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Parameter Quantification for evaluation of Vehicle's impulsive BSR noise

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ABSTRACT

In vehicles, consumer complains against BSR (buzz, squeak, rattle) noises are increasing. The BSR noises includes continuous or impulsive sounds depending on the generation mechanism. The evaluation method for rating the annoyance of BSR noises is required after taking these irregularly and periodicity. For continuous sounds, conventional Fourier transfer provides sufficient information on the spectral characteristics. However, the spectral information for impact sounds is difficult to be identified from Fourier transforms. In this study, Prony's method is applied to evaluate the spectral components (frequencies and decay ratio) of impact noises. The sinusoidal and exponential models fits a sum of damped complex exponentials. Through the auditory test, the noise level and attenuation ratio were identified as important factors influence annoyance. This attenuation term increased the annoyance of BSR sounds.

Keywords: Buzz, Squeak, Rattle, Impulsive noise
I-INCE Classification of Subjects Number(s): 13.2.1

1. INTRODUCTION

Recently, vehicle noise and vibration problems are emerging important factors for consumers complaints. There have been advances on analyzing noise and vibration for vehicle quietness. Conventionally, the acoustic characterization was performed to the steady state sounds from an engine, powertrain, and drive train. Recently, there has been rising interests on BSR(Buzz, Squeak, Rattle) noise, for example, friction between the parts or impact caused by a gap. Especially, the use of light material body and electronic communication devices increased the possibility of BSR noise generation. It became the elements of complaints directly affect the development process, design, testing, production and after-sales satisfaction.

2. NOISE CLASSIFICATION

2.1 Noise measurement and criteria for classification

Various noises generated inside vehicles with various types were selected. The time for analysis was 4 seconds and a total of 33 noise samples were measured by microphones. BSR noises were classified into two main groups. Characteristic of the criteria for classification was continuous noise or impact noise. It was identified based on periodicity(Pulse/s) and sharpness(acum). As shown in the figure 1, impact noises are accounted for most of the BSR noise. Therefore, evaluation of impact noise factors were quantified and evaluation index established by prony's method.

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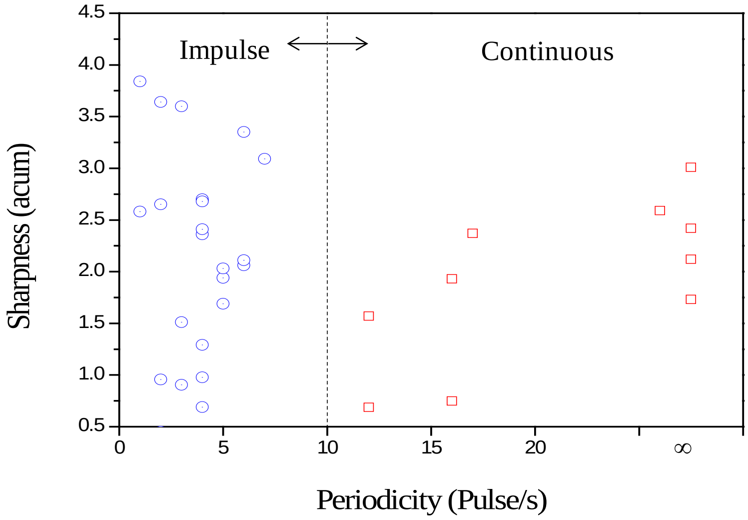

Figure 1. BSR noise classification with periodicity and sharpness

3. Prony's method

3.1 Advantage for impact noise

Similar to the Fourier transform, Prony's method extracts information from a uniformly sampled signal and builds a series of damped complex exponentials or sinusoids. This allows for the estimation of frequency, amplitude, phase and damping components of a signal. Linear model of the impact noise was configured with damping σ_i, phase frequency ϕ_i, amplitude A_i by linearly summation.

$$y(t) = \sum_{i=1}^{L} A_i e^{\sigma_i t} \cos(2\pi f_i t + \phi_i) \tag{1}$$

3.2 Auditory experiments for impact noise

Nine sound sources classified as impact noises are selected for auditory experiments to evaluate the perceived annoyance. Paired comparison refers to any process of comparing test samples in pairs to judge which samples are preferred. This test method was performed for derive a annoyance correlation between frequency, damping and amplitude. Each factor was calculated by Prony's method after approximation into 50 orders. Questionnaire assessment questions was " Choose the more annoying sound that you hear" and a total of 33 participants between the ages of from 19 to 33 with normal hearing were selected. Background noise in the room was less than 40dB. And frequency response calibration headphones (sennheiser HD600) was used.

3.3 Quantify the noise evaluation factors

The annoyance prediction equation was made by regression analysis. This analysis is statistical method to classify annoyance level. Purpose of this method is to find a linear function to predict annoyance. One of the most highly power order of prony's method damping and amplitude parameter were evaluated as an important factor.

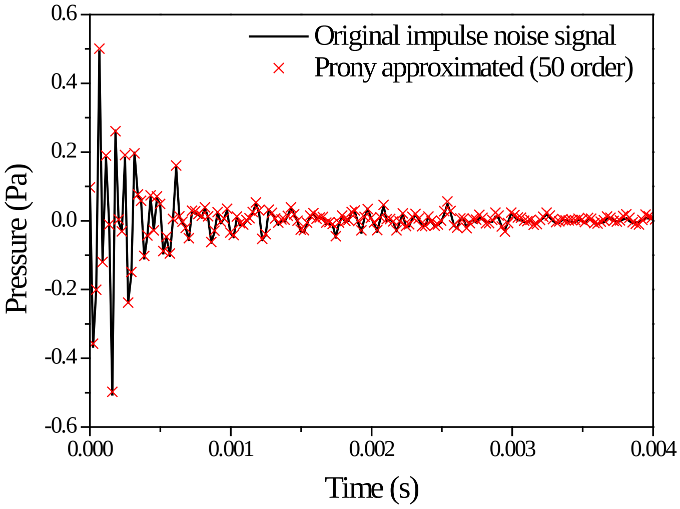

Figure 2. Prony's method approximation for BSR impulse noise

4. CONCLUSIONS

BSR noises were classified into continuity noises and impact noises. Impact noises occupied most of the BSR noises. Thus, the impact noise evaluation is an important part on analyzing BSR noise. Prony's method was applied for quantified of the factors and index. Prony's method having the characteristics of the damping term is derived after considering transient attenuation of the signal. Auditory experiments were performed for the analysis of correlation between annoyance and Prony's index.

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