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Research on Application of Acoustic Materials in Automobile Noise Reduction

Yinghang Chen ^{1*}, Dasheng Li ¹, Donger Xu ¹

¹ School of Mechanical and Vehicle Engineering, Bengbu University, Bengbu, Anhui, 233000, China

*Corresponding author's e-mail: chenyinghang@qq.com

Abstract. When buying cars, consumers pay attention not only to the power and economy of the car, but also to its riding comfort. As an important index of ride comfort, car noise has been paid more and more attention. In order to achieve the goal of noise reduction, researchers and engineers have done a lot of research work on automobile noise control. Based on the finite element method, the internal model of acoustic material is applied to the coupling system composed of car body model and cabin model to study the noise reduction effect of acoustic material. Practice shows that the application of acoustic materials in automobile noise reduction not only has theoretical significance, but also is one of the important measures to effectively solve automobile noise.

1. Introduction

The “ Noise pollution ” is the result of the destruction and development of human society and economy. It's called the “three pollution of the world” with “Water pollution” and “ Air pollution ” together. As the technology and society are progressing, “ noise pollution ” has become the problem that the whole society needs to face and solve. The automobile as one of the important modern inventions, has promoted people's travel and the development of transport and become one of the most common means of transport. The growth of car sales these days has made the automobile ownership rise rapidly. During the driving of the car, the noise in the automobile as one of the measures of influence on taking comfort has concerned more and more people.

The structure of the automobile is doomed to the existence of a variety of vibration sources, and these vibration sources will vibrate for a long time and bring noise. The noise not only destroys the stability of automobile structure but also affects the normal operation of automobile instruments. In addition, such noise will bring harmful effect to passengers in the automobile and the driver's health etc. Consequently, the automobile noise must be controlled, and the research on noise reduction of automobile must be increased.

2. The method of reducing automobile noise and selection of noise-reducing materials

2.1. The method of reducing automobile noise

In practice, there are three methods to improve automobile vibration source to reduce the automobile noise. Firstly, to improve the design mechanism of automobile for improving the design of the automobile body. The resonance of the vehicle at the design stage should be minimized, so as the control of the noise inside the automobile is realized. At the design stage , we should try to avoid the fixed frequency from the automobile body structure and the external resonance frequency . As it were,



this is “ the permanent method ”. Secondly, we adopt the bran-new sealing technology and realize the sealing of the automobile interior space to improve the airtightness of automobile body effectively. And then we can avoid the external noise to transmit to the automobile through the automobile body gap that affect the driver’s comfort in the automobile. As it were, it is a “ temporary method ”. Thirdly, we can reduce automobile resonance to a certain degree by using of acoustic materials-sound insulation material or acoustics of sound absorption material inside and outside the automobile. This is a “ temporary and permanent method ”.

2.2. Selection of noise-reducing materials

On the selection of automobile noise reduction materials to meet the requirements of automobile noise reduction material as far as possible, the following criteria are based on:

- The sound absorption and sound insulation performance should be good enough in wide frequency and must be kept long and stably.
- No pollution, neat appearance.
- The strength of the material should be enough to guarantee materials that are not easily damaged during installation and use, have good weather resistance, not easy to aging, and have long service life.
- Materials should be environmentally friendly and be free from harmful substances such as, glass fiber, asbestos etc.
- Materials should be not easy to mould, waterproof and moisture-proof, and moth prevention and corrosion resistance.
- It is best to be flame retardant and fireproof and not easy to burn.
- In the field of automobile manufacturing, materials should be light. The lightweight is the main trend of the whole development, and the automobile body weight will not be increased a lot by using lightweight material. It will not increase unnecessary fuel consumption either.
- Materials themselves are easy to cut and convenient to process.

3. Classification of acoustic materials

3.1. Specific classification

Acoustical materials can be divided into different modes of action: sound insulating material, sound absorbing material, vibration-absorptive material, tuning material, damping material and sealing material. According to material, they can continually be classified into: metallic material, non-metallic material, water-based material, clay plastic material etc. According to form, they can be classified into: board, cotton, bag, mat, strip, coating etc. The details are as follows:

Table 1. Classification of common acoustic materials in market.

Sound insulating material	Metal soundproof plate
	Nonmetal soundproof plate
Sound absorbing material	Acoustical cotton
	Acoustical board
	Sound absorbing soft bag
	Wedge absorber
Vibration-absorptive material	Shock absorber keel
	Shock pad

	Diffuser
Tuning material	Functional absorber
	Sound absorption diffuser
Damping material	Water-based damping material
	Clay plastic damping material
Sealing material	Sound sealant
	Sound sealing strip

3.2. One of the most suitable polymer materials

As far as car noise reduction is concerned, “damping coating” is the most suitable polymer material for car noise reduction among the above “acoustic materials”.

According to the table, damping paints are usually classified into: “water-based damping coating” and “solvent damping coating”. The former is a commonly used material. However, the latter, because of its material properties which is similar to asphalt and the participation of a large number of organic solvent components, makes the damping performance of such materials low, and the volatilization of more organic substances also easily causes environmental pollution. Therefore, such materials have been basically eliminated at present and will not be described in detail.

From the name we can see “Water-based damping coating” is using “water” as dispersing medium. “Water-based damping coating” is shown in the figure 1.

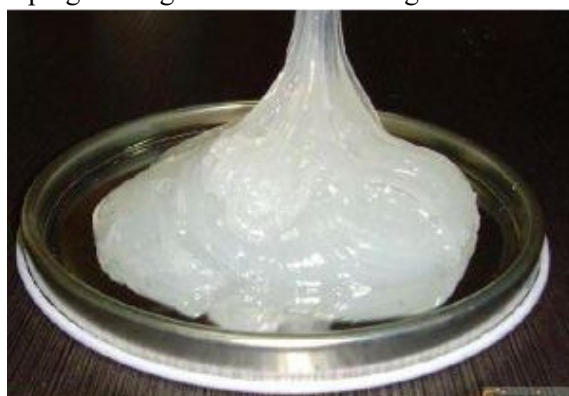


Figure 1. Water-based damping coating

The “water - based damping coating” can be seen from its name that it uses “water” as the dispersion medium. Unlike the asphalt - like “solvent - based damping coating”, its base material exhibits the texture of water emulsion, and has the advantages of safe construction and environmental protection. Compared with the damping rubber plate, the “water - based damping coating” has become the mainstream of the future development of the damping coating because it uses spraying to make the construction more convenient.

4. Noise Control Measures Based on Acoustic Principle

4.1. The sound insulation material in current market

In the limited car space, it is important to start from two aspects to control the noise: reflected noise and direct noise. In the traditional noise control, the acoustic principle is applied, and the way of arranging attracting materials in the car is usually adopted. This kind of sound-absorbing material can effectively reduce the emission of sound energy in the car, thus achieving the goal of noise reduction in the car. The test results of sound insulation materials in the current market are as follows:

Table 2. Test results of Sound insulation.

Sample No.	Surface density/(g.m-2)	Thickness/mm	Material and composition
#1	1970	2	Plastic board
#2	900	2.85	Moulded fabric
#3	290	4.00	PE polyfoam

Due to the restrictions of light weight, environmental protection, fire prevention and water proofing, there are still few sound absorbing materials that can be applied to automobiles, and the most widely used one is “ calm sound absorbing cotton ”. This kind of cotton is also an application of acoustic materials. In the analysis of the noise of various vehicles, according to the requirements of automobile noise reduction and the characteristics of automobile noise, a reasonable shaped sound absorption groove is designed to achieve the effect of doubling the area per unit sound insulation area. Through simulation and mathematical calculation, the depth, curvature, width and slope of each sound-absorbing groove are determined. Through the transition of “ quiet sound insulation and sound absorption cotton ”, the acoustic impedance of the air is matched. Thus it can absorb wide-band acoustic waves effectively and further achieve the purpose of noise reduction for the automobile.

4.2. New material for automobile noise reduction

4.2.1. Damping material

The new damping material is a new application of acoustic material in the research of automobile noise reduction. This technology uses high molecular material with X elasticity to consume vibration energy through the conversion of vibration energy and heat energy, thus realizing effective noise reduction of the car and further improving the comfort of the car.

Different from the traditional sound-absorbing materials, damping materials are more widely used, and their standards in light weight, environmental protection, fire prevention and water proofing are greatly improved. Damping materials can be used on the inside and outside of automobiles, such as fenders and chassis of automobiles, and can effectively absorb the energy of sand and gravel hitting fenders and chassis during driving. They can not only reduce noise, but also play a certain protective role to prevent damage.

Table 3. Performance index of damping material.

Item	Index
Container state	No block , it is in a uniform state after stirring
Work property	Scrapable coating or airless spraying, wet film 3mm, no flow column
Salt spray resistance (720h)	No rust, no foaming, no cracking
Nonvolatile content /%	≥ 70
Flexibility	100 mm axial bending, no cracking
Resistance to shock/cm	≥ 50
High temperature resistance(-40~80 °C)	5 circles, no cracking, no dropping
Stone resistance(0.5Mpa, 1kg, 10 times)	No apparent change in appearance
Salt water tolerance (3% NaCl, 15d)	No blistering, no falling

Damping composite	-10 °C	0.050
loss	20 °C	0.110
Consumption factor	50 °C	0.050

4.2.2. Damping paint

On this basis, researchers have developed a “ damping paint ”, which greatly improves the application range. This kind of coating also uses the “ damping effect ” and is a great improvement of acoustic materials. In automobile noise reduction, this material can be scraped or sprayed on the structural surfaces of various shapes. Through internal X-elastic polymer, part of the energy which is generated by external field actions, such as mechanical vibration and acoustic vibration, is converted into heat energy which is dissipated through internal friction, so as to achieve the purpose of vibration reduction and noise reduction.

5. Conclusion

In conclusion, the improvement of automobile noise reduction standard is the inevitable result with the development speed of automobile industry. How to deal with such high standards and strict requirements is a research problem that automobile engineers must face. The addition of “ acoustic materials ” has well developed the idea of car noise reduction and expanded the direction of car noise reduction. Among the “ acoustic materials ”, damping materials temporarily meet the requirements of automobile noise reduction due to their superior performance. In the future, researchers will need to constantly study and innovate in order to improve the performance of damping materials. Thus they can develop new water-based damping materials with better sound insulation performance, more stable physical and mechanical properties, more convenient storage, faster construction and more environmentally friendly and safe properties for application in automobile noise reduction.

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