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Flow Rate and Volume Control of Fluid Based on Arduino for Synthesis of Silver Nanowires

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Abstract. In this study, we have successfully developed a flow rate and volume control system based on Arduino. This system consists of a container containing liquid, dc motor, keypad, and Arduino UNO that serves as a controller. The principle of this system is to control pulse width modulation (PWM) and delay time of dc motor using Arduino. This fluid flow and volume rate control system aims to control how much the fluid volume enters a chamber for mixing the solution. This system has an accuracy rate of 0.5 ml and has a measurement range of up to 100 ml for one process. For forward, the system will be applied to the medical as a substitute for syringe pump and research laboratory for controlling the manufacture of solutions on the synthesis of nanomaterials, especially silver nanowires.

1. Introduction

The rapid technological advances, helping humans in various jobs one of them is the use of water pumps. During this time, the water pump is mostly used to assist in moving water from a source to a shelter [1] without controlling the volume of water. The application of the water pump is growing now. Many simple methods and tools are used in the application of water pumps for various purposes.

In the medical world, the application of the water pump was used on the syringe pump. A water flow channel in the form of an injection or automatic infusion with a flow rate system [2]. There are several studies related to this syringe pump, which are among others such as by using the microfluidics method [3]. Microfluidics method is a method to push and control the flow of a fluid through a microfluidic chip channel. This study is use the function of pressure against time in controlling fluid flow (water). Another study with a pressure function with the development of a syringe pump system that was carried out using a pressure sensor to detect infusion flow pressure [4]. For another system, the development of syringe pumps to assist the anesthesia process in injecting automatic anesthetics using a PIC16F877A microcontroller [5]. In science, a similar method for the titration was commonly used in laboratories to determine the concentration of a reactant with chemical method based on measurements of volume [6].

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In this study, we developed a simple volume control system based on Arduino as a regulator of water pump. Arduino uno is a minimum system developed from ATmega328-based microcontrollers. This study uses a DC motor (direct current) which converts electric power into mechanical power that will be the driving force of water from the water source by inputting the desired volume value on the keypad. By applying the pulse width modulation (PWM) function which is generally a way of manipulating width the signal. It is expressed by pulses in a period, to get a different average voltage. Furthermore, the results of our study are verified by using a measuring glass to calculate the value of accuracy, precision, and uncertainty.

2. Materials and Methods

Materials were used in this research: Arduino Uno R3, IBT-2 driver (BTS7960), DC pump motor, 4x4 matrix keypad, power supply, hoses, and measuring glass. The principle of the fluid volume by controlling the speed and time of the DC pump motor to spin or live using PWM technique. Controlling the rotation speed of DC pump motor by adjusting the PWM using the IBT-2 dc motor driver type of BTS7960. The DC pump motor rotation speed is made stable so that it gets the highest efficient value. After the DC pump motor speed rotation was stable, we can control the length of time the motor rotates by using the 'delaytime' function using Arduino. The 4x4 matrix keypad used to input value of the volume into the Arduino, where the 'A' button used as the enter function.

3. Results and Discussion

The control system for measuring fluid volume has been made using Arduino Uno as a controller for controlling the IBT-2 dc motor driver (BTS7960) to connected by the DC pump motor. The block diagram of the research tool as shown in figure 1 and the fluid volume measuring devices as shown in figure 2.

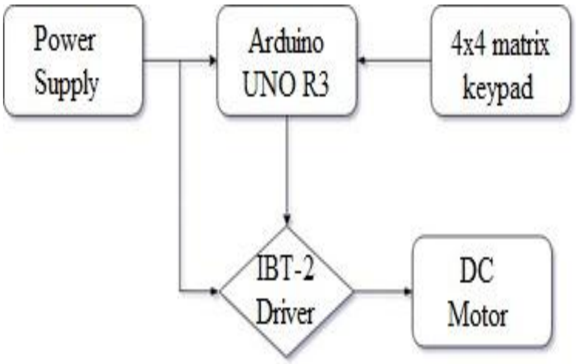

Figure 1. The block diagram of fluid volume control.

Figure 2. The rate of fluid volume measurement tool.

Figure 2 shows that the water source drawn by the pump is then flowed through a hose to the measuring tube. The first thing before starting the measurement is to make the entire hose filled with liquid that is used not to have wind on the hose or pump. Because if there is wind on the pump hose it can cause deviations in the desired output volume. The process that was first carried out in research was by calibrating between the amount of volume and the amount of time, so that it was obtained how much time was needed to turn on the pump if it wanted to get a certain volume. The results of calibration on the tools made can be seen in figure 3.

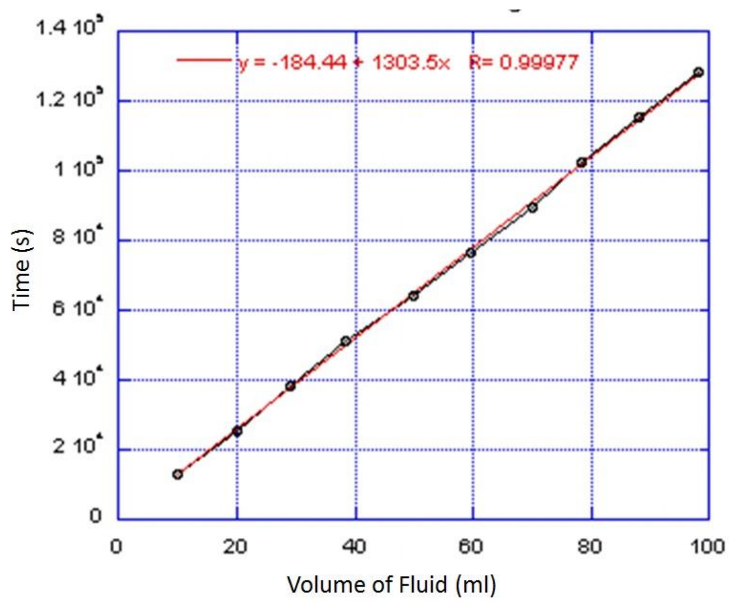

Figure 3. Calibration graph of the relationship between volume and time.

Figure 3 shows a volume calibration graph with time is obtained which has an equation $y = 1303.5x - 184.44$, where x is the desired volume value and y is the value of the time needed to achieve a certain volume target. The linearity equation obtained can be entered into the Arduino program to obtain the same volume value as the input given. A comparison chart between the value of input volume and output volume as shown in figure 4.

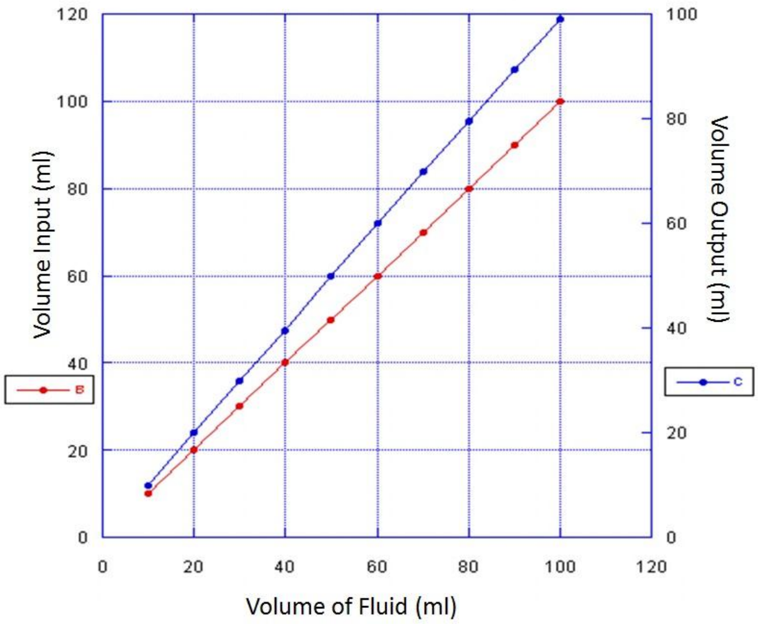

Figure 4. Graph Comparison of output volume with input volume

Figure 4 shows the difference between the value of the output volume that should be obtained with the results obtained from the measurement. Although the differences obtained are getting thinner or smaller but if the measuring instrument is used for medical purposes or the synthesis of chemical solutions that have an effect on a small value, it will be very dangerous. To minimize errors in measurements we tried to add a value of 500 milliseconds to the equation obtained. The output volume value obtained is in accordance with the desired input volume. After obtaining the output value that corresponds to the desired measuring instrument must be tested if it is repeated many times whether it can get the same value. Repeatability of measurements are shown in figure 5.

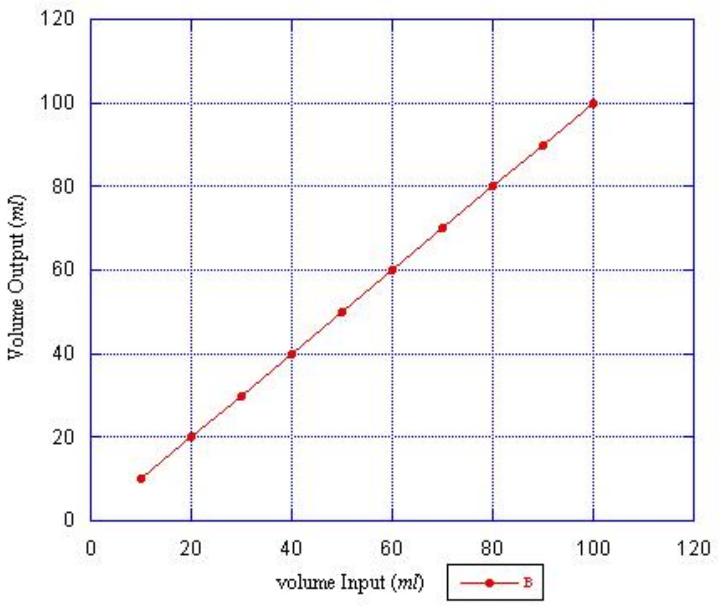

Figure 5. The repeatability of input volume and output volume

Successful solution of the problem relating to the aluminum oxide layer formation on figure 5 shows the same volume value for each repetition which is repeated 3 times. So that the ability of a measuring instrument is good enough to make measurements because even if it is repeated many times it still gets the same value. This can be seen in figure 5 even though it is repeated many times the measurement results remain linear.

The use of dc motors in research because dc motors have advantages in terms of performance that is close to linear when compared to ac motors so that it has a higher accuracy. However, maintenance on dc motors is more than an AC motor and the price is more expensive than an AC motor. Therefore, periodic checks on measuring instruments that are made greatly affect the level of accuracy of the measurements made.

The calibration carried out in this study uses a 100 ml measuring cup which has the lowest value of 1 ml. So that the tool made is only able to measure with a limit between 1-100 ml. The accuracy of the tool used can be obtained from the lowest scale value or commonly called minimum value multiplied by 0.5 ml. The volume flow rate measuring instrument can be used for medical purposes as well as the syringe pump which serves to provide the patient's bodily fluid with a certain period of time regularly. For further development this tool can be applied in the manufacture of nanofiber instead of syringe pump [7].

4. Conclusions

Calibration of measuring instruments greatly affects the results obtained by a measuring instrument. The measuring instrument designed has a measurement limit between 1-100 ml and has an accuracy value of 0.5 ml. Continuous use can make the dc motor contained in the pump become non-linear, periodic checking is necessary to stabilize the output obtained from the measuring instrument.

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