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TENSILE PROPERTIES OF SEWING THREAD AND SEWING NEEDLE TEMPERATURE AT DIFFERENT SPEED OF SEWING MACHINE

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Abstract. Needle heatup is a big issue for apparel industry especially for automobile industry seat covers where a lot of synthetic materials are used which get damaged by needle heat at high speed of sewing machine,in this article thermocamera and thermocouple are used to measure the precise temperature of needle eye and then 100% polyester 35x3 Tex thread is taken for sewing,the lockstitch sewing machine is run at 1000rpm,2000rpm and 3000rpm respectively and the both methods are used to obtain the accurate needle temperature and finally thread tensile properties are measured before the sewing and taking out the thread from the seam precisely to get the tensile properties of thread after 10,30 and 60 seconds of continuous stitching,the article is very helpful in predicting the exact temperature of needle in lock stitch machine and getting the damage to thread by the needle heat at different speeds and different stages of sewing process.

Introduction

During sewing at high speeds, the needle thread is subjected to repeated tensile stresses, heat, bending, pressure, torsion, and wearing. These stresses act on the thread repeatedly and the thread has to pass through the fabric, the needle eye, and the bobbin case mechanism 50–80 times, before becoming incorporated into the seam [1].Furthermore, local abrasion and cutting of the needle thread can occur, due to impact and rubbing at the top of the needle eye [2]. In an early research work, Crow and Chamberlain [3] reported that there is up to 60% reduction in thread strength after sewing. Later, a number of researchers observed that there could be 30–40% strength reduction in the cotton thread after sewing and various reasons assigned included structural damage, dynamic, and thermal loading [4–8]. In a recent study on the tensile properties of mercerized cotton threads, around 30% strength reduction, about 20% loss in both breaking elongation and initial modulus, and 45% loss in breaking energy was reported [9].

Experimental Part

Temperaure 26 ^{o}C and RH 60%
Following machines and instruments were used for this experiments
1-Lock stitch machine (Brother, DB2 – B755 – 403A)
2-35x3Tex 100%polyester thread (Hagal,Unipoly)Z twisted TPM=640
3-Thermocople by Omega (TJ36-CAIN-010U-6)
4-thermocouple end wireless device and receiver (MWTC-D-K-868)
5-needles(Groz-Becker t 90/14)
6-Thermocamera(TMS60)emissivity set at 0.08 after calibration for chromium sewing needle
7-Tensile tester (M350-5CT)
8-denim fabric (257GSM ,2/1 twill)
9-Fan to cool needle[12Volt DC Fan from ADDA company (Model:AD0912UX-A7BGL)
The thin thermocouple (TJ36-CAIN-010U-6) was inserted inside the groove of the needle and attached with the needle ,the lock stitch machine was set at 1000,2000 and then 3000 rpm,two layer basic 2/1 twill denim was stitched by 35x3 Tex 100%polyester thread(commonly used for denim

stitching) for continous 90 seconds and temperature was recorded for every second by the thermocouple for each speed of the machine,Then thermocamera was placed 40cm away from the needle and again the machine made to stitch at different speeds and thermocamera took reading at every 10 seconds for continous stitching of 90 seconds,The process was repeated for 5 times for both thermocouple and thermocamera .the parent thread was tested for the tensile strength and then the stitched thread was taken out precisely by removing the bobbin thread and the thread that were stitched after 10 seconds,30seconds and 60 seconds of sewing were measured for tensile strengths, The temperature of needle results were compared with both thermocouple and thermocamera results for more acuracy and for tensile properties of thread multiple readings were observed from thread after 10 ,30 and 60 seconds of stitching,

Results

Figure 1 shows the temperature of needle at different speeds of machine by the thermocamera,it clearly shows that the temperature of needle with thread is increasing with the increase of sewing machine speed from 1000rpm to 3000rpm. Fig 2 shows the temperature of needle with thread measured by thermocouple.

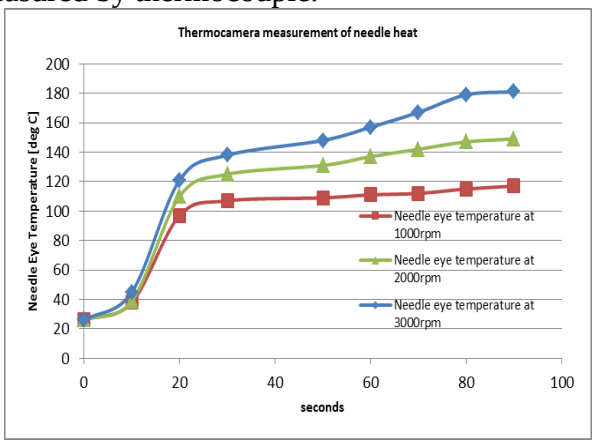

Fig. 1-Needle temperature by thermocamera

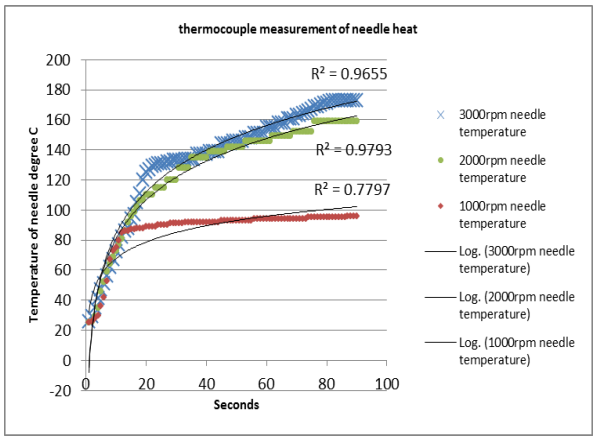

Fig. 2-Needle temperature by thermocouple

The thermo camera was placed parallel to sewing machine (see Fig. 3) and fig. 4 shows the temperature of the needle eye measurement by the thermocamera,

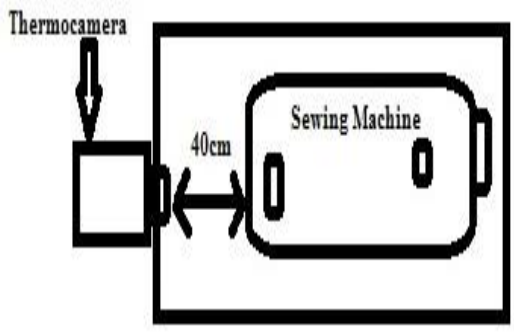

Fig. 3-Placement of thermocamera for measuring the sewing needle temperature

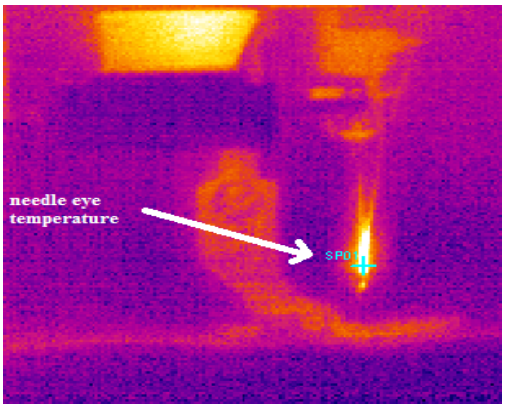

Fig 4 -Needle temperature by thermocamera

The comparison of needle temperature measurement by thermocamera and thermocouple at 1000,2000 and 3000rpm of machine respectively are shown in Table 1,the reading from thermocouple are more precise and with very less deviation. For both thermocouple and thermocamera 10 readings were taken to compare the observations,

Table. 1,Sewing needle temperature by thermocamera and thermocouple

Time of Sewing [s]	0	10	20	30	40	50	60	70	80	90
1000rpm T[degree C] by thermocamera	26	38	97	107	108	109	111	112	115	117
S.D [degree C]	0	10	1.7	4.5	2	5	1.7	3	2.5	4
1000rpm T[degree C] by thermocouple	26	75	89	91	92	93	94	94	95	96
S.D [degree C]	0	6	4	3	3	2	1	0.8	0.9	2
2000rpm T[degree C] by thermocamera	26	39	110	125	127	131	137	142	147	149
S.D [degree C]	0	4	0.5	0.3	2	4	3	3.5	4.1	5
2000rpm T[degree C] by thermocouple	26	73	110	120	135	142	148	152	159	159
S.D [degree C]	0	4	0.3	1.7	3	2.2	3	1.7	2.5	2.3
3000rpm T[degree C] by thermocamera	26	45	121	138	141	148	157	167	179	181
S.D [degree C]	0	5	0.3	2	2	1	1.7	1.9	2.5	3
3000rpm T[degree C] by thermocouple	26	72	125	133	137	146	155	163	171	173
S.D [degree C]	0	3	0.5	0.3	0.7	0.3	0.2	0.8	0.9	0.5

Figure 5 and 6 shows the Tensile strength of thread after stitching for 10,30 and 60 seconds respectively at 1000 and 2000rpm of sewing machine, the figure shows a continuous decrease in breaking elongation which was caused due to friction of sewing process and the heat generated by the needle and strength of thread is decreased more when the sewing speed is greater.

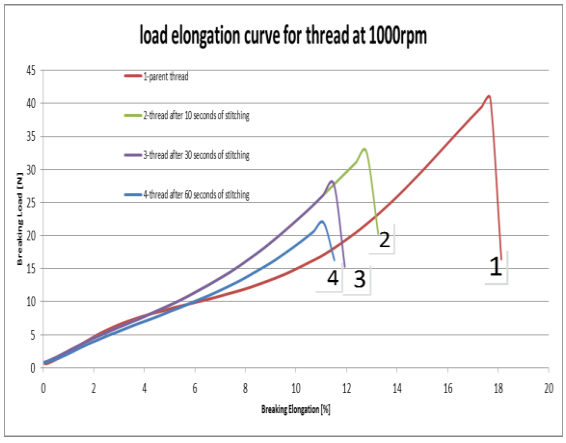

Fig 5-Thread tensile strength at 1000rpm

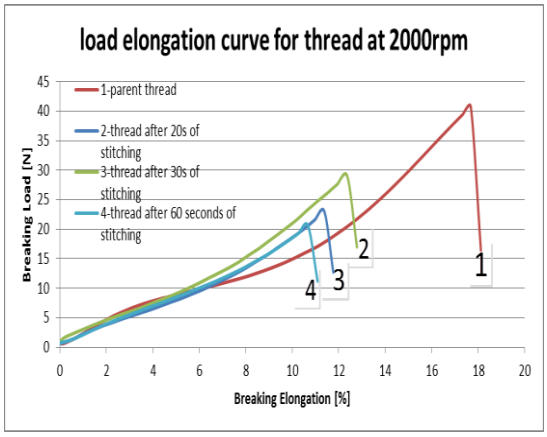

Fig 6- Break elongation curve for sewing thread after stitch for 2000 rpm of sewing

The Tenacity of the thread decreased from the parent thread the 10 observations were measured on tensile tester and column chart shows the decease of strength after different time of stitching with the error bars,(see fig 7)

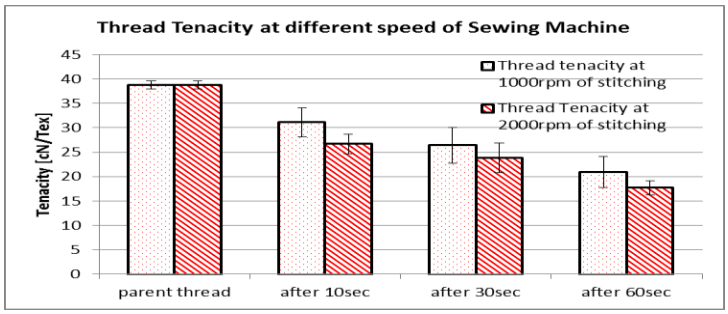

Fig 7-Thread Tenacity at 1000rpm

The needle heat can be reduced by installing fan near the needle which can reduce the heat by convention,A 12Volt Fan from ADDA company was used (Model:AD0912UX-A7BGL) the temperature of the needle was reduced to 15% at 90seconds of continous stitching at different speeds of the machine,difference of temperature with precision after 10 observations for each speed are shown below in Table 2, for each speed of the machine,

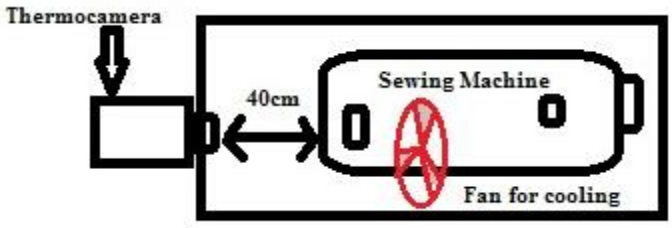

Fig 8 -Placement of fan for needle cooling

The Fan installation reduces the temperature of needle to some extent but still the change in temperature is limited to 15% reduction,(see fig 14,Fig 15 and Fig 16) which clearly shows the decrease in temperature of needle after installation of fan,

Table. 2,Sewing needle temperature by thermocouple after fan installation.

Time of Sewing [s]	0	10	20	30	40	50	60	70	80	90
1000rpm T[degree C] with fan	26	38	58	72	77	79	80	80	82	84
S.D [degree C]	0	10	1.7	4.5	2	5	1.7	3	2.5	4
1000rpm T[degree C] without fan	26	75	89	91	92	93	94	94	95	96
S.D [degree C]	0	6	4	3	3	2	1	0.8	0.9	2
2000rpm T[degree C] with fan	26	34	98	102	110	121	125	135	135	137
S.D [degree C]	0	4	0.5	0.3	2	4	3	3	4	5
2000rpm T[degree C] without fan	26	73	110	120	135	142	148	152	159	159
S.D [degree C]	0	4	0.3	1.7	3	2.2	3	1.7	2.5	2.3
3000rpm T[degree C] with fan	26	42	103	119	128	137	145	151	157	159
S.D [degree C]	0	5	0.3	2	2	1	1.7	1.9	2.5	3
3000rpm T[degree C] without fan	26	72	125	133	137	146	155	163	171	173
S.D [degree C]	0	3	0.5	0.3	0.7	0.3	0.2	0.8	0.9	1

The thread after stitching of 10 seconds ,30 seconds and 60 seconds were examined under the Scanning electron microscope and found that the thread was more damaged with the increase of sewing time,thread was more opened and with more loose and broken fiber ends.

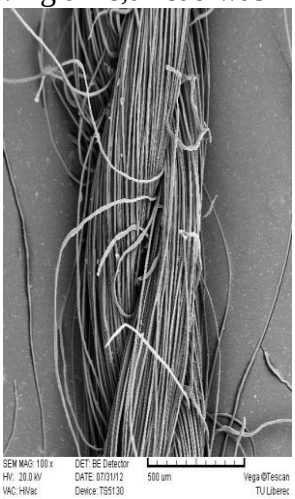

Fig 9-Parent thread

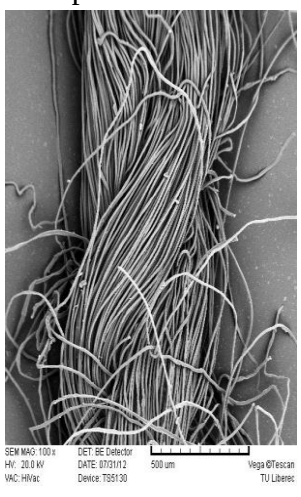

Fig10- Thread after 10second of stitching

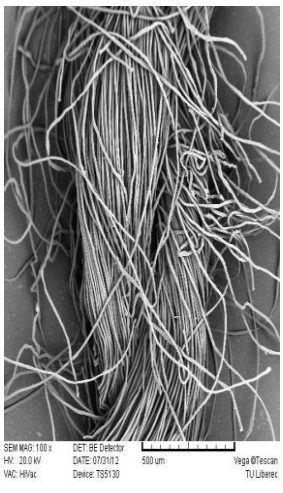

Fig 11-Thread after 30second of stitching

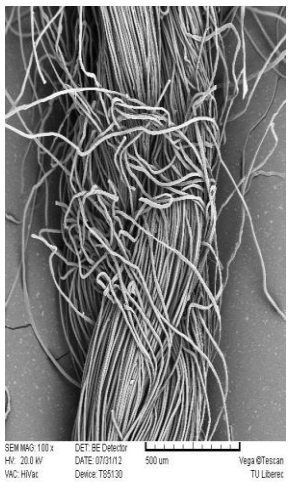

Fig 12-Thread after 60second of stitching

Conclusion

The thread is damged continously as shown in Fig 9-12 at stitching process and after continous stitching of 60 seconds the thread loses 40% of its tensile strength and damage is more with the increass of sewing speeds,Temperature of needle rises abruptly in first 20 seconds after which the sewing process stabilises with the environment. low speed sewing or cooling of needle by external means can reduce the damage to the stitching process.Thermocouple shows more precise every second meaurement of temperature of needle eye as defining emmisivity of thing fast runing needle is difficult for thermocamera,but still use of fan reduce the temperature of needle to some extent but still the difference is not more than 15%of temperature decrease.It is part of a bigger research, finally the impact on sewing thread by mechanical abrassion and needle heat will calculated seperately.

Aknowledgement

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