UNIVERSITATEA Petru Maior TÂRGU-MURES
Scientific Bulletin of the „Petru Maior" University of Târgu Mureş
Vol. 8 (XXV) no. 2, 2011, ISSN 1841-9267

SINGER CNC SEWING AND EMBROIDERY MACHINE

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ABSTRACT

This paper presents the adaptation of a classic foot pedal operated Singer sewing machine to a computerized numerical control (CNC) sewing and embroidery machine. This machine is composed of a Singer sewing machine and a two-degrees-of-freedom XY stage designed specifically for this application. The whole system is controlled from a PC using adequate CNC control software.

Keywords: CNC sewing machine, stepper motor, stepper driver, Mach 3 soft

1. Introduction

The sewing machine is a mechanical machine used to stitch fabric or other materials together using a thread. The first sewing machines were invented during the first Industrial Revolution. They appeared out of the necessity to increase the productivity of sewing and to reduce the cost of the fabric. This paper presents what can be accomplished using modern CNC equipment to extend and improve the capabilities of a foot pedal operated sewing machine.

For this application we used a one needle Singer model 99 sewing machine (Fig. 1). The frame of the machine was specifically designed for this sewing machine using low cost materials like plywood sheets.

Fig. 1. The Singer sewing machine

The frame has two compartments: one for the PC and one for the CNC command system (Fig. 2). On top of the frame we have mounted two stepper motor driven linear translation stages (Fig. 3). The linear stage consists of two induction hardened precision steel shafts with a diameter of 16mm mounted in shaft supports. The X stage contains two linear ball bearing slides, while the Y stage contains only one linear ball bearing slide on each shaft. Both stages are driven by a TR12x3 lead screw. The nut is made of polyamide polymer providing adequate accuracy and repeatability, quiet operation and low cost.

Fig. 2. The frame of the sewing machine

Fig. 3. The linear translation stages

The linear translation stages, which are driven by stepper motors, move the embroidery hoop in which we have placed the fabric. The main purpose

of the linear stage is the synchronization of the embroidery hoop's movement with the movement of the needle. The fabric can be moved only when the needle is in the up position; this ensures that the needle will not break.

For this application the 57H76-2008B stepper motor proved to be adequate. The motor is a 1.8 degrees/step stepper motor which provides a holding torque of 1.9Nm in bipolar parallel wiring.

The camshaft of the sewing machine is also driven by the same model stepper motor. The stepper motor that drives the camshaft is connected to the shaft using a synchronous timing belt transmission (Fig. 4). This transmission consists of two "T" pulleys. On the shaft of the stepper motor we have a pulley with 16 teeth and on the camshaft a pulley with 36 teeth. The pulleys are connected with a T 10mm width timing belt with a 5mm pitch.

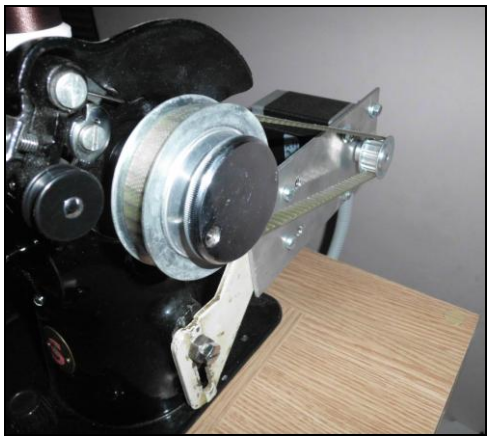

Fig. 4. The timing belt transmission

2. Stepper Motor Driver

The stepper motors are driven by a stepper motor driver. The stepper motor driver is an electronic equipment which provides an interface between a step pulse generator (in this case a PC) and the stepper motors. The CNC4X35A is a 4 axis stepper motor control board which is capable of controlling up to 4 different stepper motors in bipolar micro stepping mode. The driver can control a wide variety of stepper motors (5-30V and 0.7- 3A) in full, half, quarter and 1/16 micro stepping resolutions. The current limit and the micro stepping are adjustable by dip switches. The driver requires a minimum of 15V DC and accepts a maximum of 32V DC and is connected to a PC using the parallel port.

For this application we used a professional a Mean Well SP-320-27 320W, 27V DC CNC power supply. For the XY stage stepper motors we used a current of 2.25A and half-step micro stepping mode. The camshaft stepper motor was set to run also on 2.25A current but without a micro stepping mode (full-step mode).

The stepper motor driver and the power supply assembly can be seen in figure 5.

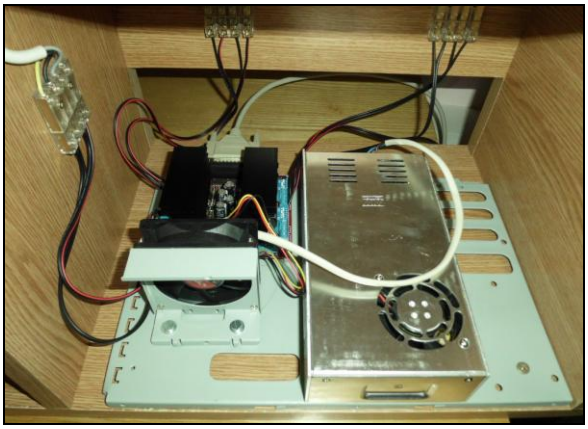

Fig. 5. The driver and the power supply

3. Control software

To create different embroidery models the Sophie Sew [1] free embroidery digitizing software was used. The embroidery models were designed (Fig. 6) with the above mentioned software and saved in tajima format (DST). The DST file was opened with the Embroidery Gcode Generator program [2], which translated the file into a gcode file format. Then a gcode interpreter program, in this case Mach3, was used to read the file and to sew or embroider the design (Fig 7).

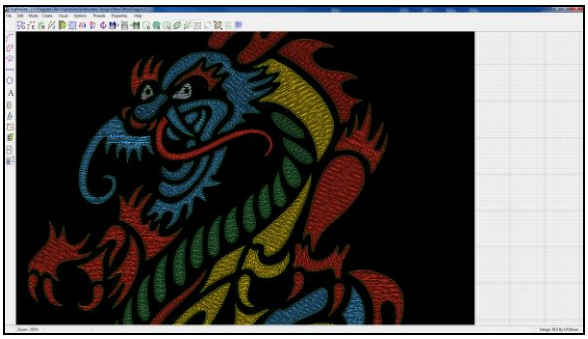

Fig. 6. Sophie Sew program interface

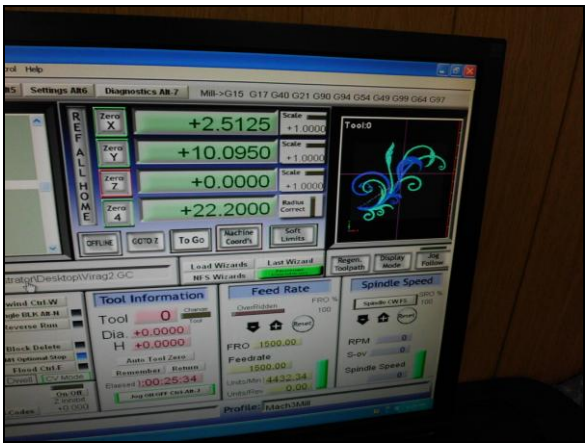

Fig. 7. Mach3 program interface

Fig. 8. The CNC sewing and embroidery Machine

Fig. 9. Experimental results

4. Experimental results

A part of the experimental research was performed in Mechatronics and Robotics Laboratory from the Engineering Faculty, "Petru Maior" University of Tirgu-Mures. The general view of the CNC sewing and embroidery machine is shown in figure 8.

The purpose of the experiment was to determine the optimal micro stepping modes for the, the accelerations and the maximum speed for the stepper motors, and also to determine the productivity of the machine by determining the maximum and the optimum sewing speeds. Also the experiment helped to determine what models can be embroidered.

The optimal result were obtained using half step micro stepping mode for the XY stage stepper motors with a maximum speed of 1.5m/min and an acceleration of $0.1m/s^2$. Using the above settings the machine managed to achieve a sewing speed of 200 stitches/min.

The embroidered models can be seen in figure 9.

5.Conclusions

We managed to prove that it is possible to create a CNC sewing machine, and that it is also possible to extend the capabilities of the classical sewing machine to an embroidery machine.

This design can be improved by using aluminum or steel for the frame. By building a frame out of these materials we can further increase the sewing and embroidery speed of the CNC machine.

References

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