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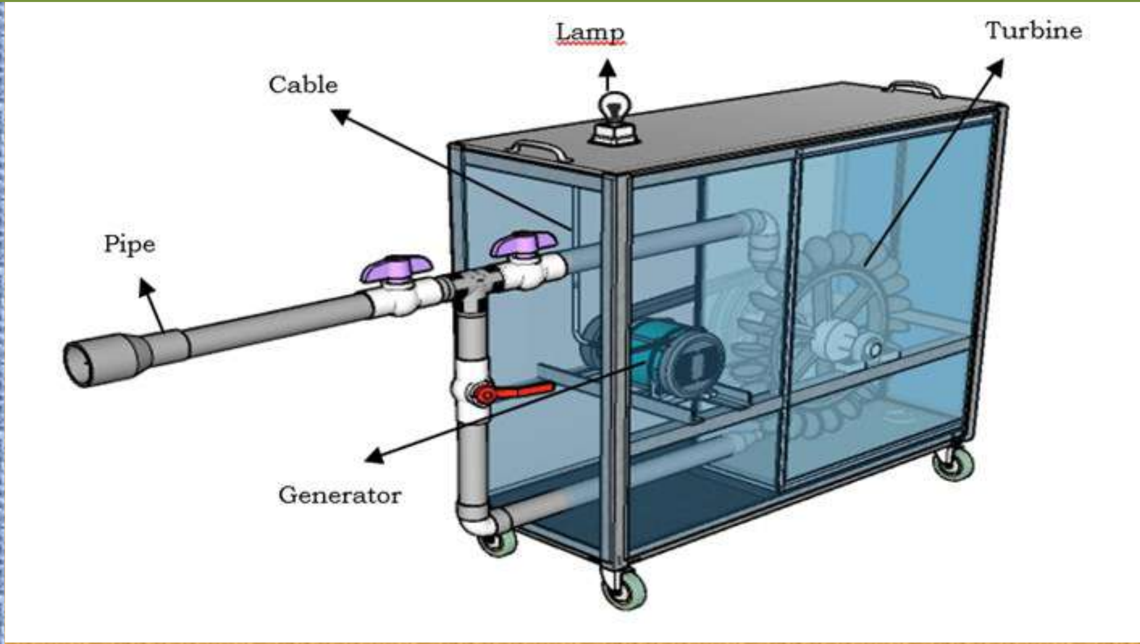

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Design and Build a Drum Collector Using a Stepper Motor Arduino Based on Nanofiber Spinning Machine (Electrospinning)

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Abstract

An Arduino-based stepper motor was used to create a nanofiber spinning machine. The hardware for this tool includes an Arduino Mega module, a 4x4 keypad, a TM1637 type seven-segment display, and L298N type stepper motor driver, a 17Hs4401 type stepper motor, a Pushbutton, and an ultrasonic sensor. The software utilized is the Arduino IDE, which is written in C. This tool's operating premise is that the Arduino processes input from the Keypad, and then the Stepper Motor Driver drives the stepper motor, which moves the collection drum up and down. The results of reading the tool will be presented in the seven segments in the form of RPM, altitude, and time. The tool has a height range of 1-10 cm, an RPM range of 10-100 RPM, and a time range of 1 minute to 1 hour. According to the test results, the tool has 99.8 percent accuracy at RPM, 99.92 percent accuracy at the time, and 97.89 percent accuracy at altitude.

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Abstrak

Telah direalisasikan sistem pemintal nanofiber menggunakan motor stepper berbasis arduino. Alat ini terdiri dari perangkat keras yaitu modul arduino mega, keypad 4x4, sevensegment tipe TM1637, driver motor stepper tipe L298N, motor stepper tipe 17Hs4401, Push botton, dan sensor ultrasonik. Perangkat lunak yang digunakan yaitu arduino IDE yang di program dengan bahasa C. Kolektor drum bekerja dengan memproses masukan yang diperintah dengan keypad, selanjutnya perintah akan di jalankan oleh motor stepper sehingga menghasilkan gerak naik/turun dan berputar. Hasil pembacan alat berupa RPM, Ketinggian dan waktu akan di tampilkan pada seven segment. Alat bekerja dalam rentang ketinggian 1- 10 cm, RPM dalam rentang 10 – 100 RPM dan Waktu dalam rentang 1 menit – 1 jam. Hasil pengujian menunjukan bahwa alat memiliki akurasi 99,8% pada RPM, Akurasi 99,92 % pada waktu, dan akurasi 97,89% pada ketinggian.

1. Introduction

Technological developments are currently overgrowing, one of which is the discovery of nanotechnology. Nanotechnology is a technology that regulates a substance or system on a nanometer scale. The development of nanotechnology produces material in the form of nano or commonly called nanomaterials. Nanomaterials have 1 to 100 nanometers, and one example is nanofiber (Riwayati, 2007). Nanofiber can be more flexible, more elastic, and reactive to other materials. The nanofiber spinning machine has a faster, simpler, and cheaper technique for get nanofibers (Herdiawan, 2013). Nanofibers are produced from several types of polymers. The polymers used are natural and synthetic (Judawisastra et al., 2012). The manufacture of nanofibers uses a device called a drum collector. The drum collector used is cylindrical and made of solid aluminum. A stepper motor drives the drum collector. Distance between the tip of the needle with the collector drum is 10 cm. The purpose of this drum collector is to produce nanofibers in sheet form (Nuryantini, 2014). The collector with a drum-type has a diameter of 150 mm and a width of 200 mm. The tool is operated with a voltage of 20 kV and a spinner jet collector distance of 10 cm. The result of the nanofiber is in the form of a thin white membrane (Wahyudi, 2011).

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Due to the lack of an automatic spinning machine for smaller materials, the author tries to make a drum collector using a stepper motor based on the Arduino Mega microcontroller on a nanofiber spinning machine (electrospinning). The microcontroller is a computer on one chip in which there are a microprocessor, memory, input and output lines, and other complete devices (Agung, 2010). The drum collector will be made with a cylindrical paper roller connected to a stepper motor and an Arduino. Arduino combines hardware, programming languages, and a sophisticated Integrated Development Environment (IDE). Two stepper motors act as drive and height regulators from the drum collector. The stepper motor can be positioned or rotated as desired, either clockwise or counterclockwise (Prakasa, 2017). The 4x4 Keypad is used as a rotation control input for the drum collector. The 4x4 Keypad consists of four rows and four columns with a push-button switch on each part (Surgina & Munandar, 2014). Seven segments whose role is to display information about the rotating speed of the drum collector. Seven segments is a configuration of 7 LED circuits put together so that the LED flame will display a decimal number (Alfith, 2015). Based on the explanation above, the researcher tried to make a drum collector using a stepper motor based on an Arduino mega microcontroller on a spinning machine nanofiber (electrospinning). Tool testing is carried out by measuring the rotational speed of the tool and the calibration results (infrared tachometer) with a rotating speed range between 10 rpm to 100 rpm. Testing the height of the drum collector with a range of 1 cm to 10 cm using a ruler. Later there will be a comparison of values between the tool and the calibration results, referred to as the percentage error (%).

2. Research Methods

The tools and materials used in this study were a rotating cylinder, two stepper motor units, 2 L298N driver units, Arduino Mega, 2 Sevensegment units, 4x4 Keypad, Flexible Coupling, 3 Push Botton units, and threaded iron, plain iron, Bearings, Aluminum Foil.

Data Retrieval

The Drum Collector Tool has been realized using an Arduino-based stepper motor, as shown in Figure 1. This tool works with an RPM range of 1-100 RPM, a height of 1-10 cm with a time of 1 hour. The voltage is used to activate the Arduino Mega as the brain drives the two motor drivers, driving the stepper motor. The movement of the stepper motor is divided to move the rotating cylinder when the RPM measurement command is ordered, and one of them is as a driver to raise or lower the drum collector when the drum collector height measurement command is ordered. Commands are given via a 4x4 keypad and displayed with seven segments.

Figure 1. Drum collector.

The A button on the keypad functions to adjust the height from 1-10 cm. B button on the Keypad to set the RPM speed of 10-100RPM. Keys C and D on the Keypad set the time in minutes and hours. This tool uses a stepper motor as its drive. The data collected will then be compared with the accuracy value and the percentage of error for each part (altitude, RPM, and time). Calculation of Accuracy and Percentage of Errors can be seen in equation (1) and (2).

$$Accuration = \left(1 - \left|\frac{Y - \bar{X}_n}{Y}\right|\right) \times 100\% \quad (1)$$

$$\%Error = \left|\frac{Y - \bar{X}_n}{Y}\right| \times 100\% \quad (2)$$

with Y= Volume input, $\bar{X}_n$ = Average Volume of measurement results.

3. Results and Discussions

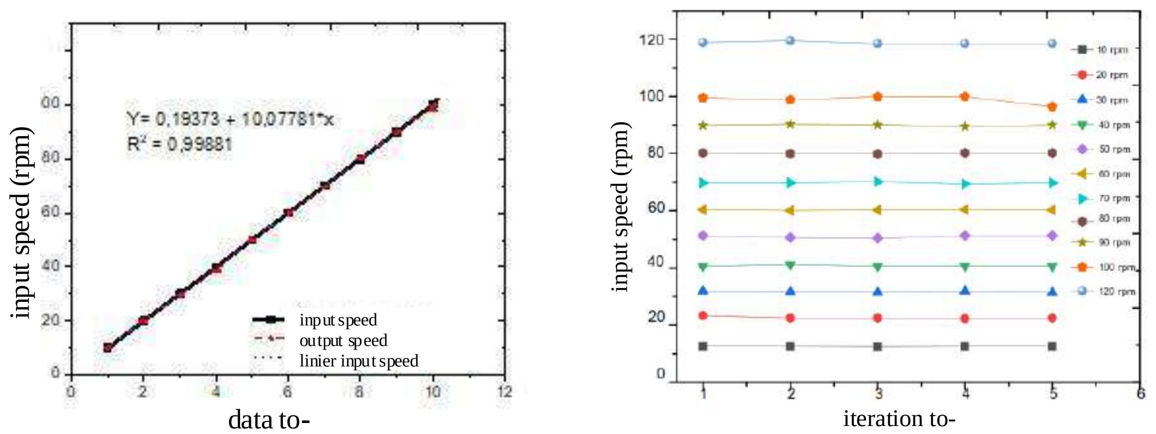
3.1 Data Collection

The data collection shown in Figure 2 is divided into three parts. The first is RPM data collection, the data taken in this experiment is between 10 -100 RPM with a calibration tool in the form of a tachometer and repeated five times at each RPM. The second data collection was in the form of a height between 1-10 cm with a calibration tool in the form of a ruler and repeated four times. The third experiment measures the time with a maximum limit of 1 hour with a stopwatch calibration tool repeated five times. Then the data will be converted into seconds to make it more accurate when calculating. Then the calculation is carried out to determine the tool's performance that has been made.

Figure 2. Display of RPM and Time on seven segments.

3.2 Data Analysis

Input speed testing with output speed aims to see the accuracy, precision, and error (error) of the tool made. Based on Figure 3(a) for the input speed to the average output speed, the value of R2 = 0.99881 is obtained. Calculating the average RPM speed error value obtained a value of 0.82%, so an accuracy rate of 99.85% was obtained. The error value obtained shows a low tolerance level because it values below 5%. The smaller the percentage produced, the better the performance of the tool. For precision results from the tool made shown in Figure 3(b).

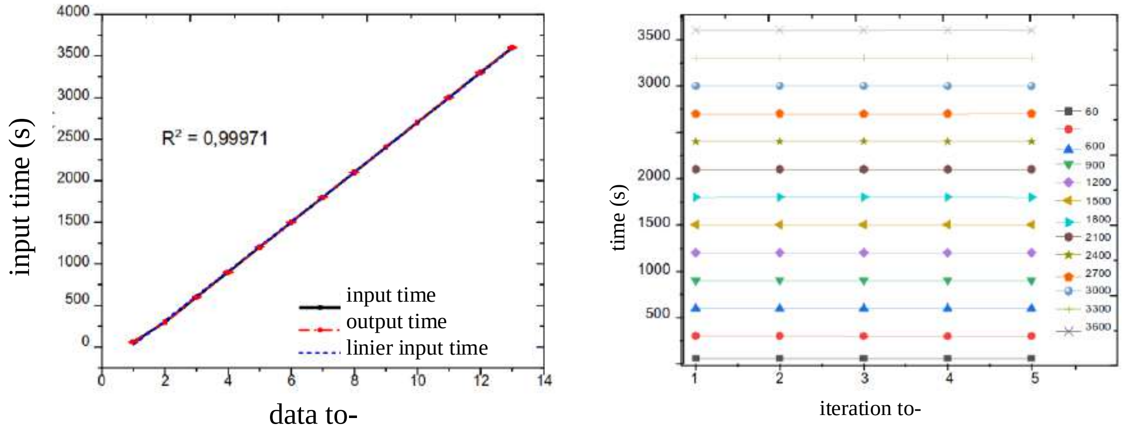


(a) Graph of accuracy-test of 10-100RPM

(b) Graph of precision of 10-100RPM

Figure 3. Graph of accuracy and precision test

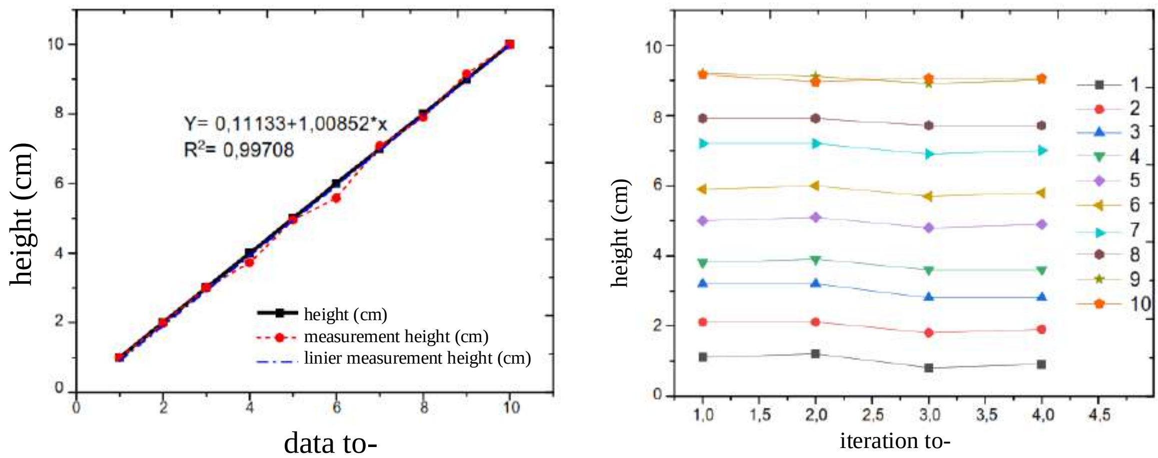
The second test, the input time test with the output time in Figure 4(a), shows the R2 value of 0.9971. The error value calculation at the time of output obtained a value of 0.08%, so the precision value is 99.92%. The value of the percentage error on the tool made is less than 5%. It can be said that the tool is working well. For precision results from the tool made shown in Figure 4(b).



(a) Graph of accuracy-test of (60 – 3600) seconds (b) Graph of precision of 60 – 3600 seconds

Figure 4. Graph of accuracy and precision of time testing

The third test is the test of the input drum collector height with the output drum collector height at Figure 5(a) has an R2 value of 0.99708. The results of the calculation of the average output height error value of 2.11%, so the precision value is 97.89%. Because the error value obtained is less than 5% then it can be said that the tool works quite well. The precision results of the tool made shown on Figure 5(b).



(a) Graph of height accuracy-test 1-10 cm (b) Graph of precision of 1-10 cm

Figure 4. Graph of accuracy and precision of height

4. Conclusions

Based on the research that has been done and based on some research data, it can be concluded that the tool has been realized with a size of 34 cm x 22 cm. The collector drum is made with a length of 25 cm and a diameter of 11 cm. The error value in the RPM measurement is 0.82%. The error value in altitude measurement is 2.11%. The error value in time measurement is 0.08%.

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