ESTABLISHING THE OPERATING SPEEDS OF EMBROIDERY MACHINE: A FUZZY LOGIC APPROACH BASED ON VIBRATION AND NOISE MONITORING

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EXTENDED ABSTRACT
THE AIM OF THIS STUDY IS TO RECOMMEND AN OPERATING SPEED OF EMBROIDERY MACHINES THAT CORRESPONDS TO THAT LEVEL OF VIBRATIONS AND NOISES FOR WHICH THERE ARE NO QUALITY DEFECTS ON THE SURFACE OF THE EMBROIDERED MATERIAL, ACCORDING TO THE GEOMETRIC ENTITIES THAT DESCRIBE THE EMBROIDERY PATTERN. FOR THIS PURPOSE, A FUZZY DECISION SYSTEM WAS DEVELOPED CONSIDERING THE LEVELS OF VIBRATIONS AND NOISES OF THESE MACHINES.

KeyWords:operating speed, vibrations and noises,fuzzy logic, embroidery machine

1. INTRODUCTION

Nowadays, the operating regimes of embroidery machines are characterized by high speeds, at which vibrations and noises occur during the embroidery process. Within this framework, the purpose of this study is to recommend an operating speed of embroidery machines that corresponds to that level of vibrations and noises for which there are no quality defects on the surface of the embroidered material. This optimal regime must also be determined differentially according to the geometric entities that describe the embroidery pattern (which may include different lines, circles, arcs of circle, etc.).

2. MATERIALS AND METHODS

In this work the material was polyester and Nm 80 needles were used. The amplitude of the vibrations was measured during the sewing process on the Happy embroidery machine. Measurement of the vibration of the embroidery machine was performed with the TopMessage device. An accelerometer was placed on the head of the embroidery machine along with the OZ axisto monitor the vibrations. The OZ axis was chosen because the vibrations have the highest values in this direction. The Center 322 sonometer was used to measure the noise level. Figure 1 depicts the devices used in this research.
The results presented in [1] shown the amplitude of vibration of embroidery machines is smaller on the arc of circle entities than on linear entities. Therefore, in the present work, the amplitude of the vibrations on different geometric entities was measured. For this purpose, embroidery patterns composed of geometric entities such as lines, circles, arcs of circle, ellipses were used. For each entity, the working speed of the embroidery machine was set so that the thread does not break. For each geometric entity, the vibrations and the noise level of the machine were determined. For example, considering the diameter of a circle equal to 8mm

and the speed of machine 500 stitches/minute, the vibration amplitude and the noise level of the machine are shown in Figure 2.

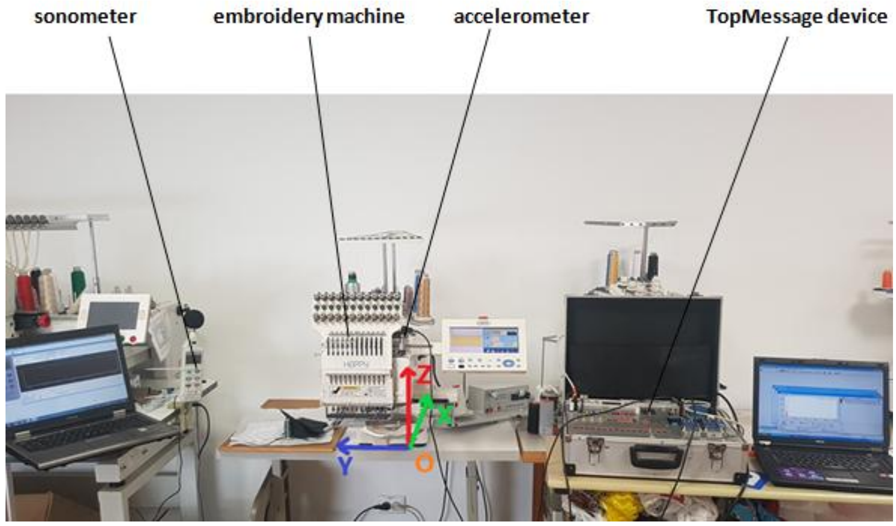
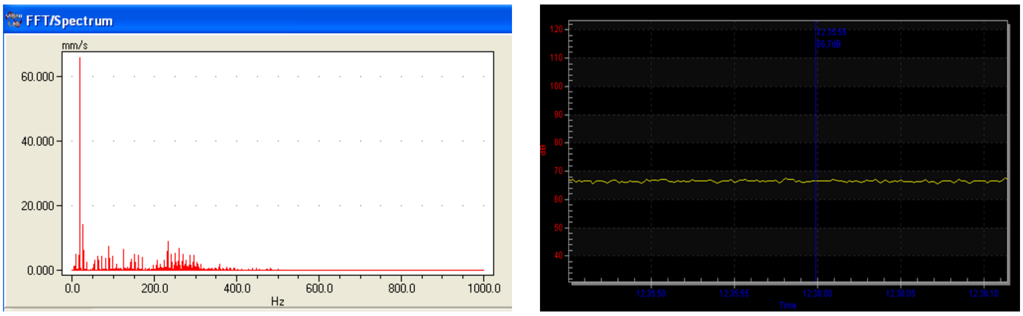


Figure 1. The experimental approach



a b

Figure2. The amplitude of vibrations and noise level of the machine embroidering a circle with 8mm diameter

3. RESULTS

A fuzzy decision system was developed to establish the optimal operating speeds of embroidery machine on different geometric entities that describe the embroidery pattern, depending on the levels of vibrations and noises. The fuzzy logic decision system to determine the speed of work of embroidery machines was developed with the Fuzzy Logic Toolbox™ of Matlab® software. As input linguistic variables were defined:
- the vibration amplitude of Happy embroidery machines with the values from 25.53 mm/s rms to 181.76 mm/s rms, which was characterized by the linguistic terms verysmall, small, medium, large and verylarge;
- the level of noise of Happy embroidery machines having values from 63.5 db to 73.3 db,which was characterized by the linguistic terms verysmall, small, medium, large and very large.

The output linguistic variable was defined as the speed of operation of the Happy embroidery machine with the values from 450 stitches/minute to 850 stitches/minute. The linguistic terms verysmall, small, medium, large and very large characterized this variable.

Triangular membership functions [2] were employed for the input variable, The Mamdani model was used and the fuzzy rules base contained 10 rules as follows:

If Ampl vib is verysmall and the Noise level is verysmall then the Speed is verysmall
If Ampl vib is verysmall and the Noise level is small then the Speed is small
.... (1)
If Ampl vib is verylarge and the Noise level is verylarge then the Speed is verylarge

The trapezoidal membership function[2] was employed for the output variable and the defuzzification was performed through the center of gravity method [3]. The fuzzy decisional system is shown in Figure 3.

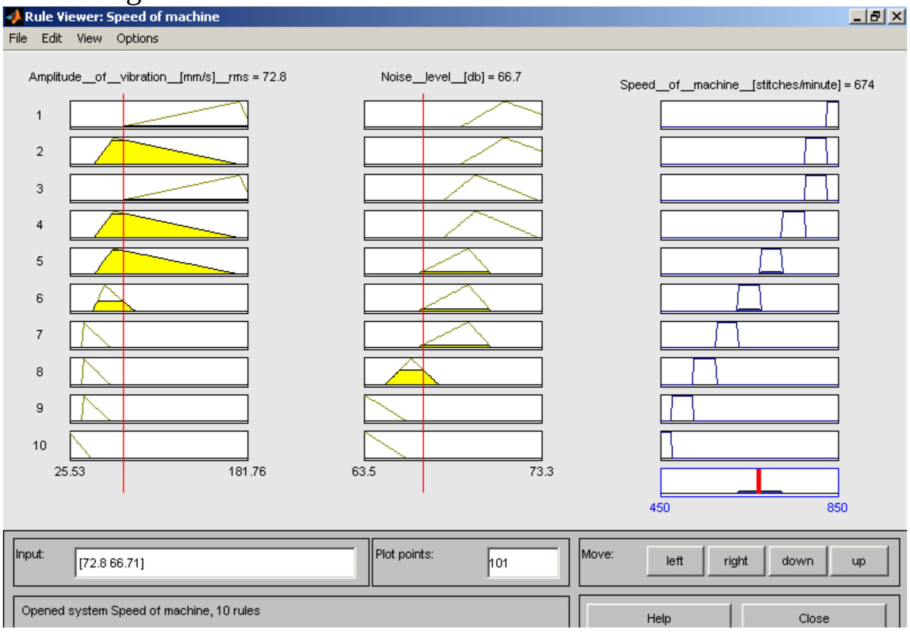


Figure3.Inference of the fuzzy decision system for determining the speed of operation of embroidery machine

For example, if the Ampl vib is 72.8 mm/s rms and the noise level is 66.7 db, then the speed resulted equal to 674 stitches/minute. However, the embroidery machine only works at the following values: 450, 500, 550, 600, 650, 700, 750, 800 and 850 stitches/minute. Therefore, the speed value of the embroidery machine will be taken the inferior value among the above values, the closest to the solution given by the developed decision system.This rule has been adopted to avoid breaking the embroidery thread due to the employment of a higher speed. Therefore, in the presented example, the speed of operation was set at 650 stitches/minute.

3. REFERENCES

1. Șuteu, M. Analysis of embroidery pattern influence on the working mode of “Happy” embroidery machineby using the vibration measurement technique,*Industria Textilă*, 2016, Vol. 67, No. 4, 250-255.
2. Jang, J.-S.R., Sun, C.T.,Mizutani, E. *Neuro-Fuzzy and Soft Computing: A Computational Approach to Learning and Machine Intelligence*, 1997, Prentice-Hall, Upper Saddle River, NJ.
3. Ross,T,*Fuzzy Logic with Engineering Applications*, 3rd ed., 2010, John Wiley & Sons Ltd.