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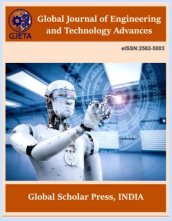

(RESEARCH ARTICLE)

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The design of a servo motor control system for an industrial sewing machine based on PLC s7-1200

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Abstract

A servo motor is used as a motor for industrial sewing machines because it produces less noise, consumes less power, and is lightweight. The only disadvantage of the servo motor is its low minimum speed of up to 5000 rpm, which is why the sewing machine cannot be used at high speeds. When working on complex parts or with thick fabrics, slowing down the machine allows for greater accuracy and avoids needle breakage. When the operator works with thinner fabrics and produces more products, the speed of the machine is usually increased. In this paper, a servo motor control system based on PLC S7-1200 is proposed. The system is designed to control the actuators of the machine, such as electromagnets and gas pedals, in addition to the main shaft motor. The comparison shows that the results obtained with the author's control system are identical to those obtained with the control system of the sewing machine JUKI DDL 8700-7.

Keywords: Servo Motor; PLC S7-1200; Industrial Sewing Machine; Control Algorithm

1. Introduction

The electronic single-needle sewing machine is widely used in the industrial sewing industry; many manufacturers produce this product, including Juki, Brother and Siruba, but the machine controls are issued exclusively by the company. through microprocessors.

The SIMATIC S7-1200 [1] series is suitable for a wide range of small to medium automation applications due to its modular design and high accuracy. Siemens S7-1200 PLC is widely used in industrial and civil applications such as conveyor systems, lighting control, high-pressure pump control, packaging machines, printing machines, textile, yarn and garment machines, mixers and so on.

Machine control or automatically programmed production lines are used in almost every industry today. PLCs are widely used in education, scientific research, and in practise to simulate or control production machines or the operation of equipment. However, there are few studies or applications of PLC control in production machines or simulation models for sewing machine research and repair in schools. Therefore, the author researched and built a model to simulate the operation of servo motors and some operations of a single-needle electronic machine using PLC S7-1200 for teaching at Hanoi University of Textile Industry.

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2. Material and methods

2.1. Research subjects

The purpose of this paper is to study, design, and simulate some electromagnetic actuators of a JUKI DDL 8700-7 [2] single-needle machine using PLC S7-1200. The SC 920 [3] control box is an electric circuit made by JUKI of Japan, which is used to control a variety of electronic sewing machines, such as: 1 needle, 2 needles, cover printing... It is an electric circuit with two components. is a source and control circuit; however, the author does not elaborate on the SC 920 circuit in the article, but focuses on the control principle of the servo motor and some actuators, which are electromagnets of the machine. JUKI DDL 8700-7 Needle.

2.1.1. The operation of the JUKI DDL 8700-7 single needle machine

When an accelerator signal is present, the electric circuit will power the engine, and the engine's speed will be transmitted to the main shaft via the belt. When the spindle moves, the sewing machine's actuators will be affected. Similarly, the control of certain actuators, such as re-pointing, thread trimming, and thread removal, will function when a control signal from the circuit or a screen key is present.

Automatic re-stitching of stitches

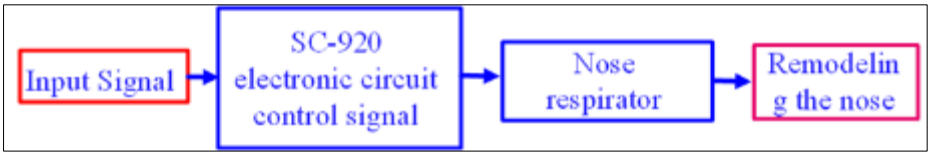

Figure 1 Stitch reorganization diagram

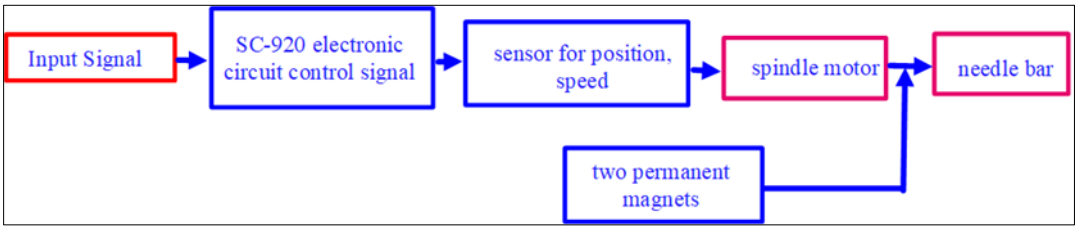

Figure 2 Schematic of the main shaft motor mechanism

A block diagram of the stitch restructuring is depicted in Figure 1. The input signal can be used for resetting the nose mode via the control panel, reswitching, or restitching. When a command to control the nose of the powered suction coil is received, the suction cap will be sucked towards the magnetic pole of the suction coil, pulling the mechanical nose structure to assist the machine in automatically resetting the nose according to the installed program.

Motor main shaft structure

When the machine is opened, the needle bar will automatically rotate to its highest position, followed by the speed sensor determining the needle position and the magnet system on the pulley bringing the needle bar to its highest position. (Figure 2).

2.2. Research Procedures

In this study, the author primarily employed synthetic and experimental methodologies.

2.2.1. Synthetic evaluation

As described in the experimental section, this paper only examines the control portion of the main shaft servo motor and the actuators of the JUKI DDL 8700-7 1-needle machine, including electromagnets and gas pedals. The author has researched and used some past practical results as a theoretical foundation for his research [4], [5].

2.2.2. Experiment

We has created a block diagram for controlling a servo motor using a PLC based on the references used in this article (Figure 3).The PLC signal is sent to the driver, and the driver's control signal generates a pulse to control the servo motor. The encoder signals will control the motor via the feedback circuit, and the motor will transmit to the main shaft pulley via the horse tooth belt.

The driver provides the servo motor with a 3-phase power signal and an encoder feedback signal. When the accelerator pedal sends a signal to the PLC, the motor controls the engine according to the parameters set. Changing the speed of the machine corresponds to adjusting the value of the rheostat. Figure 6 depicts the connection of the control signal from the PLC to a rheostat with a voltage of 24V.

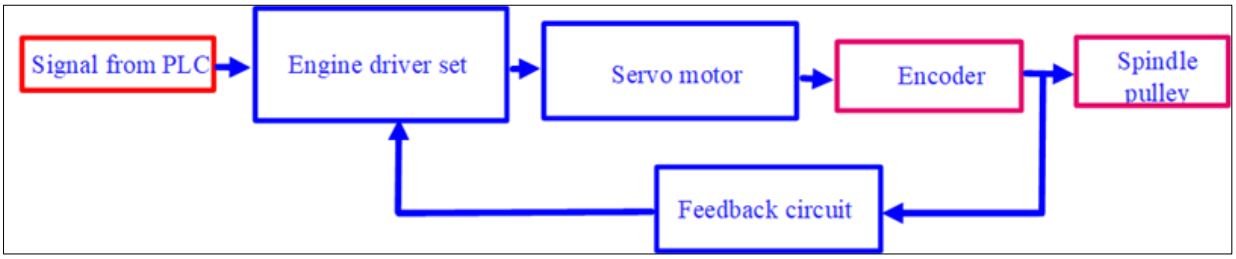

Figure 3 PLC-based servo motor control block diagram

Figure 4 Block diagram of throttle control for machine speed control

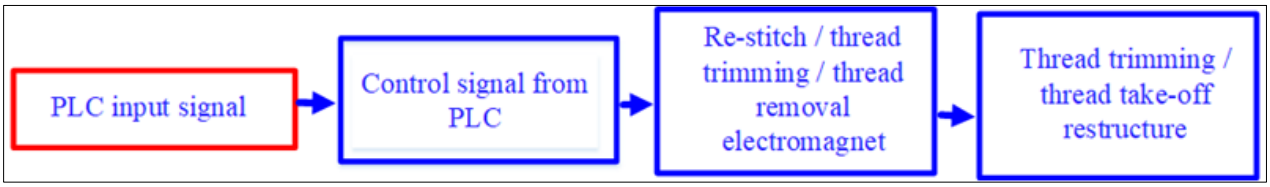

Figure 5 Block diagram for controlling electromagnets

The signal is fed into the PLC input, and through the PLC, the control signal is sent to the re-tapping/threading/spooling electromagnets to close the machine's stitch re-stitching/thread trimming/detching units (Figure 5).

3. Results and discussion

As shown in Figure 6, the author has constructed a model to control the JUKI DDL 8700-7 single-needle machine using PLC S7-1200 based on theoretical knowledge studied.

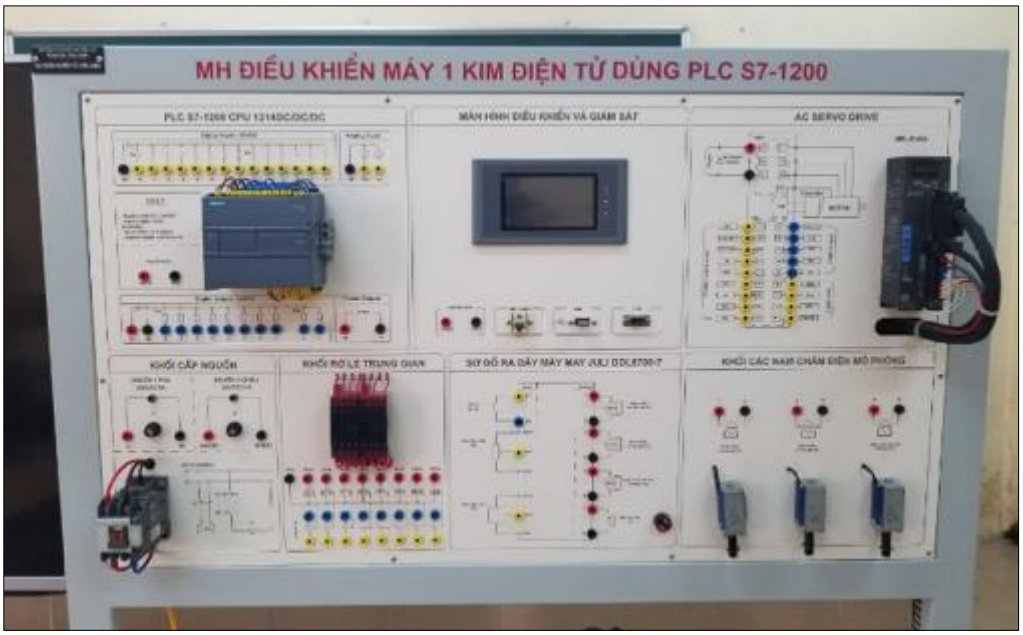

Figure 6 JUKI DDL 8700-7 single-needle machine control model using PLC S7-1200

The control model consists of the following main blocks

- PLC S7-1200
- Monitor and control screen
- AC servo driver
- Source block
- Intermediate relay block
- Block of electromagnets

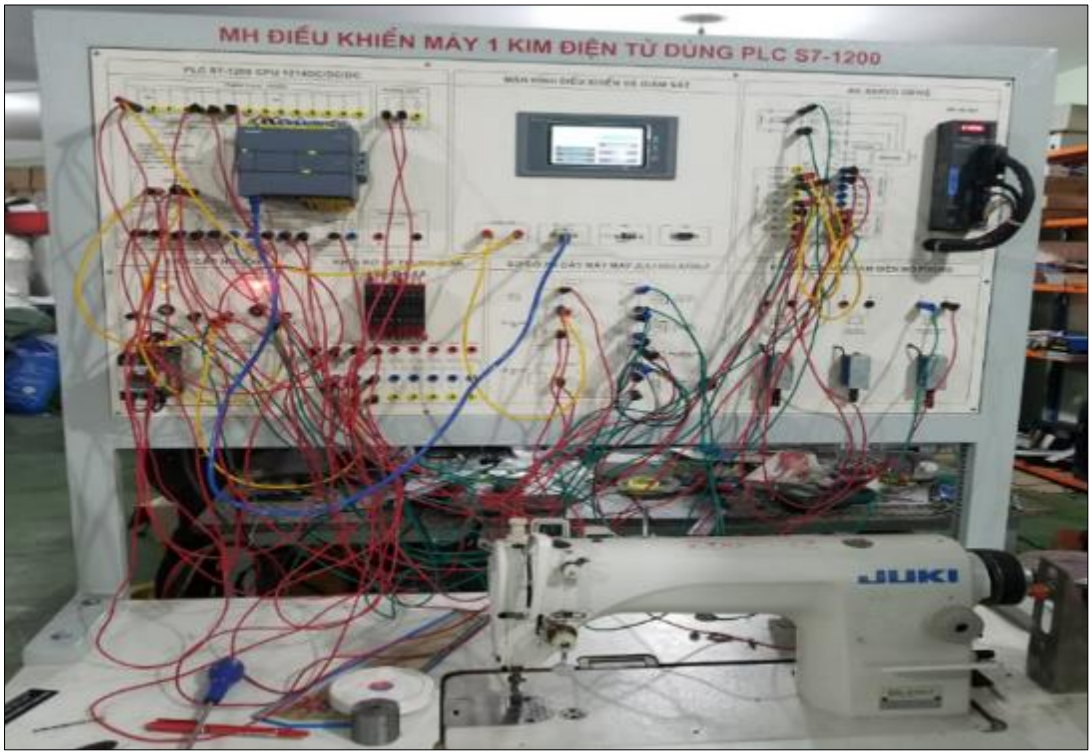

Figure 7 Model of PLC connection to control single-needle machine Juki DDL 8700-7

Figure 8 Monitor screen

Figure 8 depicts the Juki DDL 8700-7 1-needle machine control model using PLC S7-1200 after connection. The monitoring panel (Figure 11) is fully displayed after powering on. motor control functions (speed), the sub-interface appears on the screen, we can press to select the speed for the motor between a few hundred and three thousand rpm, then press enter to confirm, and the speed degree will have the highest speed corresponding to the set speed.

For good motor performance, the model uses PLC to directly control the Juki DDL 8700-7 1-needle machine; the speed can be adjusted from minimum to maximum according to the correct motor parameters. The Juki 8700-7 electronic 1-needle machine operates normally when combined with the proximity sensor and through the pulley and belt, as when controlled by the machine's circuit.

Control the range of the accelerator's speed to alter the engine's speed. When the accelerator pedal is depressed firmly, the analog signal of the rheostat causes the throttle control signals to increase, and vice versa.

Figure 9 Monitor screen displays

Accelerator Juki 8700-7 yields identical results when controlled by PLC.

On the monitoring screen (Figure 12), the parameters associated with the gas pedal's control are displayed; the signals' vibrancy facilitates easy comprehension. V_Min is the minimum voltage of the gas pedal.V_Max is maximum voltage of the accelerator

Display voltage at three levels, increasing sewing speed, and heel jerking (re-stitch, thread trimming, thread removal). Direct the electromagnets contains components as follow:

- Control the solenoid of the threader: When the engine stops and the accelerator pedal is depressed in reverse, the electromagnet must act to pull the lever mechanism into operation.
- Control the electromagnet of the seam back: The motor rotates forward and then reverses through the setting on the control screen; the magnet acts to pull the mechanical mechanism to cause the machine to rotate a specified number of times; at the end of the specified number of turns, the electromagnet is released to allow the machine to run normally. When there is a command to stop the machine (via heel jerk), the electromagnet closes so that the machine performs forward and reverse rotation for a number of revolutions (the number of revolutions is adjustable) and then continues to rotate according to the set number of revolutions.
- Electromagnet control of thread trimmer: When there is a command to stop the machine via the heel jerk at the accelerator, the electromagnet pulls the thread trimming mechanism of the machine into operation.

The electromagnet control model utilizing PLC S7-1200 can control the electromagnets to perform modes such as thread trimming, re-stitching, and thread removal to help the machine function normally. The setting to change modes sewing level, thread take-up mode, and thread trimming can be accessed via the monitor screen, similar to the adjustment on the CP-18 screen of the JUKI 8700-7 machine. In addition, the electromagnets on the model function normally; they behave identically to those on the actual machine.

The opening/closing modes of stitching, thread trimming, and thread removal can be altered. The first (single stitch) and second (double stitch) re-sewing modes are also activated via a toggle on the monitor's interface. Additionally, adjusting the number of stitches is straightforward.

Using PLC motor control, the speed can be increased or decreased arbitrarily. When there is a stop command, the motor must stop at the correct position through the proximity sensor while simultaneously energizing an electromagnet (magnet attracts the thread trimmer) so that it can begin working immediately. The motor rotates forward for a variable number of revolutions before reversing for a variable number of revolutions and continuing to rotate forward. When there is a command to stop the motor, it should perform forward and reverse rotation for a variable number of revolutions, then continue to rotate according to the set number of revolutions, stop, and energize an electromagnet. (The thread trimmer magnet attractor operates instantly.)

4. Conclusion

Throughout the research and writing of this article, the research team has focused on acquiring fundamental knowledge of the Siemens PLC family S7-1200 and comparing the control characteristics of PLC in general and S7-1200 in particular; Contrast the control signals and actuators utilized by the Juki DDL 8700-7 machine. From there, the problem of controlling by PLC on the spreading model with control signals of the actuators similar to those of the actual machine is formulated; The results indicate that the control of the servo motor and actuators such as the gas pedal and electromagnet works very well, and that the signal output from the PLC is identical to the actual machine circuit; The interface with the manufacturer by touch screen is a new point that aids in directing the control signals of the actual machine. As a result, the JUKI DDL 8700-7 machine functions normally as with the control box SC 920, and the Engine control signals, electromagnets, and gas pedals function very well due to the touch screen's simple installation. - However, in order to operate the machine, we must change the spindle motor pulley to match the motor pulley. As a result, determining the synchronous mode of the machine's mechanical systems in the thread trimming mechanism will not be absolutely accurate because the synchronous markings between the pulley and the machine wall have not been calculated, resulting in the movable thread trimmer. The article establishes a research direction based on the industrial control method (PLC) that can be used to replace existing controllers with machines and simultaneously create PLC control applications in learning, research, and development. - Develop equipment for the textile and garment industry to increase productivity, quality, and decrease product costs in the textile and garment production process. In addition, the article's product application will serve as a reference for a number of modules related to teaching industrial sewing machine equipment in schools, such as programming control programming techniques programming PLC; electronic engineering; internship in electronic sewing equipment...

Compliance with ethical standards

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Disclosure of conflict of interest

There is no conflict of interest.

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