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Microcontroller Base Spin Coating Design and IoT Data Monitoring and Storage

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Abstract

This research is the development of a research support tool, namely Spin Coating. In addition to the high price factor and limited maintenance on the equipment that has been purchased, the researcher wants to design a spin coating tool to support laboratory equipment. Not only to get a relatively affordable price but also to be able to develop homemade tools that have precise measurement capabilities, and good quality results because they use a microcontroller in the tool's work settings. Therefore, researchers created a new design for a spin coating tool with IoT technology to make it easier for laboratory users to monitor it from anywhere and anytime and storage real time. The research method is Research and Development with the stages of design calibration, and testing of tools. From the results of making the tool, the resolution of the tool through the linearity of the sensor used is 99.71% with the power value of each RPM, namely 178.05 RPM/W. The IoT innovation on the spin coating tool runs smoothly using cloud.

Introduction

Technological developments are currently developing very rapidly compared to previous years [1]. The result of very sophisticated technology is the materials in the form of a thin layer [2]. Thin layers are made of organic, inorganic, metallic, or non-metallic materials that can have the properties of a conductor, a semiconductor, a superconductor, or an insulator. In material engineering, especially thin films, the materials commonly used are In_2O_3, SnO_2, TiO_2, ZnO, and many other materials. Much research on the process of making thin films has been carried out. The methods that are often used are the sol-gel dip coating method [3], spray pyrolysis [4], RF magnetron sputtering [5], sol-gel spin coating [6]. From all of methods in manufacturing thin films, sol-gel spin coating is the most effective method with good results at low rpm [7].

Previous research on the spin coating method has been widely used, for example, in the process of making ZnO thin films for solar cells [8]. This method is very easy, so it is widely used for the process of making thin films. In previous studies, the manufacture of ZnO thin films at 4000 rpm resulted in good transparency of 92% and its application to solar cells [9]. The problem that arises in the spin coating tool in the laboratory is the determination of the RPM value which is only limited to a few variations. The calibration of the RPM (Rotary Per Minute) value has not been adjusted with the rotary sensor which can be calibrated manually. Monitoring of the existing spin coating tools is still manual and most of the current devices do not utilize the Internet of Things (IoT) [10].

The spin coating tool used in this method has simple electrical components. However, the price of spin coating tools in the market is quite high. Based on these problems, the specific purpose of this research is to consider the importance of this equipment in the research of the expert group in the field of material physics and considering that there is no IoT-based spin coating tool for monitoring and storage for data. We want to design a spin-coating tool with features that can transmit data via the Internet and remote monitoring and rpm data storage (IoT).

Experimental Method

This research is R&D method[11], (Research and Development). Part of Reseach method is tool making (design, print 3D, and asembly), calibration, and testing. Part of Development method is descriptive analysis form quantitive data. R&D flow can be seen in Figure 1.

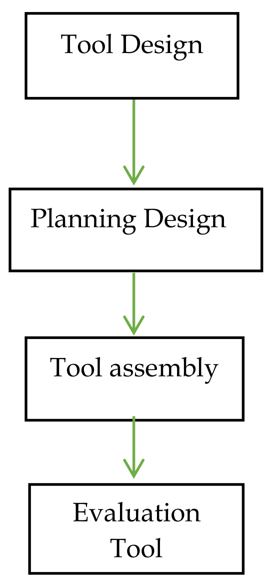
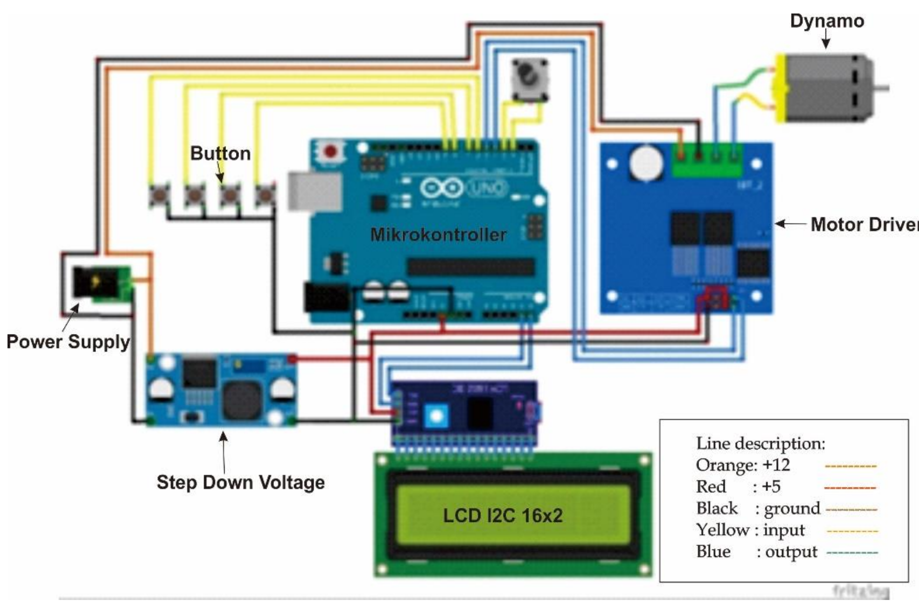
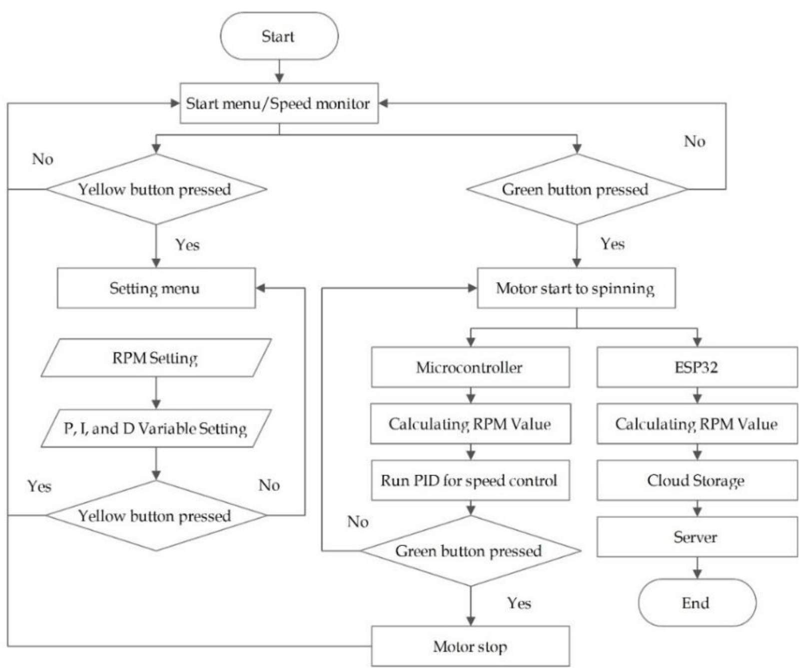


Figure 1. Research Flow of Spin Coating Tool Design

The manufacture of the spin coating tool using a rotary encoder sensor have a resolution 600 P/R. Then the sensor is connected through a converter to be acquired by the microcontroller and IoT devices to be converted into RPM values. The working principle of the rotary encoder is to change the rotation of the dynamo into numbers every second and monitor and control any movement [12]. The rotary encoder uses optical techniques to read changes in motion [13]. The rotary encoder will be assembled with other supporting components as shown in Figure 2.



(a)



(b)

Figure 2. Spin coating tool design (a) Wiring (b) Work Flow Direction

The rotary encoder will be integrated with the dynamo. So that the movement of the dynamo is detected by the rotary encoder. Data acquisition from the Rotary Encoder is carried out by the microcontroller and then converted into RPM. The data acquisition process can be seen in Figure 3.

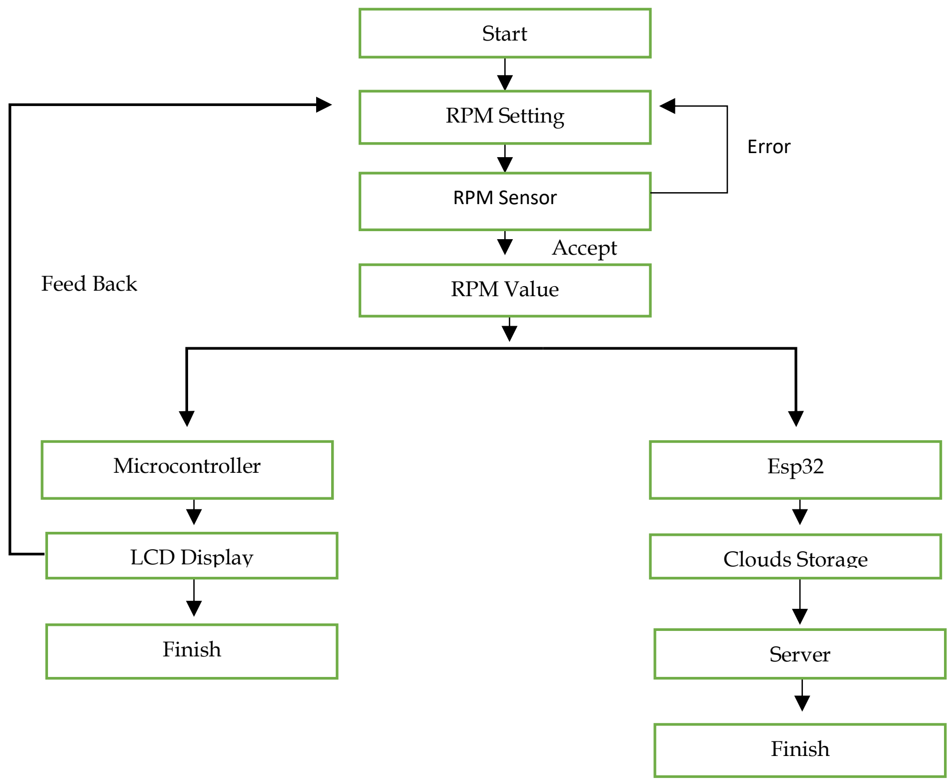


Figure 3. Data Acquisition process

Result and Discussion

The design of the spin coating tool have been carried out. The design of the tool is adjusted based on the purpose of the tool to make it easier for users according to its function. The design of the tool and the design of the tool is shown in Figure 4. The design in the form of a soft file will then be applied using 3D printers to produce the desired shape and strength. The design is broadly divided into 3 parts, namely: the interface part, the motor part, and the electrical part Assembly of 3 parts that have been designed into a single unit. The specifications of the tool will be known after the assembly is done. Figure 4 shows the assembled spin coating tools.

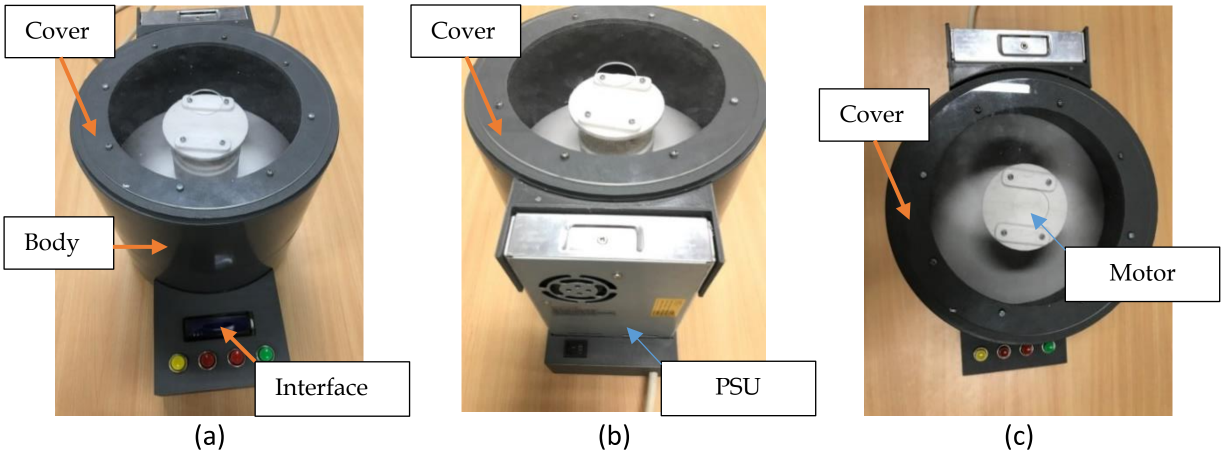


Figure 4. Spin coating tool (a) front view, (b) back view, and (c) top view

Part of Calibration, Rotary encoder sensor is the main sensor on this device. The output value from sensor before used to be a final data must check of sensor error. Accuary and precision is a part of calibration so the sensor to know about error value from linearity value. So the value linearity show in Figure 5

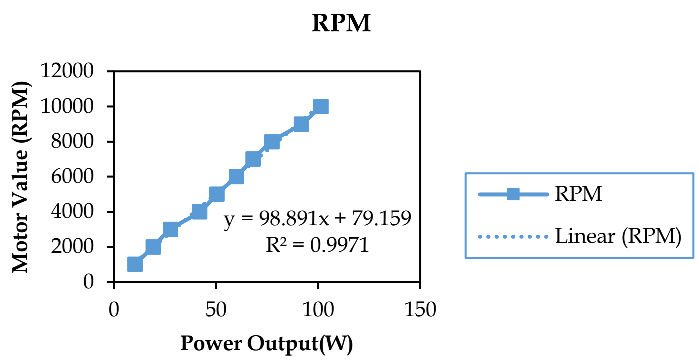


Figure 5. Rotary Encoder Power Linearity with RPM change

The linearity of the rotary encoder power change to the motor RPM value is 99.71%. This indicates a rapid correlation between changes in power to the output RPM value.

The change in rotary encoder power to the RPM value is obtained by the equation

$$Y = 98{,}891x + 79{,}159 \quad (1)$$

This is a linearity equation that can use to check a decrease value from input to output [14]; by entering x = 1 into equation 1 above, the minimum RPM of the spin coating tool is 178.05 RPM/W. With this minimum power rating, the minimum specifications of the tool have a range of 10,25 W for basic operations and the highest can be up to 100 W.

The next step after obtaining the linearity value of the sensor and the initial specifications of the tool, then the use of the spin coating tool is detailed again based on the RPM offset by measuring each RPM change and recording the working range of each RPM value. Figure 6 is an advanced specification of the IoT-based spin coating tool.

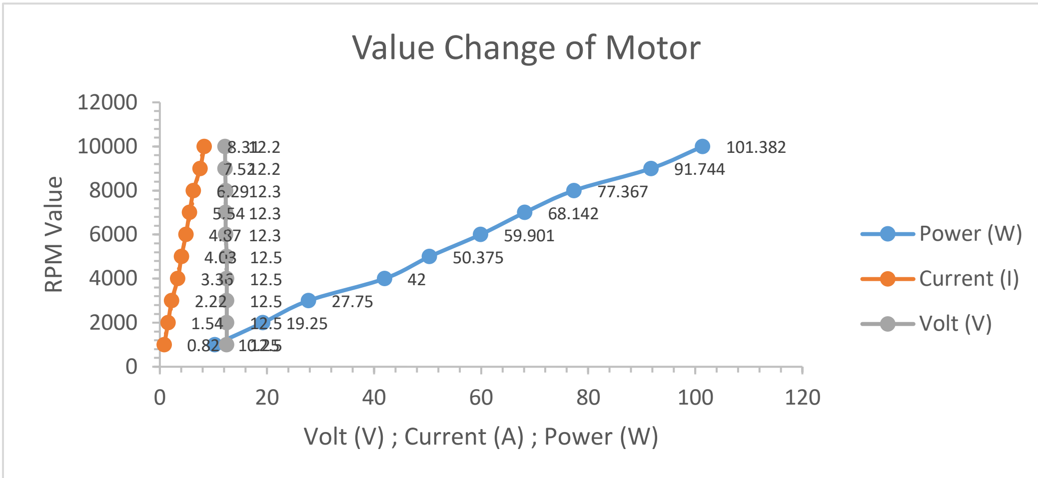


Figure 6. Graph of Value Change of Volt, Current and Power vs Output RPM

The specifications of the tool, the higher the RPM value used, the higher the power required. A high RPM value will affect the sensor reading offset. The smaller the RPM value, the smaller the maximum and minimum offset will be. Because supply current, voltage and power increase in high RPM conditions.

The steps taken after linearity are obtained, and the next innovation is the addition of IoT to the spin coating tool. Previously, spin coating equipment could only be monitored manually in the laboratory and write data manually. The spin coating tool is given access to data transmission in the clouds to automatically save and monitoring real time. The tool reading rpm data and the device that have connection to server can be monitored remotely from the website or mobile application. Figure 7 shows the display of spin coating tool data sent to the server.

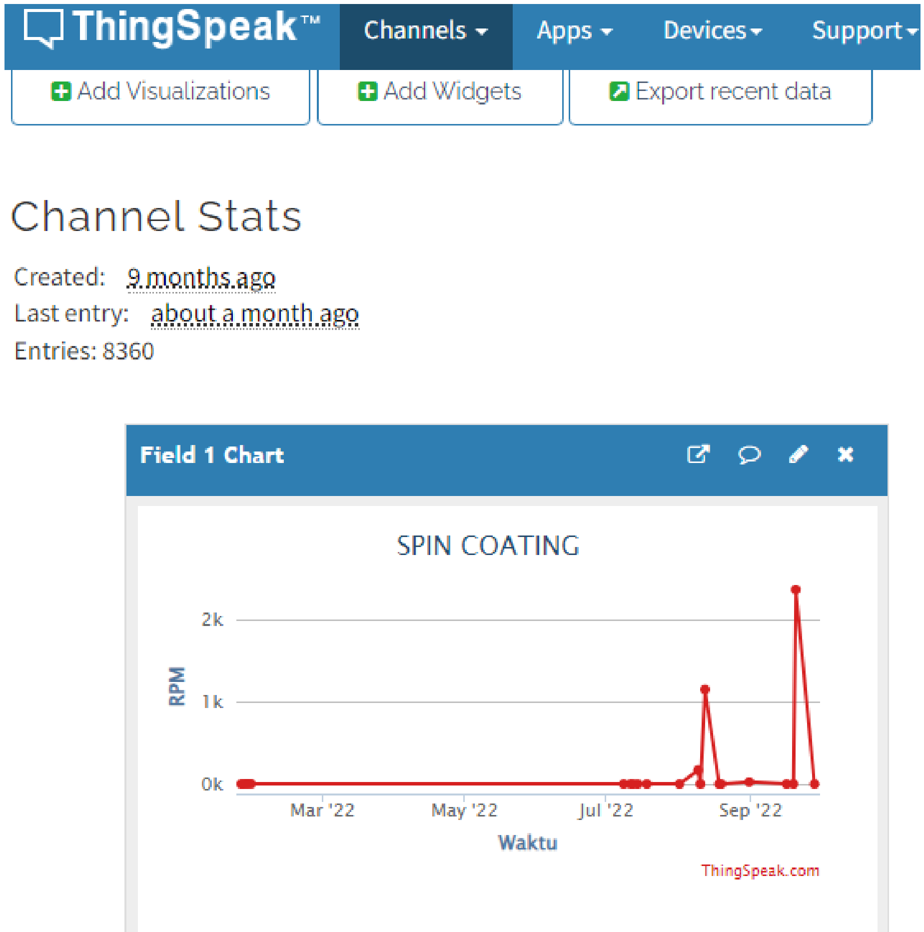


Figure 7. Clouds server spin coating tool

The last stage of making an IoT-based spin coating tool is validation and experimentation on the test material. From the results of good tool calibration, the validation of the validator is declared suitable for use. Furthermore, after expert validation, the spin coating is the easiest and most efficient way to make thin films [15,16].

Conclusion

The spin coating tool that has been made has a tool linearity of 99.71% accuracy. So that real-time data transmission via IoT can be precise. The power required by the tool is around 178.5 RPM/W. Based on the calibration obtained, the validation of the tool by the expert is declared feasible.

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