Washing and Wearing Processes Effects on Soldiers Uniforms Friction Sound Characterization

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INTRODUCTION

Sound is one of the sensory comfort features required by consumer. The sounds produced by garments can be expected for instance the rustling sound of silk or can be uncomfortable for example sounds of waterproof garments. The noise generated by fabric-to-fabric friction in the frame of military applications is essential to be studied in order to improve acoustic stealth. Although a literature review revealed some works on visual stealth, not enough work has been done in terms of acoustic stealth. The sound generated by the fabric friction is not constant along the time due to the wearing process induced by washing and use of garments. These constraints can be considered as low mechanical stress and repeated frictions will gradually modify the surface of the fabric. The ageing of material can be estimated thanks to fabric friction sound analysis.

The aim of this study is to analyze the influence of wear and washing processes on fabric friction sound generated by the friction under arms or between legs when a person is moving or walking. Previous studies have shown that the sound properties of fabrics depends on many parameters like the weave patterns or the surface roughness.

APPROACH

In this study, two sets of fabrics have been used. One is composed of samples, which are worn out thanks to Martindale abrasion tester. The second set are worn out through multiple washing (50 washes). For each samples, several acoustic parameters and mechanical properties especially compression and surface properties have been measured.

The mechanical properties of the fabrics are measured thanks to the Kawabata Evaluation System [1]. The fabrics were all conditioned during 24 hours in standard conditions (relative humidity HR%=65±5%, temperature T=20±2°C).

Acoustic measurement is achieved using an acoustic booth (Figure 1) equipped with a system reproducing the human arm motion thanks to two samples rubbing together; one sample is fixed and the other one is mobile. Both samples are placed above a silicone surface which reproduces the human skin [2].

A microphone Brüel & Kjaer 1 inch (type 4190) is used to detect the friction noise of the fabric specimen. The sound recording is performed thanks to a Brüel & Kjaer amplifier (type 2606). Duration of tests is around twenty seconds and some parameters, like the speed or the angle of scanning which were experimentally fixed, are constant.

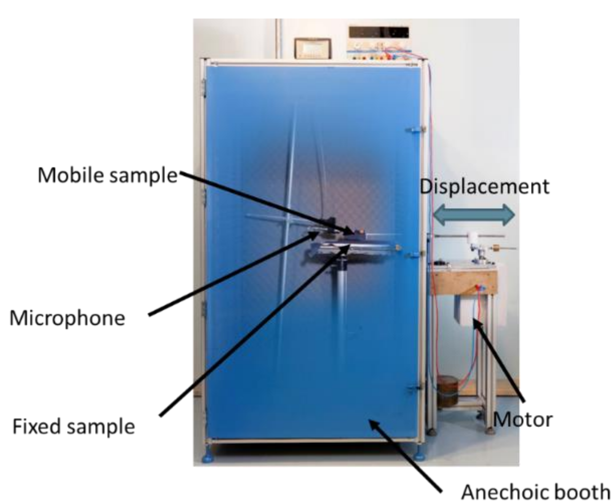

Figure 1: Experimental device

The processing of the sound [3] is performed in three steps. Firstly, two or three seconds of the recording are selected using the Audacity® software. Secondly, the signal is processed by a high-pass filter. This filter will allow to delete the interference noises essentially in the low frequencies. Finally, the filtered sound signals are processed through FFT which allows to estimate the third octave band from 20 Hz to 20 kHz and to obtain noise level in dB.

RESULTS AND DISCUSSION

The Figure 2 represents the evolution of the total noise level according to the fabric's ageing. According to the obtained results, three domains can be observed. In the first one (from 0 to 5,000 abrasive cycles), the total noise level increases which is followed by a decrease from 5,000 to 12,000 cycles. Finally, in the last zone, the total noise level goes to a stable value. In the first two areas, two linear correlation have been found between the total noise level and the number of abrasive cycles i.e. the degree of wear of the specimens.

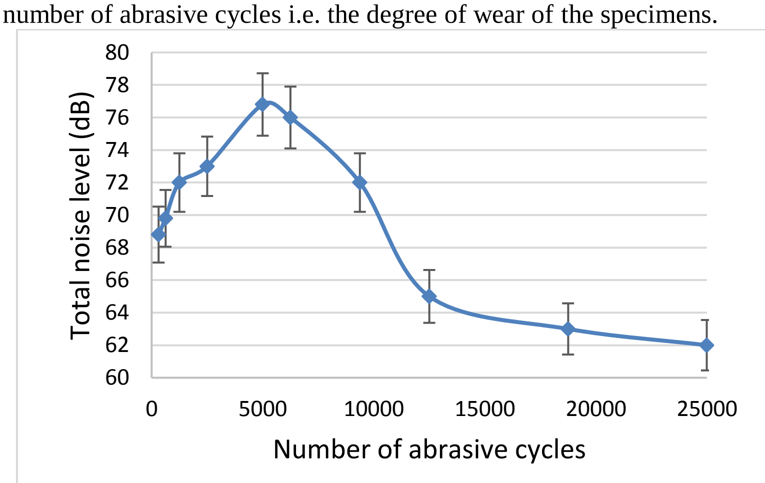

Figure 2: Evolution of the total noise level according to the degree of wear of samples

Regarding to the influence of washing, the Figure 3 shows the evolution of the total noise level. A different behavior can be observed compared to the Figure 2. In this case, the total noise level quickly decreases to reach a stable value. After 10 washes, we can conclude that the fabric's ageing, due to washing, will have a slight influence on the noise level.

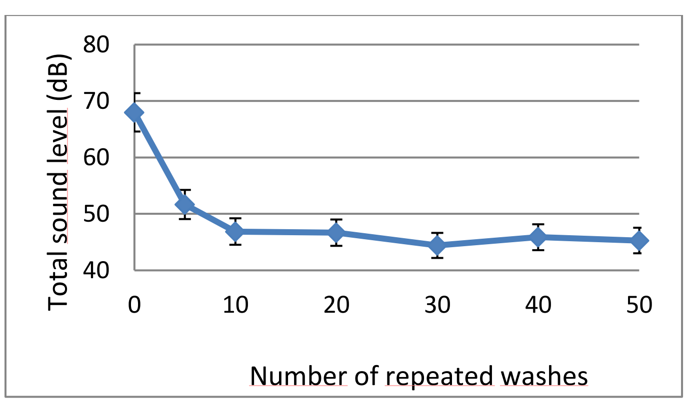

Figure 3: Evolution of the total noise level according to the nyumber of washes

A statistical analysis (Principal Component Analysis) has been done in order to find relationships between acoustic, compression and surface parameters for abrasion (Figure 4(a)) and for the washing method (Figure 4(b)).

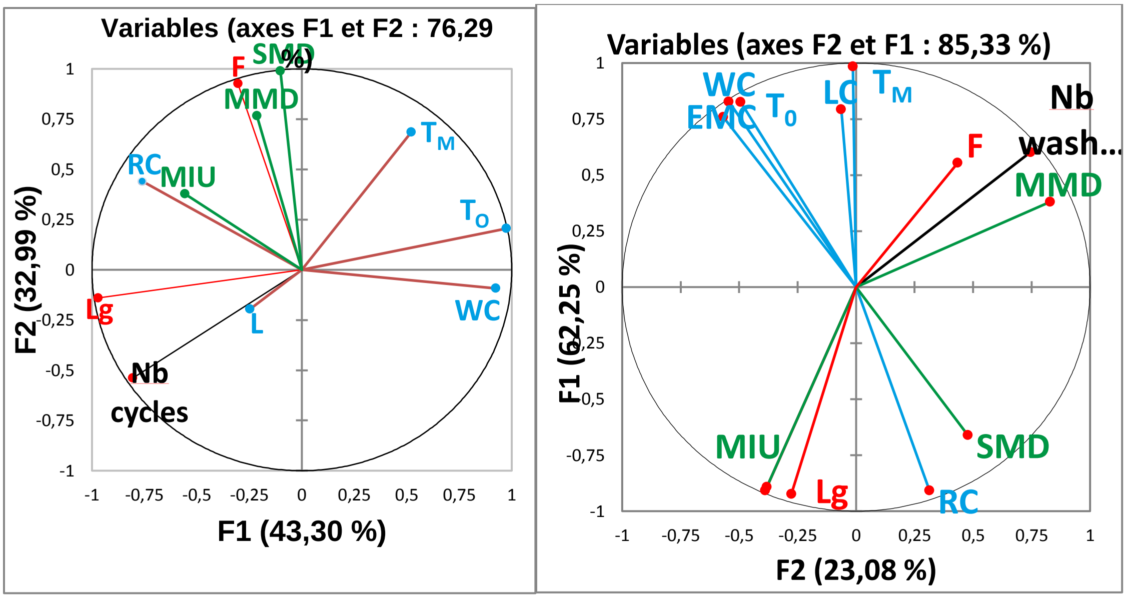

Figure 4: Principal Component Analysis (a) set of fabrics worn out by abrasion, (b) set of fabrics washed repeatedly

According to Figure 4(a), there are several correlations between the parameters. The total noise level (Lg) is correlated to the number of abrasive cycles (N), with the increase of it the number of free fibers on the fabric's surface will increases too. Therefore, there are more contact points between the two fabrics when they rub against each other and the total sound level is higher. The total sound level and the number of abrasive cycles are anti-correlated to compression properties (WC and T0). The fabric's thickness is going to decrease with the increase of the number of abrasive cycles because some material will be gradually removed from the fabric's surface.

Regarding to the peak frequency (F), it is correlated with surface properties (MMD and SMD). Indeed, the wear of the textile surface is going to cause a change in surface condition and thus the roughness, which is consistent with a change of acoustic signature.

If we look at the Figure 4(b), different correlations can be observed; only the surface properties are correlated with acoustics ones. The difference could be explain by the chemicals composing the detergent used for the washing which create a kind of coating around the fibers and change mainly change the surface properties.

CONCLUSION

Fabric's ageing has a significant influence on fabric friction sound but also on the compression and surface properties of the fabric. From the comparison between the two methods used to worn out the samples, we can conclude that the total sound level (Lg) is strongly correlated to compression and surface properties whereas the peak frequency (F) is more linked to the surface properties. The evolution of the total noise level is different according to the method used.

The follow-up study will be to conduct the same analysis on other kind of fabrics and to develop a sensory panel to compare instrumental and sensory approaches.

REFERENCES

[1] Kawabata S. The standardization and analysis of hand evaluation. 2nd ed. Textile Machinery Society of Japan, Osaka, Japan, 1980.

[2] Yosouf K, Latroch H, Schacher L, Adolphe DC, Drean E, Zimpfer V. Frictional sound analysis by simulating the human arm movement, Autex Res. J. 2017; Vol. 17, 1.

[3] K. Yosouf, E. Dréan, L. Schacher, D. C. Adolphe, A. Moukadem, A. Dieterlen, V. Zimpfer, V. Pellerin, New method to characterize the sound generated fabric friction, The spring 2014 conference of fiber society, May 21-23 2014, Liberec, Czech Republic p 97-98