DE-41 (DME)

NUST COLLEGE OF ELECTRICAL & MECHANICAL ENGINEERING

Design and Fabrication of Semi-automatic Toroidal Electromagnetic Coil Winding Machine

A PROJECT REPORT

DE-41 (DME)

Submitted by

USMAN GHAFOOR

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TAHA FERAS

BACHELORS

IN

MECHANICAL ENGINEERING

YEAR

2023

PROJECT SUPERVISOR

SAHEEB AHMED KAYANI

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PESHAWAR ROAD, RAWALPINDI

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DECLARATION

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ACKNOWLEDGEMENTS

We would like to express our heartfelt gratitude and appreciation to all those who have contributed to the successful completion of our Final Year Project (FYP) on the "Design and Fabrication of Semi-automatic Toroidal Electromagnetic Coil Winding Machine." This project has been an incredible journey, and we could not have achieved it without the support and assistance of numerous individuals and organizations.

First and foremost, we would like to extend our deepest gratitude to our supervisor, Mr. Saheeb Ahmed Kayani, for his invaluable guidance, encouragement, and expertise throughout the entire duration of this project. His continuous support and insightful suggestions have been instrumental in shaping and refining our ideas, and we are truly grateful for his unwavering commitment.

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To all those whose names may not be mentioned here but have contributed in any way, we extend our sincerest appreciation. Your assistance, advice, and encouragement have played a vital role in the successful completion of this project.

In conclusion, we are humbled and grateful for the unwavering support we have received throughout this project. The knowledge and skills acquired during this endeavor will undoubtedly shape our future careers. Thank you all for being a part of this remarkable journey.

Shahzaib Baloch
Usman Ghafoor
Taha Feras

ABSTRACT

The Design and Fabrication of Semi-automatic Toroidal Electromagnetic Coil Winding Machine project aims to develop an innovative solution for efficiently winding toroidal electromagnetic coils. This project was undertaken as a Final Year Project (FYP) by a group of dedicated engineering students from NUST CEME.

The objective of this project was to design and fabricate a semi-automatic winding machine capable of accurately and precisely winding toroidal electromagnetic coils. The machine incorporates automation to improve the winding process, reduce manual labor, and enhance overall productivity.

The project involved extensive research on coil winding techniques, automation systems, and the design considerations for toroidal coils. Through the exploration of existing literature and consultation with experts in the field, the group gained valuable insights and knowledge to guide the design and development process.

The design phase of the project focused on creating a robust and user-friendly machine. The group utilized computer-aided design (CAD) software to develop detailed 3D models of the machine components. The design incorporated features such as adjustable winding parameters, tension control mechanisms, and safety measures to ensure optimal performance and operator convenience.

Upon completing the design phase, the group proceeded with the fabrication and assembly of the machine. The fabrication process involved sourcing high-quality materials, machining components to precise specifications, and integrating various subsystems to ensure seamless operation. Rigorous testing and quality control measures were implemented to verify the functionality and reliability of the machine.

The semi-automatic toroidal electromagnetic coil winding machine successfully achieved the project objectives. It offers precise and consistent winding of toroidal coils, reducing human error and enhancing efficiency. The machine's adjustable parameters allow for customization based on specific coil requirements, ensuring versatility and adaptability for various applications.

The project also involved conducting extensive testing and evaluation of the machine's performance. The group carried out comparative studies to assess the efficiency and accuracy of the semi-automatic winding machine in comparison to traditional manual winding methods. The results demonstrated significant improvements in terms of speed, precision, and overall productivity.

In conclusion, the Design and Fabrication of Semi-automatic Toroidal Electromagnetic Coil Winding Machine project showcases the successful development of a specialized machine that revolutionizes the toroidal coil winding process. The project not only provides a practical solution for industry applications but also imparts valuable knowledge and skills to the participating engineering students.

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Coil winding technology

In electrical design, curl winding is the production of electromagnetic loops. Curls are utilized as parts of circuits, to give the attractive field of engines, transformers, and generators, and in producing amplifiers and receivers. The shape and aspects of a winding are intended to satisfy a

specific reason. Boundaries, for example, inductance, Q factor, protection strength, and strength of the ideal attractive field enormously impact the plan of loop windings. Curl winding can be organized into a few gatherings regarding the sort and calculation of the injury loop. Large-scale manufacturing of electromagnetic loops depends on robotized hardware.

1.1. Types of Coil Winding Machine

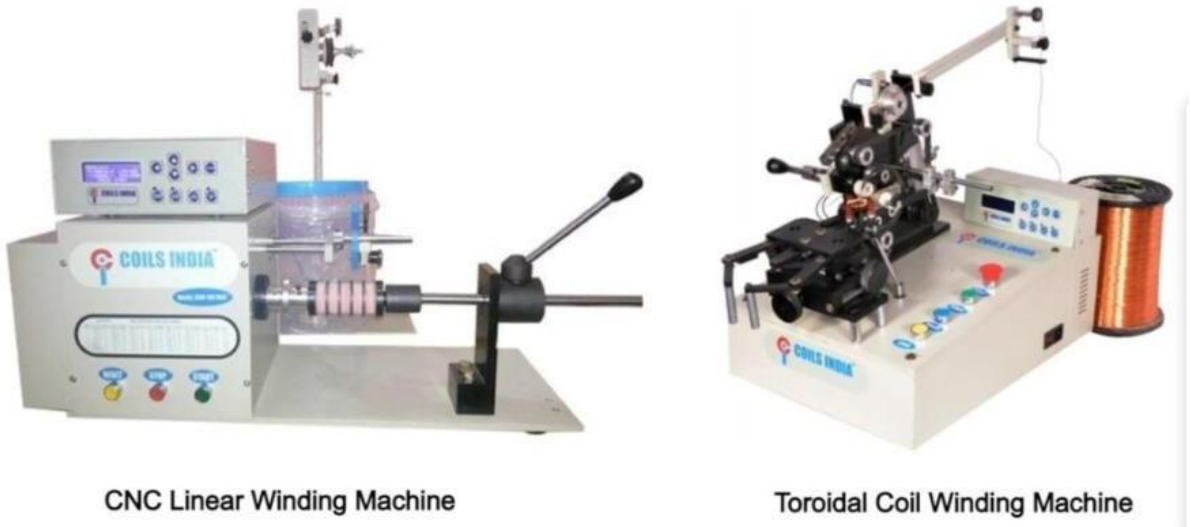
Given the normal system of working, loop winding machines are generally known to be of various kinds, which are as per the following. After having an itemized study, you can choose the most fitting twisting machine to satisfy your motivation as indicated by your site condition.

1. Manual Motor Coil Winding Machine

Manual Motor Coil Winding Machine

These are referred to as the types of winders which are found to be highly useful for small-scale industries or workshops wherein the winding requirement is not too frequent. Manual coil winding machines are found to be operated with hands and are also referred to as giving precise results in terms of coil loops.

2. CNC Linear/ Toroidal Coil Winding Machine



CNC Linear & Toroidal Coil Winding Machine

CNC direct/toroidal winding machines are for the most part utilized at those spots wherein anyone is searching for computerized twisting answers for modified one-off loops or little amount bunches of curls, then, at that point, you should choose CNC winding machines which can be awesome for your motivation.

3. Armature Coil Winding Machine

Armature Coil Winding Machine

These types of machines are ingeniously designed devices with hook commutators. Various winders come with an auto wire cutting and hooking option as well.

4. Transformer Coil Winding Machine

Transformer Coil Winding Machine

Transformer curl winding machines are known for their adaptability, strong fabrication, and solidness as these winding machines are viewed as fit for winding the loops of different sizes and shapes for the transformers. These machines are ordinarily known as these can likewise move toward those spots which are not available because of any site condition. This is how the adaptability of this machine works.

Importance of Coil Winding Machine

Transformers are alluded to as those which are found requiring various loops that have different necessities of winding. Different variables must be considered while curl twisting for transformers like:

- Number of circles
- Wire cutting
- Wire snaring
- De-spooling

- Wire pressure
- Navigating

With the assistance of a legitimate loop winding machine, these are the variables that can be dealt with precision. Mechanized winding machines are planned explicitly to stay away from the undesirable breakage of the wire or some other errors. May it be a medium or uncompromising curl winding necessity, the winders are equipped for giving blunder-free and reliable outcomes. The transformer business gives advantages from the profoundly controlled working system of loop winders.

2. Working Principle of Coil Winding Machine

.

Introduction

Effective loops are found to limit the materials and volume which is expected for a provided motivation. The proportion of the area of electrical conveyors, to the, given winding space is alluded to as the fill factor. Since the round wires are found to have some holes generally alongside the wires which have some space that is expected for the protection inside turns and layers, the fill factor is for the most part more modest than one. To accomplish higher fill factors, a rectangular or level wire can be chosen.

Thick pressing of wires is done which is liable for decreasing the air space and is said to have a high fill factor. This is the explanation that expands the effectiveness of the electrical gadget and a better intensity conductivity of the winding. For best pressing of round wires on a multi-facet winding, the wires in the upper layer are viewed as in the furrows of the lower layer for something like 300 levels of the curling circuit. The wires possess a thick bundle which is alluded to as procyclin winding. Something contrary to this would be an irregular wire structure inside the winding space, which is alluded to as wild winding

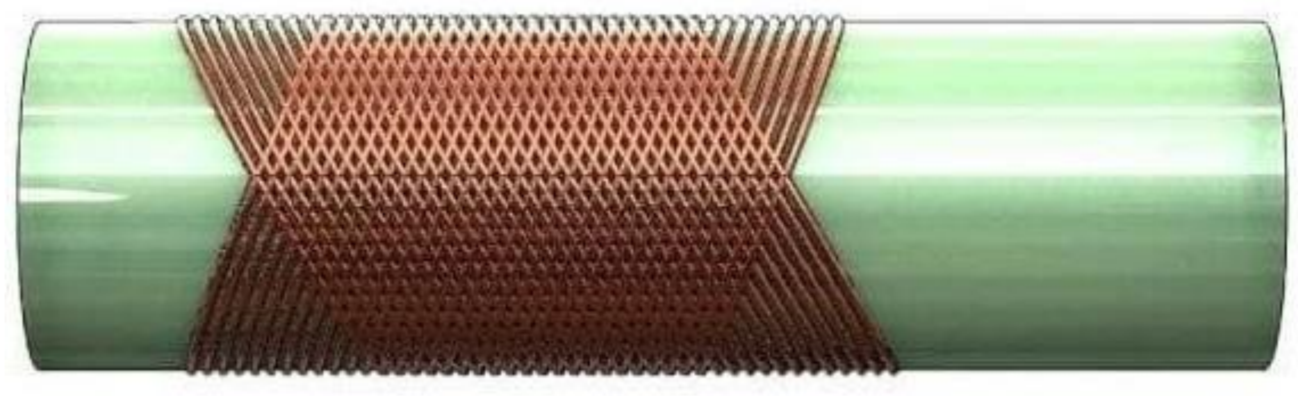
Wild Winding

Wild winding is alluded to as the irregular wire situation which prompts a more extensive

Wild Winding

circulation, coming about wire length on the curled body and subsequently a more extensive scope of electric loop protections. Regardless of its different burdens, it is normal in large-scale manufacturing. It is portrayed by low requests for apparatus and administrators which can be injured with extremely high velocity. Wild windings are for the most part applied in the contactor- and transfer loops, little transformers, start curls, little electrical engines, and by and large those gadgets which are found with moderately little wire checks up to 0.05 mm.

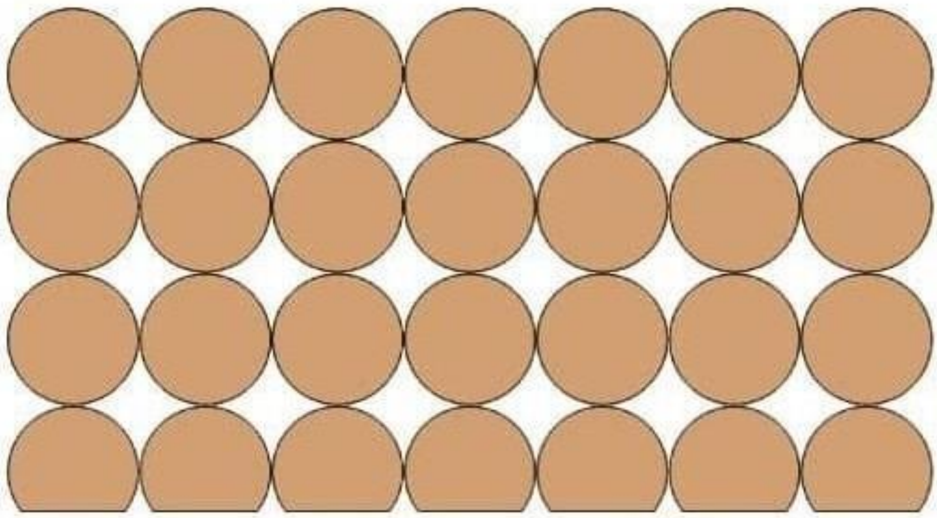
Helical Winding



Helical Winding

Helical windings are the strategy where the wires are put helically in each layer. Attributable to the heading of development from one layer to another changing between the right to left, the wires are found to cross and find themselves inside a particular hole of the layer under. A wire which guides the lower layer isn't viewed as existent. On the off chance that the quantity of layers surpasses a specific cutoff the construction can't be kept up with and a wild winding is likewise observed to be made.

Orth cyclic Winding



Orthocyclic Winding

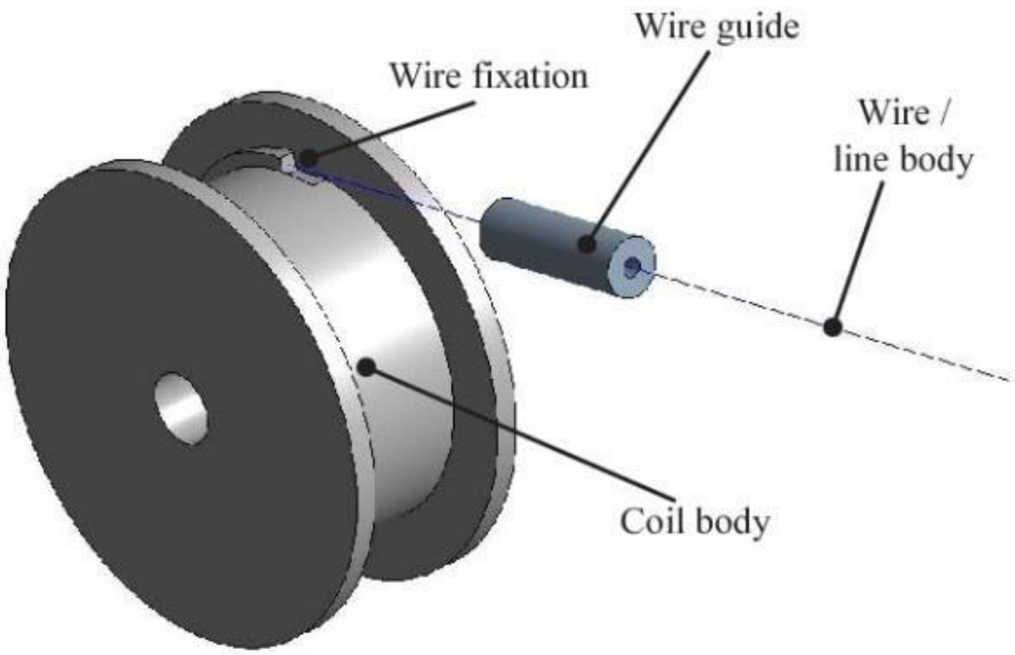
Orth cyclic winding is alluded to as a sort of winding design that makes an ideal fill factor for round wires. The windings of the upper layer should be put inside the scores which are given by the lower layer.

The best use is viewed once the winding is seen as lined up with the loop spine for a large portion of its perimeter. When the winding has been set around the loop body it will meet the past situated wire which necessities to make a stage with the size of the wire measure. This development is alluded to as a winding step. The winding step is found to possess an area of up to 60 levels of the curl perimeter for a round loop that takes one side of the rectangular loop. The region of the winding step is found to rely upon the wire measure and curl math.

2.1 Process of Winding

At this point, the rule of loop winding should be clear, presently one must understand what all cycles are remembering for the method involved with winding. Thus, beneath reference is the nitty gritty clarification of the cycles which are engaged with the most common way of winding.

1. Linear Winding:



Linear Winding

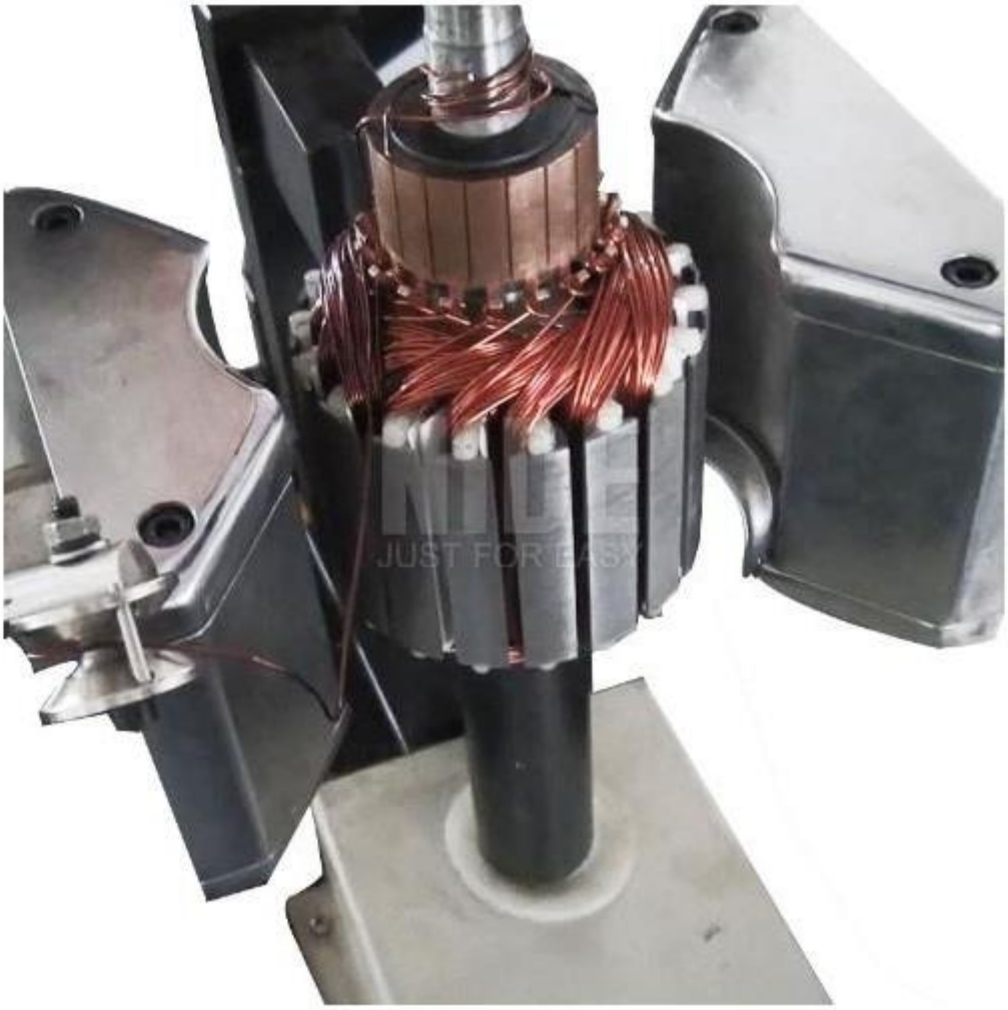
The direct winding technique is alluded to as that strategy where a winding is delivered by the assistance of winding the wire onto a pivoting curl body, part, loop conveying, and loop shaping gadget. The wire is pulled out from a stock roll which contains around 400 kg of plated copper wire. The wire is taken care of through a directing cylinder. Before beginning the genuine winding cycle, the wire is mounted to post or cinch the gadgets of the curled body or the winding gadget.

By utilizing the direct laying development of the wire directing cylinder, the part which is to be injured is turned such that the wire is conveyed all through the twisting space of the curled body. The rotational movement alongside the laying development is accomplished by utilizing the PC-controlled engines. Concerning one turn of the pivot hub and contingent upon the wire breadth, the crossing hub of the wire directs the cylinder which is moved likewise.

This prompts the rotational rates of up to 30,000 for every min, particularly while handling through the slight wires. Contingent upon the breadth of the winding, the speed of the wire can depend on

30 m/s which can be accomplished during the winding system. The parts which should be injured are mounted on the winding gadgets. The winding gadgets are combined with driven axles that can create the turning movement. Since carrying the wire into the winding region should be finished as equitably as could be expected, the rotational hub alongside the navigating hub works simultaneously during this entire winding interaction.

2. Flyer Winding

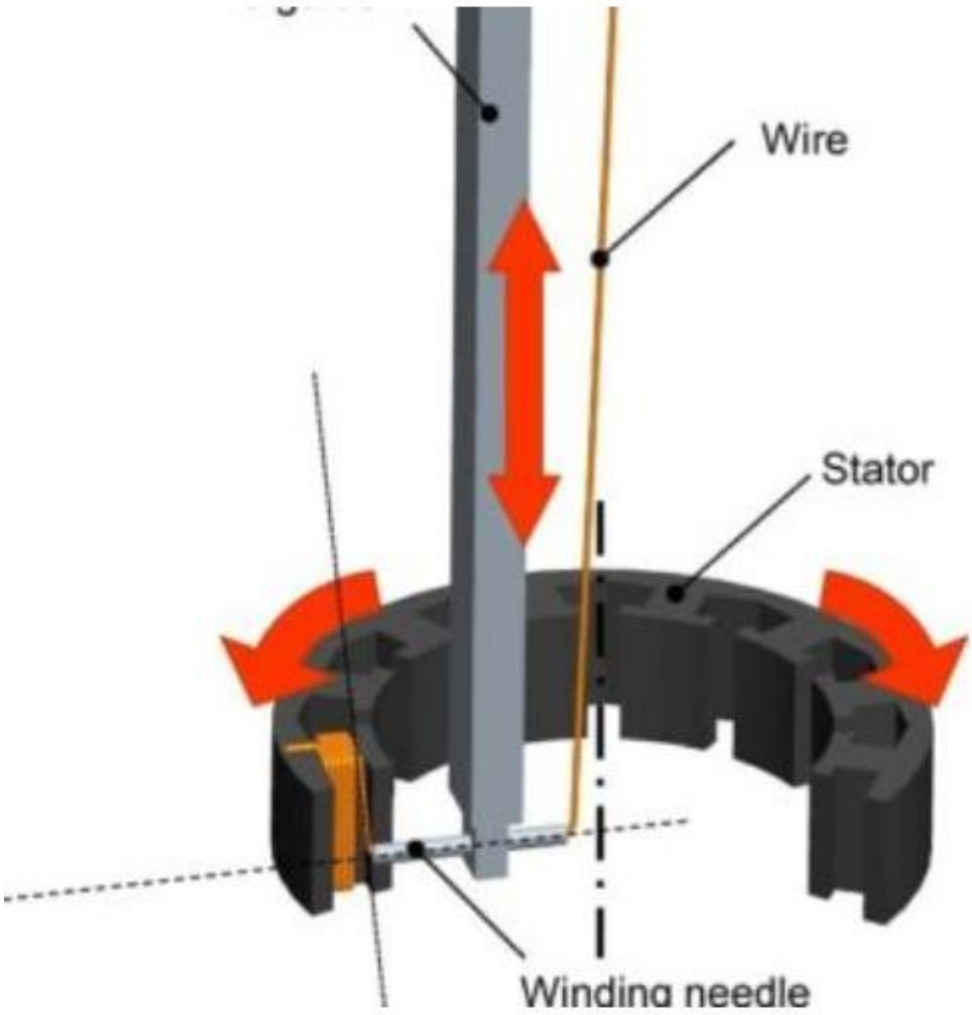


Flyer Winding

In the flyer winding strategy, a winding is created by taking care of the wire using a roll or through a spout that is joined to a flyer and is found to turn at a specific separation from the loop. The wire is taken care of by the flyer shaft. For winding the part which should be wound, it should be fixed inside the twisting region of the flyer. It is required that the wire ought to be fixed beyond the flyer whenever of the winding technique.

The obsession with the wire is made conceivable typically by the progressive winding strategy which is frequently utilized at rotational ordering tables. At the circuit of the table, there are the wire clasps or wire redirections which empower a draw along and obsession with the wire. This will continuously permit an exceptionally speedy part change, which gives that no different saving of the wire in a wire cut on the machine is required.

3. Needle Winding Technology



Needle Winding Technology

Needle winding innovation is utilized to effectively wind the post shoes which are found lying near one another to electronically drive different three-stage engines. These are viewed as covered with protection which straightforwardly wounds with the needle winding technique. A needle alongside a spout which is set at a right point to the course of development goes in a lifting movement that passes the stator packs through the notch channel inside the two adjoining posts of the engine to drop the wire in the ideal spot. The stator is then found to turn at the inversion point on the twisting head by one tooth pitch so the past cycle can run again in the opposite request.

With this winding innovation, a particular layer design can be understood. The disservice is that there should be freedom between two nearby shafts with a size of essentially the spout measurement. The distance across the spout is viewed as about threefold the measurement of the winding wire. The space between two neighboring posts can consequently not be filled.

4. Toroidal Core Winding Technology:

Toroidal Core Winding

Before beginning the winding system, the Toroidal/Attractive center is viewed as mounted into a holding installation which can start a sluggish rotating development of the center alongside for the most part three rubber-treated resources.

A wire stockpiling ring or orbital wheel is viewed as organized at a point of 90° to the toroidal center which can now be opened at the boundary and brought into the focal point of the toroidal center. After this, the wire is snaked around the wire stockpiling ring, so it tends to be shut once more. At the point when the necessary sum is available on the wire aggregator, the finish of the wire from the wire gatherer is fixed to the toroidal center which should be injured.

By comparable pivot of the toroidal center and the wire collector ring, a winding is found to foster which is dispersed along the periphery of the toroidal center. After finishing, the wire collector should be opened again to have the option to eliminate the prepared injury toroidal center. Starting from the beginning as well as the end wires are not frequently fixable deeply, the toroidal winding machines must be somewhat robotized.

Coil Winding Wire:

Coils provide the magnetic field of motors, transformers, and generators, and are used in the manufacturing of loudspeakers and microphones. The shape and dimension of the wire used in a coil winding are designed to fulfill a specific purpose.

Efficient coils minimize the materials and volume required for a given purpose. The ratio of the area of electrical conductors, to the provided winding space is called “fill factor”. Since round wires will always have some gap, and wires also have some space required for insulation between turns and between layers, the fill factor is always smaller than one. To achieve higher fill factors, rectangular, square or flat wire can be used.

Wild Winding:

Sometimes called jumble winding, this type of winding structure results in poor fill factors. The random wire placement leads to a wider distribution of resulting wire length on the coil body and consequently a wider range of electric coil resistances. Despite these disadvantages, it is common in mass production and can be wound with very high speeds and requires very little attendance of the operator or the machine used to produce it. Windings are found mostly in relay coils, small transformers, Ignition coils, small electrical motors, and generally devices with relatively small wire gauges up to 0.05 mm. Achieved fill factors with the use of round wires are about 73% to 80% and are lower compared to Orthocyclic windings with a 90% fill factor

Electronically Commutated (EC) Motors

EC Motors produce more power in less space

As a result of the requirement for better execution density in engine winding innovation, brushless EC (electronically commutated motors) drives with extremely durable magnet rotors are progressively utilized rather than the nonconcurrent innovation. Because of the conservative plan, the copper content might by and large at any point be sliced down the middle.

Makers of electric engines additionally request greater adaptability of the creation innovation. For creating offbeat engines, attracting frameworks are generally utilized that are at first winding air-center loops just to draw them later into the stator with a device. Conversely, the concentrated twisting of EC stators is more adaptable in the assembling system, energy saving when carried out, better flexible during activity and it requires less space.

What is an electromagnetic coil?

Electromagnetic coil is also known by the name inductor and is one of the simplest electric components. It consists of two distinct elements, a conductor and a core. The conductor is usually made from copper wire and is wrapped around the core. One cycle around the core is called a turn. When the wire is turned multiple times it’s considered to be a coil. The role of the coil is to provide inductance to an electric circuit. Inductance is an electrical property characteristic to electromagnetic coils opposing the flow of current through the circuit.

Orthocyclic winding:

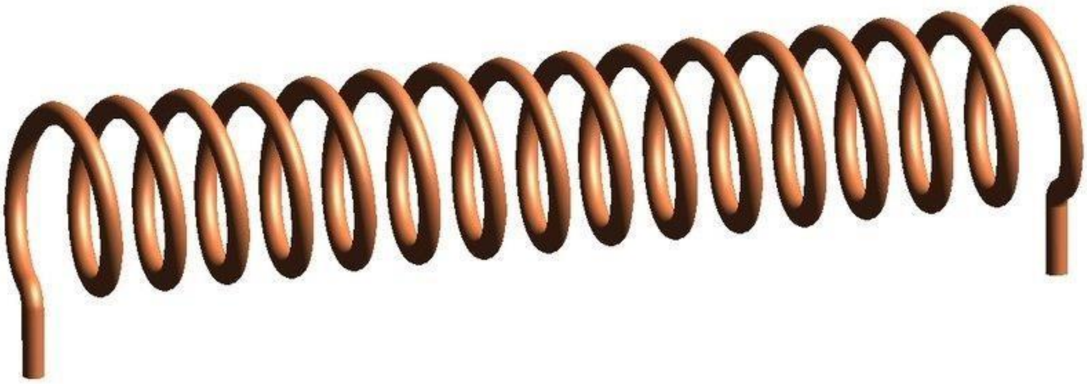
For Orthocyclic wound coils, the winding step regions is constantly situated at the area of wire entering the winding space and is gone on in helical structure against the winding heading. Subsequently, a bigger twisting width of the curl prompts a greater winding step region along the boundary of the loop. The made offset prompts an alternate place of the layer step, from the first to the subsequent layer, in contrast with the wire passage. This conduct rehashes the same thing with each layer which prompts a twisting formed hybrid segment along the edge of the winding. At the point when wires are crossing inside the hybrid segment the subsequent winding level is expanded. Subsequently, Orthocyclic wound coils with a round loop ground are never round in the get over segment, however the spiral moving winding and layer step makes a mound shape. Experience has shown that relying upon the winding width, curl and wire distance across, the hybrid segment is around 5 to 10 percent higher than the normal winding level.

How do electromagnetic coils work?

To comprehend how the inductors work, we can have a nonexistent illustration of electrical circuit, with glowing light associated in lined up with an inductor and the current is going through a switch. At the point when the switch is turned on, in principle the loop will go about as a short out and that way keep the light from emanating light, on the grounds that the curl has lower electrical opposition. Truly the light will be splendid toward the start and begin to diminish to a lower light force. A similar impact is shown when the switch is switched off.

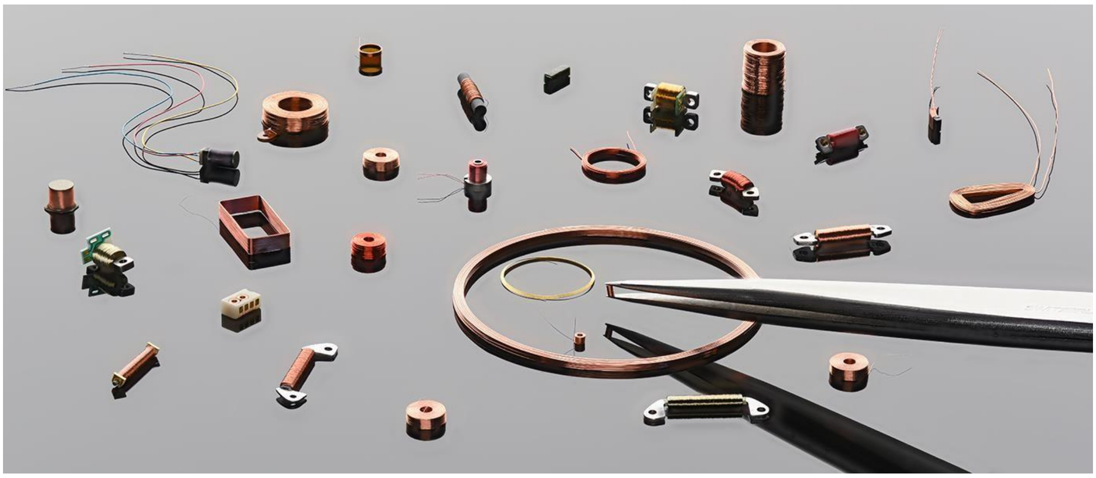
This happens on account of inductance. At the point when current is taken care of through the curl it will create an attractive field that produces one more current in inverse bearing, which will attempt to prevent the current from going through the loop. Though, when the attractive field is laid out, the current stream returns to ordinary. In another point of view, assuming the current stream is halted, the attractive field create electric current through the curl to keep up with it. Subsequently the attractive field can't be maintained and it breakdowns. The light will be lit for only a modest quantity of time.

Why does the size of coil / number of turns affect strength of themagnetic field?



The response for the initial segment of the inquiry could take some time on the off chance that I I'd go exhaustively, yet the nuts and bolts are simple to make sense of. If we take apiece of straight wire and connect it to a battery, the current will course through it and produce a magnetic field. The strength of the magnetic field produced can be determined when you know the measure of current and the length of the wire. We can imagine that we have a straight solenoid magnet. At the point when the wire is folded over the center, the heading of field lines is reshaped and sort of gathered into a more modest size. Suppose one turn is 5cm long. Contingent upon the thickness of the wire, it very well may have the option to have a few meters of snaking in a solitary layer on a center that is just couple of centimeters long. So every turn will expand the magnetic power by 5cm worth of the straight wire. If you add more layers in top of the first and it will expand the strength of the magnetic field significantly more. In specialized terms this is expanding of solidarity is known as the magnetic flux density. Anyway, when you have given current, you can add goes in to a curl partially which after the center immerses, implying that the magnetic field can't increment any longer and the all out magnetic flux density will even out off.

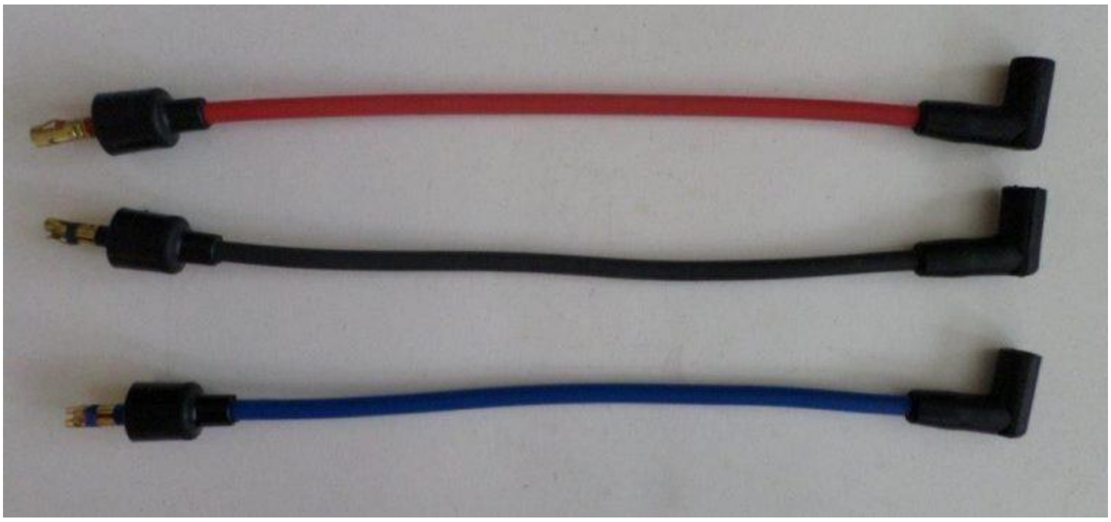
Micro Coil Manufacturing Materials:



Utilizing super fine wires to make inductive parts and give network inside scaled down clinical gadgets requires the transaction of imaginative loop winding advancements. These innovations are predicated on a variety of strategies for taking care of copper and other metal wires at any measurement, down to the best sequentially fabricated size of 8 microns (0.08 mm, or 60 AWG), some of the time 5 to multiple times more slender than a human hair.

The boundaries determined for loops by and large rely upon the application region. One of the fundamental boundaries the originator determines is the material to be utilized for a curl. Benatav makes specially crafted miniature curls from a wide cluster of materials. The most well-known materials our curls are produced using are copper, treated steel, aluminum, titanium, and high immaculateness valuable metals, to give some examples. Cautious thought is given on the metal determination to guarantee that each miniature loop is produced to greatness.

Does a coiled wire have a higher resistance than straight wire?



The straight forward response is no. Twisting wire on a non-ferrous structure won't change its obstruction.

Obviously, everything relies upon the subtleties. Assuming the wire is uninsulated, and the structure is conductive (copper, silver, gold, platinum, and so forth) the structure will short out the wire turns and diminish the complete opposition. Or on the other hand would you say you were considering protected wire? You didn't say.

Ok, you say, yet it is protected. To be exact, it's protected with enamel, and called magnet wire.

Indeed, presently it gets interesting. We should expect your reference point is a straight wire suspended between two contacts in still air. As you run current through the wire, it will warm up, regardless of whether just marginally, and for most wire materials the obstruction will change. In the event that the wire is currently wound around a type of some material, the structure will change the rate at which power is disseminated to the climate, and in this manner the obstruction. A warm separator, for example, froth, will expand the temperature of the wire. A decent warm guide, for example, silver, will more often than not lessen the temperature changes, and, surprisingly, this impact relies upon the actual subtleties of the structure to decide the drawn out temperature impacts. Size and shape will matter, and the outcome can, on a fundamental level, go one way or the other**.**

Calculation of Reactances for Ring Windings to Toroidal Inductors ofHybrid Induction Machine:

In this paper, the general expressions for self and mutual inductances of linear motors with hybrid structure were weights method. The theoretical considerations were carried out for three-phase winding-upin one layer, with even number of poles and one slot per pole and phase, as it is in our practical implementation. The magnetic asymmetries due to the different magnetic coupling of edge phases R and, respectively, S with the mean phase, are taken into account. The self inductance of mean phase I is always greater than of the other phases because it is edged by greater lengths of magnetic circuits,The magnetization reactances are determined by three methods, including: the general method used for the induction motors. Experimental testing of these expressions was based on the hybrid engine built in our laboratory.

An Actuator is a device that moves or operates something.
- An Actuator can move anything in a straight path, known as linear motion, or in a circular motion, known as rotary motion.
- An Actuator is a device that absorbs energy and uses it to move things. In other words, it transforms the energy source into physical-mechanical motion.
-

This source of energy can take three forms:

- Pneumatic
- Electric
- Hydraulic

Typical actuators in the industry include:

- Pneumatic Control Valve
- Electric Motor
- Hydraulic Motor

Electromagnetic actuators are energy conversion actuators that work on the electromagnetic principle. Electromagnetic actuators are devices that combine electrical and mechanical energy.

The energy conversion takes place in the so-called air gap that exists between the actuator's stationary member (stator or fixed contact) and moving member (rotor or moving contact).

These actuators use a magnetic field to generate force and torque. Magnetic fields have a higher energy density than electrical fields, which is why they are used in these sensors.

Faraday's rules of electromagnetic induction, the Lorenz force of electromagnetic forces, and the Biot-Savart law are the fundamental principles that regulate electromagnetic actuators.

Because the electric current fed by the power converter drives is the control variable of this type of actuator, it is easily controlled.

These are employed in a variety of applications, ranging from fine control with small actuators to relatively big powerful units with electrical drives.

Electromagnetic sensors are made up of two basic circuits: an electrical circuit and a magnetic circuit. The electric circuit determines voltage and current using circuit analysis laws, whereas the magnetic circuit determines magnetic flux and magnetic field strength.

Magnetic flux exists in the presence of a magnetic field. The permeability of the material influences the magnetic flux density B and magnetic field strength H. Magnetic flux density is proportional to magnetic field strength in a vacuum given as

$\bar{B} = \mu o\ \bar{H}$

Where o denotes the permeability constant and has a value of 4 10-7. This relationship is stated for ferromagnetic materials as

$$\bar{B} = \mu r\ \bar{H} .\ \mu o\ H$$

Where r H is the material's relative permeability. The permeability (r) of a material's dependency on H is investigated using B-H curves.

According to the Lorenz law, when a current carrying conductor is placed in a magnetic field, it experiences a force. If a current I flows in a conductor of length L in the presence of magnetic flux density B, then the experienced magnetic flux density

Lorenz force is denoted as

$\bar{F} = i\ \bar{L} \times \bar{B}$

Most of the time, B and L are orthogonal, and the previous equation can be written as F orthogonal to B and L.

$F = B\ L\ i$

A conductor's motion in a magnetic field generates an electromagnetic force (emf) across the conductor. This is known as Faraday's law or electromagnetic induction law. The induced emf in a closed circuit is equal to the rate of change of magnetic flux through the circuit, according to this law. Therefore, $e = - d\Phi/dt$

The Biot-Savart law explains the magnetic flux density produced by an electric current and is provided for a long straight conductor at a perpendicular distance r as These are the three essential laws that serve as fundamental principles for electromagnetic actuators.

$B = (\mu o\ \mu r\ i) / (2\pi r)$

Different types of actuators based on electromagnetism.

- Electrical Motors
- Soleniod actuators
- Linear solenoid
- Rotary solenoids
- Moving coil actuators
- Relays

What is an Electromagnetic Coil

One of the most basic electrical components is a magnetic coil, usually referred to as an inductor. It is made up of a conductor and a core, two separate components. The conductor is wrapped around the core and is typically constructed of copper wire. A turn is one complete rotation around the core. The wire is referred to as a coil when it has been spun repeatedly. The coil's function is to give an electrical circuit inductance. An electrical characteristic of electromagnetic coils that opposes the flow of current across the circuit is inductance.

An electromagnetic coil is most frequently used as an inductor, which stores energy within its magnetic field. Due to its lack of gain and inability to regulate the directional flow of energy, an inductor is regarded as a passive electrical component. Electric current is conducted through the inductor's body to capture energy.

According to Faraday's law of induction, the induced electromotive force, or EMF, within a closed circuit is equal to the time rate of change of the magnetic flux through the circuit, which explains why this reaction occurred. For electromagnetic coils to work in a circuit, the wire must have terminals linked to it. Taps are another name for terminals. Typically, they are covered in varnish or wrapped in insulation tape. A winding is what is present when an electromagnetic coil has taps on either end.

How Electromagnetic Coil Works

We can create an imaginary electrical circuit with an incandescent light bulb connected in parallel to an inductor and the current flowing through a switch to better understand how inductors function. Theoretically, because the coil has a lower electrical resistance than the light bulb, when the switch is switched on, the coil will operate as a short circuit and prevent the light bulb from emitting light. In practice, the light will start off strong before dimming to a lesser light intensity. When the switch is off, the same result is visible.

Inductance is what causes this to occur. The coil will produce a magnetic field when current is put through it, creating an opposing current that will try to block the current from passing through the coil. Even yet, the current flow returns to normal once the magnetic field is formed. From another angle, if the coil's current flow is halted, the magnetic field will generate electricity to keep it going. As a result, the magnetic field loses its ability to maintain itself and collapses. There will only be a brief period of time while the light bulb is lighted.

Why does the size of coil / number of turns affect strength of the magnetic field?

If I were to address the first half of the question in detail, it might take some time, but the fundamentals are rather simple to convey. A piece of straight wire will conduct current and produce a magnetic field if it is connected to a battery. When the quantity of current and the length of the wire are known, the strength of the magnetic field that is generated may be estimated. We can pretend to have a linear solenoid magnet (see Figure 3). The direction of the field lines is changed and somewhat focused into a smaller area as the wire is wrapped around the core. Suppose a rotation is 5 cm length. Depending on the wire's thickness, many meters of coiling may be possible on a core that is only a few centimeters long. Therefore, every turn will result in a 5 cm increase in the straight wire's magnetic force. The magnetic field will get even stronger if additional layers are added on top of the initial one. Magnetic flux density is the phrase used in technical jargon to describe this strength increase. However, once current has been applied, you can continue to add turns to a coil until the core saturates, at which time the magnetic field will stop growing and the total magnetic flux density will level off.

The basic equation for calculating the strength of a magnetic field is: $\phi = N * I$, where ϕ is strength, N is number of turns of the coiling and I is the current through the coiling.

3 Process of winding

The process of winding typically refers to the action of coiling or wrapping a material, such as wire or thread, around a spool, bobbin, or similar object. Winding is commonly used in various industries, including textile manufacturing, electrical engineering, and packaging. Here is a general process for winding:

Prepare the materials: Gather the material you want to wind, such as wire, thread, or yarn. Ensure that the material is untangled and ready for winding.

Select the winding object: Choose an appropriate spool, bobbin, or tube to wind the material onto. The selection depends on the specific application and the desired outcome.

Position the winding object: Hold the winding object securely or place it in a winding machine, if available. Ensure that it is stable and won't move during the winding process.

Start the winding process: Begin winding the material onto the spool or bobbin by holding the end of the material firmly and wrapping it around the object. Maintain tension on the material to create a tight and even wind.

Maintain alignment: Pay attention to the alignment of the material as you wind it. Make sure it is evenly distributed and doesn't overlap or tangle. Adjust the position of the material as needed while winding.

Continue winding: Keep wrapping the material around the spool or bobbin in a consistent manner. If using a winding machine, follow the machine's instructions for speed and tension settings.

Control the winding tension: Maintain appropriate tension on the material as you wind it. The tension level depends on the specific material and its intended use. Avoid excessive tension that could damage the material or insufficient tension that could result in loose winding.

Wind until completion: Continue winding the material until you reach the desired length, fill the spool or bobbin, or complete the specific winding requirements for your project.

Secure the end: Once you have finished winding, secure the loose end of the material to prevent unraveling. You can use tape, a knot, or other suitable methods, depending on the material and its intended use.

Store or use the wound material: If the wound material is for storage, place it in an appropriate container or location to protect it from damage. If the wound material is for immediate use, transfer it to the intended application or packaging.

It's important to note that the specific winding process may vary depending on the material, equipment, and industry involved. Always follow the guidelines and recommendations provided by manufacturers or industry standards for optimal results.

3.1Rotator and stator

An electric motors or generator consist of a cylinderical rotating part called the *rotor* and a stationary part called the *stator*. For maximum efficiency, a *gap* between the rotor and stator is kept as small as possible, typically 1-2 mm.

For most AC generators, the stator acts as the *armature*, and the rotor acts as the field magnet.

3.2 Laminations

The rotor and stator are both assembled from a stack of laminations stamped from sheetsof electrical steel, typically 1 mm thick. The laminations are designed to minimize eddy currents, which would otherwise waste energy and create heat.

3.3 Slots and teeth

Windings consist of insulated conductors, which pass through slots cut along the axis of the stator. The spaces between the slots are called teeth. The shape of the slots and teeth depends upon the design of the electric machine. Slots may be rectangular, they may taper, they may be circular, etc.

The wider part at the end of the tooth is called a tooth shoe.

Some authors use the term "groove" to mean the same thing as slot. In this article, the term groove refers to the indentations between parallel conductors in a layer of a winding.

3.4 Poles

A rotor makes a complete rotation in 360 degrees. That amounts to 180 degrees to pass by each pole of a two pole machine. The current in conductors also goes through a complete cycle in 360 degrees.

For a four pole machine, each pole spans only 90 degrees. During the 90 degrees the current in a conductor goes through a half cycle, or 180 degrees. Because there are four poles, and 4 x 180 = 720, the conductors go through two complete cycles for each complete turn of the rotor.

OBJECTIVES AND FEATURES OF THE INVENTION

- It is an objective of the present invention to provide a coil winding machine in which tape or heavy wire may be wound on a toroidal coil without imposing work hardening or other mechanical stress on the wire or tape.
- It is a further objective of the present invention to provide such a coil winding machine that will wind heavy metal wire of soft metal on a toroidal core and which will not impose a

work hardening of the wire as it is being wound on the core, but will prevent such work hardening by avoiding imposing a sharp angle or small circumference on the wire.

- It is a still further objective of the present invention to provide such a coil winding machine in which the tape or wire is not physically stressed by removing the tape or wire from the outer layer of a pile of layers.
- It is a feature of the present invention to provide a coil winding machine adapted to wind a wire or tape ("elongated conductor") about a toroidal core having a hole. For example, the wire may be a soft aluminum heavy wire which is rectangular in cross-section or a tape may be of metal. The coil winding machine includes a base and clamp means to removably hold a toroidal core.
- A ring-like shuttle magazine is rotatably mounted on the base and passes through the toroidal core hole in the case of heavy wire. The shuttle magazine removably retains a length of the elongated conductor formed into a coil. The shuttle magazine is rotated by drive means in one direction to load the elongated conductor into the magazine. It is rotated in the opposite direction to unload the elongated conductor from the inner diameter of the shuttle magazine and wind it about the core. For example, in one type of drive system, the shuttle magazine has external ring gear teeth which mesh with the teeth of a motor-driven drive gear.
- In the case of taping, the shuttle magazine removably retains a length of tape formed into a coil. The shuttle magazine is rotated by drive means in the direction of taping, to load the tape into the magazine. Loading and taping are simultaneous. In the taping operation, the tape is unloaded from the inner diameter of the shuttle magazine and wound about the core. For example, in one type of drive system, the shuttle magazine has external ring gear teeth which mesh with the teeth of a motor-driven drive gear.
- A hold-up means supports the inner diameter of the elongated conductor coil in the shuttle magazine. The hold-up means moves outwardly (relative to the imaginary center of the shuttle magazine) as the elongated conductor is payed out. A pay-off tension control means is positioned adjacent the inner diameter of the conductor coil in the shuttle magazine to control the tension on the conductor.
- It is a further feature of the invention that the hold-up means includes a plurality of shaft members whose ends are rotatably mounted on the shuttle magazine, an arm fixed to each shaft member at one end of the arm, a roller connected to each arm at the opposite end thereof, and pivot drive means which pivot each shaft as the conductor is payed out. The rollers are held in supportive contact with the inner diameter of the coil of conductor in the shuttle magazine.
- It is a still further feature of the present invention that, in the case of heavy wire winding, the pay-off tension control means includes a ring parallel to the shuttle magazine, a motor means, preferably an air motor, to rotate the ring in the opposite direction as the shuttle magazine during winding but independently thereof, and a pay-off roller fixed to the ring and positioned to contact the conductor and apply tension thereto.
- It is a still further feature of the present invention that, in the case of taping, the pay-off tension control means includes a ring parallel to the shuttle magazine, a motor means, preferably an air motor, to rotate the ring in the same direction as the shuttle magazine during winding but independently thereof, and a pay-off roller fixed to the ring, and positioned to contact the tape and apply tension thereto.

- The coil winding machine of the present invention utilizes a shuttle magazine which is a circular ring-like member driven by a gear ring which is the outer face, or secured to, the shuttle magazine. In a conventional shuttle the wire is wound in the shuttle in a number of turns and the wire is removed from the shuttle by pulling it off the top layer, imparting a considerable stress on the underlying layers. In the present invention the conductor (wire or tape) is removed from the inner layer as it lays in the shuttle magazine. This avoids the stress and distortion on the wire which would be caused by pulling it from the top layer.
- The coil winding machine of the present invention is described in connection with two embodiments. The first embodiments adapted to wind a heavy wire. For example, the heavy wire may be aluminum wire having a rectangular cross-sectional shape and a size of 1/4-inch by 1/2-inch. It is important that the heavy wire be wound on the toroidal coil without a sharp bend because such a bend will cause "work hardening" and stretching of the wire and will adversely affect its magnetic and/or electrical properties. In one specific embodiment, the heavy wire is of dead soft aluminum and is wound on a leg of a toroidal core bobbin which has a given length. It is wound in one or more layers to form the winding of a transformer, such as an electrical distribution transformer.

4 APPLICATIONS:

The Semi-automatic Toroidal Electromagnetic Coil Winding Machine developed in this project has various applications across industries that utilize toroidal coils. The machine's enhanced efficiency, precision, and versatility make it a valuable tool for the following applications:

4.1 Power Electronics:

Toroidal coils are extensively used in power electronics applications, such as transformers, inductors, and power supplies. The semi-automatic winding machine can significantly streamline the coil winding process, ensuring consistent winding quality and reducing production time.

4.2 Renewable Energy Systems:

Toroidal coils play a crucial role in renewable energy systems, including wind turbines, solar inverters, and energy storage devices. The winding machine enables efficient production of toroidal coils used in these systems, contributing to the overall performance and reliability of renewable energy infrastructure.

4.3 Electric Vehicle (EV) Industry:

Electric vehicles rely on toroidal coils in various components, such as motor windings, power electronics, and battery management systems. The semi-automatic winding machine facilitates the production of high-quality toroidal coils, meeting the growing demand for EV components with improved efficiency and performance.

4.4 Aerospace and Defense:

Toroidal coils find applications in aerospace and defense systems, including communication equipment, radar systems, and avionics. The winding machine ensures precise and consistent winding of coils used in these critical systems, maintaining optimal performance and reliability.

4.5 Medical Devices:

Many medical devices, such as magnetic resonance imaging (MRI) systems, require toroidal coils for their operation. The semi-automatic winding machine offers efficient and accurate coil winding, meeting the stringent requirements of the medical industry and improving the quality and reliability of medical equipment.

4.6 Research and Development:

The winding machine serves as a valuable tool in research and development laboratories, allowing researchers to quickly prototype and test toroidal coils for various experimental setups. Its flexibility and adjustable parameters enable customization and iteration during the R&D process.

4.7 Industrial Automation:

In industrial automation applications, toroidal coils are utilized in control systems, sensors, and actuators. The semi-automatic winding machine provides a reliable and efficient solution for mass production of these coils, contributing to the automation and efficiency of industrial processes.

4.8 Consumer Electronics:

Toroidal coils are found in various consumer electronic devices, such as audio equipment, televisions, and electronic appliances. The winding machine enables manufacturers to produce high-quality coils efficiently, meeting the demands of the consumer electronics market.

In summary, the Semi-automatic Toroidal Electromagnetic Coil Winding Machine developed in this project finds extensive applications in power electronics, renewable energy, electric vehicles, aerospace, medical devices, research and development, industrial automation, and consumer electronics. Its ability to enhance productivity, precision, and quality in coil winding processes makes it an asset in various industries.

5 Material Used:

The Semi-automatic Toroidal Electromagnetic Coil Winding Machine incorporates various materials in its construction to ensure durability, functionality, and efficient coil winding. The following are the materials commonly used in the machine:

5.1 Frame and Structure:

Steel or aluminum: These materials are often used for the main frame and structural components of the machine due to their strength, rigidity, and resistance to deformation.

5.2 Winding Spool:

Plastic or composite materials: The winding spool, on which the toroidal coils are wound, is commonly made of plastic or composite materials. These materials offer lightweight construction, smooth surface finish, and resistance to corrosion.

5.3 Winding Guide:

Ceramic or hardened steel: The winding guide, which ensures proper alignment and tension of the wire during the winding process, is often made of ceramic or hardened steel. These materials provide high wear resistance and dimensional stability.

5.4 Wire Tensioning Mechanism:

Springs: Springs made of steel or other suitable alloys are commonly used in the wire tensioning mechanism. These springs provide controlled tension on the wire, ensuring consistent and uniform winding.

5.5 Motor and Drive Components:

Various metals and alloys: The motor and drive components, such as gears, pulleys, and shafts, are typically made of metals and alloys, such as steel or aluminum. These materials offer high strength, durability, and precise movement.

5.5 Control Panel and Interface:

Plastic or metal: The control panel and interface components, including buttons, switches, and displays, can be made of plastic or metal. These materials provide a combination of durability, aesthetics, and ease of use.

5.6 Sensors and Actuators:

Various materials: Sensors and actuators used for automation and control within the machine can incorporate a range of materials, depending on their specific functions. Common materials include metals, plastics, and electronic components.

5.7 Electrical Wiring:

Copper or aluminum: Electrical wiring within the machine utilizes copper or aluminum conductors due to their excellent electrical conductivity and flexibility.

5.7 Safety Features:

Protective covers and guards: Safety features, such as protective covers and guards, are typically made of materials such as plastics or metals, ensuring operator safety and preventing access to moving parts.

It's important to note that the specific materials used in the construction of the winding machine may vary depending on factors such as cost, availability, and application requirements. The selection of materials should consider factors such as mechanical properties, electrical conductivity, corrosion resistance, and environmental considerations to ensure optimal performance and longevity of the machine.

6)COST EFFECTIVES:

Cost-effectiveness is an important consideration in the design and fabrication of the Semi-automatic Toroidal Electromagnetic Coil Winding Machine. By selecting cost-effective materials and components, the overall project expenses can be optimized while still maintaining the desired functionality and performance. Here are some strategies for achieving cost-effectiveness in the construction of the winding machine:

6.1 Material Selection:

Choose materials that strike a balance between cost and performance. Consider alternative materials or sourcing options that offer similar properties but at a lower cost. Conduct thorough market research to identify cost-effective materials without compromising on quality and durability.

6.2 Component Standardization:

Standardize components and parts wherever possible. By using readily available and commonly used components, the cost can be reduced due to economies of scale and competitive pricing in the market.

6.3 Supplier Evaluation:

Evaluate multiple suppliers for materials and components to ensure competitive pricing. Negotiate with suppliers to obtain the best possible prices without compromising on quality. Establish long-term relationships with reliable suppliers to secure favorable pricing and potential discounts.

6.4 Design Optimization:

Optimize the design of the machine to reduce material waste and minimize production costs. Consider design modifications that simplify manufacturing processes, reduce assembly time, and minimize the number of parts required.

6.5 **Automation and Efficiency**:

Incorporate automation features in the machine design to improve efficiency, reduce labor costs, and increase productivity. Automated processes can help streamline production, minimize human error, and maximize output, leading to long-term cost savings.

6.6 Maintenance and Durability:

Design the machine to be durable and require minimal maintenance. Use materials and components that offer longevity and robustness, reducing the need for frequent repairs or replacements. Regular preventive maintenance can also help extend the machine's lifespan and minimize unforeseen expenses.

6.7 Energy Efficiency:

Incorporate energy-efficient components and systems into the machine to reduce operational costs. Use energy-efficient motors, optimize power consumption, and implement intelligent control systems that minimize energy wastage during operation.

6.8 Lifecycle Cost Analysis:

Conduct a comprehensive lifecycle cost analysis that considers not only the initial construction costs but also the operational costs, maintenance expenses, and potential savings over the machine's lifespan. This analysis will help evaluate the long-term cost-effectiveness and return on investment of the winding machine.

By implementing these cost-effective strategies, the overall expenses associated with the design and fabrication of the Semi-automatic Toroidal Electromagnetic Coil Winding Machine can be optimized, ensuring a balance between affordability and performance.

7 FYP OBJECTIVES:

The Design and Fabrication of Semi-automatic Toroidal Electromagnetic Coil Winding Machine project aims to achieve the following objectives:

7.1 Design a semi-automatic winding machine:

The primary objective is to design a machine capable of semi-automatic winding of toroidal electromagnetic coils. The machine should incorporate automation to improve efficiency, reduce manual labor, and enhance overall productivity.

7.2 Precise and consistent coil winding:

Develop a system that ensures precise and consistent winding of toroidal coils. The machine should be able to maintain tight tolerances and produce high-quality coils with minimal variations.

7.3 Adjustable winding parameters:

Implement adjustable parameters within the machine to accommodate different coil specifications. The system should allow for customization of winding speed, tension, and other parameters to meet specific requirements of various applications.

7.4 Improved efficiency and productivity:

Increase the efficiency and productivity of the coil winding process compared to traditional manual methods. The machine should be able to wind coils at a faster rate while maintaining high accuracy and reducing human error.

7.5 Versatility and adaptability:

Design a machine that can handle a range of toroidal coil sizes and wire diameters. The system should be adaptable to different coil dimensions and wire types commonly used in various industries.

7.6 Safety considerations:

Incorporate safety features and mechanisms to ensure the protection of operators during the winding process. The machine should adhere to relevant safety standards and guidelines to minimize the risk of accidents or injuries.

7.7 Cost-effectiveness:

Strive to achieve a cost-effective solution by optimizing the design and construction of the machine. Consider materials, components, and manufacturing processes that strike a balance between affordability and functionality.

7.8 Testing and validation:

Perform thorough testing and validation of the winding machine to ensure its performance meets the desired objectives. Evaluate the machine's efficiency, accuracy, reliability, and durability through comparative studies and real-world coil winding experiments.

By accomplishing these objectives, the Design and Fabrication of Semi-automatic Toroidal Electromagnetic Coil Winding Machine project aims to contribute to the advancement of coil winding technology. The project seeks to provide an efficient and reliable solution for industries that utilize toroidal coils, improving their manufacturing processes and overall productivity.

8 IMPORTANCE:

The Design and Fabrication of Semi-automatic Toroidal Electromagnetic Coil Winding Machine holds significant importance due to the following reasons:

8.1 Enhanced Efficiency:

The semi-automatic winding machine improves the efficiency of the coil winding process by reducing manual labor and incorporating automation. It enables faster and more accurate coil winding, thereby increasing production output and reducing manufacturing time.

8.2 Consistent Winding Quality:

The machine ensures precise and consistent winding of toroidal coils, minimizing variations in coil characteristics such as turns, tension, and pitch. This consistent quality improves the overall performance and reliability of devices and systems that incorporate toroidal coils.

8.3 Time and Cost Savings:

By automating the winding process, the machine reduces the reliance on manual labor, resulting in time and cost savings for manufacturers. The increased efficiency and productivity contribute to higher throughput and reduced production costs, ultimately improving the profitability of the manufacturing process.

8.4 Customization and Versatility:

The adjustable winding parameters of the machine allow for customization based on specific coil requirements. This versatility enables manufacturers to produce a wide range of toroidal coils with varying specifications, meeting the diverse needs of different industries and applications.

8.5 Improved Safety:

The incorporation of safety features and mechanisms ensures the protection of operators during the winding process. By reducing manual intervention, the machine minimizes the risk of accidents or injuries, enhancing workplace safety and creating a safer working environment.

8.6 Advancement in Technology:

The project contributes to the advancement of coil winding technology by introducing a semi-automatic solution. It showcases the application of automation and precision engineering in the field, opening doors for further innovations and advancements in the coil winding industry.

8.7 Industrial Applications:

Toroidal coils are widely used in various industries, including power electronics, renewable energy, electric vehicles, aerospace, and medical devices. The efficient and precise winding offered by the machine improves the manufacturing process in these industries, leading to better product performance and reliability.

8.8 Academic and Professional Development:

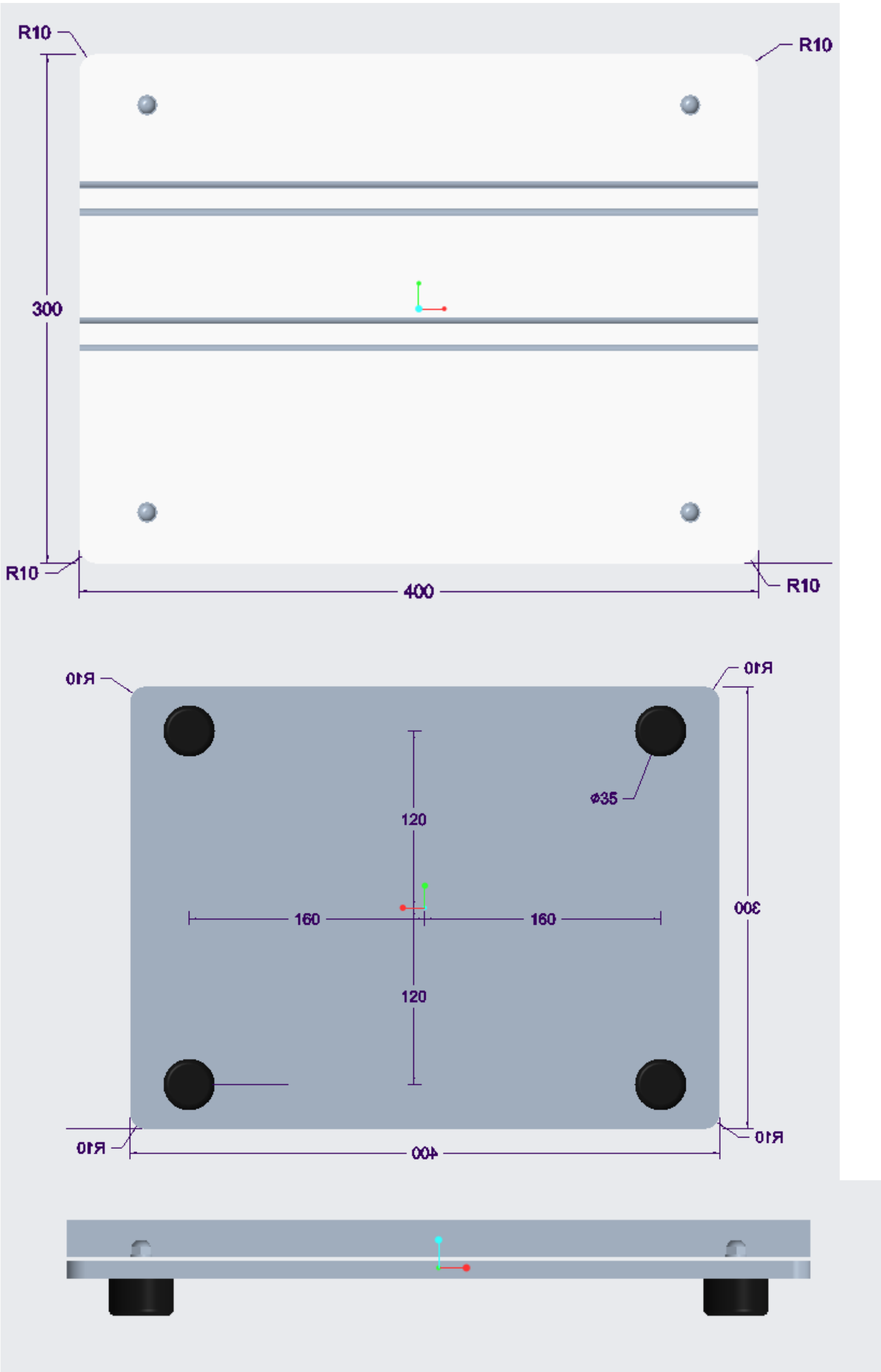
The project provides an opportunity for the participating students to apply their theoretical knowledge and practical skills in a real-world engineering project. It enhances their understanding of coil winding technology, automation, and precision engineering, preparing them for future academic and professional endeavors.

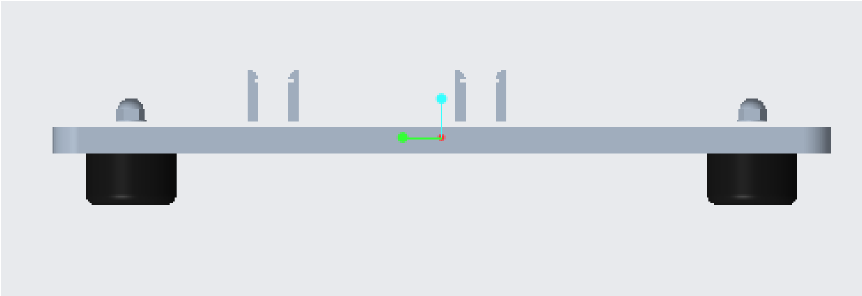
In conclusion, the Design and Fabrication of Semi-automatic Toroidal Electromagnetic Coil Winding Machine holds immense importance in terms of enhancing efficiency, ensuring consistent quality, saving time and costs, improving safety, advancing technology, and benefiting various industries. It serves as a significant contribution to the field of coil winding and provides valuable learning experiences for the students involved in the project.

9 DESIGN AND FABRICATION:

9.1 3D Modelling of Electromagnetic Coil Winding Machine

- After the Design Stage, the next part was to bring the design to a working Model. To bring the concept to reality, a bridge needed to be constructed, this bridge was 3D Modelling.
- To do 3D Modelling, we used PTC Creo Parametric (CAD Software).
- All parts were made separately, and then combined in an assembly, to showcase the entire Electromagnetic Coil Winding Machine.

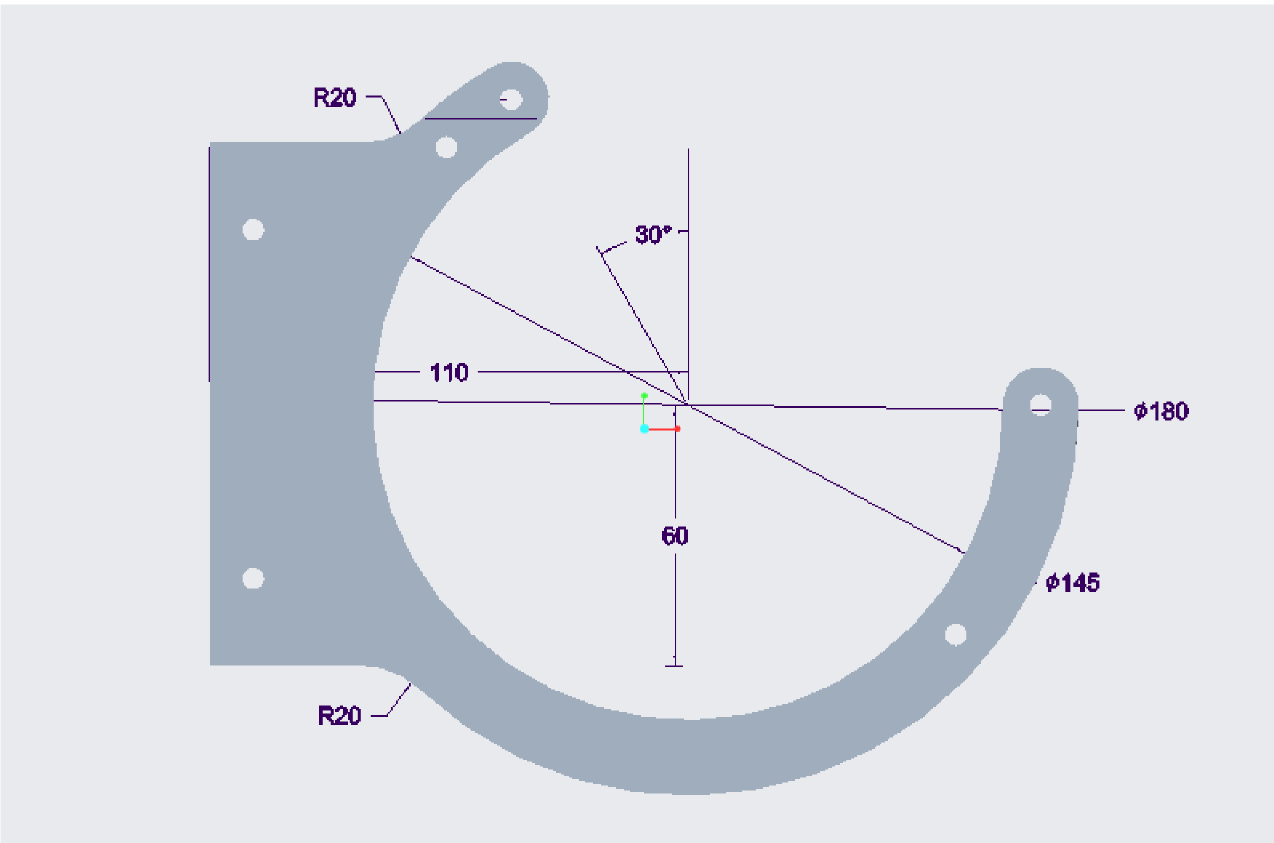




- Note (From now onwards Electromagnetic Coil Winding Machine will be written in Abbreviated form EMCWM.)

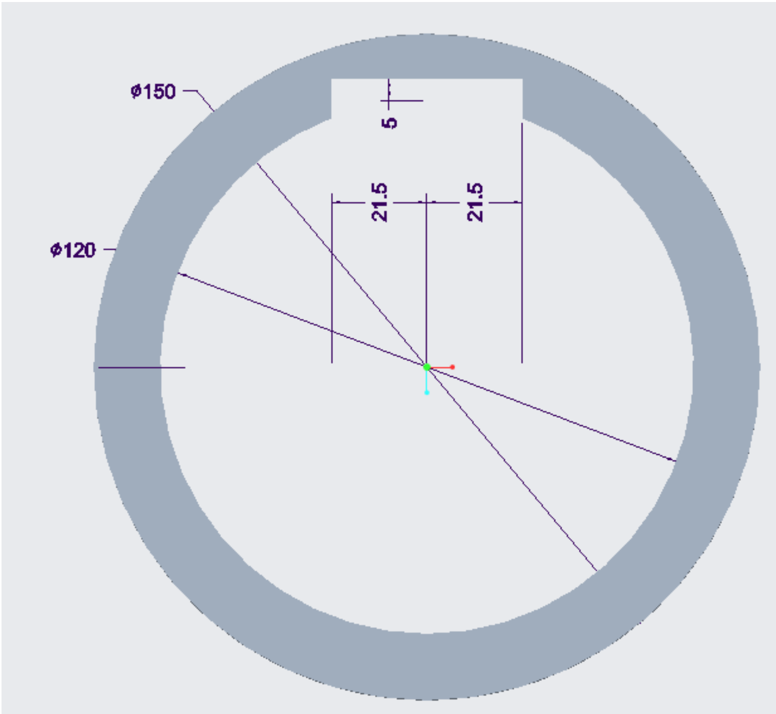
9.2 Base

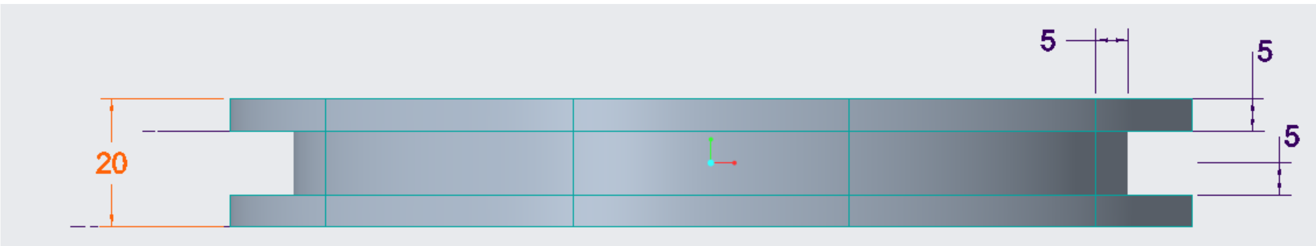
- The Base of the EMCWM will be made of Mild Steel Sheet (Gauge 9-10 depending on Market availability)
- Choosing this MS Sheet will help us absorb the vibrations of the rotation.
- The base has 4 rubber shoes, which help in absorbing vibrations and keeping the noise to a minimum while in operation, also helps in keeping the Base Stable.
- On the face of the Base, there are two MS Steel lines that will help in holding and movement of the Toroid Roller Holder.



9.3 Body and Body Arm

- The Body will also be made of MS Steel Sheet (Gauge 9 or 10)
- The Dimensions are chosen using the best approximation based on Design Variables.
- This will sit onto the base in between the 2 Steel Strips. (Will be shown in the final assembly)
- This acts as the stationary outer ring of the Inside
- The Body arm will sit in the 180 Degree Hole to help the movement of the inner rotating Spool ring.



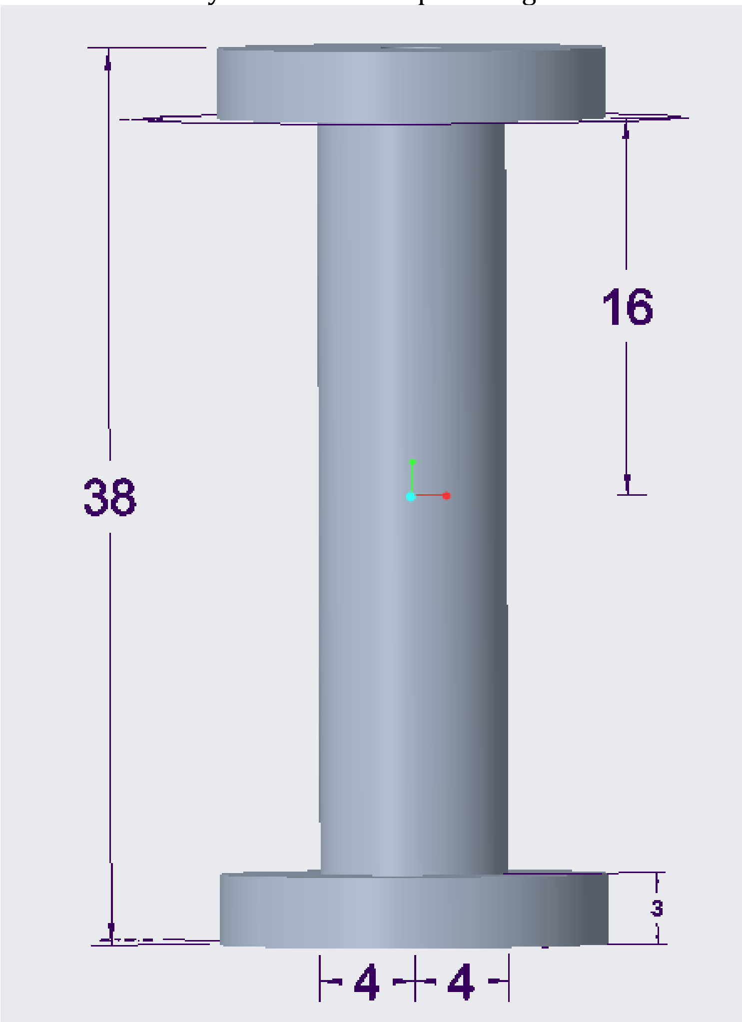


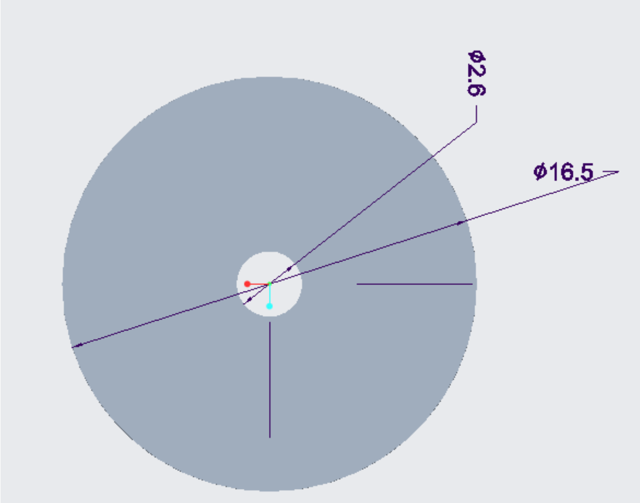
9.4 Spool Ring

- This is the Spool Ring, this will be the Rotating component of our EMCWM.
- The Spool Ring has a cutout for the Spool to Fit inside. (This will be like the original coil wound

which will provide us with the coil Winding.)

- The center of the spool ring is free as this is where the belt will be mounted in order to generate the rotary motion of the Spool Ring via the motor.



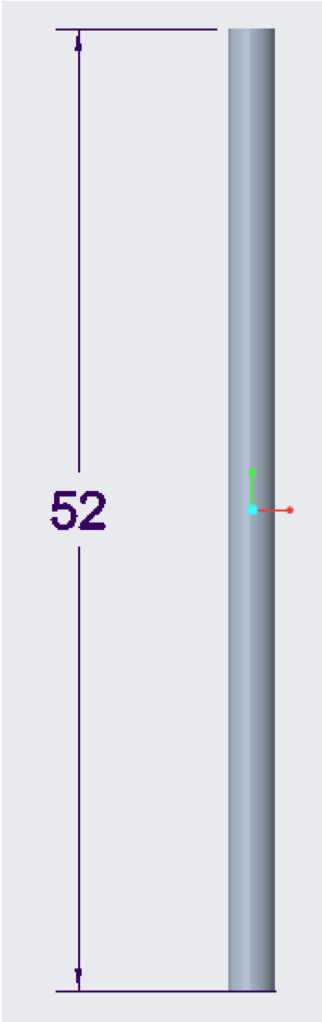


9.5 Spool and Pin

- These are the Spool and the Pin which will attach this component to the previously mentioned Spool Ring.
- The Size is just so that this can freely rotate inside the Spool ring to release the coil as it is being

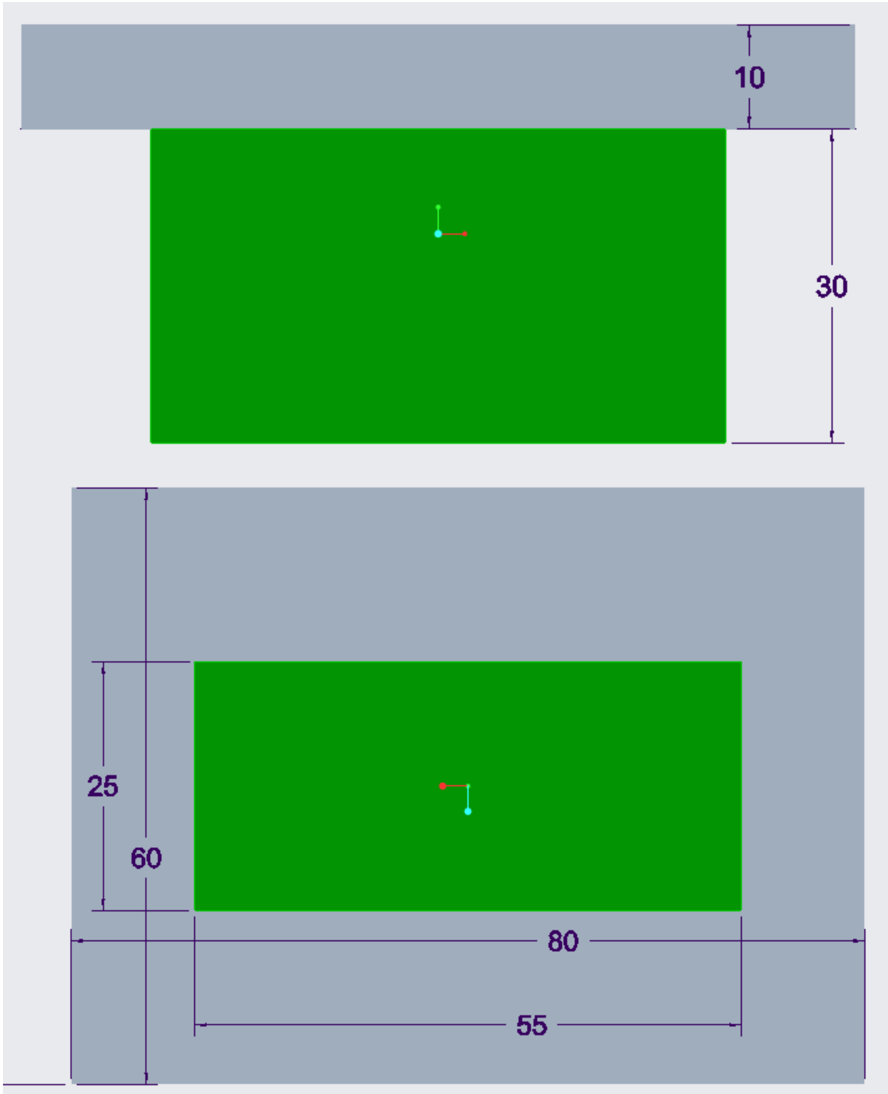
wound on the toroid.

The dimensions mentioned are enough for this to be a steady process.



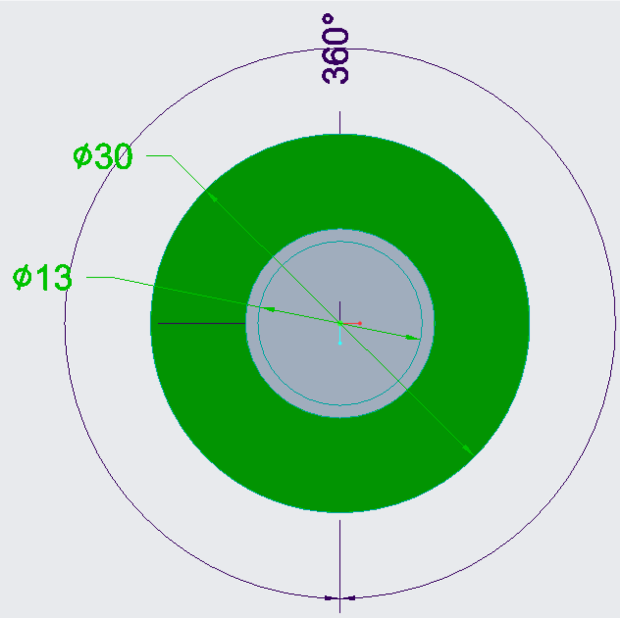
9.6 Motor and Base

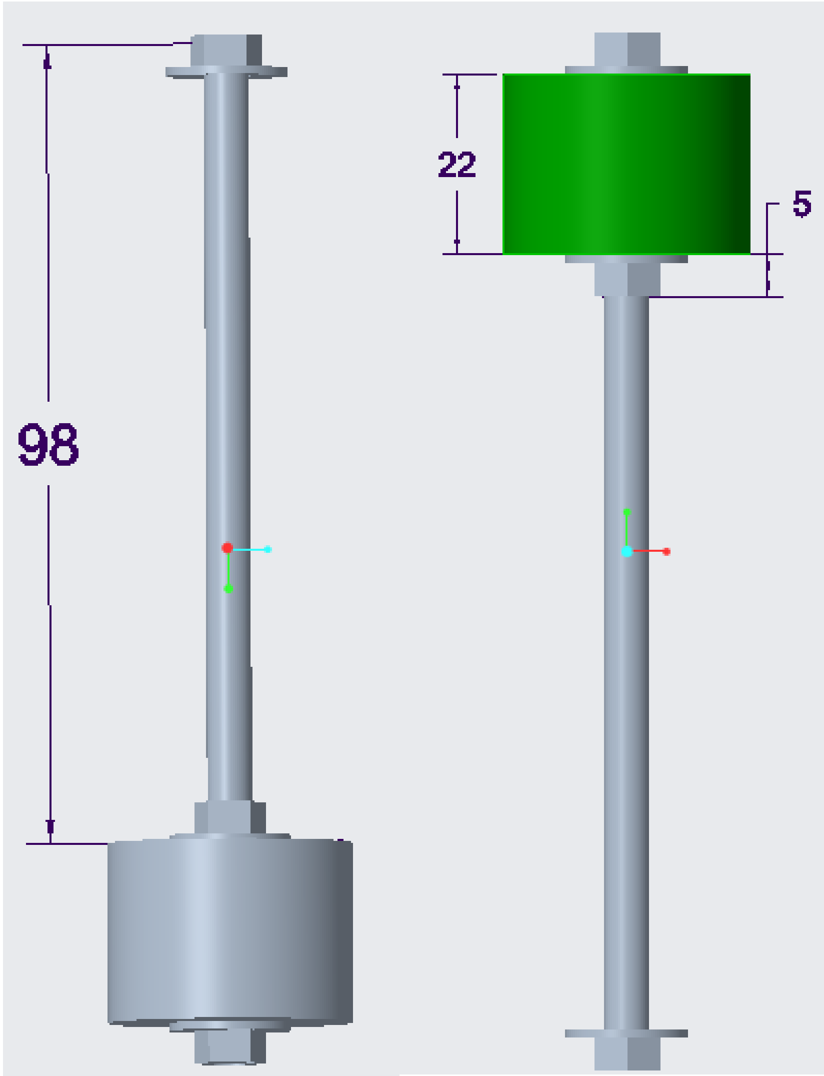
- The Green Colored Portion is where the Motor will be Placed and the Top part is where 1 of the Three Toroid Coil Holders will be mounted.
- This part will have linear motion, to be adjustable to hold the toroid while performing the Coil Winding.

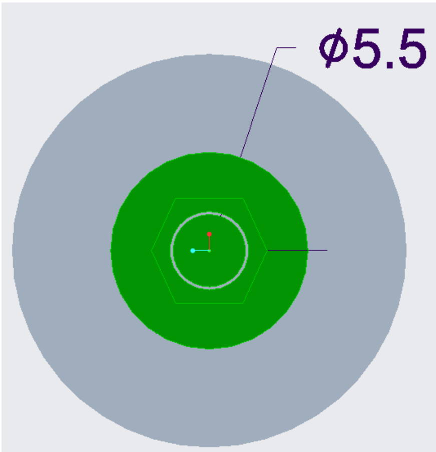


9.7 Toroid Coil Roller Holder

- This is the Toroid Coil Holder which has the roller Present, (Highlighted as Green)
- This will rotate as the Toroid is rotating while maintaining grip and holding it in place.
- This is paired with many small components such as a pin, Washer, and Nuts, the Nuts we have used here are M5 HEX HEAD NUTS. (Due to Common use and easy availability.)

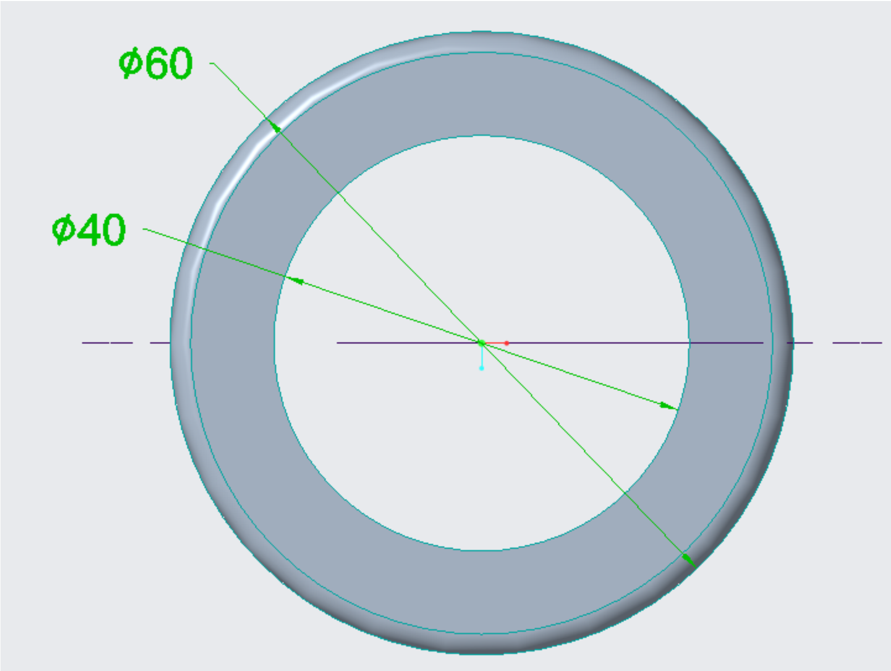


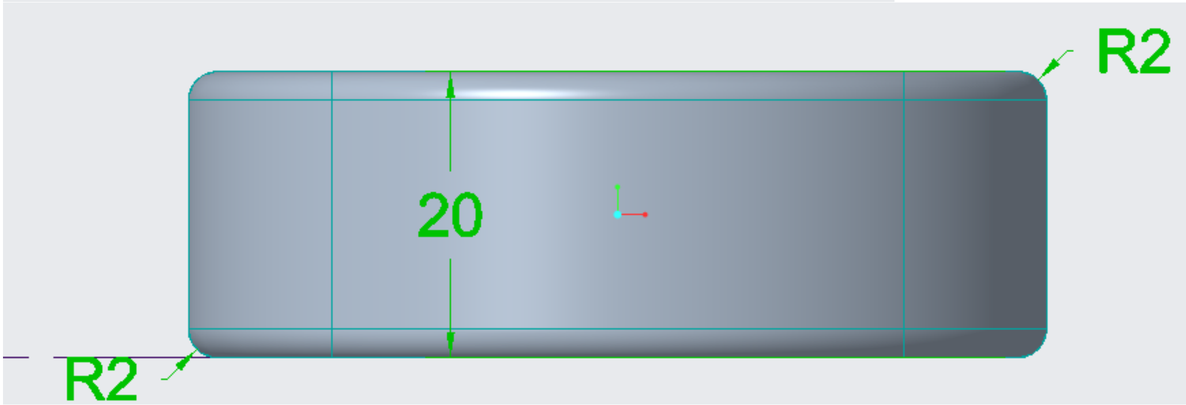




9.8 Toroid Coil

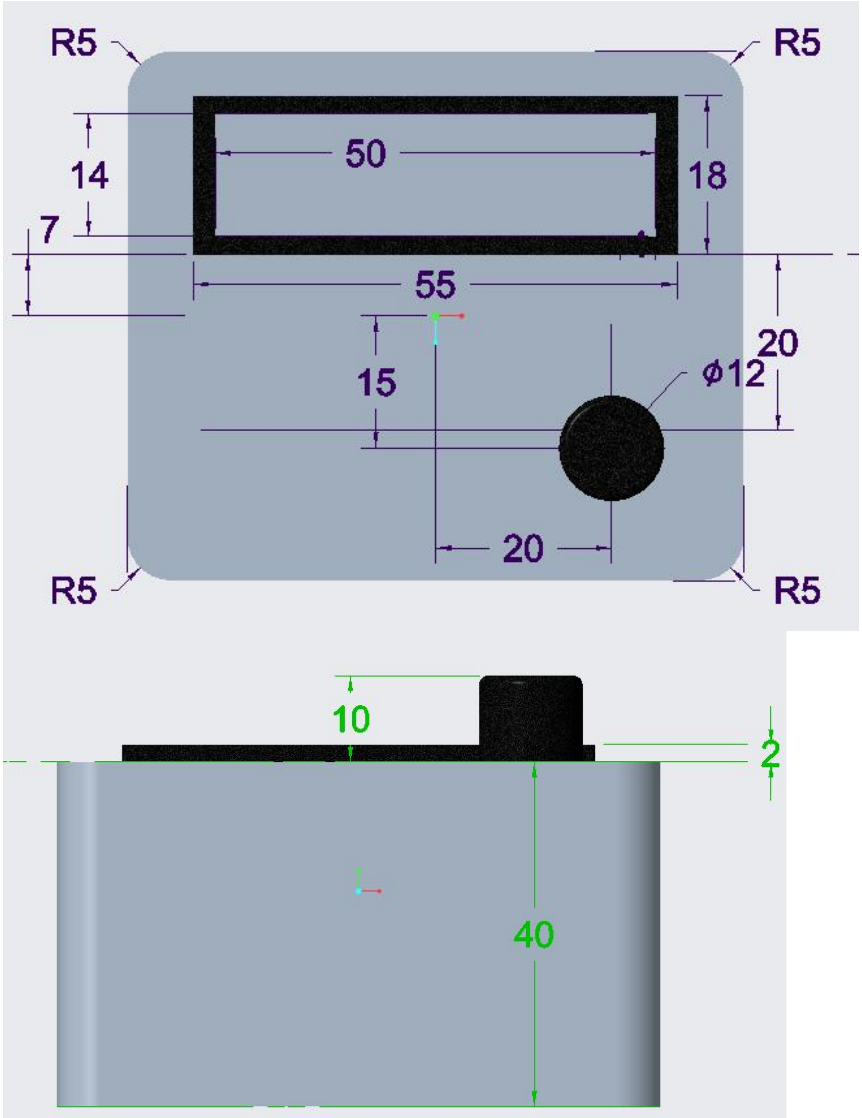
- This is the example Toroid which we will be using as an example.
- On this Toroid, the coil winding will be done.





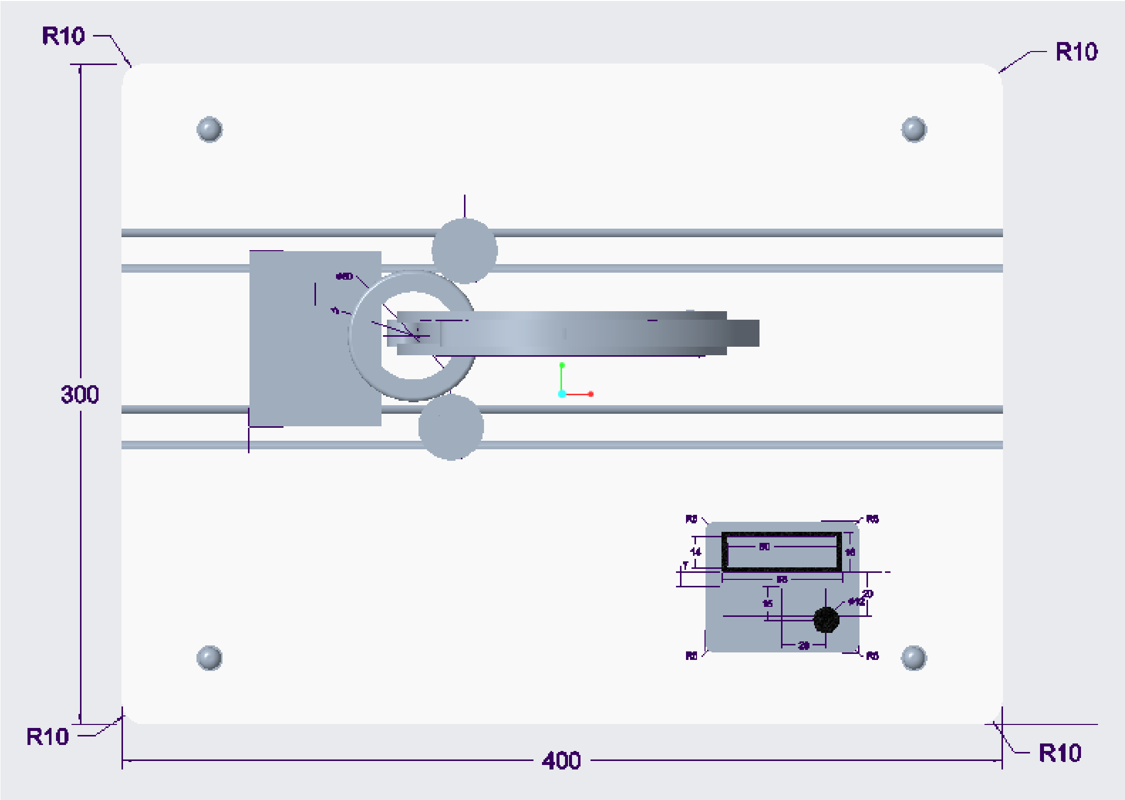
9.9 Arduino Box

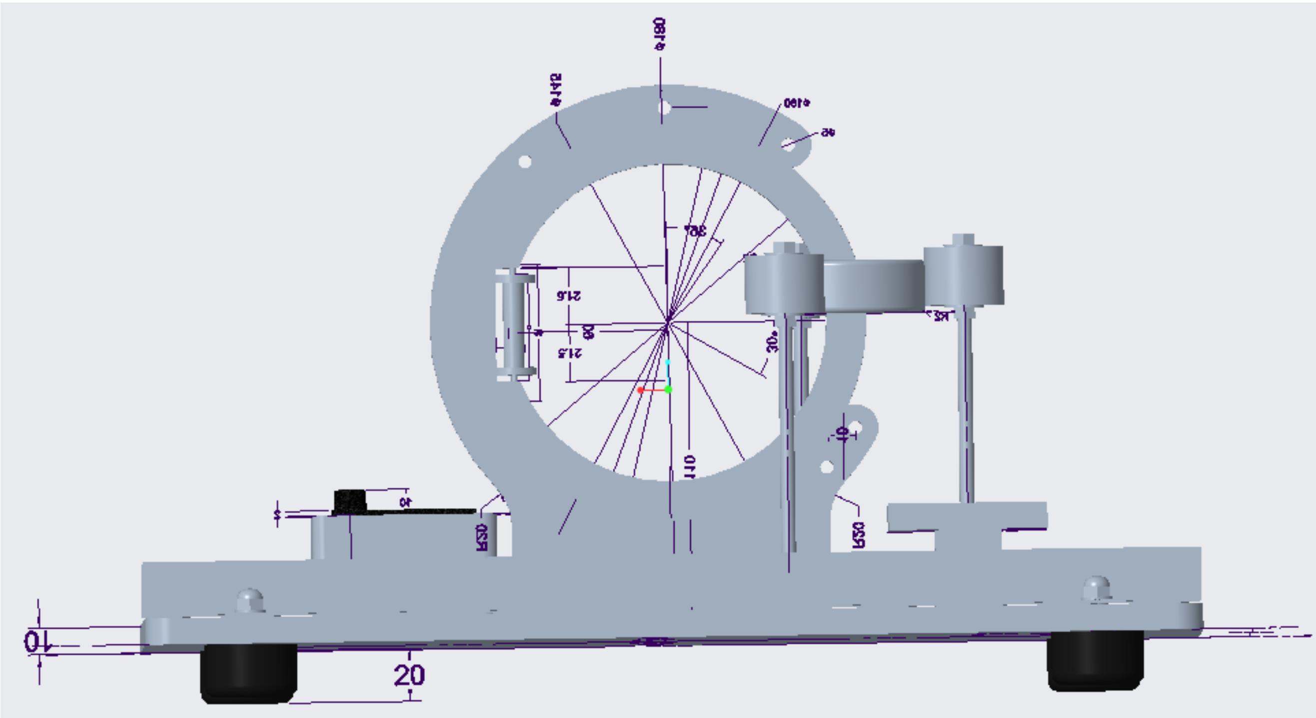
- This is the Box Casing in which the Arduino UNO will be placed with all the Wiring.
- There is a Black Knob, this will be our manual input control method, in which we will rotate the knob to select the angle at which want to perform the coil winding
- Then we will press it to enter the value and perform the coil winding process.

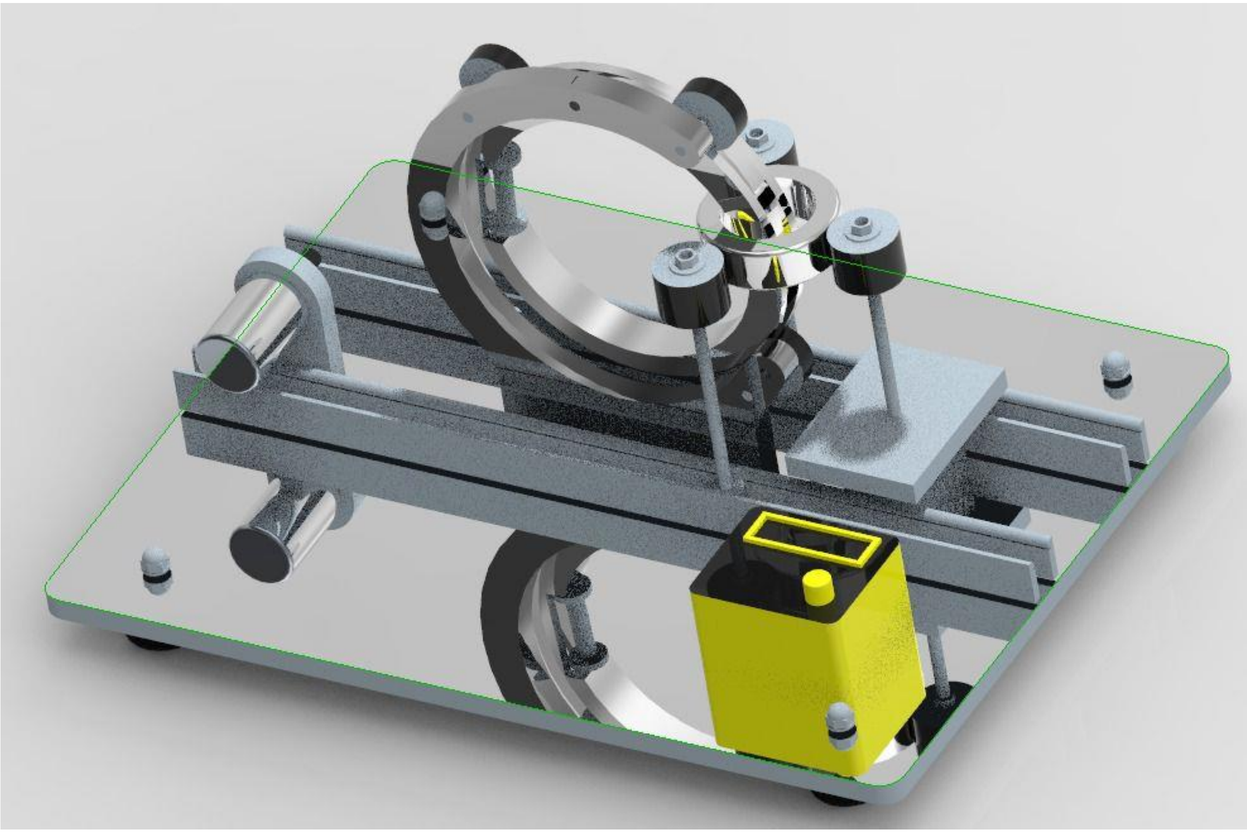


9.10 Combined Assembly

- This is the final Assembly after combining all the components into a single model.
- Minor parts may be added later upon the requirement which will be updated simultaneously in the original CAD Files.


R10
R10
300
R10
400
R10

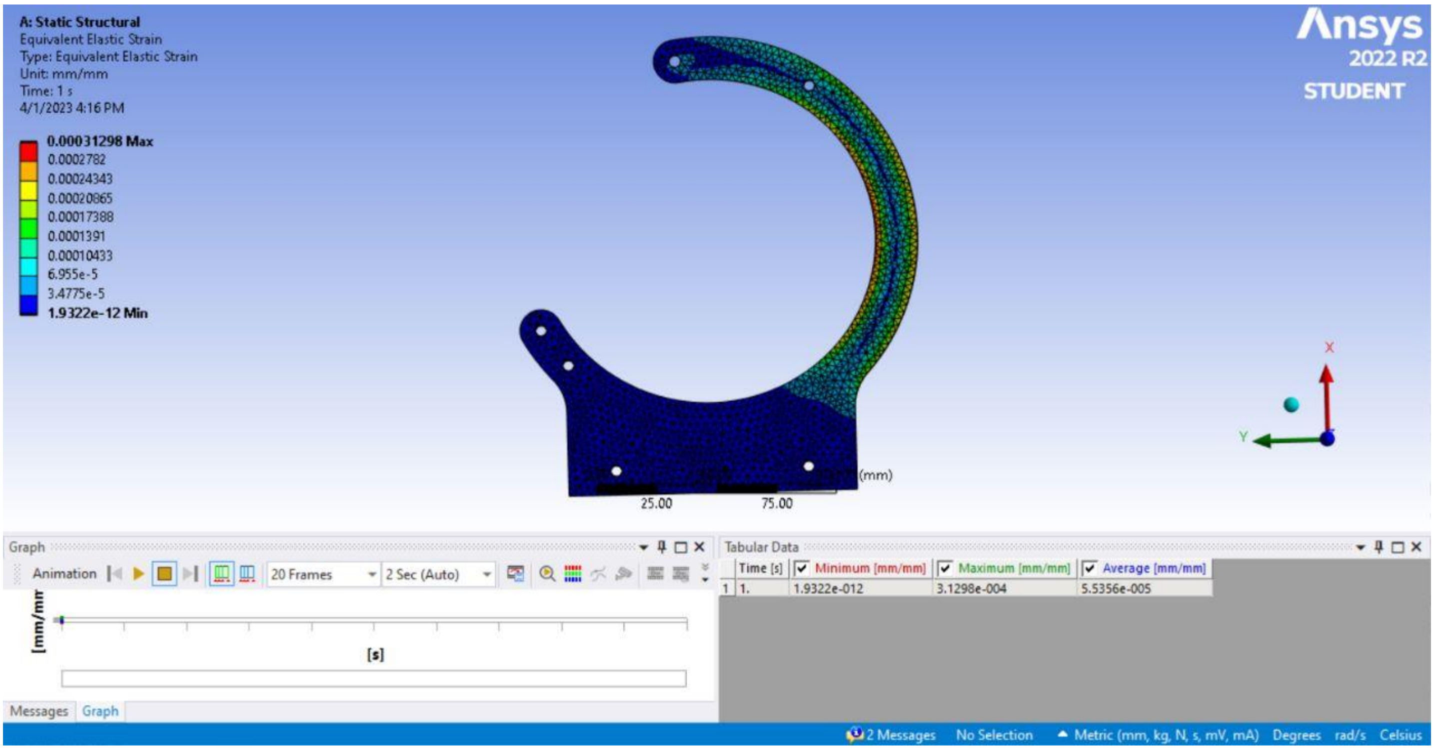

10
20



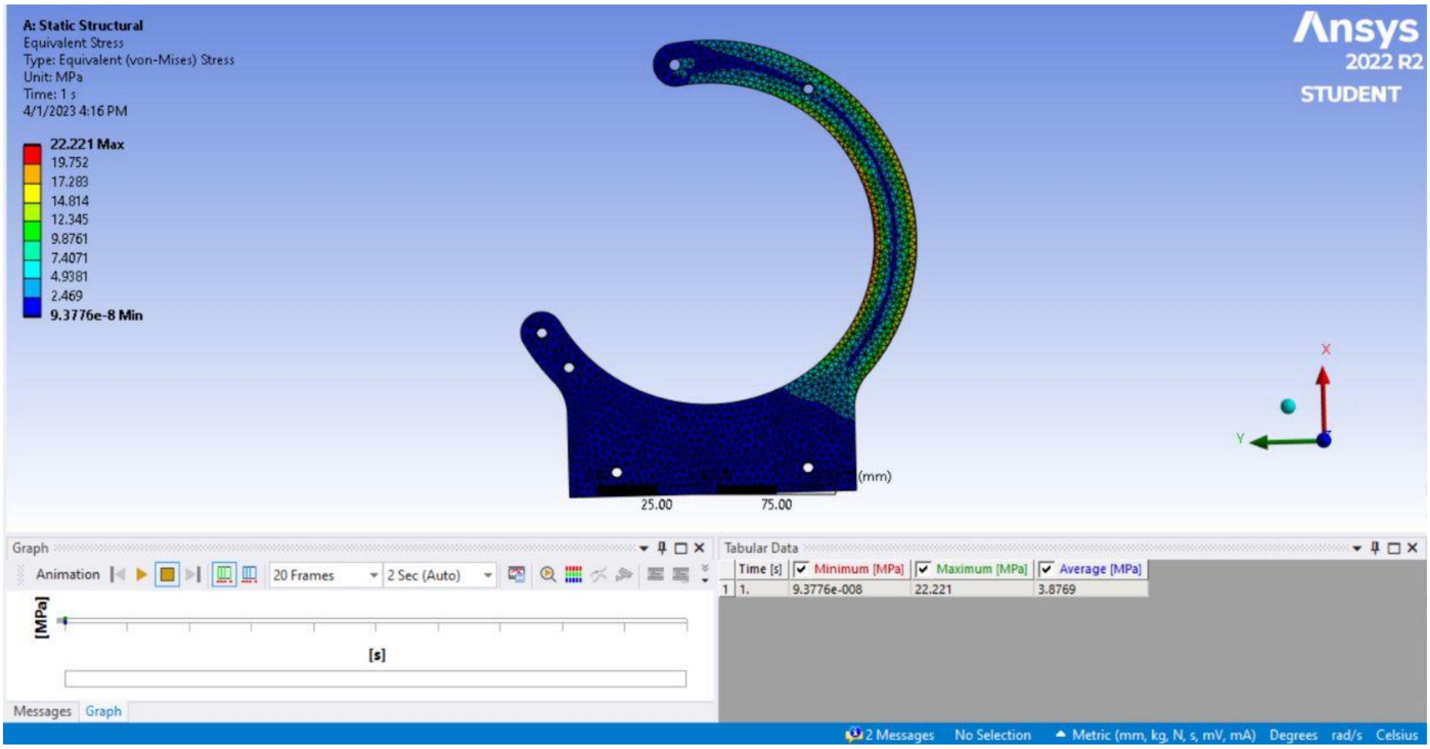
9.11 MODEL ANALYSIS

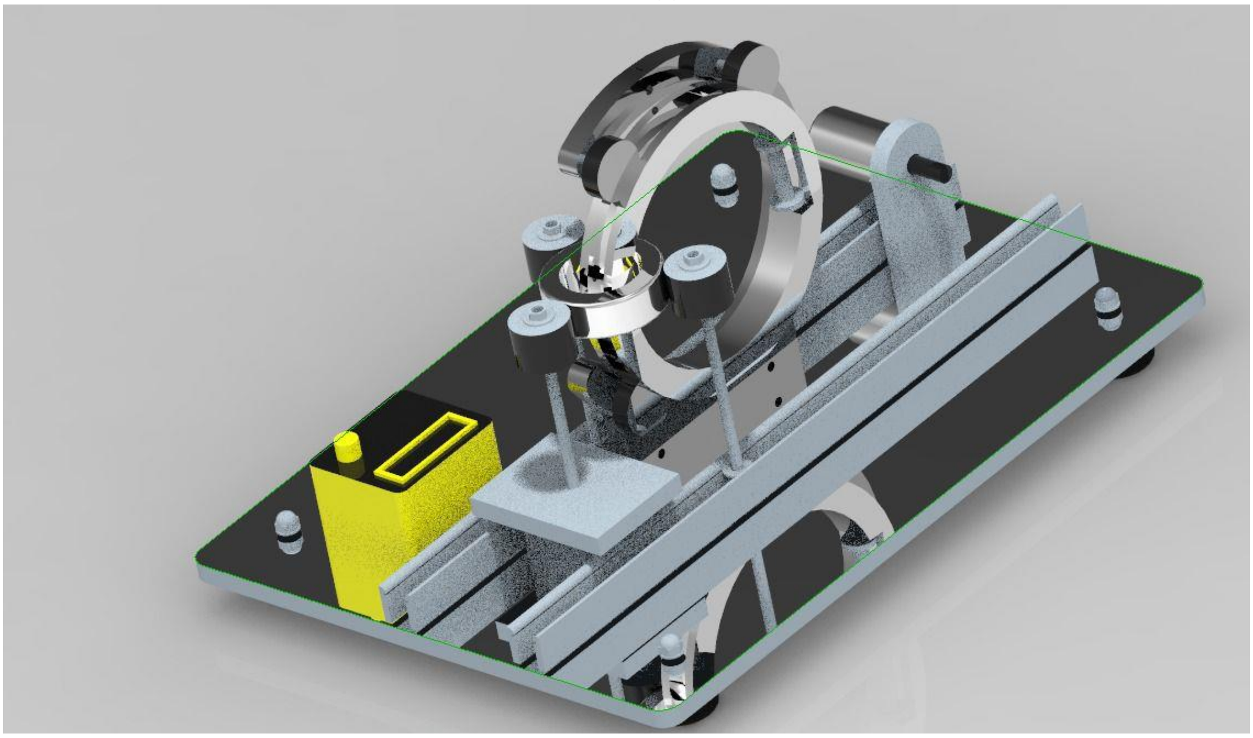
These are for 150N force applied which is roughly 15Kg Mass applying a force on the top of our outer ring.

Equivalent Strain

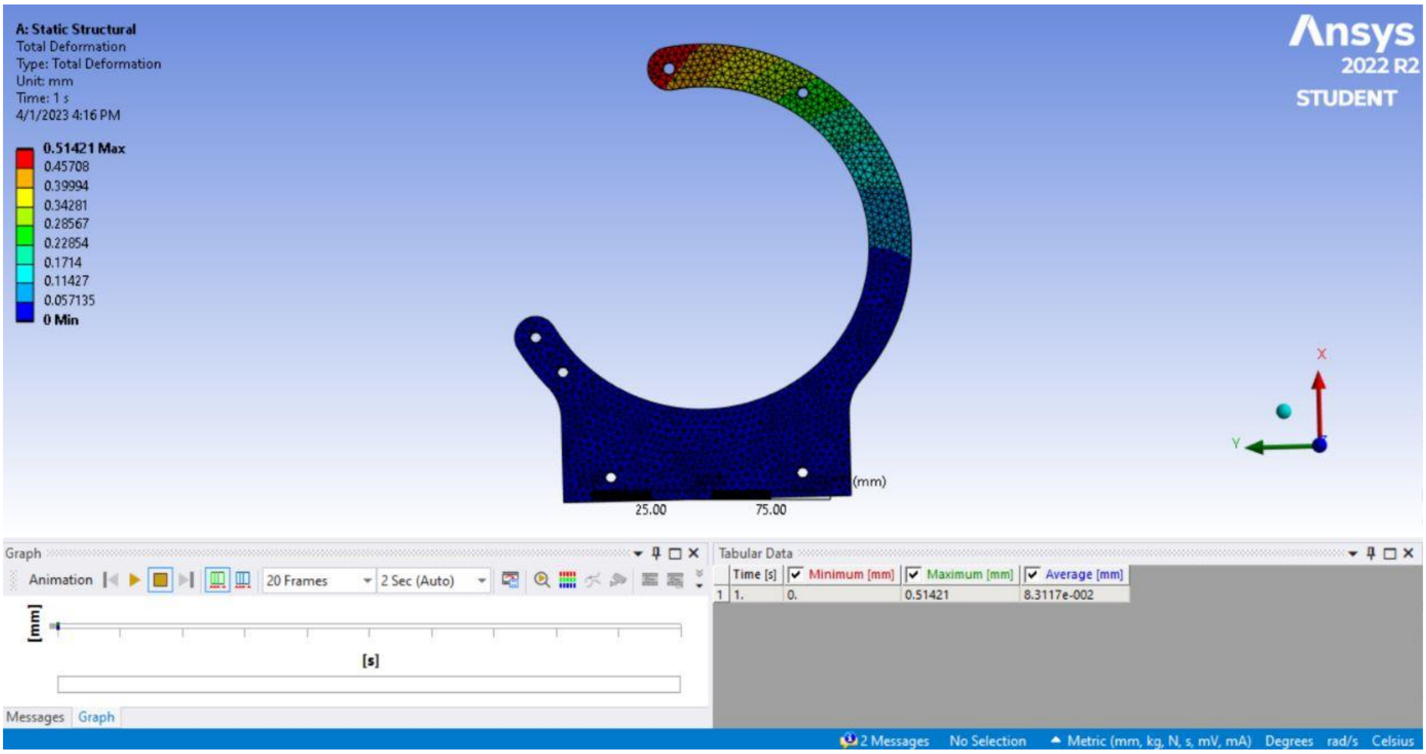


Equivalent Stress





Total Deformation



10 Vendor’s List

These are the following vendors we have taken help from.

10.1 Nano Technologies TM Plaza College Rawalpindi

Project Hardware Fabrication Related help was taken from them.

10.2 Saeed Eng Solutions TM Plaza College Rawalpindi

Project Software and other electronic elements related help was taken from them.

10.3 Electrobes Islamabad

Various electronic components were purchased from them.

11 Conclusion

In conclusion, the Design and Fabrication of Semi-automatic Toroidal Electromagnetic Coil Winding Machine has been a significant undertaking that has successfully achieved its objectives. Through the collaborative efforts of our group members and the guidance of our supervisor, Saheeb Ahmed Kayani, we have designed and developed a semi-automatic winding machine that offers improved efficiency, precision, and versatility in the coil winding process.

The project has demonstrated the importance of automation and technological advancements in streamlining industrial processes. By incorporating adjustable winding parameters, our machine allows for customization and caters to a wide range of toroidal coil specifications. The consistent winding quality and enhanced productivity of our machine contribute to the overall improvement of manufacturing processes in industries relying on toroidal coils.

The successful completion of this project has also provided valuable academic and professional development opportunities for the group members. Through the application of theoretical knowledge, research, and hands-on experience, we have gained a deeper understanding of coil winding technology, automation, and precision engineering. These skills and experiences will undoubtedly benefit us in our future careers.

Furthermore, the Design and Fabrication of Semi-automatic Toroidal Electromagnetic Coil Winding Machine holds great potential for industrial applications across various sectors. Its versatility and improved efficiency offer advantages in industries such as power electronics, renewable energy, electric vehicles, aerospace, and medical devices. The machine's cost-effectiveness and safety features further enhance its appeal and practicality for manufacturers.

As with any project, there were challenges and limitations encountered along the way. However, we were able to overcome these obstacles through effective collaboration, problem-solving, and the support of our supervisor. We believe that the outcome of this project has laid a solid foundation for further research and development in the field of coil winding technology.

In conclusion, the Design and Fabrication of Semi-automatic Toroidal Electromagnetic Coil Winding Machine has been a rewarding and insightful journey. We are proud of the accomplishments we have achieved and the contributions we have made to the field. We express our gratitude to our supervisor, Saheeb Ahmed Kayani, for his guidance, support, and expertise throughout the project.

We hope that our machine's successful demonstration and its potential applications inspire further advancements in coil winding technology. The culmination of our efforts in this project marks the beginning of a promising future in the field of industrial automation and contributes to the progress of the manufacturing industry as a whole.

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