NVH Application Note

NVHAN-083 Investigation of Brake Pad Damping Coefficient

Link Engineering has over 25 years of experience in Noise, Vibration, and Harshness (NVH). Whether you need a complete NVH test system, a laboratory screening of brake system NVH performance, vehicle subjective testing, or a fundamental NVH investigation, we have the experience and expertise to assist you. Please do not hesitate to contact Jim Thompson at 734-453-0800 or sales@linkeng.com. To learn more about our NVH activities and expertise, visit our website at www.linkeng.com.

Introduction

The following gives a brief description of an investigation performed to determine how changes in the formulation of disc brake friction material affect the damping characteristics of the brake. Friction material damping is felt to be an important factor in reducing brake squeal.

Figure 1. Brake Pad Used for Testing

Although there are several theories pertaining to the cause of brake squeal, it is clear that high amplitude vibration response near resonance is a major contributor. One means to lessen the magnitude of response is to increase the amount of damping present in the system. It has been theorized that the coupling of vibration modes between the caliper assembly and the disc is a key source of high noise levels. The friction material is a crucial physical link between these components. Therefore, friction material formulations that provide increased damping can be helpful in reducing noise from the braking system. Link undertook this program to investigate the relationship between friction material formulations and damping.

Brake Pad Q-Factor and Loss Coefficient

A client asked Link to determine the Q-factor and loss coefficients of several sets of disc brake pads. For those unfamiliar with these terms, Q is inversely proportional to the damping coefficient, and the loss factor is directly proportional to damping. Several different formulations were developed by the client to determine how different components affected the damping. The brake pads were mounted to a backing plate to simulate actual operational conditions. The Q-factor and loss coefficient of a bare backing plate were also measured to provide baseline data for comparison. Frequency analysis was used to determine the damping coefficient of each of the pad materials.

Performing the Test

To begin the test, the brake pads were suspended by elastic cords to simulate a free-free state. Accelerometers were placed at 2 positions on each sample, 1 at the center of the backing plate and 1 at the edge of the backing plate, as seen in Figure 2. Both of the locations were excited using a modal hammer. A noise analyzer was used to acquire both force and acceleration data and to compute Fourier transforms for each sample over a frequency range of 0 – 5000 Hz.

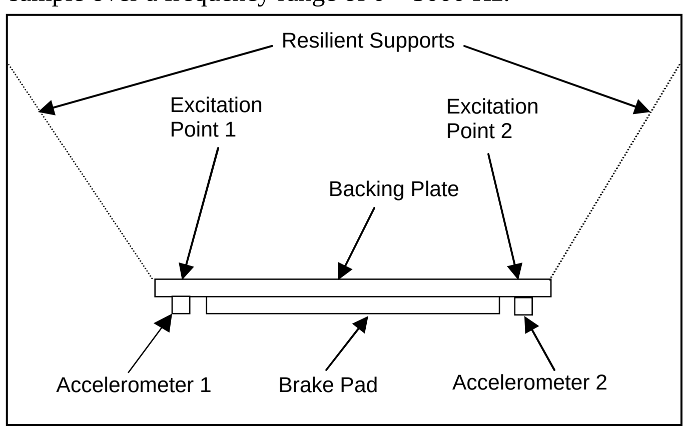

Figure 2. Brake Pad Set-Up

Analyzing the Data

Once the data had been collected for all of the brake pads, the transfer function of each pad was plotted over the frequency range, as seen in Figures 3 and 4. Figure 3 shows the transfer function of the bare backing plate, while Figure 4 shows the transfer function of one pad formulation. Since the Q-factor represents the amplification at resonance, the Q-factor is much higher for the lightly damped bare backing plate. This can clearly be seen in these figures. For the more highly damped cases with the friction material attached, the peaks in the transfer function at the resonant frequency are much smaller. In the cases of the highest damping, the peaks are almost obscured. The Q-factor and loss coefficient of each material was calculated from the plotted transfer functions.

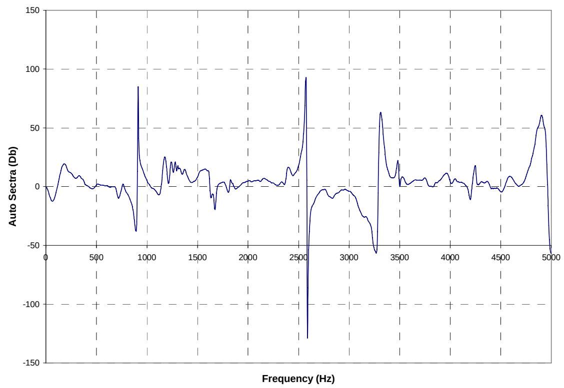

Figure 3. Typical Measured Transfer Function for Bare Backing Plate

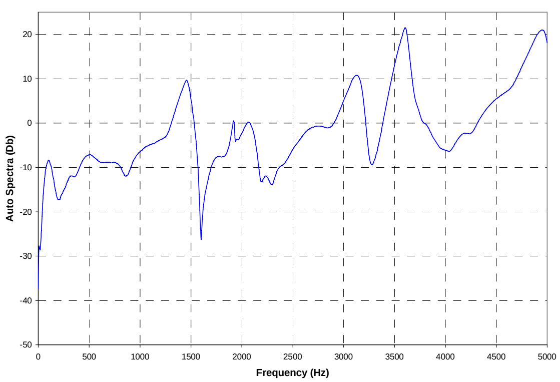

Figure 4. Typical Measured Transfer Function for Brake Pad Mounted on Backing Plate

Results

Table 1 shows the resulting Q-factors and loss coefficients calculated from the transfer functions. Clearly, the different formulations did result in changes in the damping properties.

Table 1. Calculated Q Factor and Loss Coefficient for Each Sample

Description	Q Factor	Loss Coefficient
Bare Backing Plate	265.3	0.0038
Formulation 1	42.6	0.0235
Formulation 2	26.1	0.0383
Formulation 3	113.6	0.0088
Formulation 4	49.8	0.0201
Formulation 5	29.6	0.0338
Formulation 6	20.7	0.0483
Formulation 7	72.5	0.0138
Formulation 8	82.6	0.0121

Conclusions

As can be seen from the results, the damping present in the brake friction material is an order of magnitude more than found for the bare backing plate. One can see that the formulation of the friction material can be used to modify the damping of the system. Further testing would be required to assess the effectiveness of changes in damping to reduce the noise levels or to prevent noise from occurring. The nature of brake friction materials suggests that damping performance at the higher temperatures found during normal operation may be significantly different.

Please contact us to learn how we can help you with test system development and engineering services related to NVH.

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