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Digital Control of Temperature with the Volume of Geyser and Reduction in Water Wastage

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Abstract: The proposed research in this study is carried out in order to reduce water wastage. On an average, one person wastes a minimum 30 L of water every month during the Winter season or throughout the year in countries where ground water is not used in showers. The proposed study uses a circuit named as the water controller circuit which reduces water wastage. The water controller circuit has an insulated storage tank placed between the geyser and the shower water lines, the insulated storage tank is connected to both water line coming out of the geyser and main water line. The water flow in the insulated storage tank is controlled with the help of a digital timer and a temperature sensor. The timer counts time in minutes and temperature in °C. This circuit is built with the help of the microcontrollers. The timer circuit is compared with the timer of "Polar Smart Watch" and Apple iPhone 6s. The temperature sensor circuit is tested by placing in the 9 L bucket of melted ice water and in another test placed closed to heater operating at maximum heat. The proposed research is tested with three geysers of different makes and a gas geyser. The circuit provides excellent results.

Key words: Polar smart watch, Apple iPhone, microcontrollers, gas geyser, storage tank, temperature

INTRODUCTION

Due to global warming, some countries are facing the problem of drought. The researchers of this study is living in Cape Town which faced a serious drought in year 2015-2017, the city was almost approaching to "Day Zero". The dam levels fall to 10% in March 2018. South Africa is a water scarce country and ground water is also not suitable for drinking and cooking purposes in the most parts of it (Donnenfeld *et al*., 2018). The people are using different ways to save water and researchers are also working to find ways. Tangwe *et al*. (2018), a retrofitting geyser with hotspot device is used to control and monitor water utilization. The solar water heater is used to collect solar energy in a device named as the collector and then solar energy is converted to thermal energy which is then transported to the storage tank of hot water using the thermosiphon process (Barry, 1940). The Air Source Heat Pump (ASHP) is proposed by Levins (1982). It is capable of providing energy saving of around 50-70% as the ASHP unit has a performance co-efficient ranging from 2-4 (Bodzini, 1997; Morrison *et al*., 2004). Patil and Bhadade (2017) a method is proposed in which coil directly heats the fluid. The static model and analytical results of gas inflow is done for a spouting period by Kagami (2015). The researcher in literature focusses on saving of electric energy while heating the geyser. The researcher in this study focuses on saving water without affecting the performance of geyser. The Cape Town residents are facing water restrictions, people are using the shower water for gardening and flushing purposes this attracts the researcher attention to develop something which can reduce the water wastage. Mostly in the Winter season, people take bath in hot water and geyser is used for heating the water. When a shower is turned on initially a minimum of 1L water gets wasted before hot water comes out and another litre or more to set the required temperature of the water. The researcher in this study is done to minimize this wastage of water using a water controller circuit placed between the geyser and the shower.

Water controller circuit: The block diagram of the water controller circuit is shown in Fig. 1. It consists of a Display Unit (DU) placed on wall of shower where the required temperature and volume are entered, a geyser, main system functional units for hot and cold water named as H and C. The H unit controls the flow of hot water and C unit controls the flow of cold water in the insulated storage tank. The insulated storage tank is capable of keeping temperature nearly constant for 30 min. The H and C units take temperature data from temperature sensors and decides the time for which knobs of hot water and cold water will be turned on and off. The measurements of required volume of hot and cold water is carried out by a microcontroller. The water lines of hot

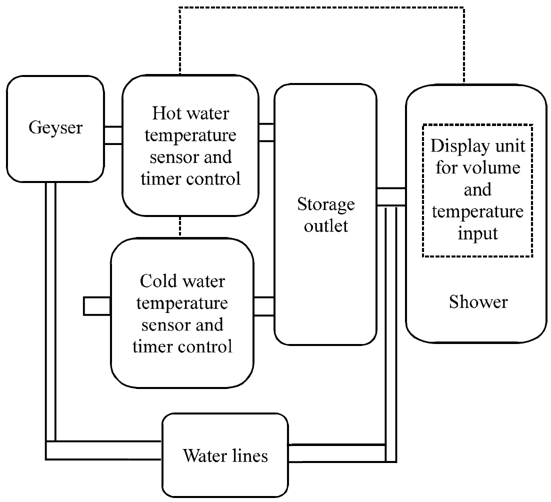

Fig. 1: Block diagram of water controller circuit

and cold water are turned off after transferring the required volume of hot and cold water in storage tank. The water lines are normal water lines in which water comes from municipal lines.

The water in water lines is considered as cold water and is denoted by T_c. The water coming out of the geyser is hot water and is denoted by T_H. The temperature denoted by T_F and volume denoted by V will be entered by user on the display unit in the shower. The input volume is equal to sum of hot and cold water volume denoted by V_H and V_C, respectively, also $V = V_H+V_C$. For m_H and m_C mass of hot and cold water, S is specific heat of water where $m_c = \rho V_C$ is density, replacing $m_H = \rho V_H$ and $m_C = \rho V_C$. Using equation of entropy:

$$m_H = (T_H\text{-}T_F)S = m_C(T_F\text{-}T_C)S \quad (1)$$

We have:

$$V_H = V\frac{(T_F\text{-}T_C)}{(T_H\text{-}T_C)} \text{ and } V_C = V\frac{(T_H\text{-}T_F)}{(T_H\text{-}T_C)} \quad (2)$$

Let tap of geyser fills ι_F L of water in time t minutes and cold water tap fills ι_2 L of water in time minutes. The total time taken denoted by (t) in minutes to fill storage of V litre of final Temperature T_F can be calculated as:

$$t = \frac{t_1}{\iota_1}\times V_H + \frac{t_2}{\iota_2}\times V_C \quad (3)$$

The water at temperature T_F and volume V will be stored in storage tank. The geyser input line is kept turned off during the time its output line or hot water line is on. Figure 1, the storage tank water line going to shower is connected to another line which is connected to a normal water line of home. This line sucks the remaining water in this line and the storage tank when the shower tap or knob closes, after a delay of 5 min and loop back to the input line of the geyser. This will increase the temperature of the water going inside geyser which will reduce electricity consumption.

MATERIALS AND METHODS

The sensors chosen for temperature sensing is IC LM35DZ. The reason for selecting this IC is due to its low impedance, its precise regulation capability which results in easy interfacing and linear output. The control units for hot and cold water have an ADC and microcontroller. The ADC chosen is CA3162. The information received from temperature sensor ICs is time domain coded, requires noise removals and edge sharpness for proper sampling which is provided using anti-aliasing filter. The ADC is also adjusted to provide better accuracy. The microcontroller chosen is Atmel, AT89C4051-24 PU. It's an 8-bit microcontroller and has 4K Bytes of flash memory. The display unit chosen is PC 1607-A which can be activated using microcontrollers only and has LCD display. The microcontroller programming is written in C-language.

RESULTS AND DISCUSSION

The timer circuit is compared with timer on the Smart watch of Polar (M600) and on iPhone 6s all the three timers started simultaneously. The temperature sensor was also tested in two scenarios: placed close a heater and is put inside a bucket of ice. The reading is compared with the reading of a digital thermometer. The difference in reading was acceptable and is $<\pm 0.025$. The water controller circuit was tested on three different company's electric geyser. Both the temperature and timer units performed adequately. The temperature in storage tank unit is measured and is in accuracy of $\pm 0.05T_F$°C which is acceptable as work is not finally assembled. One of the tested geyser is shown in Fig. 2 and the microcontroller circuit with temperature display is shown in Fig. 3. In Table 1, geysers with hot water set at different temperature are compared.

The Temperature T_H^A : T_C^A and T_F^A, represents actual temperature reading in temperature sensor circuits in water controller circuits while T_C, T_H and T_F are temperature readings of digital thermometer. The used geysers are 100 L and insulated storage tank is of 9 L.

Fig. 2: Geyser with temperature sensors and control

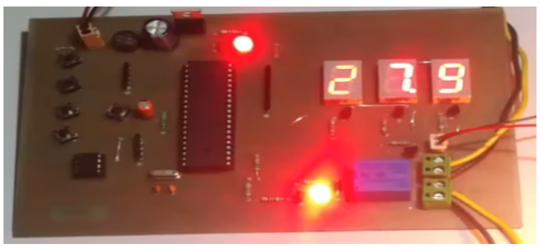

Fig. 3: Display unit and microcontroller circuit board

Table 1: Comparison of different geysers

Geyser	T_H	T_H^A	T_C^A	T_F	T_F^A	V_C	V_H	t-values
1	60	59.8	6.9	41	40.8	3.2	5.8	2.2
2	58	58.1	7.05	42	41.9	2.8	6.2	2.9
3	59	58.7	7.15	43	42.8	2.8	6.2	2.9

L_1/t_1 = 3.785 litres/min, L_1/t_1 = 3.785 litres/min Tc = 7.V = 9

From results of Table 1, it’s clearly evident that higher is the temperature of the hot water less water is required from geyser and less time to store required volume of water for shower.

CONCLUSION

In this study, a water controller circuit is explained which is placed close to geyser in homes. The main aim of the work is reduce water wastage during shower. The circuit performed excellently with different company’s geyser and variable speeds of water lines. The circuit is cost effective too as microcontrollers are used to build the circuit. In future, research can be done to connect the display unit with a smart phone, so that, user can enter the required temperature and volume of the water from outside home. The cost of circuit is also very less as it is built using microcontrollers and tested with scrapped geysers.

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