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Automated Transformer Coil Winding Machine

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ABSTRACT
A few years ago winding of the transform coil was done manually, by hand-driven machines, or using some motored machines for swift mechanism. In this modern era, industries still rely on hand-driven & manual winding machines which are used to wind not only in various types of transformers but also some other components and products such as AC/DC Motors, Inductors, and Generators. Some improvement can be seen in winding machines like Programmable transformer winding & automatic transformer winding machines using microcontrollers. Therefore, a further step towards advancement and latest technology in Automation Industry this work can now be completed using some automatic devices like Arduino, geared DC motors, Servo Motors, Motor Drivers, IR sensors which are easily available in the market as well as trouble-free to understand and program. IR sensor used for the detection of the number of winding which to is displayed on 16*2 LED display and push buttons also to be given to set the input and present the real-time status display for the number of windings for the transformer. By using this machine, the efforts for winding can be completed with precision & less human interference as compared to other machines. This machine is inexpensive and can be used for some small-scale production. It can also be helpful for university students to understand the process of winding miniature transformers.

Keywords— Coil Winding machine, Transformer, Arduino, Servo motor, Automation.

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I. INTRODUCTION

Industries always need these three parameters they are cheap cost, precise task, and long life of the product for the machines they are using so that the production will be more appreciative and effortless. Mainer times the windings done by manual machines are loose due to which problems occur and customers are also unsatisfied with the product. Apart from this manual machine & programmable machines consumes much amount of time, labour work and power consumption. Therefore, to overcome the standard problems that occurred during the production of the transformer using manual machines, the automated winding machine can be proven as the best performers as well as satisfactory results are obtained. Here we are using the latest and cheapest technology that is Arduino Nano, IR sensor DC motors & servo motors. By using these tools, the servo motors are programmed such that it not only possesses the automatic rotational movement but also a lateral movement which helps to readily wind the coils of the transformer.

The Objective of the development of this model is

- To reduce human interference.
- Accurate & Precise work for the last product.
- Manufacture a cost-effective machine.
- Study of automatic transformer winding for students.

II. LITERATURE REVIEW

The recent upgrades regarding automated coil winding machines include many high-end fully automated transformer winding machines operating with very complex mechanisms. These high-end machines are generally used for many high powers and high-capacity transformers. The ones used to wind the small-scale 1 ampere or 2-ampere transformers used in the electronics field are still complex to use and are not suitable for undergraduates to fully work with them as it more often requires fine-tuning. We propose the system using a very simple design and control which can be easily used by undergraduates helping them understanding the manufacturing process and various terms are taken into consideration while making a transformer and, they can work with the system as well. Our system was previously presented by some of the authors in recent years, the survey resulted in knowing more about working as well as drawbacks of the existing systems. The first system [1] used the two stepper motors, one for lateral and one for the rotational movement and the calculation of the step was used to measure the rotations of the bobbin for which complex programming was required. The second system [2] simplified the complexity by using two geared dc motors instead of stepper motors but the accuracy was hindered because the wire wound on the bobbin may get overlapped too often which may result in uneven after results. The third system [3] used the threaded shaft mechanism for lateral movement and also tried to simplify the user interface using Bluetooth connectivity and a controlling system using a phone, the use of CNC shield V3.0 makes it moderately complex compared to other systems. The fourth system [4] used the comparatively simpler system with two dc motors and improved the power handling of the system by connecting the system with SMPS. They also used the aftermarket readymade keypad for user interface and programmed using Arduino Uno. The main thing about all the above paper is the use of the dc or stepper motor for lateral movement which made it compulsive for them to use the threaded shaft mechanism, depending on its quality and cost-effectiveness it may require regular maintenance and all of the four systems were focused for industry purpose. Our proposed system uses a speed-controlled servo which is restricted to move in an arc for the lateral movement and as it is placed between wire bundle and bobbin, it provides an additional benefit of overall wire tension control for the system. The system works pretty accurately while maintaining productivity and by avoiding the stepper motor, the calculations that are used for step count reduced our programming complexity as it is replaced by the simple object detector which counts the number of rotations made by the dc motor.

III. METHODOLOGY

In the Block diagram given above, the liquid crystal display with 16*2 pixels i.e., 16 columns and 2 rows of pixels. The LCD is used to display the real-time status of the number of turns made on the bobbin will be displayed on the LCD. The inputs from the

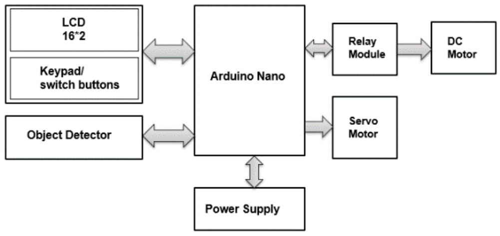

Figure 1: Block diagram of a system for automated transformer coil winding

keypad or switch buttons while selecting the number of turns to be wound are also displayed. The object detector is used here to count the number of turns made by the dc motor. Here, the object detector includes an IR led and a photodiode so that it will measure the number of turns made by the shaft of the dc motor.

The 5V relay module is used to control the dc motor via Arduino, another motor is the servo motor which is directly connected with the Arduino Nano. Two types of movements are required to wound the wires to the bobbin, first rotational movement, and second lateral movement. The rotational movement controls the number of turns to be wound and the lateral movement is used to cover the overall woundable size of the bobbin. Here, instead of using the threaded shaft, we have used the servo motor to control the area covered in the winding process. So, the servo motor is used within the previously decided range which is finalized using trial and error.

As seen in the flow chart from figure 2 the user provides the input (i.e., the numbers of turns to wound on the bobbin) to the Arduino then, the selected number of turns as well as relative information will be displayed on the lcd display. According to the input from keyboard, the Arduino will activate the dc motor for rotational movement via 5V relay module, and drive the servo in arc fashion to provide a sort of lateral movement which will allow wire to spread uniformly over the bobbin.

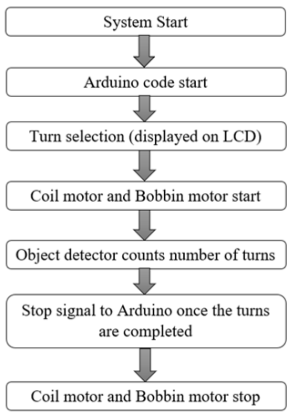

Figure 2: The overall presentation of a system

The object detector will detect the number of rotations made by the dc motor and thus provide the feedback to the Arduino. The lcd will display the progress of the machine in real time, and when the wounding is done it will update the status. The Onboard green and red led lights will state whether the system is busy or ideal. The user can interfere the system at any time just by pressing the button from the keypad which will result in system halt.

IV. REQUIREMENTS

A. Hardware Requirements

1) Arduino Nano:
It is a complete, breadboard-friendly, and small board based on ATmega328 (i.e., Arduino Nano 3.x), which has moreover the same functionality of Arduino Duemilanove without a DC power jack and connects to the computer using a Mini-B USB cable rather than the standard one.

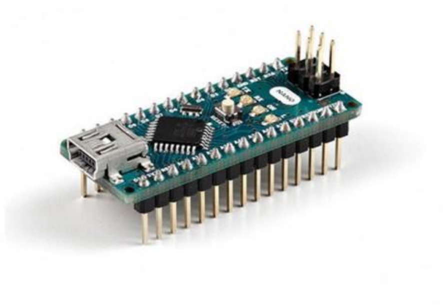

Figure 3: Arduino Nano

Arduino nano comes with an ATmega328 microcontroller based on AVR architecture which operates on 5 Volts (DC). Its peripherals include the flash memory of 32KB out of which 2 KB is used by bootloader, an SRAM of 2KB, the clock frequency of 16MHz, and an EEPROM of 1KB. Nano has 8 analog input pins and 22 digital input/output pins out of which 6 are PWM (Pulse Width Modulation) pins. Arduino nano working - with an input voltage of 7-12V, gives 40mA of current through its input/output pins.

2) Servo Motor:
The Tower Pro SG-90 operates at a typical 5V producing a torque of 2.5kg/cm with an operating speed of 0.1s/60^o. Servo motor uses plastic gears, provides the rotation of 0^o-180^o, weighs approximately 9gm, and comes with additional gear horns and screws.

Figure 4: Servo Motor

The servo motor has three wires priorly connected to it which helps with interfacing with different microcontrollers [6]. Usually, the colour pattern of these wires is the same, Brown is the ground wire connected to the ground of the system, Red powers the motor and needs typical +5V, Orange is the PWM signal is given through this wire to drive the motor.

3) The Relay Module:
The single channel relay module is an electromechanical device that uses current to open or close the common terminal of a switch, it also includes the components that acts as indicators to show status of the module.

Figure 5: The Relay Module

The relay module works on the supply voltage of .375V to 6V, while in active state the relay works on 70mA. The relay can handle maximum contact voltage of 250VAC or 30VDC.The Relay Module includes the components, 5V relay, Transistor, Diode, LEDs, Resistors, etc. For this project, the Relay as a switch to control the dc motor in normally open configuration.

*4) LCD 16*2:*
A liquid-crystal display (LCD) is a flat-panel display or another electronically modulated optical device that uses the light-modulating properties of liquid crystals. Liquid crystals do not emit light directly, instead of using a backlight or reflector to produce images in colour or monochrome. LCDs are

available to display arbitrary images (as in a general-purpose computer display) or fixed images with low information content, which can be displayed or hidden, such as preset words, digits, and 7-segment displays, as in a digital clock

Figure 6: LCD Display 16*2

LCD 16*2 works with an operating voltage of 4.7V to 5.3V and consumes 1mA without a backlight. Here each character is built by a 5* 8-pixel box, LCD can work on both 8-bit and 4-bit mode also, it is capable of displaying any custom generated characters and is available in green and blue backlight.

5) I2C adapter:
I2C module is used to convert parallel data from lcd to serial form so that less number of pins would be needed to interface the lcd. The module also includes the contrast adjustment potentiometer to control contrast of the lcd display.

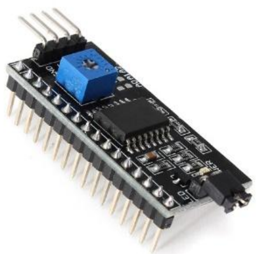

Figure 7: I2C Adapter for LCD

The operating voltage for I2C module is 5V, it provides the Serial I2C control of LCD display via PCF8574, the I2C module is compatible for 16*2 LCD, the data realization only 2 data pins would be used.

6) IR Module (object detector):
IR module includes an IR transmitter and a photodiode receiver. IR light has a wavelength of 700nm-1mm which is much higher than the visible light range. IR LEDs emits light at an angle of approx. 20-60 degree and ranges from few centimetres to several feet, depending on the manufacturer.

Figure 7: IR Module (object detector)

The IR module also includes onboard LM358 OP-Amp which is used as a voltage comparator and the output of the comparator is sent to the output terminal. The module operates at 5V dc and input/output pins are compliant with 3.3V and 5V, it has a range of up to 20cm including an adjustable sensing range that works on a 20mA supply current.

7) Geared DC motor:
Gear motors are a mix of a regular dc motor and a servo motor and they can be moved bidirectionally (one step at a time), positioned accurately, but can also provide continuous rotation. As the aim of our project is to minimize the scale and cost of the system, the dc motor is advantageous over the stepper motor as it's easy to control, program, and also cost-effective.

Figure 8: Geared DC Motor

8) Button switch for keypad:
Instead of using the ready-made keypad from the market, we chose to use our keypad made from these push-button switches which work on tactile feedback with a power rating of a maximum 50A 24V dc. It has an operating force of 2.55 N (0.69 variable), contact resistance of 100mOhms, and an operating temperature range of -20^{o}C to +70^{o}C.

Figure 9: Pushbutton Switch

9) Potentiometer:
The potentiometer is a 3 terminal variable resistor where the resistance is manually varied to control current. The two types of general potentiometers are rotary potentiometer and linear potentiometer

Figure 10: Potentiometer

Potentiometer shown above has uniform resistance placed in semi-circular pattern placed between two terminals. The middle terminal is connected to rotary knob via sliding contact. Rotating the knob results in movement of sliding contact on resistance.

B. Software Requirements
1.) Arduino IDE:
Arduino Integrated Development Environment (IDE) written in function from C++ and C is a cross-platform application, which is used to write and upload programs to different kinds of microcontroller-based Arduino boards.
The usage of the software results in easier programming complexity and its simplicity makes it easier to control the servo motor with modified speed constraint and restricted arc movement suitable for the system which is selected and finalized with the trials and errors procedure while programming the system.

V. RESULTS

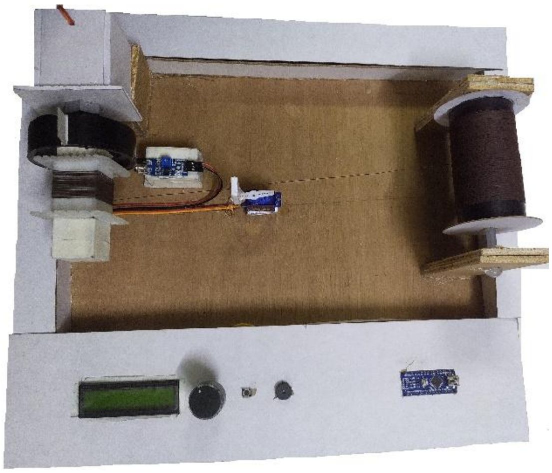

Figure 10: The designed setup of the machine

As seen in the figure above the servo is placed in between the wire bundle and the bobbin. The green slate on the bobbin represents the area only on which the wire is wounded. The two wires (pink and violate) between the bobbin and the servo show the maximum and the minimum threshold on which wire is wounded. The servo motor is configured to run at a slower speed by moving the shaft of the servo motor degree by degree while adding the delay in between, this allows slower movement of the servo shaft resulting in proper spreading of the wire on the bobbin. Also, during the entire duration of the winding process, the green led is maintained on as well as the overall status of the system is displayed on the LCD.

In this way, the use of threaded shaft is avoided and the frequency of maintenance is also reduced without affecting the overall outcome of the system as well as improved system cost requirements. The system maintains precision and reduced human interference required also, the system is perfect for students to use and experiment to build different kinds of transformers and analyse them.

VI. CONCLUSION

Having examined the previous coil winding models a conclusion can be sorted that the preceding machines do not have such quality precision, had high maintenance, and extreme human interference. To overcome these problems, some upgrade versions were also made so that the parameters such as cost and human interference to be reduced to make it automatic but did not have the perfect precision for the number of coils and tightness during the procedure.

Therefore, for such precision and equal distribution over the area of the bobbin with thickness and tightness of wire Programmable Coil winding machines are used. But the only drawback we found here is the size of the machine is from medium to a large scale (which consumes a lot of areas), expensive controllers, parts, and components, as well as more power consumption, is found. Skilled men are also required to handle the device with care

To resolve all these problems a compact-sized, well designed, accurate & precise transformer winding machine is made. The only problem that may occur is the speed of winding the coils. If the speed is nominal the machine works great with the precision point of view, but if speed increases then there may be chances that winding may get spilled and crumble over the area of the bobbin.

When using on the very large-scale production [12], this system can be very useful in future as the built cost is very less and all the systems can be monitored just by using the GPS system to monitor the status and change the inputs Also, System is flexible with respect to gauge of wire to be used thus system can be easily modified into different versions and solutions with slight adjustments to suit the winding application.

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