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Research on Subjective Rating Attenuation Analysis of Automobile NVH Characteristics

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Abstract

This paper explains the concept of high mileage automobile NVH(Noise Vibration and Harshness) robustness. Based on the NVH characteristic subjective rating method, a quantitative analysis and evaluation method for NVH robustness of high mileage automobile is proposed. By using the subjective rating attenuation method of high mileage automobile NVH robustness and combine the actual parameters of three different types of cars, According to the calculation and analysis of the decline and attenuation of subjective rating attenuation method, the NVH robustness characteristics and change rules of three different types of cars at different mileage stages are obtained, which provides a reference for the NVH robustness analysis of high mileage automobile and the development of automobile NVH.

Keywords: vibration and noise, attenuation rate, robustness, high mileage automobile, subjective rating

1. Introduction

The current research on the NVH characteristics of automobile is mainly focused on the vibration, noise and comfort of the new automobile, but less research on the vibration, noise and comfort of high mileage automobile after use. With the gradual increase of the mileage of the automobile, the automobile parts, components and the performance of the automobile must be attenuated to a certain extent. The attenuation of its comprehensive

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performance will inevitably lead to the gradual reduction of the NVH characteristics of the high mileage automobile. High mileage automobile NVH robustness refers to the holding capacity of original acoustic quality in the automobile, when the vehicle is purchased by the user and will be influenced by various factors in the process of use, from the gradual increase of the mileage from zero to a mileage[1,2,3]. This paper proposes a quantitative analysis and evaluation method based on subjective rating attenuation for high mileage automobile NVH, and studies the robustness of automobile NVH characteristics.

2. NVH Robustness Analysis Based on Subjective Rating Attenuation

2.1 Subjective rate

Based on the large subjective evaluation of vehicle vibration and noise, this method is called subjective evaluation level. According to the actual feeling of the size and comfort of vibration and noise, it is usually to facilitate the subjective evaluation of vibration and noise. The personnel of vibration and noise analysis will convert the qualitative evaluation index to the quantitative evaluation index value so as to facilitate the accurate analysis.

According to the actual situation, generally speaking, the quality of vibration and noise can be defined as multiple levels to indicate its NVH performance[4,5,6,7], as shown in Table 1.

Table 1. classification of subjective evaluation of vibration and noise

level	1	2	3	4	5	6	7	8	9	10
opinion	unacceptable				acceptable transition stage		acceptable			
Accepted object	all customers	the majority of customers			critical customers			trained people		

In the above table, the evaluation level of vibration and noise is increased from left to right in turn, indicating that the quality of vibration and noise quality evaluation is increasing gradually, and the acceptability is increasing gradually; the lower the grade, the stronger the vibration and noise, the first stage is very strong in vibration and noise, and it is unacceptable in this environment of vibration and noise. With the subjective evaluation level are improved, indicates that the vibration and noise occurred from strong to weak change. The higher the level in the table shows that the vibration and noise are very weak. It only feels weak vibration and noise in the car, and even does not feel the existence of vibration and noise.

In the actual situation, the new automobile starts from the use of input, with the increase of the mileage from the zero, the decrease of the material performance, the wear and tear of the parts, the structural variation and the crack extension will lead to the gradual decrease of the subjective evaluation level of the automobile NVH.

In a certain mileage, the less the subjective rating of automobile decreases, the stronger the robustness of the NVH characteristic of the car, otherwise the weaker the robustness of the NVH characteristic, and the easier the NVH quality is to be biased by the influence of various interference factors.

2.2 Subjective rating attenuation level

The rating level of vibration and noise is the original reference value of NVH quality based on the zero mileage of automobile. As the number of mileage increases, when the number of mileage is reached, the subjective rating is defined as the difference of the actual evaluation value between the two8,9,10. Its theoretical calculation formula is as follows:

$$\Delta L_i = L_0 - L_i \tag{1}$$

In the above calculation formula, it is expressed as the variation of the subjective rating after a certain mileage of the automobile NVH, which is the subjective rating attenuation value. If the difference is bigger, the greater the quality attenuation of vehicle is, the smaller the performance attenuation is if the value is smaller.

However, the subjective evaluation level of some models is higher when they are delivered and used with zero mileage. With the gradual increase of the mileage of vehicles, the subjective rating of NVH will gradually decrease, so that after a certain mileage stage, the characteristics of high mileage automobile cannot reach the comfort requirements of the initial calibration of the products.

Therefore, the high and low initial vehicle NVH rating level does not mean that the NVH robustness is strong or weak. There is no necessary connection between them.

We can calculate the speed of the corresponding decline of automobile NVH subjective rating by calculating the attenuation rate. The rating of subjective evaluation is defined as the reduction of subjective rating per kilometer. Considering that the subjective evaluation level of vibration and noise is a small number, the mileage of the automobile is a large number. If the attenuation value per kilometer is measured, it will bring a considerable difficulty to the calculation, so for the convenience of calculation, the attenuation rate of the subjective rating of the automobile NVH per thousand kilometers is actually calculated, and the attenuation rate is used for Avn, its theoretical calculation is as shown in formula 2.

$$A_{vn} = \frac{\Delta L_i}{\dot{I}} \tag{2}$$

In the upper formula, ΔL_i is the actual NVH subjective rating reduction

3. NVH Robustness Example Analysis of High Mileage Automobile Based on Subjective Rating Attenuation

3.1 The initial NVH analysis of automobile

The paper uses the literature[11] as the original reference data, and uses the method proposed in this paper to analyze three different types of cars, A, B, C. After a certain period of use, when these three cars reach 58 thousand km, 96 thousand km and 160 thousand km different mileage stages, the NVH evaluation level and its attenuation change law are calculated. According to the level of NVH subjective rating in different mileage stages, we analyze the NVH robust performance under its high mileage. From the two aspects of qualitative and quantitative analysis, we can grasp the change rules and characteristics of NVH in different mileage stages of high mileage cars. The subjects' initial rating of three different types of car subjective ratings is shown in Table 2.

Table 2. the initial statistical value of the three car of subjective evaluation level

type	A	B	C
The initial NVH level	7.8	7.6	7.4

3.2 Analysis on the decline of automobile at different mileage stages

The average subjective ratings level of the three cars NVH's at 58, 96 and 160 thousand km are shown in Table 3 respectively.

Table 3. NVH Subjective rating level under different mileage stages

mileage stages / type	0km	58 thousand km	96 thousand km	160 thousand km
A	7.8	7.6	7.5	7.3
B	7.6	7.5	7.4	7.35
C	7.4	7.2	7.1	6.5

From the above table, we can see that along with the continuous increase of mileage, the subjective ratings of all NVH cars are decreasing. According to the subjective rating values of A, B and C under different mileage stages in Table 3, we draw the change charts of different mileage stages in reference coordinates as shown in Fig.1.

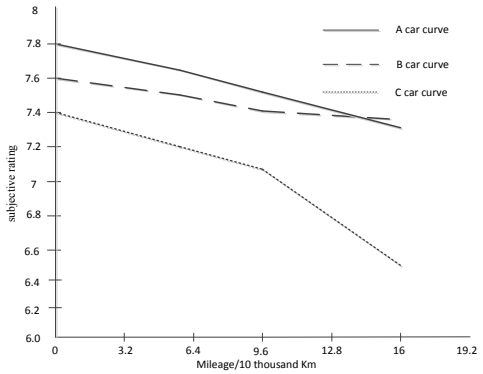

Fig 1. three different types of cars after the same mileage, NVH subjective rating.

Fig.1 shows the attenuation level of the three cars at different mileage. It can be seen from the graph that the subjective rating of car C is the fastest, while the subjective evaluation level of car A and B is the slowest. Compared with A and B, the A car NVH subjective evaluation level is better than the B car at 0 mileage, but with the increase of the mileage, the NVH subjective evaluation level attenuation value of these two cars is different, which leads to the greater change of the NVH subjective rating of the two cars after a certain mileage, and the NVH evaluation level of B car is more than A when it reaches 160 thousand km. It indicates that the NVH robustness of the B car is better than A car with the increase of mileage. Therefore, we can find out the NVH subjective rating attenuation value under each mileage stage, as shown in Table 4.

Table 4. subjective rating decline at different mileage stages

mileage stage / type	0～58 thousand km	58～96 thousand km	96～160thousand km
A	0.2	0.1	0.2
B	0.1	0.1	0.05
C	0.2	0.1	0.6

A, B and C cars from 0~160 thousand km, the NVH subjective evaluation level attenuation value is compared and analyzed, as shown in Table 5.

Table 5. comparative analysis of the subjective evaluationof vibration and noise of the three cars at different mileage stages

mileage stage	analysis results
0～58 thousand km	B car have little decline, A and C cars have a larger decline
58～96 thousand km	A, B, and C cars have the same decline
96～160 thousand km	The number of B cars is smaller, the A car has smaller decrement, while the C car has larger decrement.

3.3 Analysis of automobile attenuation rate at different mileage stages

According to the NVH attenuation of A, B, and C cars at different mileage stages, the NVH subjective evaluation level attenuation curve of A, B and C cars at different mileage stages can be drawn as shown in Fig. 2.

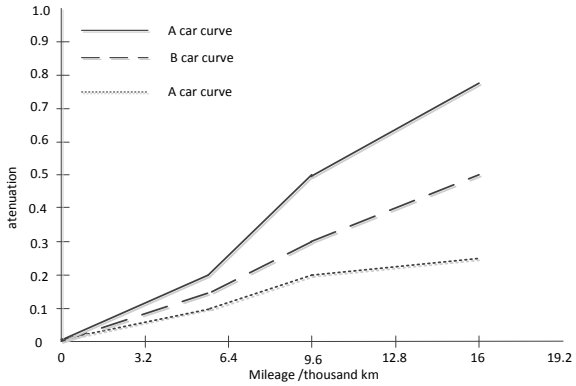

Fig 2. the vibration and noise attenuation level of three different types of cars after the same mileage.

As shown in Figure 2, the attenuation rate of the three cars in each mileage stage shows that the attenuation rate of C vehicles between 64 thousand and 96 thousand km is the largest, and the attenuation rate decreases after 96 thousand km, and the attenuation of B cars at the beginning stage is larger, but the attenuation rate between 96 thousand and 160 thousand km is obviously reduced, indicating that the attenuation rate is significantly reduced. After a high mileage, its NVH has strong performance, and its attenuation rate at all stages is shown in Table 6.

Table 6. Subjective rating attenuation rate at different mileage stages

mileage stage / type	0～58 thousand km	58～96 thousand km	96～160 thousand km
A	0.034	0.026	0.031
B	0.017	0.026	0.008
C	0.034	0.026	0.094

A, B and C three cars are between 0~160 thousand km, and their NVH subjective rating attenuation rate is compared, as shown in Table 7.

Table 7. Comparison of attenuation rate at different mileage stages

mileage stage	comparison result
0～58 thousand km	The attenuation rate of A and C vehicle is the same, and the attenuation rate of B vehicle is small.
58～96 thousand km	The attenuation rate of A, B and C cars is similar
96～160 thousand km	The attenuation rate of B car is the smallest, the attenuation rate of A car is smaller, and the attenuation rate of C car is the largest.

Through the attenuation rate of different mileage stages, the attenuation trend of automobile NVH quality can be analyzed quantitatively and qualitatively. Through the trend analysis of attenuation rate, the reasons for the decrease of NVH quality in this stage can be emphatically analyzed in order to improve the NVH quality measures, methods and enhance the robustness of automobile NVH.

4. Conclusion

1) The attenuation and attenuation rate analysis can be used to quantify the attenuation and variation of NVH characteristics of high mileage automobiles at different mileage stages. Therefore, the key components or main factors that lead to the decrease of NVH characteristics of high mileage vehicles at different mileage stages can be studied for the establishment of the NVH control measures of automobile, which provides an important basis.

2) In the initial NVH characteristics of the three cars, the subjective rating level of the car type A is higher than that of the B, but after 160 thousand km, the subjective rating level of the B car is higher than that of the A car. Therefore, the initial NVH characteristics cannot explain the change of the high mileage automobile in this characteristic, and it is necessary to use the attenuation or attenuation rate to reflect the laws of the change of the NVH characteristics.

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