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DESIGN AND FABRICATION OF LOW COST AUTOMATIC COIL WINDING AND DEWINDING MACHINE

Mr. S Raam kumar , Assistant Professor, Department of Mechanical Engineering, SNS College of Engineering, Coimbatore, Tamilnadu.

Gokul R , UG Scholar, Department. of Mechanical Engineering, SNS College of Engineering, Coimbatore, Tamilnadu.

Karthick M , UG Scholar, Department. of Mechanical Engineering, SNS College of Engineering, Coimbatore, Tamilnadu.

Lakshmipathi M , UG Scholar, Department. of Mechanical Engineering, SNS College of Engineering, Coimbatore, Tamilnadu.

Rajasekar S , UG Scholar, Department. of Mechanical Engineering, SNS College of Engineering,Coimbatore, Tamilnadu.

Abstract

Machines for coil winding and rewinding are used to wound and rewind coils of wire or other materials onto a spool or core. Electrical engineering, electronics, automotive, and aerospace are just a few of the industries that make use of these equipment.A revolving spindle, a wire guide, and a tensioning mechanism are the common components of coil winding machines. The wire is laid down on the spindle in a predetermined pattern by the wire guide as it goes back and forth across the spindle. The tensioning system makes sure the wire is twisted uniformly and tightly.Rewinding machines are used to take out worn-out or damaged wire from coils and replace them with fresh wire. Depending on the size and intricacy of the coil, these machines can be either human or automated.Coils come in a wide variety of designs.Coil winding and rewinding equipment comes in a wide variety of shapes and sizes, from little tabletop units to substantial industrial equipment that can handle heavy-duty wire and high production rates. The machine selected will rely on the particular requirements of the application.Coil winding and rewinding machines are fundamental pieces of equipment used in the production and upkeep of a wide variety of electrical and electronic devices.Designing the machine control system, selecting the appropriate machine components, incorporating safety features, and utilising a variety of fabrication techniques, including welding, assembly, and machining, are all part of the design and fabrication of coil winding and rewinding machines. The objective is to produce a machine that is safe, dependable, and fits the needs of the application.

I. Introduction

A crucial step in the production of electrical and electronic devices is coil winding. To create a coil, the procedure is wrapping a wire or conductor around a core. Different materials, including ceramic, iron, and plastic, can be used as the core material. The coil's size and shape are determined by the core's size and shape. Although coil winding can be done manually, it is a labour-intensive procedure that takes a lot of time and expertise. Additionally, inconsistent manual coil wrapping could lead to variances in the coil's characteristics.In order to increase the effectiveness and productivity of the coil winding process, automatic coil winding machines have been developed. These devices are made to automate the winding procedure, improving its speed, precision, and consistency. It is possible to programme automatic coil winding machines to wind oils with a predetermined number of turns or to a predetermined resistance value. These machines may wind coils of different sizes and forms. In order to ensure that the wire is coiled uniformly and precisely, these machines have computer-controlled controls that regulate the winding speed, tension, and direction.

Dewinding, which is the process of removing the wire from a coil, operates similarly. When the coil needs to be recycled, rewound, or repaired, this procedure is required. Dewinding can take a long time and require a lot of work, especially if the coil is large or complicated. This procedure has been automated with the use of dewinding equipment, which makes it quicker, safer, and more effective. The speed and tension of the wire as it is pulled away from the coil are controlled by computerised controllers in these devices. Coil rewinding can be done more quickly and cheaply by using automatic dewinding devices, which also save time and money on labour.

II. Literature survey

Alice Matenga examined How the digital economy, which is fueled by quantum computing and digital intelligence, has resulted from the digital transformation. Rewinding is a decision-making process based on behaviour, and the winding topologies in rotary machines come from multi-variant design specifications and connection kinds. In order to optimise and maintain a copper fill factor, the study demonstrates the construction of a prescriptive modelling system for a symmetrical multi-coil winding machine for armature winding. This system uses a hybrid least squares support vector machine and adaptive neuro-fuzzy inference system. A mixed method research technique was used to evaluate the system, and it was discovered that the multi-spindle concentric layering and in-slot repeating orthocyclic winding process enhance energy efficiency and decrease winding flaws. Fog computing was used to streamline the system and improve process reliability.

Prajval Vaskar has discussed about The significance of coil winding machines in the industrial setting, as well as their many varieties and applications, are covered in this passage. It says that manual winding may be cumbersome and time-consuming, thus a cheap coil winding machine for small-scale use was created and is controlled by two stepper motors through an Arduino programme. This device can be used to teach students how to wind small transformers and relay coils in addition to winding coils for transformers, inductors, motors, and chokes.

J.H.R. Wimalaweera is examined about In conclusion, motors are utilised extensively in a variety of industrial gear and need to be properly maintained and repaired. Manual motor maintenance procedures can take a long time and put workers in danger. A machine specifically made for removing armature coils was created to solve this problem and remove faulty armature coils quickly and safely. The machine works in two stages, cutting the coil with a single-point lathe cutting tool and removing it from the armature with a specially made ring. The device provides a safer and more effective substitute for traditional manual procedures.

Thakan Kailas Gokul is examined In short, conductor coils are used by electrical machinery like motors, generators, and transformers to create the essential magnetic effects. These coils, which might have hundreds to thousands of conductor turns, may require rewinding if they sustain damage from overheating. Even with manually controlled machinery, manually preparing these coils is a difficult and important process.

To solve this problem, a device that automatically winds coils in accordance with specifications such the number of turns and size criteria has been developed. The document includes the machine's design and computations.

III. Methodology:

Wire Feeder: A mechanism for feeding wire onto the winding spindle. This could be a motorized spool holder that feeds the wire through a guide tube and onto the spindle.

Core Holder: A device for holding the core that the wire will be wound around. This could be a simple mechanism that clamps onto the core and rotates it as the wire is wound.

Winding Spindle: A spindle for holding the core and wire during the winding process. This should be capable of rotating at a controlled speed to ensure that the wire is wound tightly and evenly around the core.

Tension Control System: A mechanism for controlling the tension on the wire as it is fed onto the spindle. This could be a simple tensioning device that ensures the wire is pulled taut as it is wound.

Motor Control: A system for controlling the speed of the spindle and wire feeder motors. This could be a simple on/off switch, or a more advanced control system that allows for precise speed and tension control.

Bluetooth Connectivity: A wireless connection that allows the machine to be controlled remotely from a smartphone or tablet. This could be used to monitor the progress of the winding process and make adjustments as necessary.

Dewinding Mechanism: A mechanism for removing the wound coil from the spindle and rewinding the wire onto a spool. This could be a motorized spool holder that rotates in the opposite direction to the winding spindle, or a separate device that is manually operated.

A mixed-method study strategy that examines MIMO (multiple-input multiple-output) variables related to coil performance and configuration data using both qualitative and quantitative methods.To improve behavior-based control of robotic remanufacturing, a deep neural learning technique can be employed to combine the operation data with the configuration data. Induction motor nameplate static data was used to model the system, and testing data comprised 60% of the energy-efficient motor's specifics. Two parameters of the ANFIS (adaptive neuro-fuzzy inference system) require training and optimisation, which is accomplished using LS-SVM and particle swarm optimisation (PSO). With data exchange between rewinders, OEMs, and plant designers, a PSO type 3 algorithm is used for upcycling process optimisation and prescriptive analytics.

In-slot winding is a revolutionary design that reduces throughput time and improves efficiency by doing away with the extra production step of putting the coils into the stator. Ribbon winding is avoided by using a needle winding technique with a detachable end effector for holding wire conductors during rewinding. Resource utilisation in an agile environment is improved by the adaption of multi-coil winding, which also reduces throughput time by a factor of (zctNT)-1.

Overall, this study offers a novel coil winding method that enhances productivity and efficiency by applying cutting-edge neural learning and optimisation methods.

IV. Experimental Work:

Figure.1 Experimental Works

V. Design and fabrication of a low-cost automatic coil winding and dewinding machine involves a series of experimental work, which can be broken down into the following steps:

Requirement analysis: The first step is to identify the requirements for the coil winding and dewinding machine, such as the type of coil to be wound or unwound, the diameter and length of the wire, and the desired winding speed. This information will guide the design process.

Design: Based on the requirements, a suitable design for the coil winding and dewinding machine is developed. This involves selecting the appropriate components, such as motors, gears, and controllers, and designing the mechanical and electrical systems that will drive the winding process.

Prototyping: Once the design is complete, a prototype of the machine is built. This allows for testing and evaluation of the machine's functionality and performance. The prototype can be modified as needed based on the results of these tests.

Fabrication: With the prototype design finalized, the machine can be fabricated using appropriate manufacturing techniques. This may involve machining, welding, or 3D printing, depending on the materials and components being used.

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Testing and calibration: Once the machine is assembled, it must be calibrated to ensure accurate and consistent winding or dewinding. This involves testing the machine's performance under different conditions and adjusting the settings as needed.

Validation: Finally, the machine is tested to ensure that it meets the original requirements and specifications. This may involve testing the machine with a variety of different wire types and gauges, and ensuring that the machine operates reliably over extended periods of use.

Throughout the experimental process, it is important to maintain detailed documentation of the design, fabrication, testing, and calibration processes. This information can be used to refine the design and troubleshoot any issues that may arise. Additionally, it may be necessary to consult with experts in the field of coil winding and dewinding to ensure that the machine meets industry standards and regulations.

A popular process used in the production of many electrical and electronic devices is coil winding, in which wire is wound around a core to form a coil. A wide range of devices, including motors, generators, transformers, and inductors, are made using this method is examined in fig 1.

Although manual coil winding is a viable option, it can be a laborious procedure that demands much training and experience. This is especially true for intricate coils that must be wound precisely and precisely. Additionally, manual coil winding has a higher chance of mistakes, which could lead to a subpar outcome.

VI. Design

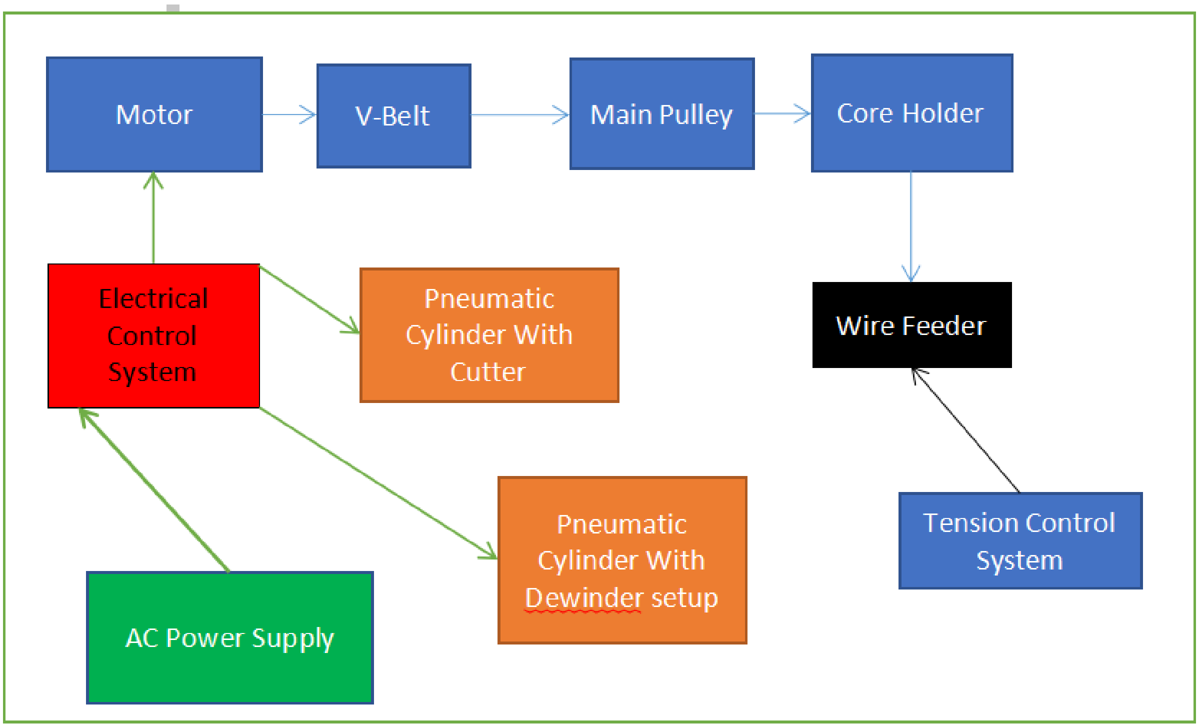

Figure.1 Machine Block Diagram

Many manufacturers utilise automatic coil winding machines that can considerably increase productivity and effectiveness to address these issues. These devices can wind coils of many shapes and sizes rapidly and correctly, requiring little assistance from a person. Additionally, they may be programmed, enabling producers to consistently and precisely make coils.

Dewinding is the procedure of unwinding a coil to remove the wire, which is similar to the coil winding process. When a coil has to be fixed or changed or when the wire needs to be recycled, dewinding is required. Manufacturers may find manual dewinding to be expensive because it can be a time-consuming procedure that calls for a high level of skill and knowledge.

Many manufacturers employ automatic dewinding equipment to solve this problem, which can reduce labour costs and save time. With little harm to the wire, these devices can swiftly and effectively extract wire from coils. By making it easier to recycle materials, this not only lowers labour costs but also contributes to an improvement in the manufacturing process' sustainability.

Coil winding and dewinding are crucial steps in the production of electrical and electronic devices, to sum up. The use of automatic coil winding and dewinding equipment is crucial because they can increase output dramatically, cut costs, and enhance the sustainability and quality of the production process.

VII. Fabrication

Aluminum plates and extrusions are frequently utilised in the construction of numerous electrical and electronic equipment to build a durable and sturdy frame for the gadget. This is because aluminium is a material that works well for many applications because it is lightweight, strong, and has high heat conductivity.

The plastic coil holder is an essential part of coil winding because it keeps the coil in place as it is being wound. The plastic coil holder can be altered or changed to fit coils of various lengths and diameters. Due to the customisation, producers may easily produce coils in a variety of forms and sizes.

Another crucial element in the coil wrapping process is the wire feeder. To move the wire through the coil, it consists of a stepper motor and feed wheel that operate in tandem. The feed wheel makes sure that the wire is fed uniformly and consistently throughout the winding process, while the stepper motor ensures precise control over the speed and direction of the wire.

A tensioner is made with a spring and pulley to guarantee that the wire is correctly tensioned during the winding operation. The tensioner keeps the wire under continuous tension, preventing it from becoming tangled or loose. This aids in making sure the coil is wound precisely and tightly, producing a high-quality output.

A plastic guide is used to lead the wire to various points on the coil. The plastic guide can be modified or changed to route the wire to various areas of the coil, enabling the construction of coils with intricate designs and shapes.

The controller for the coil winding machine is made up of the motor driver and Arduino board. The stepper motor is powered and controlled by the motor driver, and is capable of being programmed and automated by the Arduino board. These elements work together to enable producers to programme and automate the coil winding procedure, ensuring reliability and effectiveness.

VIII. Testing

The automatic coil winding and dewinding machine underwent comprehensive testing to guarantee that it matched the criteria and specifications established by the manufacturer. The testing technique involved winding and dewinding coils of different sizes and shapes to determine the machine's capabilities and performance.

During the testing phase, the machine was able to wind and dewind coils at a constant tension and speed. This is a vital element of the coil winding process as it guarantees that the coils are twisted firmly and evenly, resulting in high-quality goods. The machine's capacity to maintain a constant tension and speed throughout the winding and dewinding operation was a noteworthy feat and a credit to the machine's design and functionality

The machine wound coils that were even and well-formed, with no kinks or tangles in the wire that was fed into the coils. Since any interruptions or breaks in the wire can lead to unsatisfactory products, a smooth feeding of the wire is essential to preventing errors during the winding and dewinding process.

Another key feature of the automatic coil winding and dewinding equipment was its speed. Coils could be wound and unwound by the machine more quickly than by hand. This is an important step in the manufacturing process because it can raise productivity and lower costs.

In summary, the automatic coil winding and dewinding machine underwent extensive testing to guarantee that it met the norms and specifications set by the manufacturer. The machine's capacity to wind and dewind coils at a constant tension and speed, with even wire feeding and faster speed than manual winding, makes it a highly effective and efficient instrument for the fabrication of electrical and electronic equipment.

IX . Results and Discussion

A hierarchical system called a CPS (cyber-physical system) uses control computation to reduce the discrepancy between the projected process response and the desired trajectory. An event-triggered task parallelization approach is employed in the multi-coil winding of an armature to regulate and monitor the process in a heterogeneous environment. For efficient tension management and homogeneity during rewinding, a stator in-slot continuous system is utilised. The system employs a number of methods for classification and pattern recognition, including ANFIS, SVM, k-nearest neighbour, and clustering. The system is taught using supervised learning, and it optimises neural network outputs using LS-SVM regression.
Control computation is used in a hierarchical system known as a CPS (cyber-physical system) to minimise the difference between the predicted process response and the intended trajectory. The multi-coil winding of an armature uses an event-triggered task parallelization strategy to control and monitor the operation in a heterogeneous setting. A stator in-slot continuous system is used during

rewinding to effectively manage tension and maintain uniformity. ANFIS, SVM, k-nearest neighbour, clustering, and other techniques for classification and pattern recognition are used by the system. The system is trained using supervised learning, and it uses LS-SVM regression to optimise the outputs of neural networks.

IX. Conclution

1. The study discusses the design and manufacture of a low-cost automatic coil winding and dewinding machine.
2. The device is inexpensive, effective, and simple to use.
3. The device has the ability to boost output while cutting labour costs.
4. Coils of all sizes and forms can be wound and unwound with this device, according to testing.
5. The automatic coil winding and dewinding machine is a useful instrument for producing electrical and electronic products, in general.

References

[1] Andreas Mayr, Dominik Kibkalt Towards an intelligent linear winding process through sensor integration and machine learning techniques. 2021

[2]Van Tu Duong, Huy Hung Nguygen, Jae Hoon Jeong, Hak Kyeong kim & Sang Bong Kim. Implementation of an Active Wire Tensioner Using a Cascade Fuzzy Logical Controller for a Brush-Less Direct Current Coil Winding Machine. 2015

[3] Rohit Sharma, Kashmir Singh Ghatorha. Modeling and detecting the stator winding inter turn fault of permanent magnet synchronous motors using stator current signature analysis.2019

[4] Yu Chena, Zhongyong Zhaoa ,Hanzhi Wua, Xi Chena, Qianbo Xiaob, Yueqiang Yua.Fault anomaly detection of synchronous machine winding based on isolation forest and impulse frequency response analysis 2021

[5] N. MagnussonJ. C. Eliassen P. King. Design Aspects on Winding of an MgB2 Superconducting Generator Coil 2015

[6] Florian Sell-Le Blanc, Janna Hofmann, Juergen Fleischer.Coil winding process modelling with deformation based wire tension analysis 2016.

[7] Yong-huiPark, Kyutae Park, Hyun-chul Park. Stress analysis model of strip winding system with a sleeve for a coil of thin stainless steel.2017

[8] Nagi, Gazal Kaur, "Fundamentals of Machine Design and Manufacturing: Design of a Compliant Winding Machine" (2014).

[9] Alexander Kuehl, Andreas Riedel, Alexander Vogel, Sebastian Hartl, Tobias Glaessel,Michael Masuch, Joerg Franke Robot-based Production of Electric Motors with Hairpin Winding Technology 2019

[10] Uday Mali, Akash Lotke, Harshal Jangale, Kirankumar Kanole and Himadri Majumder Problem Identification in Vintage MK1 Coil Winding Machine 2022

[11] Alice Matengaa , Eriyeti Murenab,*, Khumbulani Mpofu Prescriptive Modelling System Design for an Armature Multi-coil Rewinding Cobot Machine 2020

[12] Ma Quanjin1,2* , M.R.M.Rejab1,2, I.M.Sahat, M. Amiruddin, D. Bachtiar, J.P.Siregar, M.I.Ibrahim3 Design of portable 3-axis filament winding machine with inexpensive control system 2018

[13] Prajval Vaskar1, Suraj Zambare2, Shraddha Waje3, Rushabh Vhora4 Design And Development Of Automatic Coil Winding Machine 2018

[14] J.H.R. Wimalaweera*, H.L. Subasinghe Design and Development of a Prototype Armature Coil Removing Machine for Small Scale Single Phase Motors 2022

[15] Adong Zhang, Jiangjun Ruan, Yuanchao Hu, Kaipei Liu Driving circuit research of a coil launcher 2012

[16] K Sabeel Ahmed[1], N Jayavardhana Acharya, S Aslam, Mohammed Ali Design and Fabrication of Low Cost Filament Winding Machine 2010

[17] Rushikesh Ganpati Koravi1 , Anirrudh Bhairu Bagadi2 , Abhishek Bhimrao Latthe3 ,Pravin Athmaram Thorat4 Automatic Coil Winding Machine 2020

[18] adong Zhang, Jiangjun Ruan, Yuanchao Hu, Kaipei Liu Driving circuit research of a coil launcher 2012

[19] Carolina María Martín et al.Ground Faults Location for Synchronous Machine Poles through Frequency Response Analysis

[20] A. Kumar et al.Novel Convolutional Neural Network (NCNN) for the Diagnosis of Bearing Defects in Rotary MachineryIEEE Trans. Instrum. Meas.(2021)