Understanding sources and sound radiation of a snowmobile track

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1 Introduction

Maximum permissible sound levels are fixed by the Snowmobile Safety and Certification Committee standard. Classical acoustical solutions are difficult to use in snowmobile because of weight and space requirements. It requires understanding noise generation in order to act at the source. This paper investigates the noise emitted by this system.

Previous studies on snowmobile noise [1, 2] show that the system composed of the track, the suspension and the tunnel is deemed to be an important source. Moreover, the track noise is unpleasant [2]. Kleinendorst [2] have used Finite Element Analysis (FEA) to compute the stress transmitted to the tunnel by the impacts between the rods and guiding wheels. The noise was then reconstructed using measured Frequency Response Function between the tunnel and microphones. Results were however found to be inconsistent with the measurements.

Arz [3] shows that the noise of the system is generated at passing frequency of the track elements. From this, it was deduced that the noise was caused by the impacts between the fiberglass stiffener rods and other elements of the suspension. According to Kleinendorst [2] the noise is caused by the impact between the rods and the guiding wheels.

2 Method

2.1 Test bench description

Due to fast changing snow conditions, it is difficult to make repeatable track noise measurement [4]. To circumvent this problem, a test bench was developed. On this test bench, the track is driven by a silent electric motor and slips on a steel plate lubricated with water. The speed of the track is automatically controlled and the load applied on the suspension is controlled and continuously recorded. This test bench allows to isolate the noise of the track and to make repeatable measurements. Two successive tests show a maximum noise difference of only 1 dB.

2.2 Sources of vibration

There are many potential sources on the track, suspension and tunnel system. All of them are at the same frequency, which makes noise mapping difficult [5]. To understand which sources of vibration were important for noise radiation, 22 parameters were tested in two Plackett–Burman (P-B) design of experiments. P-B design allows obtaining the effect of many parameters with few tests. A variance analysis was also made to obtain the probability that the observed effects were indeed caused by the various design alternatives. By example, figure 1 shows the effect of parameter A and its degree of confidence

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in function of the speed of the track. It shows that above 80 km/h, parameter 1 will decrease the noise of almost 1 dB with a probability higher than 0.9. The efficiency of each parameter varies depending on the speed.

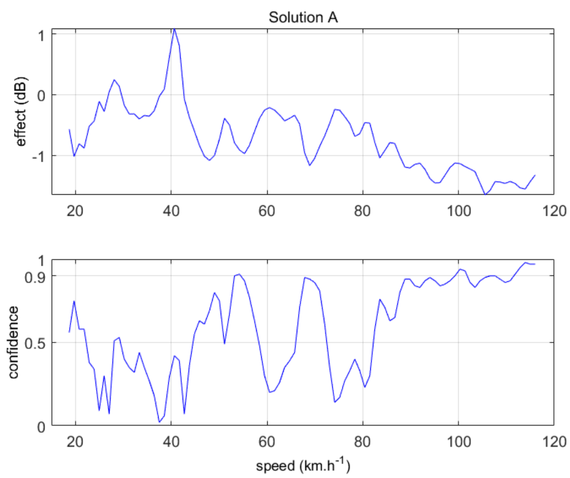

Figure 1: Effect of solution A.

2.3 Track and tunnel contribution

Mote [6] shows that the vibration of a moving continua becomes unstable as its speed and mass increase when compared to its tension. The track of the snowmobile has a high speed and mass and a low tension, so its vibrations can be nonlinear. High speed videos of the track were made between 20 to 120 km.h^{-1} but no instabilities have been reported.

A test bench has been designed to reproduce the environment and the tension of a track in use (figure 2). Impact testing were made on two track sections to understand their noise radiation in different tension conditions.

A rig for making tests without a tunnel was also fabricated. Hence, the noise of the system could be measured with and without a tunnel, so as to understand its contribution.

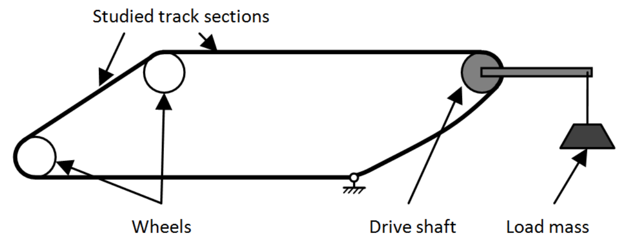

Figure 2: Static test bench

3 Results

3.1 The track generates vibrations, not noise

The most effective solutions were found to be those that decrease the elevation of the wheel when it passes over the lugs. This shows that this is the most important source in the system and it explains why the system is noisier on ice than on snow.

Static tests on tracks show that they radiate under the 1st and 3rd bending modes of the rods. Figure 3 shows the noise radiated by two tracks with different rod 1st and 3rd modes. There is no correlation between the rod modal frequencies and the radiated noise.

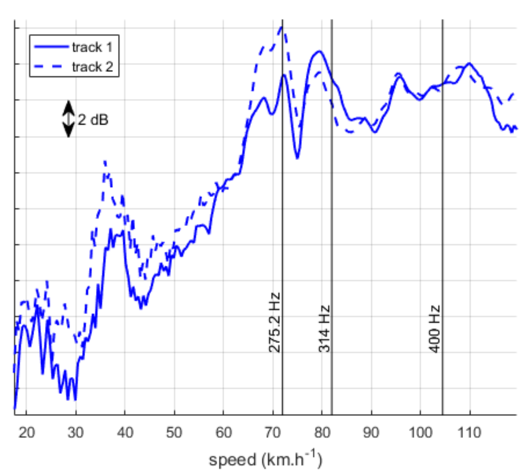

Figure 3: Noise of two tracks. Their third mode is respectively at 314 Hz and 400 Hz.

3.2 The noise is radiated by the suspension and the tunnel

Under 90 km.h^{-1}, the suspension without the tunnel made a noise of up to 5 dB less than that with the tunnel (figure 4). Above 90 km.h^{-1}, the noise of the two configurations is the same. It means that, in a standard configuration, the noise is radiated by the suspension under 90 km.h^{-1}, and by the tunnel after. This conclusion may change depending on the geometry of the tunnel and the suspension. Nassardin Guenfoud [7] made a Transfer Path Analysis improved of the system in order to understand how the energy is transmitted from the wheels to the radiating elements.

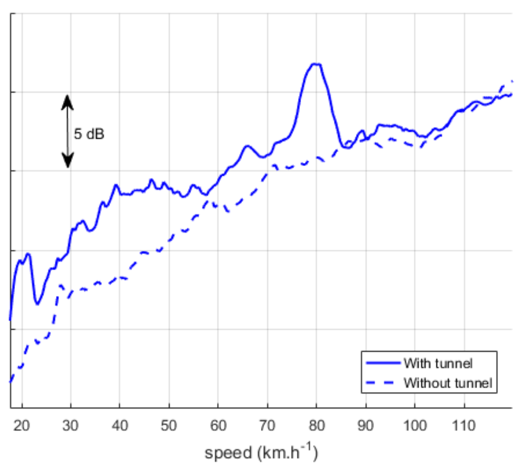

Figure 4: Noise of a track with and without tunnel.

4 Conclusions

Owing to the presented work, the understanding of the noise generation by a snowmobile track and suspension has been improved. The most important excitation source was found to be the passage of the guiding wheels over the lugs. This excitation propagates in the suspension on which the tunnel of the snowmobile is attached. The sound radiation and the dynamics of the track have not been identified as important contributors in the system. Finally, depending on the track speed, the system has two preferred ways to generate noise: airborne noise from the suspension itself and structural sound radiation from the tunnel.

Further studies are still needed to find out how the suspension and tunnel radiate noise.

Acknowledgments

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