Experimental analysis of the sewing machine

Jaroslav Beran¹, Martin Bílek¹, Jiří Komárek^{1a}, and Pavel Němeček²

¹Technical University of Liberec, Dept. of Textile Machine Design, Studentská 2, 461 17 Liberec 1, Czech Rep.

²Technical University of Liberec, Dept. of Vehicles and Engines, Studentská 2, 461 17 Liberec 1, Czech Rep.

Abstract. This paper is concerned with experimental analysis of the behaviour of mechanisms of sewing machines. There has been carried out mapping of the sound field in the vicinity of the sewing machine, in order to locate the source of impact loading and to establish the overall hygienic loading of the machine. Based upon this analysis, the acceleration of the needle bars has been measured. These two measuring have led to the conclusion that it is the cam mechanism which most contributes to the noise and impact loading.

1 Introduction

The present trend in the development of sewing machines is to shorten the sewing times in the sewing process and to increase the productivity of this process. Other requests upon sewing machines manufactured nowadays are e.g. silent running, minimum vibrations, long service life of employed mechanisms and easy operation of the machine [1-3]. The analysed Deco 2000 Hand Stitch sewing machine uses the floating needle system, developed by AMF Reece, to produce a “true hand stitch” as represented in figure 1.

Figure 1. Hand stitch types.[7]

The machine uses a double pointed needle which has an eye in the middle, as represented in figure 2. By the use of two needle bars, one above and one below the work plate, a length of thread is passed through the material on every stitch, reproducing the seamstress work, accurately and at an incomparable speed. The needle bar is represented in figure 3.

Figure 2. Double pointed needle. [7]

The needle bar performs a rectilinear reverse movement obtained by a cam mechanism.

^a Corresponding author: jiri.komarek@tul.cz

Figure 3. Needle bar. [7]

The sewing machine is operated at 190 rpm now. The aim of the manufacturer is to operate it at 250 rpm. This velocity can be achieved without any alterations of the machine design; however, in such a regime the sewing machine shows considerable vibrations and high levels of intensity of noise, which are undesirable, and because of hygienic regulations, not admissible legally. At the velocity of 250 rpm, the machine components wear out more, too, with shorter service life of the machine as consequence. The assignment of the experimental analysis has been to establish the hygienic loading of the machine with respect to its vicinity, and to find out critical points of the machine. For this purpose, the intensity of the sound has been measured, and the resultant weighted noise level has been determined. As the next step, there have been measured the values of acceleration of the needle bar in dependence upon the angular displacement of the main cam. The measuring points have been chosen on the needle bar. The

measuring has been carried out both on the upper needle bar and on the lower one [4-6].

2 Mapping of sound field in the vicinity of the sewing machine

The measuring of sound field has been performed by means of equipment of the firm Brüel & Kjaer. There has been employed a dual-channel analyser, a transducer of intensity of the sound, an acoustic calibrator and a sound intensity calibrating set. The measuring equipment has been set up to measure the intensity of sound, and adjusted by means of the calibrating set. The sewing machine has been surrounded with gauging grid with partial areas 10 cm x 10 cm. the measuring areas have been set out in the front and in the rear of the machine, in its L.H. and R.H. sides and in the upper section of the machine. The measured object has been operated at 190 rpm and 250 rpm in uncovered state, and in the operating regime of 250 rpm in covered state. In the centres of partial areas of the grid, there have been measured both the level of active intensity of sound (the vector component in the direction off the source) and the level of acoustic pressure. By means of the software, in the gauging grid there have been established the areas with a constant range of sound intensity. These areas have been visualised on the background of a photo of the measured object, for the purpose of the overall weighted noise level. The figure 4 shows the spectrum of the sound intensity level and of the level of acoustic pressure. The spectrum has been established at the front side (at the attendant's place) in the centre of the segment of the gauging area tracing out the position of the visible section of the sewing machine.

From the spectrum, there can be seen the dominant amplitude at the frequency 40Hz. Moreover, high amplitude can be seen at the frequency 315Hz. There is an increased level in the frequency band around 1-2 kHz, too. The frequency spectrum has a comb-like shape, which points to generation of impacts in the machine. Once the machine has been equipped with covers, the peaks in the frequency spectrum diminish. The difference between the level of sound intensity and the level of acoustic noise is due to the diffusion (reflectance) of the sound field.

The following table shows the overall weighted levels of sound powers established in individual gauging areas.

Table 1. Levels of sound powers (dB).

	without covers		with covers
rpm	250	190	250
in the front	83,4	80,1	83,6
in the rear	80,8	77,7	78,2
R.H. side	78,0	74,3	78,2
L.H. side	76,8	73,4	75,7
upper section	80,0	76,6	79,7

Figure 4. Example of the spectrum of sound intensity level and level of acoustic pressure.

Figure 5. Example of distribution of the sound intensity level (front side at 250 rpm, with covers)

Figure 6. Example of distribution of the sound intensity level (right side – at 250 rpm, with covers)

From this table there is evident that the highest sound power is emitted to the front side, i.e. towards the machine attendant. Moreover, we can state higher values of sound power in the covered state compared to the uncovered one in the front and in the R.H. side. Consequently, the employed covers have not been devised adequately, as far as acoustic loading of the machine is concerned.

In the figs. 5 and 6, we can observe an example of distribution of the sound field in the front side and in the R.H. side at the velocity 250 rpm in covered state. By means of these two figures, we can locate the dominant source of noise and of impact loading, namely the area of the contact of radial cam with the roller, connected to the double-arm lever. This cam mechanism provides for the movement of the two needle bars from their upper position to the lower one and back. This analysis and the subsequent localisation of the biggest source of the noise have induced us to measure the acceleration of the needle bars

3 Measuring and evaluation of the acceleration of needle mechanism

For sensing the values of the acceleration, there has been employed a piezoelectric acceleration sensor of the type 4520 with a charge amplifier of the firm Brüel & Kjaer. For sensing the angular displacement of the cam, there has been employed an incremental sensor marked IRC 305 of the firm LARM a.s. (Inc.). For processing the ascertained values there has been employed the centre MGCXplus of the firm HBM. The measuring of acceleration of the needle bars has been performed both at the velocities 190 rpm and 250 rpm. The ascertained courses of the acceleration have been evaluated in dependence upon the angular displacement of the main cam. The ascertained courses have been hardware filtered by a high-pass filter, on which the filtration values 1000 Hz and 40 Hz have been set up. This filtration of the input signal has brought about flattening of the log, thanks to elimination of high-frequency effects. The log processed in this manner is more transparent and more suitable for its further analysis. If a filter of the value 40 Hz is set up, we obtain a theoretical course of the acceleration nearly, generated by the link mechanism driven by a cam.

The tables 2 – 4 show the maximum and minimum values of acceleration of needle bars for individual velocities and for different settings of the filter.

From the recorded courses of acceleration it is obvious unequivocally that needle bars are exposed to impact loading. These impact loads are generated in particular by the plays in the entire cinematic chain (play in the cam and link mechanism, plays in the seating of needle bars in the machine frame etc.). An incorrectly devised lift dependence on the cam can contribute to impact loading as well.

The acceleration occurring on the upper needle bar is markedly higher than that on the lower needle bar, which can be caused by different adjustment of the needle bar

mechanisms. There has been analysed the original adjustment of the machine from the manufacturing plant.

The maximum and minimum acceleration appearing on the measured components is many times higher than the theoretical values (these have been found out from the supplied data of geometry of the driving cam).

4 Conclusion

There has been carried out measuring of the sound intensity. This measuring has determined the overall weighted level of sound powers ascertained in the

gauging areas. This measuring also indicates the maximum value of the level of sound power 83.6 dB at the velocity 250 rpm. in the covered state. Furthermore, the measuring has located the area with the biggest source of noise; it has been in particular the area of contact of the roller and the cam. In the second part of the experimental analysis, there has been performed measuring of acceleration of the needle bar. This measuring has established the maximum and minimum values of acceleration of the said components, and has identified the impact loading of the needle mechanism.

Figure 7. Example of the courses of acceleration of upper and lower needle bars

Figure 8. Course of acceleration of the needle bar if employing high-pass filters, compared with theoretical

Table 2. Maximum and minimum values of acceleration without employing a filter.

Without filter		Acceleration of lower needle bar (m.s^{-1})	Acceleration of upper needle bar (m.s^{-1})
Minimum value	190 rpm	- 1762.9	- 4545.1
	250 rpm	- 3305.6	- 5322,7
Maximum value	190 rpm	1742.1	2863.1
	250 rpm	1965.0	3407.2

Table 3. Maximum and minimum values of acceleration employing filter 1000 Hz .

Filter 1000 Hz		Acceleration of lower needle bar (m.s^{-1})	Acceleration of upper needle bar (m.s^{-1})
Minimum value	190 rpm	- 767.0	- 1833.7
	250 rpm	- 1510.7	- 2288,7
Maximum value	190 rpm	500.0	2258.8
	250 rpm	757.7	2627.1

Table 4. Maximum and minimum values of acceleration employing filter 40 Hz .

Filter 40 Hz		Acceleration of lower needle bar (m.s^{-1})	Acceleration of upper needle bar (m.s^{-1})
Minimum value	190 rpm	- 243.0	- 254.4
	250 rpm	- 347.7	- 386.2
Maximum value	190 rpm	193.9	208.1
	250 rpm	289.5	304.0

Acknowledgement: The paper has been elaborated with financial support of TUL in the framework of specific university research competition.

References

1. Komárek, J., Beran, J., Lima, M. Machado, J., Silva, J.: Finding the Optimal Setting of the Sewing Needle Transfer Mechanism Using Simulation Software, The 41st Textile Research Symposium, TRS2012, Guimaraes-Portugal, pp.: 401-404, ISBN 978-972-8063-67-2.
2. Komarek, J.: Influence of the rubber pad stiffness on the noise of the needle transfer mechanism. IV Miedzynarodowa Konferencja Młodych Naukowcow

- Szkol Wyzszych Euroregionu Nysa, Jelena Gora, 2010, pp.:135-139, ISBN 978-83-61719-86-1
3. Beran, J. Pejchar, K., Komárek, J.: Analysis and optimisation of the needle transfer mechanism. ACC JOURNAL XVI 2010, Liberec, 2010, pp.: 5-13, ISSN 1803-9782.
4. Beran, J. Pejchar, K.: Dynamic Analysis of Needle Bar Mechanism of Sewing Machines. Acc Journal XVI 2011, Liberec, 2011, pp.: 60-71, ISSN 1803-9782.
5. Pejchar, K.: Verification of the Mathematical Model of the Needle Bar Mechanism. V. Miedzynarodowa Konferencja Młodych Naukowcow Szkol Wyzszych Euroregionu Nysa. Jelena Gora, 2011, pp.: 136-143, ISBN 978-83-62708-21-5.
6. Pejchar, K.: Dynamic Analysis of the Needle Mechanism. 18th International Conference STRUTEX, Liberec 2011, Czech Republic, 2011, ISBN 978-80-7372-786-4.
7. DECO 2000 - Decorative Hand Stitching Machine. AMF Reece. [vid. 2015-04-07] : <http://www.amfreece.cz/d364-deco-2000.html/>