OPTIMIZING SEWING SPEED FOR BETTER SEAM QUALITY OF DENIM FABRIC

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Abstract: *Sewing process is the most common task in any garments manufacturing company. The worker usually gets paid according to number of items made, which causes the demand to run the sewing machines at highest speeds. In this research it is determined if this high speed effect the seam strength and what should be optimum speed considering denim fabric with commonly used polyester core spun thread. The results shows that the seam strength is significantly decreases with increase of sewing speed and the acceptable quality with better production can be achieved if the sewing speed is 40 Hz.*

Keywords: *Sewing, needle, temperature, clothing*

1 INTRODUCTION

A sewing machine is one of the most common machine of any clothing, automobile, footwear or home textile products. Saint in 1790 is considered as the inventor of first working sewing machine [1]. Lockstitch sewing machines due to strong stitch and easy use are the major sewing machines used in any clothing industry. Lockstitch is a stitch performed in most household and industrial sewing machines (single needle) [2]. The upper thread runs from a spool, through guides and finally passes through the needle eye. The lower thread in the bobbin assembly located under [3]. Ideally, the stitch is made in the middle of the fabric layers considering the tension of the upper and lower thread are adjusted properly [4].

1.1 Basic thermal mechanism of needle heating

The actual sewing needle heating is rather a complicated process. Needle temperature rises as the sewing starts and continues to rise till the steady state is attained. During the complete process, the needle temperature varies minor at the needle penetration and withdrawal from fabric [5-7].

The heat is generated from the following sources:

Heat flux is dependent on needle penetration force, withdrawing and frictional forces acting on needle by the fabric. Heat flow from the friction between sewing thread and needle eye. It is dependent on type of sewing thread and thermal conductivity of thread, needle and friction coefficient between yarn and needle can influence the needle temperature. The sewing needle heating thermal heating mechanism is shown in Figure 1.

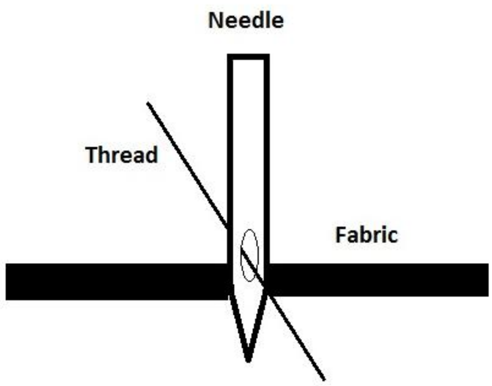

Figure 1 Illustrative image of sewing needle and thread

On the other hand, the heat leaves the needle by [1]:

- Convection of the outer surface of the needle to the environment. Heat loss by convection is considered as the major source in cooling the needle. The convective heat flow equation can be expressed by Newton's law of cooling
- The heat conduction in the needle from higher point to lower temperature points, also the heat loss to the needle holder. The conductive heat flow can be expressed by Fourier's law.
- The heat of conduction from the needle to sewing thread and fabric, the needle and textile materials have great difference of thermal conductivity but still at the time of machine stoppage the ultimate contact with needle-thread and needle–fabric causes local heating and damages the textile material.

Conductivity factor λ [W/(m.°C)] cab be expressed by following equation:

$$\lambda = Q.L/A.t.(T_1\text{-}T_2) \quad (1)$$

where Q is heat flow, L is textile material thickness, t is time interval and T_1-T_2 is temperature difference.

Radiation heat between the needle outer surface and the environment. According to the researchers [5] the radiation play minor role in needle cooling, due to thin size and very low emissivity [4]. The equation can be expressed by the Stefan-Boltzmann law as:

$$P = \varepsilon.\sigma.A.(T^4\text{-}T_s^4) \quad (2)$$

where P is radiated power, ε is emissivity of material, A is radiation area, σ=5.67*10^{-8} W/m^2·K^4, T is temperature of radiator [°C] and T_s is temperature of surrounding [°C].

1.2 Experimental techniques of measurement

There are multiple efforts in the past to experimentally observe the sewing needle heating. The experimental techniques to measure sewing needle temperature can be classifies as we can see in Figure 2.

2 METHODOLOGY

It is known from previous research [8-12] that the inserted thermocouple method gives precise and repeatable results; same method is used in this research work.

2.1 Inserted thermocouple method

In this method for measuring sewing needle temperature, a thermocouple by Omega (K type 5SC-TT-(K)-36-(36)) was inserted into the groove of the sewing needle and soldered. The thermocouple was located near the eye of the needle to measure the exact needle temperature and the temperature was measured at different sewing speeds. This method proved to be very efficient as it provided continuous changes in needle temperature every second and it had a low standard deviation. Figure 3 shows the placement of the thermocouple inside the needle groove. The thermocouple remained inside the needle groove during the sewing process and measurements were recorded wirelessly on a computer through a wireless end device (MWTC-D-K-868).

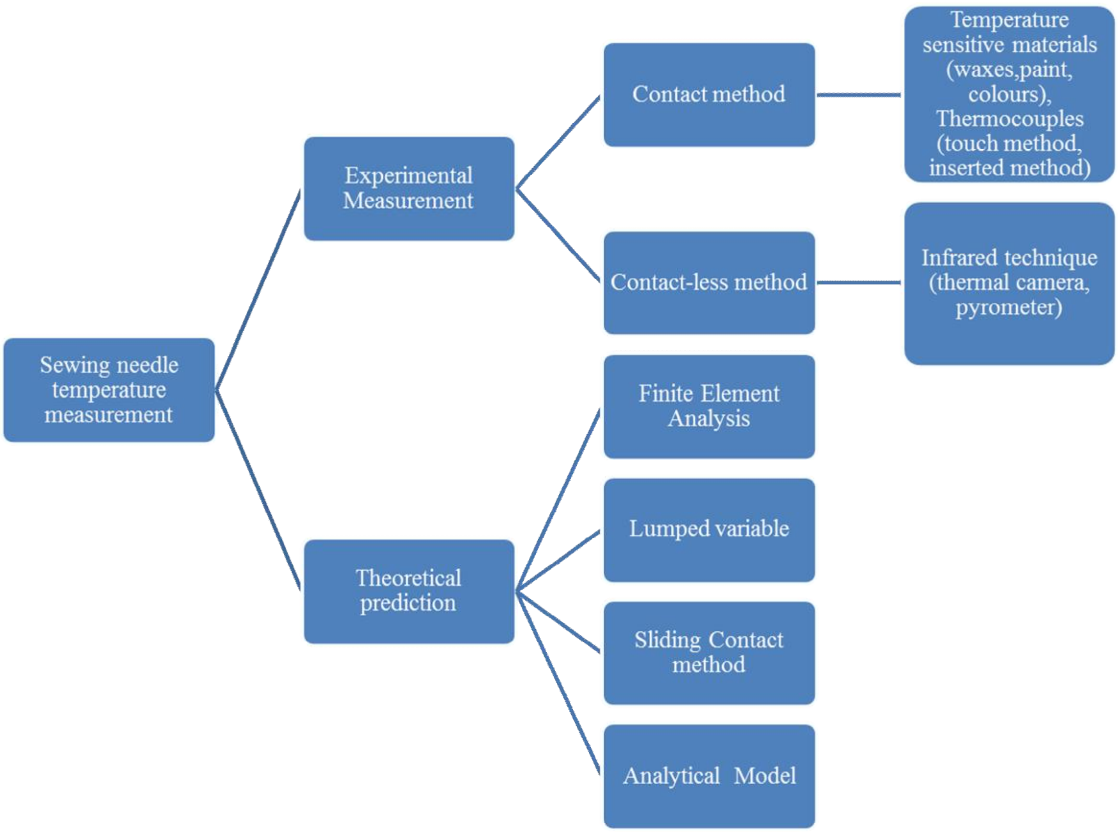

Figure 2 Experimental and theoretical methods to measure needle temperature

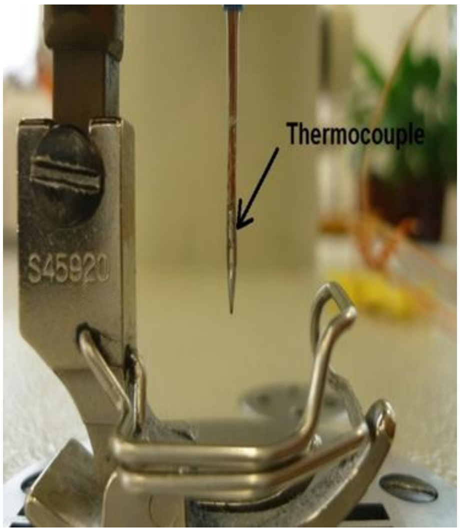

Figure 3 Thermocouple inserted inside needle groove

Conditions for all experiments were kept constant at 26°C and 65% RH. The devices used for the experiments are listed below:

- Lockstitch machine (Brother Company, DD7100-905).
- Thermocouple by Omega (K type 5SC-TT-(K)-36-(36)) for the inserted method.
- Thermocouple by Omega (TJ36-CAIN-010U-6) for the touch method.
- Needles (Groz-Becker 100/16) R- type.
- Relevant parameters of the sewing thread are shown in Table 1.
- Relevant parameters of the denim fabric are shown in Table 2.

Table 1 Sewing thread used for the experiments

Thread type	Company name	Fineness [tex]	Twist [t/m]	Twist direction (ply/single)	Coefficient of friction µ
Polyester–polyester core spun	AMANN-Saba C-80	20x2	660	Z/S	0.13

Table 2 Fabric used for the experiments

Fabric type	Weave	Weight	Ends/cm	Picks/cm	Fabric thickness
100%cotton denim	2/1 Twill	257 g/m^2	25	20	0.035 cm

3 RESULTS AND DISCUSSION

In our research the machine speed of 16-80 Hz is tested for polyester core spun thread and it is concluded that the needle temperature rises linearly with the increase of sewing speed. The higher the speed, the more heat goes to the needle during the unit time, hence resulting in an early high peak temperature. The more heat is taken by the needle within unit time, the faster it reaches it stability temperature because the heat absorption rate decreases when the machine speed is going higher. The important reason for this needle temperature rise is also due to the higher thermal conductivity of the needle as compared to the textile material and more friction heat goes in to the needle during each cycle with higher sewing speed.

It is seen in Figure 4 that the sewing speed has linear relation with the needle temperature and it is visible the breaking strength of the thread decreases linearly with higher sewing speeds.

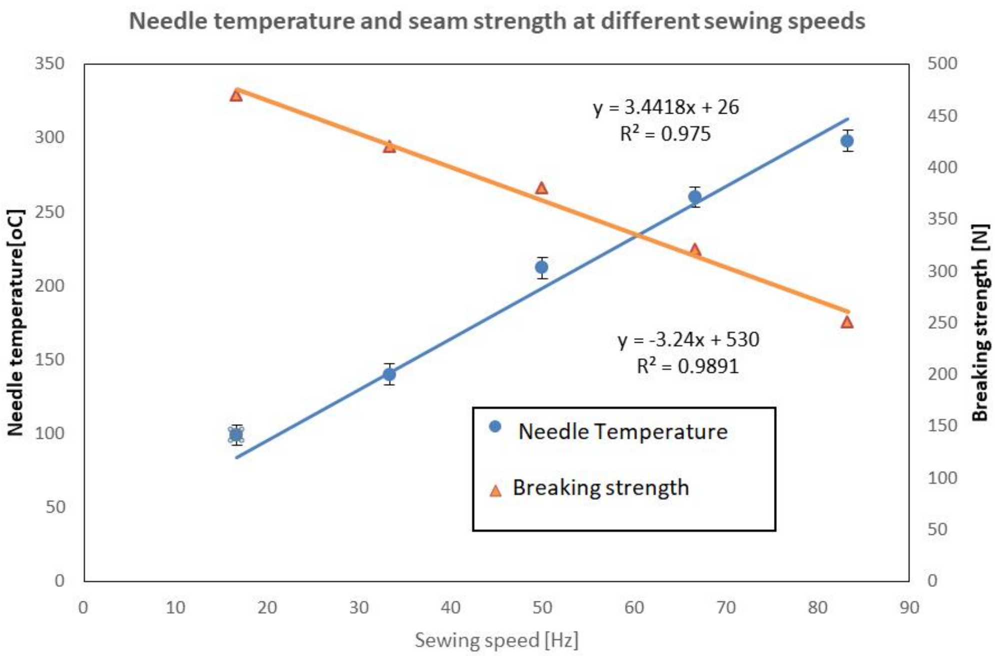

Figure 4 Effect of sewing speed on breaking strength

3.1 Effect of fabric thickness

In this research work, it is observed that the fabric thickness plays an important role in the needle heating, with the thinner fabrics or low number of layers the peak temperature is decreased greatly. With each new layer of fabric the temperature is increased by nearly 10°C. One reason is obvious that there will be low friction generated by thin fabrics. The other reasons are that the needle takes in much more friction heat in the same time period and makes bigger temperature difference for different fabric thickness. This allows the operator to do the sewing for longer time for thin or low number of layers of fabric as the peak temperature is less and temperature stability is reached much earlier as compared to heavy or multi-layered fabrics. The Figure 5 shows a marginal increase in temperature with addition of every extra layer at different speeds of sewing.

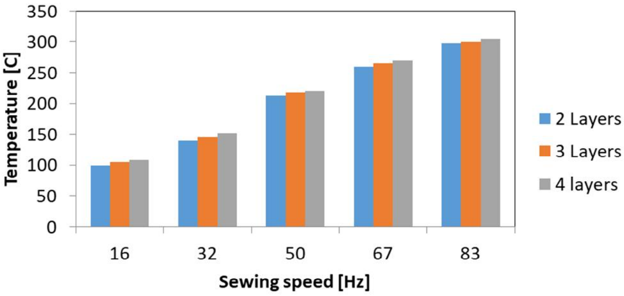

Figure 5 Effect of fabric layers on sewing needle temperature

4 CONCLUSION

This research shows that needle temperature has a dominant influence on the strength of sewing thread. Seam thread was considered as the thread with the weakest tensile properties as compared to the parent thread, the research shows that the hot needle mainly damages the thread. As thread moves from cone to the seam, it undergoes various stresses; there is a marginal decrease in tensile strength for thread at 16-15 Hz of machine, whereas loss of tensile strength of thread is much significant from 40 Hz of machine and higher. The seam loses 60% of its actual strength when sewing speed is low (nearly 16 Hz) as compared to high sewing speed (nearly 80 Hz). There are multiple solutions how to decrease the sewing needle temperature but the focus of this research is to show the impact of high speed sewing on the seam strength of the denim fabric. It is recommended to use the sewing machine at lower speed to have better sewing thread's strength.

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5 REFERENCES

1. Li Q., Liasi E., Zou H-J., Du R.: A study on the needle heating in heavy industrial sewing – Part 1: analytical models, International Journal of Clothing Science and Technology 13(2), 2001, pp. 87-105, https://doi.org/10.1108/09556220110390700
2. Hersh S.P., Grady P.L.: Needle heating during high speed sewing, Textile Research Journal 39, 1969, pp. 101-120, https://doi.org/10.1177/004051756903900201
3. Midha V.K., Mukhopadhyay A, Chatopadhyay R., Kothari V.K.: Studies on the changes in tensile properties of sewing thread at different sewing stages, Textile Res Journal 79(13), 2009, pp. 1155-1167, https://doi.org/10.1177/0040517508101456
4. Li Q., Liasi E., Zou H-J., Du R.: A study on the needle heating in heavy industrial sewing - Part II: finite element analysis and experiment verification, International Journal of Clothing Science and Technology 13(5), 2001, pp. 351-367, https://doi.org/10.1108/EUM0000000006281
5. Sondhelm W.S.: Causes of seaming damage: Needle heating, Journal of Textile Institute Transactions 44(11), 1953, pp. 580-585, https://doi.org/10.1080/19447025308662618
6. Laughlin R.D.: Needle temperature measurement by infrared pyrometry, Textile Research Journal 33(1), 1963, pp. 35-39, https://doi.org/10.1177/004051756303300105
7. Yukseloglu M., Citoglu F., Cetinkaya B.: A study on the needle heating in polyester blend upholstery fabrics, Industria Textila 63(5), 2013, pp. 246-253
8. Mazari A., Havelka A., Hes L.: Experimental techniques for measuring sewing needle temperature, Tekstil ve Konfeksiyon 24(1), 2014, pp. 111-118
9. Li Q., Liasi E., Simon D., Du R.: Heating of industrial sewing machine needles: FEA model and verification using IR radiometry, In: Thermosense XXI, Proc. SPIE, R.N. Wurzbach, D.D. Burleigh Eds., 3700, 1999, pp. 347-357
10. Mazari A., Bal K., Havelka A.: Prediction of needle heating in an industrial sewing machine, Textile Research Journal 86(3), 2016, pp. 302-310, https://doi.org/10.1177/0040517515586160
11. Liasi E., Du R., Simon D., Bujas-Dimitrejevic J., Liburdi F.: An experimental study of needle heating in sewing heavy materials using infrared radiometry, International Journal of Clothing Science and Technology 11(5), 1989, pp. 300-314, https://doi.org/10.1108/09556229910297563
12. Mudzhikova M., Mazari A., Havelka A., Mangat A., Bajzik V.: Effect of sewing thread pretension on the seam for car seat leather cover stitching, Vlákna a Textil (Fibres and Textiles) 22(3-4), 2015, pp. 18-25