Squeal Noise of an Automotive Wiper Blade

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Abstract—This paper proposes a design guideline to reduce squeal noise generated by an automobile wiper blade. In order to explain the squeal noise phenomenon, a source of squeal noise is experimentally investigated using a rotating disk equipment, and then a single-degree-of-freedom stick-slip vibration model is established for a blade tip. Based on analytical results, we discuss about a tendency of the squeal noise for various parameters.

Keywords—squeal noise; vibration; automotive wiper blade; noise reduction

I. INTRODUCTION

A noise problem in a windshield wiper system is one of main issues in automobile industry, because uncomfortable noise is generated in a wiper system. The functions of a wiper system are to wipe out water such as raindrop and to clean the windshield for a driver. The noise generated in a wiper system can be classified into three categories: squeal noise, chattering noise and reversal noise. Squeal noise is caused by high-frequency vibration (usually more than 1000 Hz) [1−5], while chattering noise is caused by low-frequency vibration (usually less than 100 Hz) [6, 7]. On the other hand, reversal noise [8, 9], which is a kind of impact noise with a frequency range of less than 50 Hz, is generated when a wiper reverses.

In this paper, the squeal noise due to the friction between a wiper blade and windshield is experimentally investigated. For this purpose, an experimental test setup is configured with a wiper blade fixed by a fixture and a circular glass disk driven by an electric motor. The signals of noise and vibration are measured as changing the physical parameters such as the blade length, arm pressure and rotating speed of disk. From these signals, the characteristics of squeal noise are analyzed and the mechanism of squeal noise is identified. In addition, using a single-degree-of-freedom model for stick-slip, the squeal characteristics are confirmed.

II. MEASUREMENT OF SQUEAL NOISE AND VIBRATION

Fig. 1 shows an experimental setup to measure the squeal noise and corresponding vibration generated between a wiper blade and glass disk. As shown in Fig. 1, the glass disk rotates together with a steel disk which is driven by an electric motor. The wiper blade fixed to a fixture contacts with the glass disk. When the glass disk rotates, the relative motion occurs between the blade and disk. This relative motion leads to the friction between the blade and disk. The arm pressure is adjusted by screws of the fixture and the pressure is measured by a pair of piezoelectric sensors. The nose signals generated by the contact of the blade and glass are measured by a microphone, while the vibration signals from the blade are measured by a laser vibrometer.

The squeal noise signal measured by the microphone is presented in time domain (see Fig. 2(a)). As shown in this figure, the squeal noise is generated periodically. A frequency spectrum corresponding to the time signal is shown in Fig. 2(b), where squeal noise has frequency components greater than 1000 Hz. It is interesting that squeal noise has harmonic frequency components of 3000, 6000 and 9000 Hz. The change of the fundamental frequency of squeal noise as the rotating speed of the glass increases is shown in Fig. 3, where Figs. 3(a) and 3(b) represent noise and vibration signals, respectively. Fig.
Fig. 3. Waterfall plots of the squeal noise and vibration: (a) noise and (b) vibration.

3 shows that the squeal frequency converges to about 2800 Hz as the rotating speed increases. It can be verified by the modal test for the wiper blade that this converged frequency coincides to the natural frequency of the blade.

To understand the squeal noise mechanism, a single-degree-of-freedom model for a stick-slip motion is adopted, as shown in Fig. 4. The mass $M$ is on a moving belt with a constant speed and a spring $K$ and damper $C$ are attached to the mass. The time responses for this model are used to analyze the effects of the negative gradient of the friction coefficient, arm pressure, damping coefficient, and relative speed of the friction surfaces.

III. CONCLUSION

It is found from this study that the negative gradient of the friction coefficient, arm pressure, damping coefficient and relative speed of the friction surfaces influence the squeal noise generated by the friction between the wiper blade and windshield grass. We propose some suggestions to reduce the squeal noise of a wiper blade system.

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REFERENCES


