Implementation of a High-Accuracy PLC-Driven Coil Winding Machine

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***Abstract*— Coil winding is a critical process in the manufacturing of electrical machines such as motors, transformers, and inductors. Conventional manual winding methods suffer from low productivity, inconsistent quality, and high dependency on operator skill. This paper presents the design and implementation of a Programmable Logic Controller (PLC)-based coil winding machine aimed at improving accuracy, efficiency, and repeatability. The system integrates a PLC, motor drive, Servo Motor, and tension control mechanisms to automate the winding process. Experimental results demonstrate significant improvements in turn accuracy, production time, and operational reliability compared to manual winding systems.**

***Index Terms*— PLC, HMI, Industrial Automation, Coil Winding Machine Process Control.**

I. INTRODUCTION

The growing demand for high-quality electrical machines has increased the need for precise and reliable coil winding techniques. Coil winding quality directly affects the efficiency, thermal performance, and lifespan of electrical equipment. Traditional manual winding processes are time-consuming and prone to errors such as uneven tension, incorrect turn counts, and inconsistent layering. Industrial automation using Programmable Logic Controllers (PLCs) provides a robust solution to these challenges. PLCs offer high reliability, flexibility, real-time control, and ease of integration with industrial sensors and actuators. This paper focuses on the development of a PLC-based coil winding machine that automates the winding process while maintaining high precision and operational safety. The coil Winding Machine very important in industrial application.

II. LITERATURE REVEW

Previous research highlights the limitations of manual and semi-automatic coil winding systems. Microcontroller-based solutions have been proposed; however, they often lack industrial-grade reliability, noise immunity, and scalability. Studies indicate that PLC-based automation systems provide:

- Improved process accuracy• Enhanced safety and diagnostics
- Better adaptability to varying production requirements
- Improved Production

Existing PLC-based winding systems often lack integrated tension control and flexible parameter settings. This research addresses these gaps by implementing encoder-based turn counting and programmable speed and tension control.

III. OBJECTIVES

The primary objectives of this research are:

- To design a PLC-controlled automatic coil winding machine
- To achieve precise control of winding speed and number of turns
- To compare system performance with conventional manual winding methods

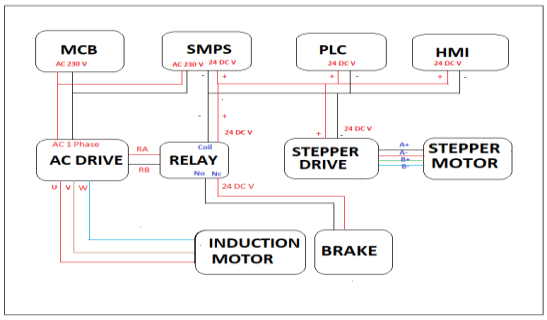
IV. SYSTEM ARCHITECTURE

PLC: Controls overall system operation

- Motor and Drive: Regulates spindle speed
- Rotary Encoder: Provides real-time feedback for turn counting
- Sensors: Sensor Total Turn Count
- HMI: Allows operator input and real-time monitoring

V. ELECTRICAL BLOCK DIAGRAM

A. Figures block Diagram



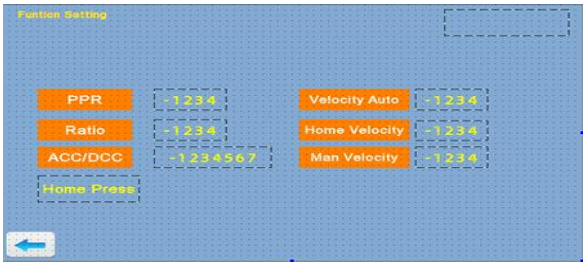
B. Control Panel

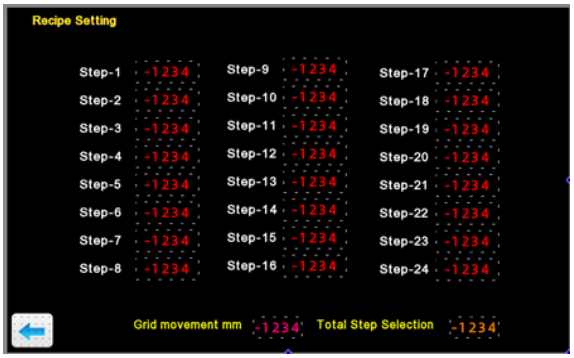
C. Plc Programing & Logic Design

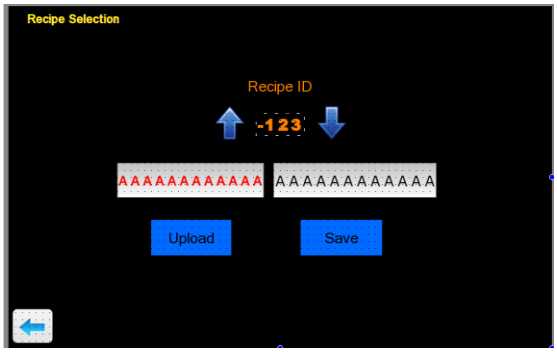
The PLC program is developed using ladder logic and structured into the following modules:

Project Source data Google Drive - https://drive.google.com/file/d/1xTM4bJrz45VmVNXXeUdvmeMfTf2gfSXH/view?usp=drivesdk

D. Hmi Screen Design







VI. EXPERIMENTAL SETUP & METHODOLOGY

Parameter	Specification
PLC Type	Flexem
Motor Type	Induction Motor
Speed Range	Max 50 Hz
Maximum Turns	Via HMI

VII. RESULT

The Performance comparison between manual and PLC-based winding systems is shown below:

Parameter	Manual Winding	PLC-Based Winding
Turn Accuracy	±5%	±1%
Production Time	High	Reduced by ~50%
Repeatability	Low	High
Operator Dependency	High	Minimal

The results confirm that the PLC-based system significantly enhances productivity and precision.

VIII. CONCLUSION

This research demonstrates the successful design and implementation of a PLC-based coil winding machine. The automated system offers improved accuracy, reduced production time, and enhanced reliability

compared to conventional methods. PLC-based automation proves to be a cost-effective and scalable solution for modern coil winding application

IX. FUTURE SCOPE

Future developments may include:

1. Closed-loop tension control using PID algorithms
2. IoT-based data logging and remote monitoring
3. Automatic wire layering mechanism

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