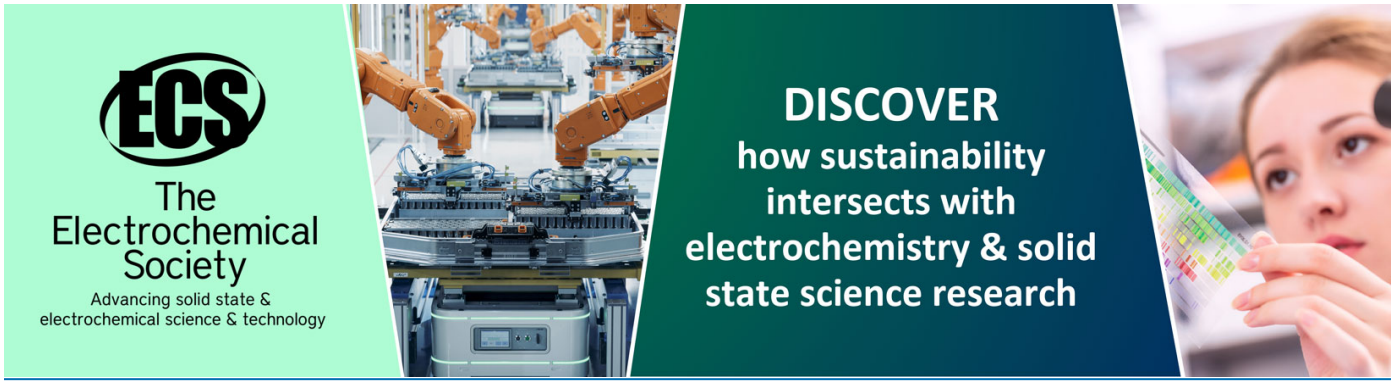
Development of a glass melting furnace with online control systems



Development of a glass melting furnace with online control systems

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Abstract. In this research, a small glass melting furnace was built with a dimension of 12 x 12 x 9 cm^3. The tracking control and notification systems were developed using the Arduino board running through the internet. The 1.2-mm wires were twisted into the 8.3-mm heating coils with the resistance 12.0 . When 11.0-A current was applied to the heating coil, the furnace can be operated at maximum heating rate around 5.7 /min. and max continuous operating temperature at 1200 . After the test run of this furnace and control system, it was found that this apparatus can be used as a replacement of a traditional one. Furthermore the cost of this furnace is cheaper than a traditional one up to 17 times.

Keyword: Melting furnace, Pot furnace, Temperature controller, Arduino

1. Introduction

Glass melting furnace can be regarded as a chemical reactor producing glass by a series of solid-liquid state reactions. All glass formation reactions occur at very high temperature in a confined space surrounded by refractory [1]. The heat generated for melting is supplied by oil, natural gas or electrical system combustion. However, only a portion of the total heat input is used for melting glass. As a matter of fact, most of the heat can lost to the walls, the crown and the opening holes of the furnace [1]. Each design of furnaces has different advantages depending on the suitability of use.

Electric furnace, a heating chamber with electricity as the heat source for achieving very high temperatures to melt an alloy metals and refractories. The electricity has no electrochemical effect on the metal but simply heats it [2]. There are many types of electric furnaces, one of which is resistance furnace. Resistance furnace is an electric furnace in which the heat is developed by the passage of current through a suitable internal resistance that may be the charge itself, a resistor embedded in the charge, or a resistor surrounding the charge [2-3]. Automatic control of the power and, consequently, of the temperature conditions in such a furnace is easily implemented.Resistance furnaces are readily mechanized and automated, thus alleviating the work of personnel and facilitating the inclusion of such furnaces in automatic transfer lines. In addition, they are compact [4]. Such furnaces provide a secure environment for various processes. One problem is cost because the controller in automatic power control is expensive. [3,5]

In this research, the glass melting furnace with tracking control and notification system was developed. The system was invented using Arduino board working through the internet. It was

designed to substitute a microcontroller system and can reduce the cost by 17 times compared to the conventional one. The performance of the furnace were investigated in terms of the electrical resistance and current of the heating wires and the heating rate and maximum temperature of the furnace.

2. Experiment

In this work the glass melting furnace was made to a cubic shape from light brick C-2 and covered with fiberglass blanket as shown in Figureure 1a. The top of the furnace was designed to be opened for load out crucibles. The inner part was surrounded by a resistance coil in ceramic protection tube, which is the source of heat furnace, as shown in Figure.1b.The thermocouple was placed above the coil to measure the temperature inside the furnace. The tracking control and notification systems were developed using the Arduino board displayed and running through the internet on the Blynk application, which makes this an inexpensive system compare with traditional control system.

Figure 1. a. Glass melting furnace, which is 14 cm high and 23 cm wide

Figure. **1.** b. The inner of the furnace, which is 9 cm high and 12 cm wide

he schematic diagram of the device is shown in Figureure 2. The thermocouple (Arduino sensor MAX 6675) and solid-state relay are connected to the Arduino board (WeMos D1 WIFI ESP8266). When the device is ON, the Arduino board receives data from the thermocouple. The data is then processed to control the solid state relay applying electrical current into the circuit according to the conditions in the commanding code.

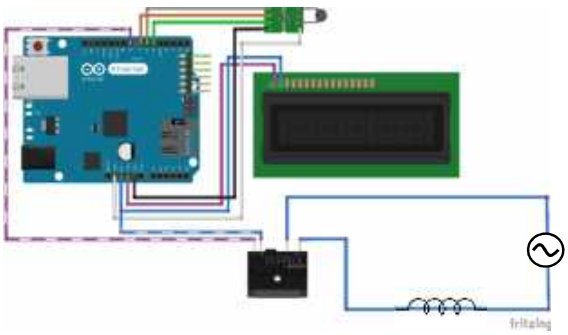

Figure 2. A schematic diagram of the device and electrical circuit

Figure 3. show the interface of tracking control and notification running through the internet by Blynk application. This application can be connected to an Arduino circuit board for data logging and transferring data to the Arduino board. In the interface have components for tracking control as shown in Figure.3. In the work tracking part, at the top is the temperature profiles for shown the heating rate of melting furnace middle-left is the temperature gauge for show current temperature. Middle-right is working power button and the below is a slider button for setting the target temperature.

Figure 3. Interface for tracking control of Blynk application

3. Results and discussion

Table 1. Some parameters of furnace in this work

Max continuous operating temperature, °C	1200
Maximum heating rate, °C/min	5.7
Electric current, A	11.0
Input power, W	2420
Working chamber dimensions, mm	120 x 120 x 90
Wire diameter (d), mm	1.2
Outer coil diameter (D), mm	8.3
Heating coils with the resistance,	12.0
Furnace atmosphere	Air

Some parameters of the glass melting furnace have been presented in Table 1. The furnace use about 2420 W of power consumption. The 1.2-mm wires were twisted into the 8.3-mm heating coils with the resistance 12 . Measurable currents about 11.0-A. When current was applied to the heating coil, the furnace can be operated at a maximum heating rate around 5.7 /min as shown in Figure.4 and max continuous operating temperature at 1200

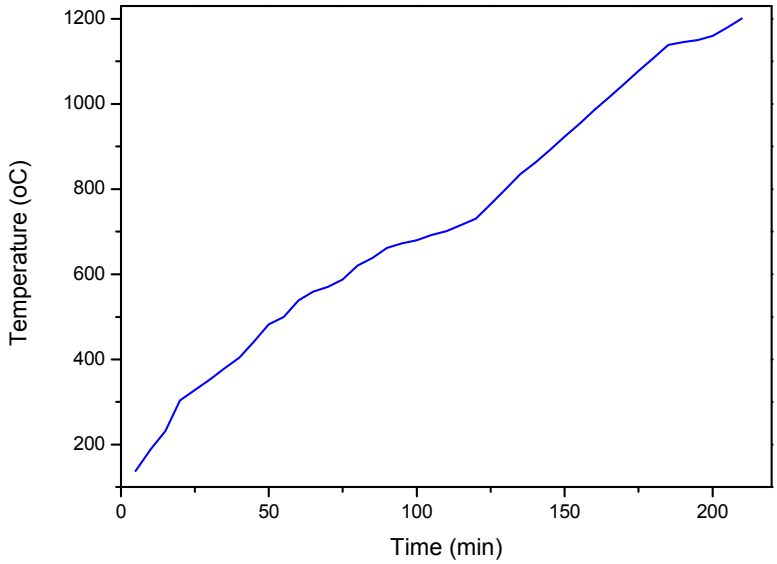

Figure 4. Temperature versus time of furnace with heating rate 5.7 /min

Table 2. List of individual components to assemble device and purchase price

Components	Price (US $)
Micro-Computer (Arduino WeMos D1 WIFI ESP 8266)	8.36
Arduino sensor (MAX 6675)	3.09
LCD monitor (LCD monitor 1602 5V for Arduino)	1.61
Jumper wire for Arduino	1.00
TOTAL	13.06

The cost of the various components, that were used to make the device, is listed in Table 2. The primary components, the Arduino board (WeMos D1 WIFI ESP 8266), Arduino sensor (MAX 6675), LCD monitor, together with cost US$13.06. When compared to the controller a traditional one (temperature controller FU72, US$ 231.78). Obviously, the cost of this furnace is cheaper than a traditional one up to 17 times.

4. Conclusions

The result of test performance of the furnace when operate at maximum temperature (1,200 °C) show that.

- The maximum heating rate was about 5.7 °C /min.
- Power consumption of furnace was about 2420 watt.
- The tracking control and notification running through the internet.

- The cost of this furnace is cheaper than a traditional one up to 17 times.
- The controller board can be designed temperature profiles more than traditional control.

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