CONCEPTUAL DESIGN OF STEPPER MOTOR REPLACING SERVO MOTOR FOR CONTROL ROD CONTROLLER

Mohd Dzul Aiman bin Aslan*, Mohd Khairulezwan bin Abdul Manan, Mohd Sabri bin Minhat ,
Mohd Idris bin Taib, Tn Hj Izhar bin Abu Hussin
Malaysian Nuclear Agency
Bangi, 43000 Kajang, Selangor Darul Ehsan, Malaysia
***e-mail: dzulaiman@nuclearmalaysia.gov.my**

Abstract

In PUSPATI TRIGA Reactor, current control rod controller are using servomotor to control the movement. Control rod is a very important safety element and measure in every nuclear reactor. So, precision is very important in measurement of security in the nuclear reactor. In this case, there are a few disadvantages when using the servomotor is measurement of the motor is not precise. One solution to overcome this is by shifting servomotor with stepper motor. A stepper motor (or step motor) is a brushless, synchronous electric motor that can divide a full rotation into a large number of steps.

Introduction

In nuclear reactor, control rods are used to control the rate of fission of uranium and plutonium. It is made of chemical elements that capable of absorbing many neutrons without fissioning themselves. Because these elements have different capture cross sections for neutrons of varying energies, the compositions of the control rods must be designed for the neutron spectrum of the reactor it is supposed to control. The motor's position can be controlled precisely without any feedback mechanism, as long as the motor is carefully sized to the application. Stepper motors are similar to switched reluctance motors which are very large stepping motors with a reduced pole count, and generally are closed-loop commutated. Stepper motors operate differently from DC brush motors, which rotate when voltage is applied to their terminals. Stepper motors, on the other hand, effectively have multiple "toothed" electromagnets arranged around a central gear-shaped piece of iron. The electromagnets are energized by an external control circuit, such as a microcontroller. To

make the motor shaft turn, first one electromagnet is given power, which makes the gear's teeth magnetically attracted to the electromagnet's teeth. When the gear's teeth are thus aligned to the first electromagnet, they are slightly offset from the next electromagnet. So when the next electromagnet is turned on and the first is turned off, the gear rotates slightly to align with the next one, and from there the process is repeated. Each of those slight rotations is called a "step," with an integer number of steps making a full rotation. In that way, the motor can be turned by a precise angle.

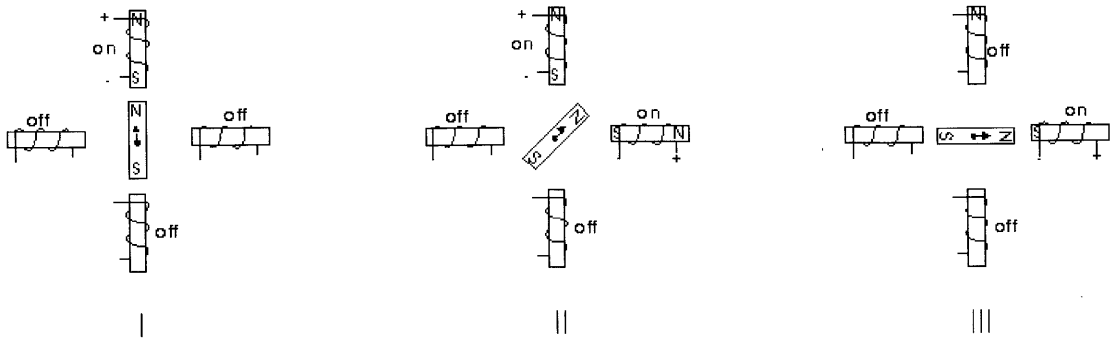

Figure 1: Control rod controller movement

Problem Statement

Currently, for TRIGA PUSPATI Research Reactor, control rod controllers are using servo motor as the motor drive. The problem with servo motor is they are not precise and the brushes need to be replaced during certain period of time of activity. Solution for another motor is needed to replace the servo motor. Other than that, the current research reactor nowadays are using stepper motor so that it will be easier to integrate with new digital console system. In this paper, it will discuss the comparison of benefit using stepper motor than using the servo motor.

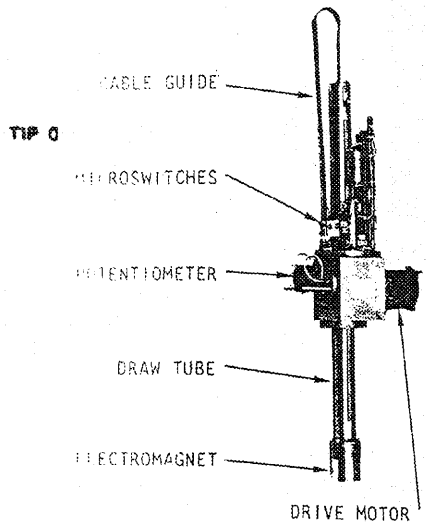

Figure 2: Control Rod for the Reactor TRIGA PUSPATI

Result and Discussion

Comparison Between Stepper Motor and Servo Motor		
Characteristics	**Servo Motor (DC Brushed)**	**Stepper (Hybrid)**
Cost	The cost for a servo motor and servo motor system is higher than that of a stepper motor system with equal power rating.	This feature would have to go to stepper motors. Steppers are generally cheaper than servo motors that have the same power rating.
Versatility	Servo motors are very versatile in their use for automation and CNC applications.	Stepper motors are also very versatile in their use for automation and CNC applications. Because of their simplicity stepper motors may be found on anything from printers to clocks.
Reliability	This is a toss up because it depends on the environment and how well the motor is protected.	The stepper takes this category only because it does not require an encoder which may fail.
Setup Complexity	Servo motors require tuning of the (PID) closed loop variable	Stepper motors are almost plug-and-play. They require only the motor wires to be wired to the

	circuit to obtain correct motor function.	stepper motor driver.
Motor Life	The brushes on servo motors must be replaced every 2000 hours of operation. Also encoders may need replacing.	The bearing on stepper motors are the only wearing parts. That gives stepper motors a slight edge on life.
Low Speed High Torque	Servo motors will do fine with low speed applications given low friction and the correct gear ratio	Stepper motors provide most torque at low speed (RPM).
Repeatability	Servo motors can have very good repeatability if setup correctly. The encoder quality can also play into repeatability.	Because of the way stepper motors are constructed and operate they have very good repeatability with little or no tuning required.
Overload Safety	Servo motors may malfunction if overloaded mechanically.	Stepper motors are unlikely to be damages by mechanical overload.
Availability	Servo motors are not as readily available to the masses as are stepper motors.	Stepper motors are far easier to find than quality servo motors.
Motor Simplicity	Servo motors are more mechanically complex due to their internal parts and the external encoders.	Stepper motors are very simple in design with no designed consumable parts.
Direct Drive Capability	Servo motors usually require more gearing ratios due to their high RPM. It is very rare to see a direct drive servo motor setup.	Stepper motors will work fine in direct drive mode. Many people simple use a motor couple and attach the motor shaft directly to the leadscrew or ballscrew.

Suggestion

Stepper motor is competitive solution for servo motor replacement. Modern Instrumentation and Control in Nuclear Reactor use stepper motor controlled by microprocessor for easy integration with Digital Instrument. Microcontroller can be programmed to control the stepper motor so that the movement of the motor will be precise.

Conclusion

In conclusion, stepper motor probably the best solution to replace the servo motor for control rod controller in the current nuclear reactor. As we are moving towards Digital Instrumentation and Control (I&C), it is best that we have a precise system that we can control. Microcontroller can suit programming well in integration with the digital system.

References

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