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DESIGN AND DEVELOPMENT OF AUTOMATIC COIL WINDING MACHINE

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Abstract - *A coil winding machine is a machine for winding coil onto a spool, bobbin and many more. This coil winding machine is one of types of winding machine that available in industries today. From multi speeded machines to medium, large and extra-large machines, these machines come in various types and categories, performing a range function. The common applications for a coil winding machine are to wind coils for transformer, inductors, motor and chokes. To complete a coil using manual coil winding machine will be inconvenience and waste of time. Therefore, fabrication of coil winding machine will be done in this project which is controlled by two stepper motor using Ardiuno program. This machine is inexpensive, easy to operate and build in a small-scale size. This project also can be used for training students in winding of small transformers & relay coils.*

***Key Words*: Ardiuno, Stepper motor, Driver board, Tensioning device, Creo 3.0, ANSYS 16, Automation**

1. INTRODUCTION

Coil Winding machines are used to wind coils for transformer, stators of motor and chokes. To wind a coil using manual coil winding machine will be inconvenient and waste of time. Various Automated coil winding machines are available in the market to overcome the drawbacks present in manual winding machine. The machines present in the market are bulky, complicated and costly. So, in this project these drawbacks of automated machine are overcome. Therefore, fabrication of coil winding machine will be done in this project which is controlled by two stepper motor using Arduino program. This machine is inexpensive, easy to operate and build in a small scale size [1].

In this paper Ardiuno programming is used for automation purpose. Stepper motors are used for the rotation of threaded shafts on which bobbins and armature is mounted. The whole assembly will contain three shafts to mount wire drum bobbin and armature. The tension is maintained by the bobbin. The wire is wounded on armature through bobbin from wire drum. Arduino board controls the feed of coil [2].

1.1 Types of Coil Winding Machine

1. Manual Coil Winding Machine

A coil winder is a device which is used to create tight, evenly wound coils. Handheld winding machines are perfect for home electronics projects to commercial packaging of products typically sold in coils

Fig – 1: Manual Coil Winding Machine

2. Automatic Coil Winding Machine

Fig – 2: Automatic Coil Winding Machine

Multi Bobbin Winding Machines are automatic winding machines designed to wind coils requiring complex wind, wrap, cut & routing functions. These machines are Equipped with AC Servo motors for axes & spindle control provide outstanding performance, maintenance free operation & higher productivity

1.2 OBJECTIVES

- To build up a low cost automation machine.
- To maintain accuracy and precision.
- To determine which methods are appropriate to wind a coil.
- To identify the importance of tension control in coil winding machine.

2. SELECTION OF COMPONENTS

- **Electrical Components.**

1. Motor

Nema 17 (Bipolar) Current (A): 0.5

Step angle: 1.8° Torque (kg.cm): 4.2

Voltage (V): 8 Control Wires: 4

Fig – 3: Nema 17 Stepper Motor

A stepper motor is a brushless DC electric motor that divides a full rotation into a number of equal steps. The motor's position can then be commanded to move and hold at one of these steps without any position sensor for feedback (an open-loop controller), as long as the motor is carefully sized to the application in respect to torque and speed [7].

2. Ardiuno

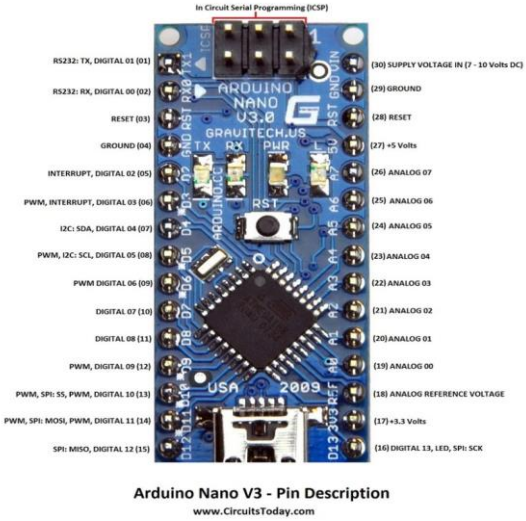


Fig – 4: Ardiuno Nano 3.0

Nano v3.0

Microcontroller: ATmega328

Operating Voltage: 5 V

Input Voltage: 7-12 V

Analog Input Pins: 8

Clock Speed: 16 MHz

Arduino is an open-source electronics platform based on easy-to-use hardware and software. Arduino boards are relatively inexpensive compared to other microcontroller platforms. The Arduino Software (IDE) runs on Windows, Macintosh OSX, and Linux operating systems. The Arduino software is published as open source tools, available for extension by experienced programmers. Even relatively inexperienced users can build the breadboard version of the module in order to understand how it works and save money [9].

3. Motor Driver Board

The A4988 is a micro stepping driver for controlling bipolar stepper motors which has built-in translator for easy operation. This means that we can control the stepper motor with just 2 pins from our controller, or one for controlling the rotation direction and the other for controlling the steps.

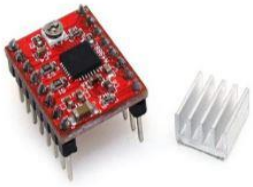


Fig – 5: Driver Board

Min operating voltage: 5 V
Max operating voltage: 35V
Minimum logic voltage: 3V
Maximum logic voltage: 5.5 V
Micro step resolutions: full, 1/2, 1/4, 1/8, and 1/16

What is micro stepping?

Micro stepping is a way of moving the stator flux of a stepper more smoothly than in full- or half-step drive modes. This results in less vibration, and makes noiseless stepping possible down to 0 Hz. It also makes smaller step angles and better positioning possible [9].

MS1	MS2	MS3	Micro step Resolution
L	L	L	Full Step
H	L	L	Half Step
L	H	L	Quarter Step
H	H	L	Eighth Step
H	H	H	Sixteen Step

Table no. 1. Micro Stepping of motor

- **MECHANICAL COMPONENTS**

1. Coupler

Fig – 6: Flexible Coupler

Flexible couplings are designed to accommodate misalignment between shafts and various types of load conditions. In this machine, no misalignment can be tolerated. So, flexible coupling of 8mm and 5mm is selected.

2. Linear Bearing

Fig – 7: Linear Bearing

A rolling-element bearing is generally composed of a sleeve-like outer ring and several rows of balls retained by cages. The cages are originally machined from solid metal and are quickly replaced by stampings. It features smooth motion, low friction, high rigidity and long life. Linear bearing allows free movement of the shaft.

3. DESIGN

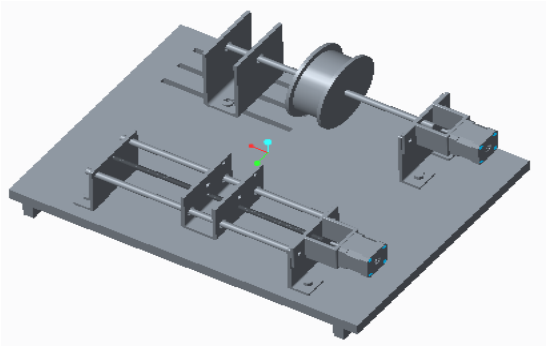


Fig – 8 : Isometric view of Machine

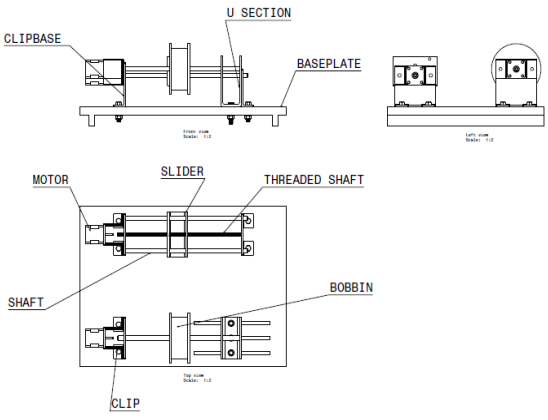


Fig – 9: Orthographic view of Machine

Threaded shaft is used for axial movement of slider of 1.25mm in one revolution. Its working is same as lead screw in case of Lathe machine. The Slider is made to slide over the guide ways to cover the length of the shaft. The linear movement of the slider gives even winding over the length of the armature. It has 4 holes for linear bearing which is used for frictionless sliding movement over the guiding shaft. Support clip is mounted on the base plate via bolts. It is used for supporting guide ways and threaded shaft Motor mount is attached to the support clip which is bolted to the base plate. It is mandatory to keep the motor shaft and threaded shaft collinear, so the motor mount should be properly manufactured as well as mounted on the support clip. Base plate is made up of plywood, which is cheap & has less weight. The weight of assembly is low so there is no need of metal base plate and plywood is suitable for low weight application. Bobbin is used for tensioning the coil which is to be wound. It is made up of Nylon, which is cheap and easily available.

The whole assembly is fixed to the base plate which is made of wooden with guide ways. These guide ways allows wide range of lengths of armatures to get fit on the shaft for winding. The clips are fixed on the base plate by bolting. These clips are drilled at the exact position to hold the motor co-axially and to have minimum eccentricity. The stepper motor is connected to the shaft via flexible coupler made of aluminum. Coupler helps to compensate the angular deflection which helps in case of eccentric shaft. The Slider contains Roller as well as pen mechanism to provide tensioning. Two stepper motors are used, one for axial motion of slider and second for rotary motion of armature. The Automation is done by the Ardiuno. Slider assembly consists of threaded shaft and slider, threaded shaft is of 8 mm diameter and 1.25 mm pitch. Slider has holes and internal thread of same hand and same pitch i.e. 1.25 mm.

4. WORKING

Two stepper motors runs in synchronization such that in one revolution of armature shaft the slider advances according to the diameter of armature wire. This helps in even and windings without gaps. The flexibility of the program is such that it can easily accommodate the changes in diameter of armature.

Initially the coil is setup is done i.e., the coil is firstly attached to the armature manually through the slider assembly. The power supply is connected and Ardiuno is started. Then the program is allowed to run. According to the program the armature shaft rotates equal to the diameter of the wire in one revolution and slider linearly advanced 1.25mm in one revolution. The program helps in synchronizing these two shafts and slider to obtain accurate rotation.

Program Calculations

Reel circumference =22/7×reel dia initial circumference of windings

Steps per Shift= 200×16/1.25×dia×2

Steps per Loop= (3200×22/7×reel dia)

Steps per Loop= (steps Per Loop/7)

Where,

One step = 1.8°

Therefore, number of steps per loop = 360/1.8 = 200

By using micro stepping the steps per loop can be increased up to 200×16 = 3200

Pitch of lead screw = 1.25mm

Pi value = 22/7

Reel Diameter = 40mm

Wire Diameter = 0.5mm

5. ANALYSIS

1. Threaded Shaft

While analyzing the shaft one end of the shaft was fixed and the total deformation and stresses induced are calculated by applying on the other end as,

1) Motor torque of 4.2 kg-cm. i.e. 0.4118N-m

2) Vertical load of 250 gm. of bobbin

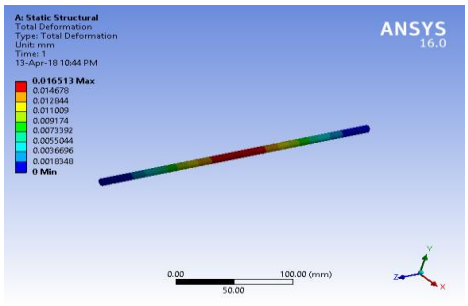


Fig –10: Deformation of Threaded Shaft

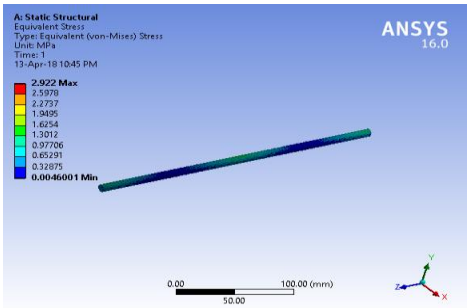


Fig –11: Stress in Threaded Shafts

As per analysis the maximum stress induced is 2.922 N/mm² and deformation observed is 0.01653mm which is negligible as compared to the strength of the material of shaft.

2. Base plate

For analyzing the wooden base the bottom is fixed and following forces are applied

1) Vertical load of 5.17 N due to weight of 0.517kg of Clip base

2) Vertical load of 5.17 N due to weight of 0.517kg of Clip base

3) Vertical load of 5.17 N due to weight of 0.517kg of Clip base

4) Vertical load of 10.2N due to weight of 1kg of U-support

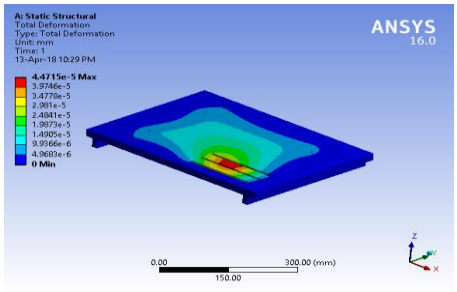


Fig –12: Deformation in Base plate

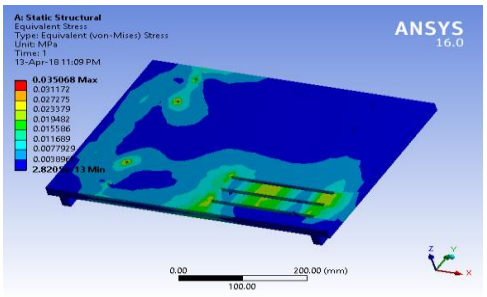


Fig –13: Stress in Base plate

As per analysis the maximum stress induced is 0.35 N/mm² and deformation observed is 0.044715 mm which is negligible as compared to the strength of the material of shaft.

6. Actual Model

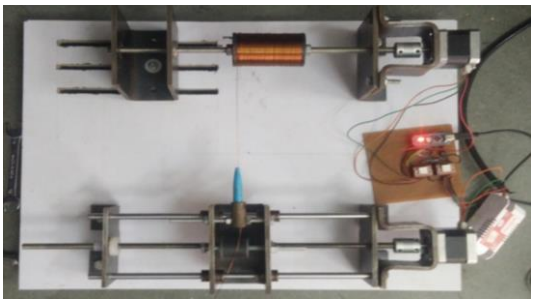
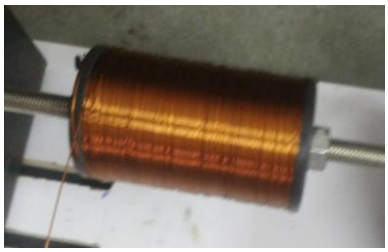


Fig –14: Assembly of Machine



Fig– 15 : Armature after winding

7. CONCLUSIONS

The earlier method of manual coil winding was hectic and time consuming. The accuracy of winding was very low and even spacing between two consecutive winding could not be achieved. While the Automatic winding machine currently used in the industry is complex, bulky and costly. The main objective of the project was to overcome these hurdles by building a low cost and compact automatic coil winding machine. The literature gap found during the literature survey provided us with a problem statement.

Currently industrial coil winding machines uses PLC which needs complex and lengthy programming. Instead the project employs Nano Ardiuno which has simpler programming and is low in cost. Proper tensioning of wire was complicated task as the coil drum has to move along with the slider.

The stepper motor used for the rotation of the threaded shaft enabled precise winding and equal distance between the consecutive windings with varying diameters of the wire. The objective of compactness of the project was achieved with proper design and adequate thickness of the parts.

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