International Journal of Advance Research in Science and Engineering
Vol. No. 5, Special Issue No. 01 , May 2016
www.ijarse.com
IJARSE
ISSN 2319 - 8354

COUNTERMEASURE FOR DISC & DRUM BRAKE CHILD PARTS NOISE & ITS CORRELATION WITH CAE

Aniket B. Ghatwai[1], S.V.Chaitanya[2], S.B.Phadke[3]

[1]*M.E. Student, AISSMS COE Pune, Maharashtra, (India)*

[2]*Dept. of Mechanical Engineering, AISSMS COE Pune, Maharashtra, (India)*

[3]*Deputy Manager,Chassis Brakes International,puneMaharashtra, (India)*

ABSTRACT

Disc brake noise and vibration control in vehicle has received significant attention in the last years, the noises are generated in Disc and Drum Brakes where there is a transition from static to dynamic condition or vice versa. The Eigen Value characteristics of a brake child parts is the important tool to detect brake noises. Frequency response measurement is frequently used counter-measures for eliminating or reducing squeal ,by getting high excitation frequencies, The Experimentation has been done on disc brake child parts (i.e. caliper, rotor, pad, bracket) by FRF testing and by knowing Eigen values, results will be compared with the CAE results to verify the Frequency Modes.

Keywords: Disc & Drum Brake Child Parts, , FRF Measurement, FFT analyzer , Eigen Values, CAE, Abaqus, Mode Shapes.

1. INTRODUCTION

Two key characteristics of a comfortable vehicle are good vehicle dynamics and low noise levels. Reduced noise levels in the cabin can be achieved through the tailoring of aerodynamics and drive train isolation. The success of these general noise reduction activities has made other vehicle noise sources, such as disc brake Noise, more apparent. In spite of significant engineering efforts, a generally accepted theory for brake Noise is not yet available, as most experimental, analytical and numerical investigations yield inconsistent results. Therefore, it is one of the most important issues that require a detailed and in-depth study for prediction as well as eliminating brake Noise.

Brake noise that generated in the disc brakes of the automobile & has been handled as a one of the major businesses in the automotive industry due to the persistent complaints that reduces Users satisfaction with their vehicle. Most of the scientist and engineers have agreed that Brake noise in the disk brake is initiated by instability due to friction forces, contributing to self-excited vibrations.

The Braking noise refers to the high-frequency sound emissions from a brake that are generated during the braking phase and characterized by a periodic or harmonic spectrum. This phenomenon is common to both drum and disc configurations and concerns with automotive brakes.

Therefore, the geometry and the dimension of brakes can vary widely, thus leading to very different sets of squeal frequencies and associated modes.

The purpose of this report is to discuss frequency response functions. These functions are used in vibration analysis and modal testing. The purpose of modal testing is to identify the natural frequencies, damping ratios, and mode shapes of a structure. And validate those results By using CAE.

II.FREQUENCY RESPONSE FUNCTION

A natural frequency is the frequency at which the structure would oscillate if it were disturbed from its rest position and then allowed to vibrate freely. All structures have at least one natural frequency. Nearly every structure has multiple natural frequencies. Resonance occurs when the applied force or base excitation frequency coincides with a structural natural frequency .

A frequency response function (FRF) is a transfer function, expressed in the frequency domain. Frequency response functions are complex functions, with real and imaginary components. They may also be represented in terms of magnitude and phase. A frequency response function can be formed from either measured data or analytical functions. A frequency response function expresses the structural response to an applied force as a function of frequency.

The response may be given in terms of displacement, velocity, or acceleration.

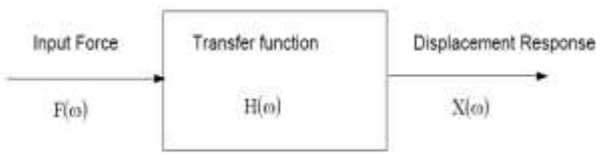

Fig.1 Frequency Response Function Model

F(w) is the input force as a function of the angular frequency w . H(w) is the transfer function. X(w) is the displacement response function. Each function is a complex function, which may also be represented in terms of magnitude and phase. Each function is thus a spectral function. There are numerous types of spectral functions. For simplicity, consider each to be a Fourier transform. The relationship in Figure 1 can be represented by the following equations.

$$X(\omega) = H(\omega) . F(\omega) \ldots\ldots \quad (1)$$

$$H(\omega) = \frac{X(\omega)}{F(\omega)} \ldots\ldots \quad (2)$$

Usually brake squeal occurs in the frequency range between 1 to 20 kHz. Squeal is a complex phenomenon, partly because of its strong dependence on many parameters and, partly, because of the mechanical interactions in the brake system. Thus Frequency response in this case is considered between 1 to 16500Hz.

III. FRF MEASUREMENT PROCEDURES

1.Component Identification:

Components like Caliper ,Carrier, pads, disc for Disc Brake and Back plate, Leading Shoe ,Trailing Shoe, for Drum brake to be identified. Dissemble the components from each other ,Remove dirt and oil on the surfaces, remove the damping material if attached to the part. Emboss Component Name for easy identification.

2. Provide free hanging condition:

This Condition is to be provided for component to vibrate freely after the excitation.

3. Fix the accelerometer Location:

It is to be fix on the part whose frequency to be measured. The accelerometer location is based on the desirable results to be obtained. generally accelerometer is located at the corners of the component in X,Y,Z Direction to get the maximum frequency response in inplane and outplane modes.

Fig.2 Accelerometer location on caliper with free hanging condition

4.Connectivities:

Provide the Power supply to measurement LMS system, attach the LMS to Laptop(in which Software is installed) by LAN Cable .LMS is 5 channel front end, we attach accelerometer and hammer to the 2 channels.

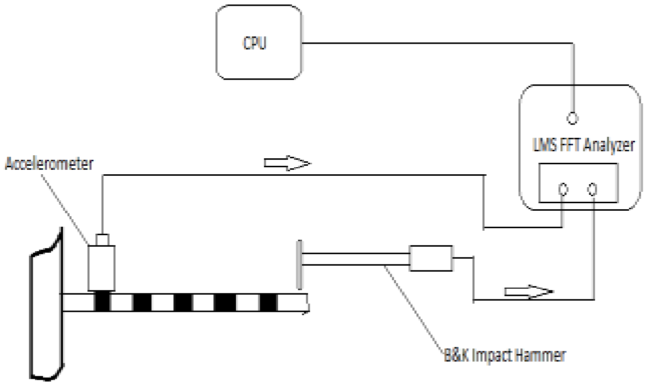

Fig.3 Basic Equipment for modal analysis

5.System Configuration:

The Primary Settings are to be done in LMS software. like creating working Directory, setting up the two channels for accelerometer and hammer ,calibration of accelerometer ,input parameters like force(N) and acceleration(g) levels generally the force levels are vary in 46N to 250 N and Acceleration level is in between 197 to 2500 g.

Fig.4 LMS FFT Analyzer.

IV. HARDWARE SPECIFICATION

LMS System:

1. 5 channel Data Acquisition system with maximum sampling frequency of 256khz
2. Hardware, LMS Scadas Mobile SCR01
3. Software, LMS Test Lab 9A
4. Make LMS Belgium.

Accelerometer:

1. Light Weight Modal Accelerometer
2. Weight <3gm

3. Frequency Range upto 17Khz
4. Make DJB France

Hammer:

1. Impulse Hammer/ force Transducer
2. Frequency Range upto 16.5Khz
3. Make Bruel & Kjaer, Denmark

V.EIGEN VALUES FOR CHILD PARTS BY FRF

Caliper Without Piston:

Sr. No.	Frequency(Hz)	Sr. No	Frequency(Hz)
1.	2221	11.	8140
2.	2701	12.	8703
3.	3708	13.	9326
4.	4488	14.	10720
5.	5014	15.	12854
6.	6094	16.	13292
7.	6563	17.	13777
8.	7021	18.	14574
9.	7203	19.	15078
10.	7337	20.	15284

Disc Brake Rotor:

Sr. No	Frequency(Hz)	Sr. No	Frequency(Hz)
1.	1374	15.	7221
2.	2675	16.	7660
3.	2995	17.	8672
4.	3166	18.	9024
5.	3209	19.	9248
6.	3395	20.	9290
7.	3494	21.	9331
8.	4373	22.	10145
9.	4752	23.	10715
10.	5943	24.	11004
11.	6038	25.	12098
12.	6245	26.	12598

13.	6303	27.	12781
14.	6670	28.	12781

VI. EIGEN VALUES FOR CHILD PARTS BY CAE

The rapid development of specialized test equipment and efficient numerical methods for modal calculation of structures has revolutionized vibration analysis. The computational analysis of automotive noise, vibration, and harshness (NVH) performance is most often done with mode based finite element procedures. The accuracy of such analyses increases if the associated frequency range is increased to cover a larger fraction of the audible spectrum. However, the increased accuracy comes at the expense of model size; mesh refinement must increase to accurately capture higher frequency modes .The Eigen Frequency Values calculated By Modal analysis in abauqs .The input parameters like Material properties, elastic modulus are inserted in software .

Caliper Without Piston:

Sr. No.	Frequency(Hz)	Sr. No.	Frequency(Hz)
1.	2177	11.	7911
2.	2728	12.	8126
3.	3457	13.	8921
4.	4466	14.	10824
5.	4883	15.	12557
6.	5664	16.	13386
7.	5998	17.	14158
8.	6664	18.	14517
9.	6934	19.	15078
10.	7266	20.	15542

Disc Brake Rotor

Sr. No.	Frequency(Hz)	Sr. No.	Frequency(Hz)
1.	1382	15.	7338
2.	2689	16.	7695
3.	3016	17.	8756
4.	3182	18.	8955
5.	3206	19.	9110
6.	3404	20.	9241
7.	3419	21.	9425
8.	4309	22.	10230
9.	4795	23.	10816

IJARSE
ISSN 2319 - 8354

10.	5748	24.	10892
11.	5987	25.	12015
12.	6290	26.	12558
13.	6327	27.	12878
14.	6734	28.	12895

VII.COMPARISON BETWEEN FEA & FRF

Caliper Without piston:

Modes	FEA	FRF	FEA-FRF	%Variation
1.	2177	2221	-45	-2.0
2.	2728	2701	27	1.0
3.	3457	3708	-250	-6.8
4.	4466	4488	-23	-0.5
5.	4883	5014	-131	-2.6
6.	5664	6094	-431	-7.1
7.	4998	6563	-565	-8.6
8.	6664	7021	-356	-5.1
9.	6934	7203	-269	-3.7
10.	7266	7337	-70	.1.0
11.	7911	8140	-229	-2.8
12.	8126	8703	-577	-6.6
13.	8921	9326	-405	-4.3
14.	10824	10720	104	1.0
15.	12557	12854	-297	-2.3
16.	13386	13292	94	0.7
17.	14158	13777	381	2.8
18.	14517	14574	-58	-0.4
19.	15078	15078	0	0.0
20.	15542	15284	259	1.7

Disc Brake Rotor:

Modes	FEA	FRF	FEA-FRF	% Variation
1.	1382	1374	8	0.6
2.	2689	2675	14	0.5
3.	3016	2995	21	0.7
4.	3182	3166	16	0.5
5.	3206	3209	-3	-0.1
6.	3404	3395	9	0.3
7.	3419	3494	-75	-2.1
8.	4309	4373	-64	-1.5
9.	4795	4752	43	0.9
10.	5748	5943	-195	-3.3
11.	5987	6038	-51	-0.8
12.	6290	6245	45	0.7
13.	6327	6303	24	0.4
14.	6734	6670	64	1.0
15.	7338	7221	117	1.6
16.	7695	7660	35	0.5
17.	8756	8672	84	1.0
18.	8955	9024	-69	-0.8
19.	9110	9248	-138	-1.5
20.	9241	9290	-49	-0.5
21.	9425	9331	94	1.0
22.	10230	10145	85	0.8
23.	10816	10715	101	0.9
24.	10892	11004	-112	-1.0
25.	12015	12098	-83	-0.7
26	12558	12598	-40	-0.3
27.	12878	12781	97	0.8
28.	12895	12781	114	0.9

VIII.MODE SHAPES IN ABAQUS

For Disc Brake Rotor

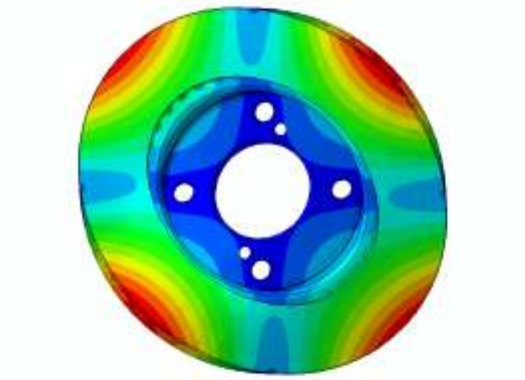

Fig.5 Mode Shape at Frequency 1382Hz.

For Bracket

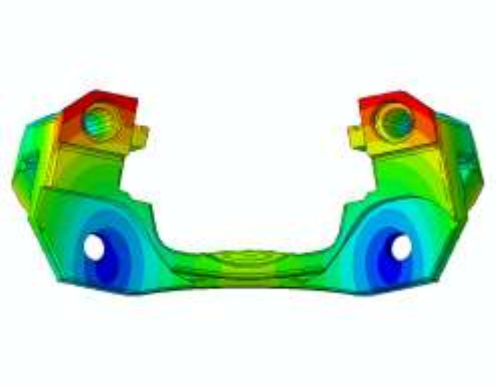

Fig.6 Mode Shape at Frequency 1159Hz.

For Pads

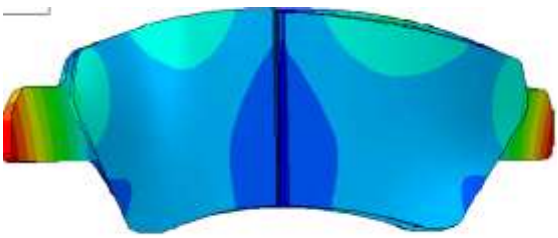

Fig.7 Mode Shape at Frequency 5236Hz.

IX.DISCUSSION

1.The main issues for accurately measuring brake Child Parts natural frequency and damping are Accelerometer location, attachment (cable/wire), contact excitation, and signal acquiring and processing.

2.The accelerometer mass effect on damping may be negligible when compared with the component

3.The frequency modes are selected by adjusting the cursors at highest amplitude peaks, peak may split in two in case of Double Hammer hitting. high frequencies, especially above 6 kHz. However, the effect may be case-by-case or mode-by-mode.

4.It should be noted that the study is based on a actual and CAE verification result for Common sized Components. The above experiment can Serve as a guideline. Further study may Include how the mass addition in component weight effects the frequency shift.

5. The LMS FFT analyzer is in Principle, the ideal method for measuring Natural frequency and damping. However, More channel FFT analyzer (pulse) can be used to measure natural frequencies of bigger component.

X. CONCLUSION

- The Process of Eigen Value analysis & Verification by FRF Testing Provide the Accurate cause of Noise generation in Disc and Drum Brakes.
- It is the system that covers most of the needs of different assessments strategies in NVH testing.
- The System is able to predict subjective rating for every noise event.
- The Mode Shapes we got in abaqus software are the simulation for the actual in plane and out plane modes of child parts.
- Eigen Value Determine whether the expected Frequency response violates the percentage variation criteria with the same part(with same manufactured batch)

REFERENCES

[1] SAE Paper 2002-01-0922 "Modal Coupling and Its Effect on Brake Squeal" Research and Vehicle Technology, Ford Motor Co.

[2] SAE International, surface vehicle recommended practices, Automotive Disc Brake pad Natural Frequency and Damping test, J2598, issued2006-01

[3] Brooks, P. C., Crolla, D. A., Lang, A. M. and Schafer, D. R.(1993). Eigenvalue sensitivity analysis applied to discbrake squeal. Proc. IMechE, C444/004, 135-143.

[4] Earles, S. W. E. and Chambers, P. W. (1987). Disc brake squeal noise generation: Predicting its dependency on system parameters including damping. Int. J. Vehicle Design 8, 4/5/6, 538-552.