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Development of Electric Control Panel to Control a CNC Thread Milling Machine

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Abstract: In the modern manufacturing industry, automation is critical for achieving enhanced productivity, precision, and efficiency. CNC (Computer Numerical Control) rotothread milling machines exemplify such advancements by performing high-precision threading and milling tasks essential in sectors like automotive, aerospace, and industrial machinery. Central to the operation of these machines is the electrical control panel, which ensures effective system management, user interaction, and machine performance. This report provides an in-depth overview of the development of electrical control panels for CNC rotothread milling machine. It covers the layout of the control panel, key power supply components, circuit protection devices, control devices, input/output modules, communication devices, safety components, and cable management practices. By exploring each of these elements, the report aims to highlight their roles in enhancing the functionality and reliability of CNC milling machines.

Keywords: Power Distribution, Control Devices, Power Supply Components.

1. Introduction

CNC machines are essential in various industries for their high-precision threading and milling tasks. The control panel is a critical component that allows operators to input commands, monitor machine status, and adjust parameters for optimal performance. It serves as the interface between the operator and the machine, enabling precise control of machining processes. The panel typically includes a touchscreen or a combination of buttons and displays to provide real-time data about the machine's operations. The PLC, known for its reliability, executes the programmed instructions to control the machine's operations, managing functions such as tool changes, axis movements, and safety interlocks.

2. Literature survey

Zhang [2] in his paper reported about the data acquisition, the speed and position control of the two axes are successfully realized through Beckhoff PLC and its various modules. The servo driver is controlled by Beckhoff PLC HMI for forward rotation, reversal, origin and function to realize multi axis movement, which can easily realize the quasi synchronous operation of multiple axes. Ye [4] discussed the vector control, V/F control, slip compensation, torque compensation and so on. They have further discussed suitable applications for a variety of industries, including automotive, textile, printing, chemical and so on. It can be widely used in various industrial production lines, such as mixing equipment, conveyor belts, hydraulic pumps, etc., as well as automation equipment, such as robots and machine tools. Bingül [6] designed and developed an experimental setup for the ECDLSM (E C D L S M). In the experimental setup, the force was calculated based on the spring's stiffness. The forces of the ECDLSM were analyzed using the position errors obtained from the load and stepper motor position. Thakkar [7] has reported the process of designing of the electrical panel for the HVAC system. This paper describes how the actual panel works from the power circuit diagram and control circuit diagram.

3. Objectives

- Control and operate CNC thread milling machine
- Provide a Safety to the operator

4. Development of electrical control panel

The development of an electrical control panel for CNC rotothread milling machines involves designing a robust system to ensure precise control, reliable operation, and safe interaction between the operator and the machine.

5. Design and Layout

An electrical control panel is a critical component in managing and regulating the electrical system of a CNC thread milling machine. Housed within a durable metal enclosure, the control panel is designed to accommodate all necessary components and wiring, with its size selected according to the machine's complexity and the number of control elements involved.

Control panel It includes

- Power Supply Components
- Circuit Protection Devices
- Control Devices
- Input/output (I/O) Modules
- Communication Devices
- Safety Component
- Indicator Lights and Alarms
- Wire Ducts and Cable Management
- Grounding

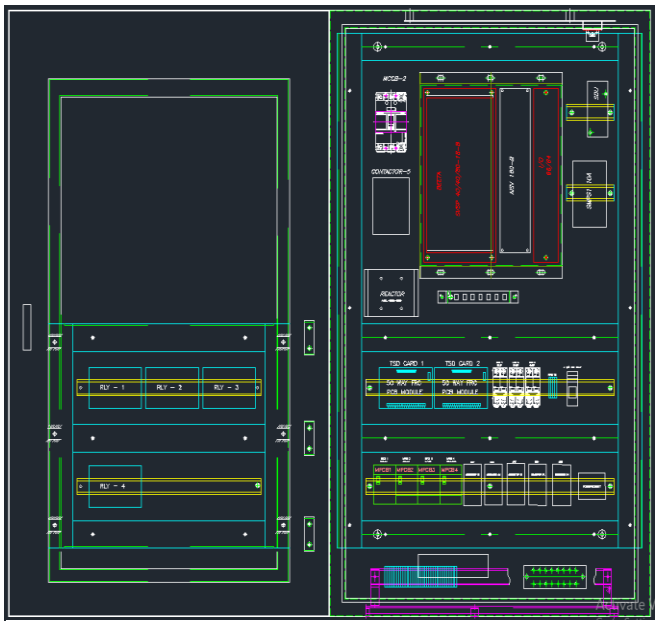


Fig. 1, Layout of Electric Control panel

5.1 Power Distribution

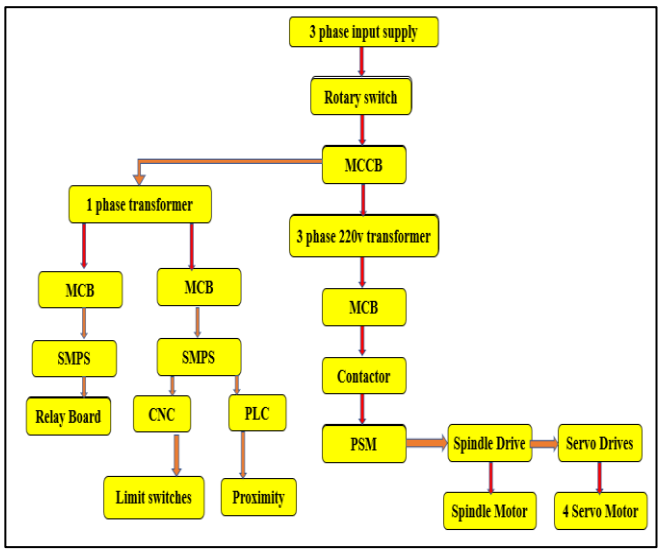


Fig. 2, Power supply in control panel

Power distribution within an electrical control panel is crucial for ensuring reliable operation and safety of the machinery. the control panel receives electrical power from an external source, typically a three-phase supply. This input power is often at a high voltage and needs to be adjusted and distributed appropriately within the panel. The main power distribution section manages the incoming power and routes it to different components within the panel. Main Circuit Breaker Provides overcurrent protection and isolation for the entire control panel. It allows for safe disconnection of power during maintenance or in case of faults. Bus Bars Conductive strips or bars that distribute power from the main supply to various circuits within the control panel. They ensure efficient and organized power distribution. Multi-Tapping Transformers used to step up or step-down voltage levels as needed. They provide various output voltages from a single input voltage, ensuring compatibility with different components and systems within the panel. Miniature Circuit Breakers (MCBs)Automatically disconnect circuits in case of overcurrent or short circuit conditions, protecting the wiring and connected components. Molded Case Circuit Breakers (MCCBs) Provide protection for larger circuits and equipment, offering both thermal and magnetic protection against faults. Distribution Panels Manage the allocation of power to different areas or components of the control panel, ensuring that each part of the system receives the correct voltage and current. Switched-Mode Power Supplies (SMPS) Convert and regulate voltage to provide stable and clean power for control systems and other sensitive electronics. Reactors Used to smooth out fluctuations and improve the quality of the power supplied to components such as servo drivers. Wire Ducts and Cable Management Organize and protect cables to prevent damage and ensure safe operation. They also facilitate easier maintenance and troubleshooting. Grounding Ensures that all metal parts and electrical components are properly grounded to prevent electrical shock and protect against electrical faults.

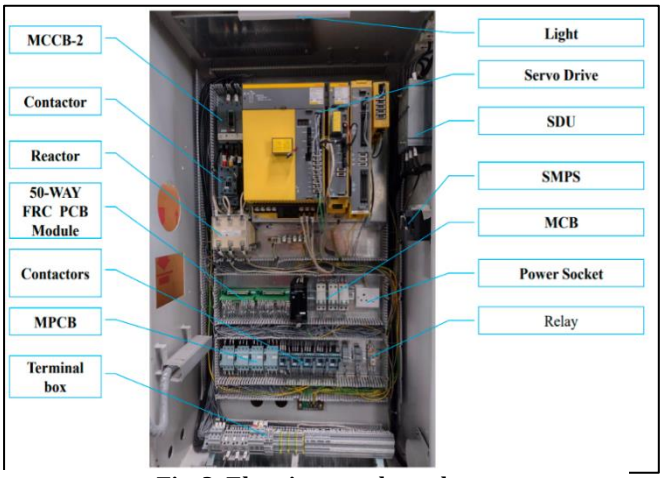
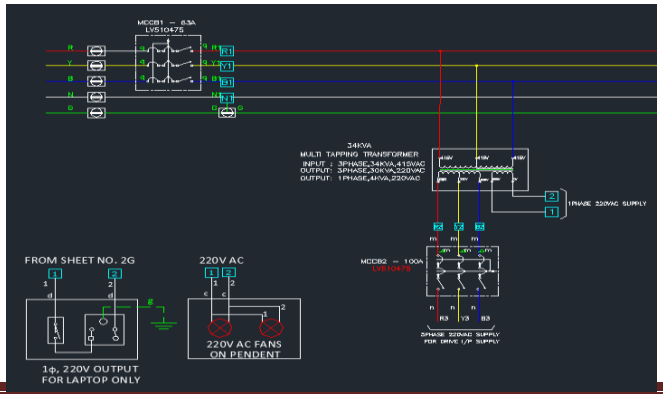


Fig. 3, Electric control panel

5.2 Main Power supply to Control panel

Mainly power supply is given from external block 415VAC to MCCB through the wires R Y B N and C the output coming out from MCCB1 (63A) is named as R1 Y1 B1. Basically, MCCB provide protection against overload conditions by breaking the circuit when the current exceeds the rated capacity of the breaker. This prevents overheating and potential damage to the wiring and connected equipment. Ensures the electrical components and wiring are not subjected to excessive current, which can cause insulation failure or fire hazards. The output of the MCCB1 is given to the multi tapping transformer which v have used is 34KVA. A Multi tapping transformer, also known as a

Fig. 4, Circuit representation of Main Power Circuit



multi-tap transformer, is a type of transformer that has multiple connection points (taps) on its windings, allowing for different voltage outputs from a single transformer. These taps provide flexibility in selecting various output voltage levels from the transformer by adjusting the connection points. They offer versatility in power distribution systems, enabling the same transformer to be used in different applications and settings without needing to replace or adjust the primary transformer, by allowing precise voltage adjustments, multi-tap transformers can help in minimizing energy losses and improving the overall efficiency of electrical systems. We will be getting two outputs from the transformer that is 3phase 30KVA 220VAC and another is single phase 4KVA 220VAC. 3phase is given to next MCCB2 of 100A and single phase is given to 220VAC supply connected through terminal block R2 Y2 B2. The output of MCCB2 R3 Y3 B3 is three phase 220VAC supply is given to FANUC drive input supply coolant fan are operated by 220VAC.

5.3 CNC INTERFACE

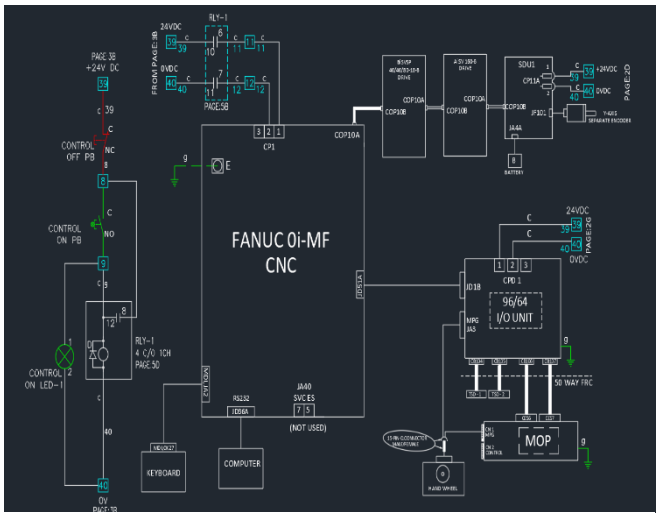


Fig. 5, Circuit representation of CNC Interface

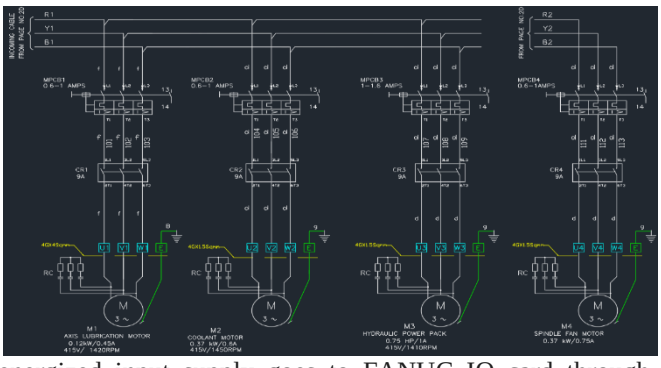
For the Fanuc drive input supply is given from 24VDC and 0VDC and both are connected to the relay -1 parallel to each other through terminal block 11 and 12 and connected to input of drive that is 3 2 1 and COP section is given to another 3 drive serially connected COP 10A ,COP10B and COP10B in SDU1 JA4A is given to battery and CP11A is given to terminal block of 39 and 40 which is of 24VDC AND 0VDC in the JD51A section of drive is given to JD1B and IO input 1 and 2 is given to 24VDC AND 40 is given to 0VDC. MPGJA3 is given to handwheel that handwheel is connected to mop (manually operated panel), CB104 is connected to TSD1 and CB105 is connected to TSD2, CB106 and CB107 is connected to CE56 and CE57 of MOP .in order to connect IO unit and MOP 15pin D connector male/female is used. In order to control Fanuc drive push button is given supply from 24VDC which is always normally closed there is two condition where current will be directly flowing from terminal block 8 which is directly connected to LED ,the LED is given to 0V and other one is another pushbutton which is NO is given to LED as soon as current comes from control off pushbutton control on pushbutton is activated and LED glows another control on LED is installed between terminal block 9 to 40 .

5.4 External Motor Circuit Connections

R1 Y1 B1 what we have got from MCCB1 which is connected to FANUC IO card from TSD card2 to X3.0 from Farol number 303. MPCB1(0.6 TO 1AMPS) MPCB is A Motor Protection Circuit Breaker (MPCB) is a specialized device designed to protect electric motors from overloads, short circuits, phase failures, and other electrical faults. MPCB s are designed to protect motors from overheating due to overload conditions. They do this by sensing the current drawn by the motor and tripping if the current exceeds a pre-set value for a specific period. MPCB s often have adjustable settings for both overload and short circuit protection, allowing for customization based on the specific requirements of the motor and application. In order to make axis lubrication motor run previously from the MCB2(0.6 to 1AMPS) 2A 2P, this MPCB2 his given to input FANUC IO card from TSD card card2 to X3.1. through Farol number 304. MPCB is given to contactor supply from terminal block 3 and 4 from the terminal block 3 and 4 200VAC supply is given to contactors that is CR1 through Farol number 407 it is given to relay 2RLA coil C1 which is given 24VDC and negative end of coil is given to 0VDC to the relay card 2 now the coil is energized, now the energized current goes to TSD card2 through Farol 339 passing from the flat cable it is connected to the FANUC IO card.

Connector which is CR1 normally open as soon as the load comes from MPCB1 it becomes normally closes and axis lubrication motor is activated. Next in order to activate the coolant motor same mechanism involves as in the axis lubrication motor where coolant motor is getting supply 220 VAC which it is connected to relay CR2, and MPCB3 (1 to 1.6AMPS) is connected to FANUC IO card from TSD card2 to X3.2 through Farol number 305 and CR2 is given to relay coil 2RLB other end of coil is getting supply from 24VDC. In the relay card2 coil is energized and input supply goes to FANUC IO card through TSD card from the terminal block 40 to Y3.1. Next in order to run hydraulic power pack, motor is getting supply of 220VAC which it is connected to relay CR3, CR3 is given to relay coil 2RLC and other end coil is getting supply from 24VDC. In the relay card 2 coil is

Fig. 6, Circuit representation of Feed Motor



energized input supply goes to FANUC IO card through TSD card from the terminal block 41 to y3.2. next is from R2 Y2 B2 is given to MPCB4(0.6 to 1AMPS) 24VDC supply is given to MPCB4 is taken as an input X3.3 to FANUC IO card through TSD card2 flat cables have been given to TSD card and FANUC IO cards farol 112 113 114 is connected by contactors ,contactors here by r connected through 220vAC is given to CR4 ,relay 2RLD is given

24Vdc coil is energized and load is given to relay coil 2 as an output y3.3 passing through TSD card2 42.

5.5 Axis Motor Circuit Connections

In a CNC milling machine, precise control of axis motors is essential for accurate machining. Each axis motor—typically X, Y, and Z and B axis-plays a crucial role in positioning the cutting tool and workpiece. For an automatic rotothread milling machine, the choice of motors and motor controllers is crucial to ensure precise and reliable operation. Here's a detailed outline of considerations and components typically used in such machinery. There are 4 main motor is used to achieve a X, Y and B axis, also additional motors like Axis lubrication motor, Coolant motor, Hydraulic power pack motor and Spindle fan motor. All these motors are connected to respected motor controller to control of a motor output.

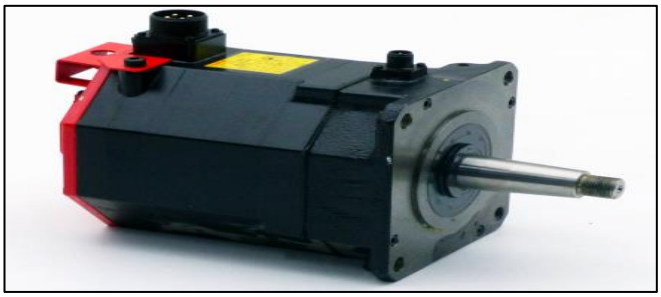


Fig. 7, Servo motor

- **Type**: Servo motors depending on the precision and speed requirements of the machine.
- **Characteristics**: Servo motors offer high precision, speed, and torque, suitable for rapid positioning and precise threading operations.
- Integrated with motion controllers to achieve accurate movement along the X, Y, Z and B axes.

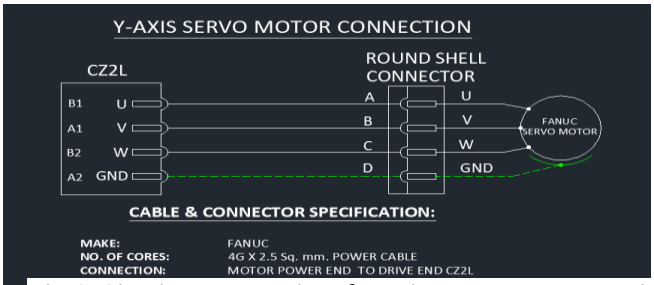


Fig. 8, Circuit representation of Y-axis servo motor connection

5.6 Working of CNC Thread Milling Machine

- *Spindle:* In the spindle the workpieces are mounted buy the help of 4-jaw hydraulic operated chuck to rotate the workpiece at required speed by the help of spindle motor which is belt driven, it is mounted on Y-axis.
- *Tailstock:* The Manually operated tailstocks are used to secure and support the free end of a workpiece while it is being machined, tailstock is helping the workpiece is in the same axis to machining.
- *Work tool:* The control, movement and precision of machine tools through the use of preprogrammed computer software, which is embedded inside the tools.

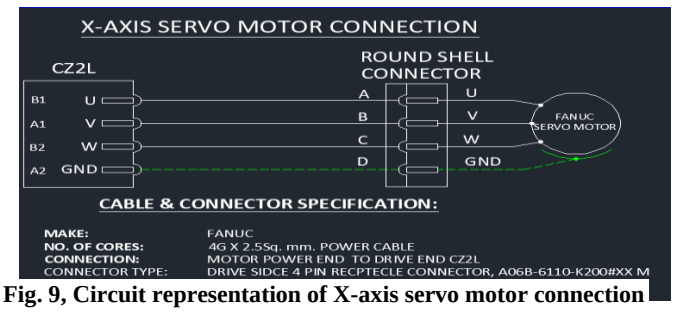


Fig. 9, Circuit representation of X-axis servo motor connection

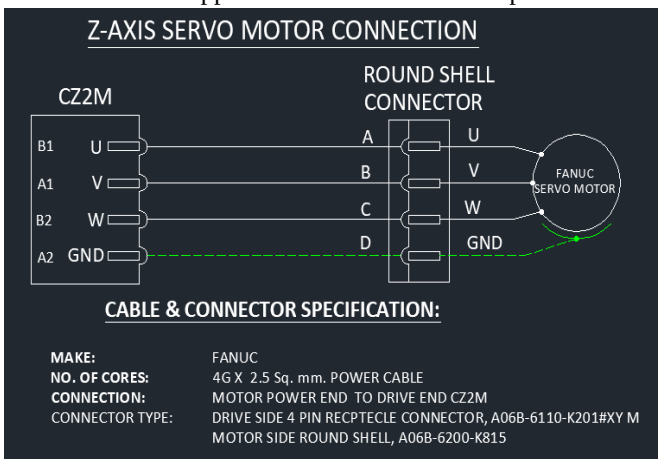


Fig. 10, Circuit representation of Z-axis servo motor connection

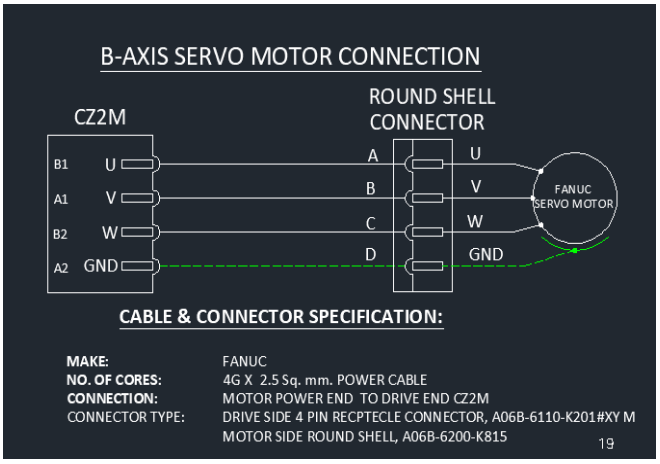


Fig. 11, Circuit representation of B-axis servo motor connection

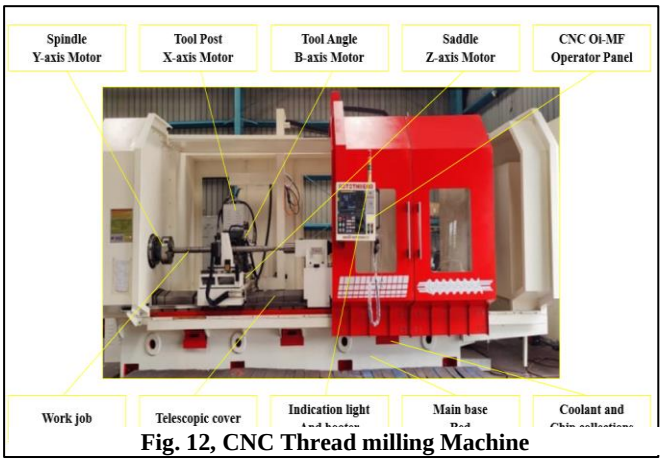


Fig. 12, CNC Thread milling Machine

It also has B-axis to change the angle of tool the whole assembly is mounted in X-axis.

- *Steady rest Clamp, DE-clamp:* To avoid the job sag while machining, it has auto clamp and de-clamp.it is mounted on saddle Z-axis.
- *Coolant:* To remove heat from a system during machining, it is a mixture of water and glycol/ethanol.
- *Control Panel:* It is to transmit the control signal into motor movement/spindle and axis speed.
- *Feedback sensors (Proximity):* A proximity sensor is a device that can detect or sense the approach or presence of nearby objects and for this it does not need physical contact.

CONCLUSION

The electrical control panel is a fundamental component of CNC (Computer Numerical Control) thread milling machines, providing the essential interface between the operator and the machine's mechanical systems. This report has explored the intricate roles and functionalities of the control panel, highlighting its critical importance in ensuring precision, reliability, and efficiency in thread milling operations. The electrical control panel is a cornerstone of CNC thread milling machines, embodying the integration of electrical engineering and mechanical precision. Its role in managing power distribution, executing commands, and ensuring safety underscores its importance in modern manufacturing environments. By addressing the associated challenges and implementing recommended practices, manufacturers can leverage the full potential of their CNC thread milling machines, driving improved precision, efficiency, and reliability in their production processes. the ongoing evolution of control panel technology will continue to shape the future of CNC machining, offering new opportunities for optimization and innovation.

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