0C temperature indicator LED is shown in fig 3.3

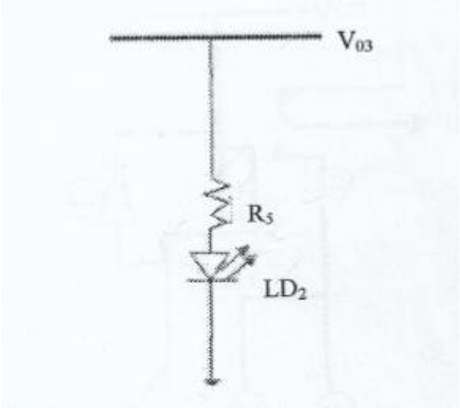

Fig-3.3: 35^0C Temperature Indicator LED

Recall; LED specification.

$I_{LED} = 20mA$, $V_{LD} = 2V$.

Applying the equation.

$$R_{LED} = \frac{V03 - VLD}{ICD} \text{ …………………… } 3.2$$

$$R_5 = \frac{5.7-2.0}{20 \times 10-3}$$

$R_5 = 185\Omega$

$R_5(p_{ref}) = 180\Omega$.

3.4 Design of the automatic heater control (switching) circuit.

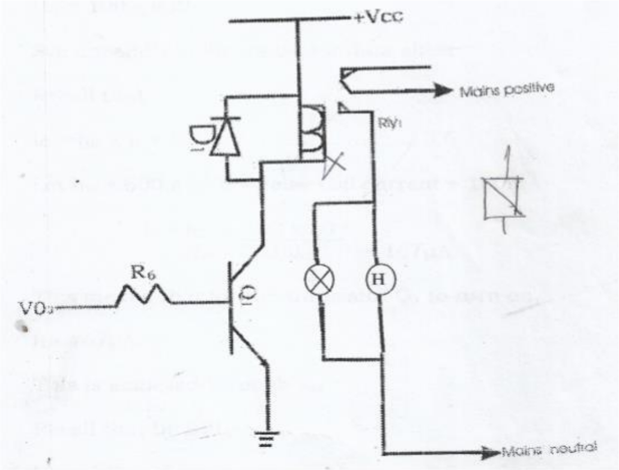

Fig-3.4: The Automatic Heater Control (Switching) circuit.

Heater element specification

The heater element has the following specification

Voltage = $220V_{ac}$, Power = 1000watts

Recall that;

P = IV Where; I = current, V = Voltage, P = Power, $I = \frac{P}{V} = \frac{1000}{220} = 4.\ 54A$.

4. RESULTS

The following tests were carried out to determine the overall performance of the circuit and the corresponding observations and results were recorded and tabulated in table 4.1 to 4.3

Table-4.1: Environmental Temperature and Cassava Fermentation process Temperature (under control) and time of measurement.

S/N	Day	Time	Env. Temp	FER. Process temp
1	Day one	9:00am	27^0C	34^0C
2		2:00pm	28^0C	34^0C
3		7:00pm	28^0C	33.5^0C
1	Day two	9:00am	27^0C	34^0C
2		2:00pm	28^0C	34^0C
3		7:00pm	27^0C	34^0C
1	Day three	9:00am	26^0C	33^0C
2		2:00pm	28^0C	34^0C
3		7:00pm	28^0C	34^0C

Remark: fermentation process complete after the third day

CARGO CASSAVA SPECIE UNDER CONTROL

Table-4.2: Environmental temperature and cassava fermentation process temperature (under control) and time of measurement

S/N	Day	Time	Env. temp	Ferm. Process temp
1	Day one	9:00am	27^{0}C	34^{0}C
2		2:00pm	28^{0}C	34^{0}C
3		7:00pm	28^{0}C	33.5^{0}C
1	Day two	9:00am	27^{0}C	34^{0}C
2		2:00pm	28^{0}C	34^{0}C
3		7:00pm	27^{0}C	34^{0}C
1	Day three	9:00am	26^{0}C	33^{0}C
2		2:00pm	28^{0}C	34^{0}C
3		7:00pm	28^{0}C	34^{0}C
1	Day four	9:00am	26^{0}C	33^{0}C
2		2:00pm	28^{0}C	34^{0}C
3		7:00pm	28^{0}C	34^{0}C

Remark: Fermentation process complete after the fourth day

Table-4.3 Environment and Cassava Fermentation process temperature (uncontrolled)

S/N	Day	Time	Env. Temp	Fermentation. Process temp
1	Day one	9:00am	27^{0}C	32^{0}C
2		2:00pm	28^{0}C	30^{0}C
3		7:00pm	28^{0}C	30^{0}C
1	Day two	9:00am	27^{0}C	29^{0}C
2		2:00pm	28^{0}C	31^{0}C
3		7:00pm	27^{0}C	30^{0}C
1	Day three	9:00am	26^{0}C	29^{0}C
2		2:00pm	28^{0}C	31^{0}C
3		7:00pm	28^{0}C	30^{0}C
1	Day four	9:00am	26^{0}C	29^{0}C
2		2:00pm	28^{0}C	28^{0}C
3		7:00pm	28^{0}C	29^{0}C
1	Day five	9:00am	26^{0}C	28^{0}C
2		2:00pm	28^{0}C	30^{0}C
3		7:00pm	28^{0}C	29^{0}C
1	Day six	9:00am	26^{0}C	29^{0}C
2		2:00pm	28^{0}C	30^{0}C
3		7:00pm	28^{0}C	30^{0}C

Remark: Fermentation process complete after the sixth day

5. CONCLUSION

This test was carried out to determine the effect of the environmental temperature on cassava fermentation process. Two set of tanks were used to soak the cassava, one was under control (temperature controlled water tank) and the other not controlled. The environmental temperature and process temperature (controlled and uncontrolled) has been recorded. The design and construction of the temperature controlled water tank for cassava fermentation was based on electronic principles as it provides a detailed report on the key features of each component. However, the research is opened to further studies as further work could be done in improving the aesthetics and providing a digital temperature display for the component.

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