

A Study of Wheel Guards for Reduction of High Frequency Road-Noise

Hyunggyung Kim
Hyundai Motor Company

ABSTRACT

This Study describes about the development of new concept' rear wheel guards for the reduction of Road Noise in the passenger vehicles. The new wheel guards are proposed by various frequency chamber concept and different textile layers concept. Two wheel guards were verified by small cabin resonance and vehicle tests. Through new developing process without vehicle test, Result of road noise will be expected if this concepts and materials of wheel guard are applied into automotive vehicle. As this concept consider tire radiation noise frequency and multilayers sound control multilayers, 2 concepts reduced road noise from 0.5 to 1.0dB. The proposed method of part reverberant absorption is similar to results of vehicle tests by part absorption index. Furthermore, optimization of frequency band in wheel guards will reduce more 0.5 dB noises. As a result of the application of Aimed Helmholtz and Multilayers concept, this paper classifies reduction of the road noise, cost and weights.

CITATION: Kim, H., "A Study of Wheel Guards for Reduction of High Frequency Road-Noise," *SAE Int. J. Passeng. Cars - Mech. Syst.* 8(1):2015, doi:10.4271/2015-01-1309.

INTRODUCTION

In general, road noise of a passenger vehicle may be roughly classified into four kinds of noises according to a frequency area. The noises may include road booming noise generated in a frequency area of 200Hz or less, tympanic noise generated in a frequency area of 200 to 250Hz, rumble noise generated in a frequency area of 250 to 450Hz, and high frequency noise generated in a frequency area of 500 to 20,000Hz.¹⁾ This research is aimed to reduce the high frequency noise occurring in the frequency area of 500 to 20,000Hz. In general, road noise is generated by irregular vibration from the road surface, and high frequency noise has no clear characteristics unlike tympanic noise with a clear vibration source. During operation of a vehicle, a vibration force of the road surface vibrates a tire tread part, and is introduced to the vehicle through a side wall and a suspension. However, the high frequency noise exhibits complex behavior due to a rotational force of the tire tread part and interference caused by flowing vortex and traveling wind around the vehicle body. Thus, there have been difficulties in clearly understanding the behavior, analyzing the phenomenon, and determining contribution rates of main transfer paths, which makes it difficult to apply an effective improvement direction. Furthermore, depending on the types and positions of engines of vehicles, the vehicles have different tendencies. Thus, research has not been conducted on various fields, except a material improvement method. They say that European vehicles exhibit excellent characteristics in sound quality rather than interior noise, and Japanese vehicles generate a small amount of interior noise. In particular, due to the exhaustion of oil and the environmental problems, weight reduction is required to improve fuel efficiency. Thus, innovative technical development of the vehicle design is required to satisfy both vehicle quietness and weight reduction. In the past 20 years, the technical

development has been focused on material optimization, while maintaining the existing methods.^{2, 3)} A wheel guard is an external part of a vehicle, which is mounted on a vehicle body at a wheel part of the vehicle and prevents damage of the vehicle body, caused by flying stores from the road.⁴⁾ Furthermore, the wheel guard blocks or absorbs high frequency noise generated from the road surface and a tire, and maintains quietness for passengers in the vehicle. The wheel guard includes front and rear wheel guards, and is formed of plastic or non-woven fabric to perform the above-described functions. Each automobile company adds intensified test items in order to establish a design goal. The wheel guard is divided into a plastic wheel guard and a non-woven fabric wheel guard. The plastic wheel guard is formed of an inexpensive material, but exhibits low sound absorption performance. The non-woven fabric wheel guard can be reduced in weight, but applied only to luxury vehicles because the non-woven fabric wheel guard is formed of an expensive material.^{5, 6)}

This research has been conducted on a new concept of wheel guard design for improving sound absorption performance of a rear wheel guard of a vehicle and reducing the weight and material cost of the vehicle. Through a sample test and a part test, conditions for sound absorption performance and sound absorption structure have been drawn.⁶⁾ This paper has proposed a resonator wheel guard using the Helmholtz resonator principle through frequency allocation based on contribution rate analysis. Furthermore, this paper has also proposed a three-layer non-woven fabric wheel guard using the interlayer separation principle for sound absorption and sound insulation of non-woven fabric. In this paper, after parts are manufactured, tests for checking sound absorption performance of a part and sound absorption performance of a vehicle were performed to confirm a performance improvement effect. This research will propose an

evaluation model capable of improving road noise without a vehicle test, a weight and cost reduction concept through evaluation, and a sound absorption concept.

METHOD DEVELOPMENT AND VALIDATION

The sound of road noise refers to invisible vibration of air particles, and the human beings sense vibration through the number of vibrations (frequency) and pressure using the air particles as a medium. The pressure that the human beings can sense through the eardrums ranges from 0.00002 to 60Pa, and the audibility of the human ear ranges from 2 to 20 KHz. In reality, the human beings are insensitive to a frequency of less than 100Hz and more than 10 KHz, and sensitively respond to a frequency of 4 KHz because the natural frequency of the ear drums is substantially equal to 4 KHz. Fig. 1 shows measurement items for road noise generated from the road surface during vehicle operation. Table 1 is based on a wideband analysis method which averages high frequency sounds in a frequency area of 500 to 4 KHz, but performs 1/3 octave analysis for accurate analysis.

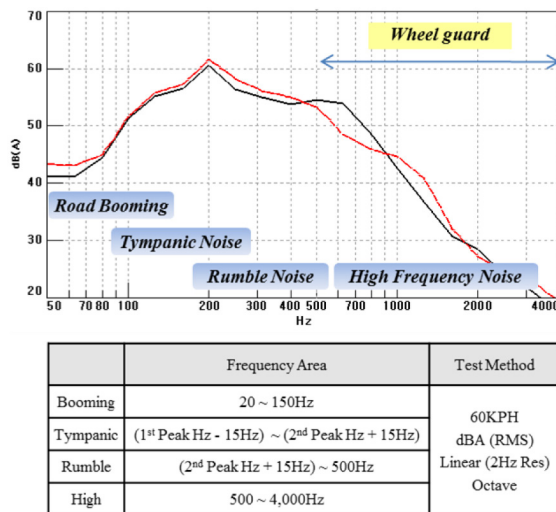


Fig. 1. Frequency area of road noise

Table 1. Frequency Area of Road Noise

Octave	31.5	63	125	250	500	1K	2K	4K	8K	16K
Frequency (Hz)	20 ~40	40 ~80	80 ~160	160 ~320	320 ~640	640 ~1.2K	1.2K ~2.5K	2.5K ~5.1K	5K ~10K	10K ~20K

Suggestion of Wheel Guard Concept

This research is aimed to improve sound absorption performance of a rear wheel of 'i30' as a new concept development product in comparison to the current sound absorption performance for high frequency noise which is representative road noise. Furthermore, a comparative performance test is performed to verify a similarity between sound absorption performance of a part and sound absorption performance of a vehicle. Figs. 2 and 3 illustrate two

concepts proposed by this research, before and after structures are changed. The concept using the Helmholtz resonator principle is a resonator wheel guard which includes a narrow neck and a cavity having a larger volume than the volume of the resonator neck as illustrated in Fig. 4. This research applies many different chambers which are used in a tire wheel and an engine cover and have three-dimensional (3D) frequency allocation instead of one frequency. 7)

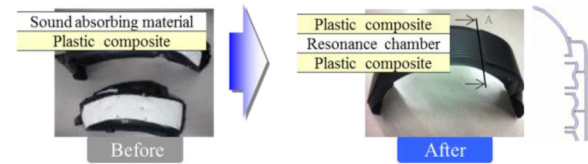


Fig. 2. New 1st Concept of wheel guard

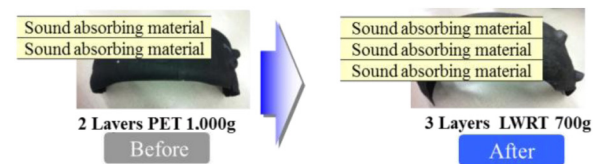


Fig. 3. New 2nd Concept of wheel guard

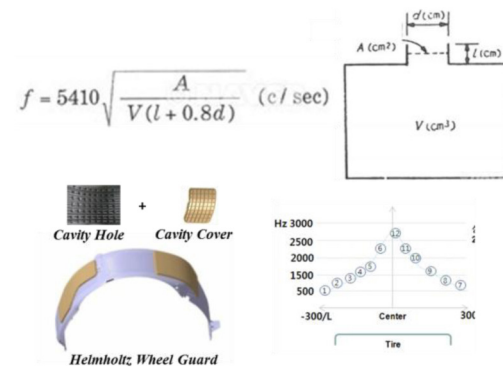


Fig. 4. Many Different Chambers into wheel guard

Verification of Sound Absorption Performance

The performance of the wheel guard for road noise includes sound insulation and sound absorption. The sound absorption refers to a phenomenon in which sound attenuates while the sound energy is converted into thermal energy or kinetic energy of a sound absorbing material. An absorption rate refers to a ratio of incident energy to absorbed energy in an object. A method for evaluating the absorption rate may include a pipe method, a reverberation chamber method, and a scaled reverberation chamber method. In this research, the absorption rate is measured through the scaled reverberation chamber method and calculated through the Sabine formula, and Fig. 5 illustrates the evaluation equipment and the absorption rate formula. In order to overcome a difference in shape between a part test sample and a vehicle test part, a vehicle part was used as the part test sample. FIGS. 6 and 7 illustrate states before and after test sample are changed.