Modal Analysis of an Automotive Bell Housing

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Abstract- **This paper details the modal (vibration) analysis performed on an automotive bell housing, which lists the natural frequencies, damped vibrations and mode shapes. The techniques used for determination of the above mentioned factors would be numerical and experimental methods.**

With respect to the numerical method, the aforementioned component is modeled on CATIA and the finite element model is analyzed on ANSYS and for a more practical approach, experimental modal analysis is performed using a fast Fourier transform analyzer to obtain the dynamic properties of the component in the frequency domain.

I. INTRODUCTION

Vibration qualification testing is currently indispensable for any vehicle manufacturer. Due to the reasons that excessive vibrations result in wear and tear of machine parts and also increase NVH levels in automobiles. The bell housing in particular is subjected to many loads, mainly from the two sides it is attached to. Which being the engine and the transmission, they are all linked in order to function as one entity. The more significant vibrations are the ones coming from the engine.

Modal analysis is used to determine the natural frequencies, damped vibrations and mode shapes at various periods. Finite element method and experimental testing enables us to deduce the structural integrity of the bell housing and also to better understand the system behavior.

Our goal is to find the vibration specifications of both numerical and experimental analysis used to validate the mechanical endurance of the bell housing experiencing vibration loadings. Therefore, it is necessary to study the behavior of the bell housing by analyzing its dynamic properties.

II. PROCEDURE

A. *Methodology*

The aspects here involved are numerical and experimental procedures, which are carried out in two phases. The numerical method consists of component design and FEA mathematical modelling. The experimental part consists of experimental modal testing.

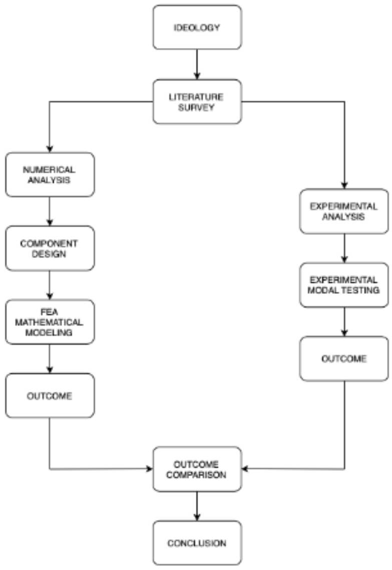

Table 1. Methodology

B. *Component Design*

Modeling of the bell housing is done on the CAD software – CATIA V5.

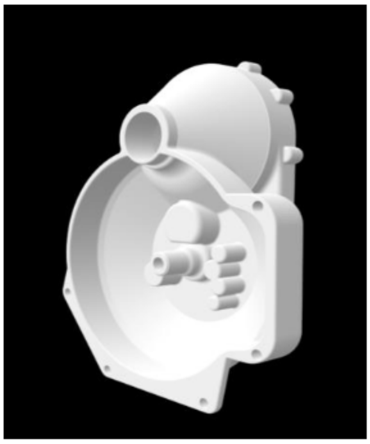

Fig. 1. 3D model of the bell housing

C. *FEA Mathematical Modeling*

Numerical analysis on ANSYS Workbench is done systematically. To begin, modal analysis is selected. The required data is inputted and the model is imported into the software. Similar to how the node points are assigned manually on the component, the meshing is taken care of by the software in a similar fashion. The meshed component is further solved for a total of 5 deformation solutions, which represent the mode shapes.

Material type	Gray Cast Iron
No. of mode shapes to find	11 (first 6 are not considered, since < 0)

Table 2. Properties of the component

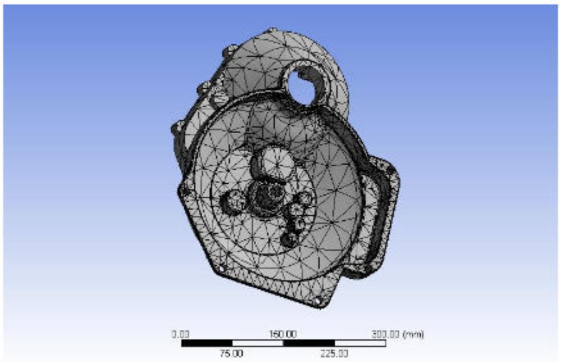

Fig. 2. Meshed structure of the component

D. *Experimental Setup*

To mimic infinite degrees of freedom in static condition, free-free analysis is conducted by suspending the component on a supporting structure. Dytran hammer (1) & Endevco isotron accelerometer (2) are the main input and output sources respectively. These channels are connected to the data acquisition system - N14431 (3), which are in turn recorded on the software - ME'scope (4).

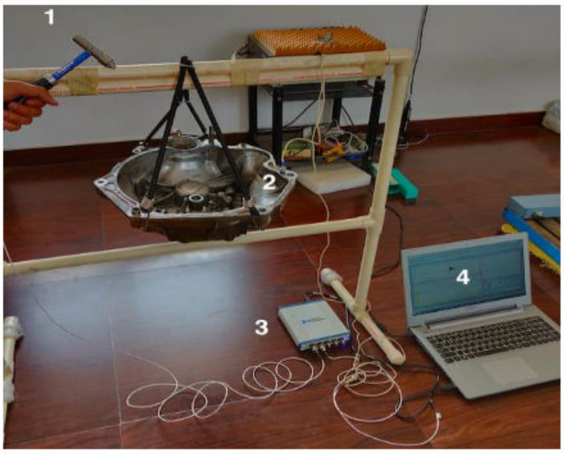

Fig. 3. Components of experimental setup

E. *Experimental Study*

Once the setup is complete. The node points are distributed evenly across the bell housing. Similarly, we have assigned 40 node points evenly across the surface around the base, top and around the component.

After the points have been marked, we begin the analysis by striking the hammer on the respective nodes in an ascending order. Each node is struck in the negative Z axis direction three times to get an average reading from the accelerometer. This is stored in the data acquisition system and fed into the fast Fourier transform analyzer software. The same procedure is again repeated for the next 39 nodes.

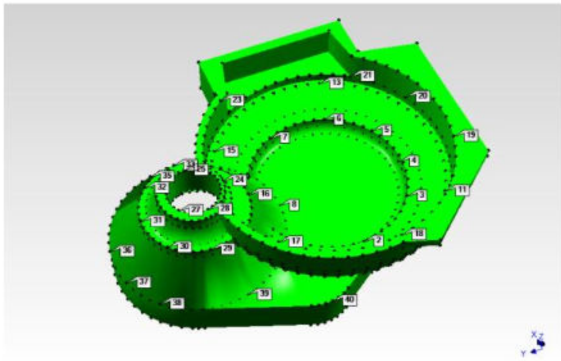

Fig. 4. Node points highlighted on the component

III. RESULTS

A. *Experimental Results*

Select Shape	Frequency (or Time)	Damping	Units	Damping (%)	Label	MPC
1	396.23	2.7201	Hz	0.68648	Global-Poly	0.92099
2	439.9	3.5383	Hz	0.80431	Global-Poly	0.96782
3	799.85	13.503	Hz	1.6879	Global-Poly	0.51944
4	893.53	11.412	Hz	1.277	Global-Poly	0.83886
5	1122.6	4.467	Hz	0.39789	Global-Poly	0.99056

Table 3. Frequencies from experimental testing

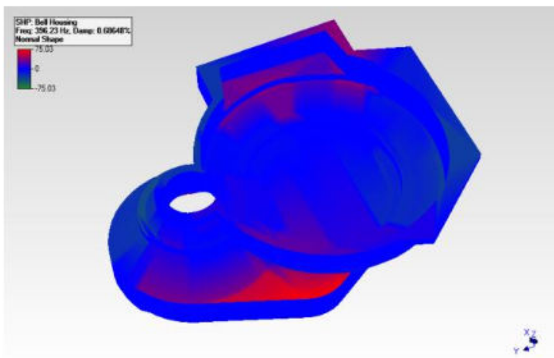

Fig. 5. Experimental method mode shape 1

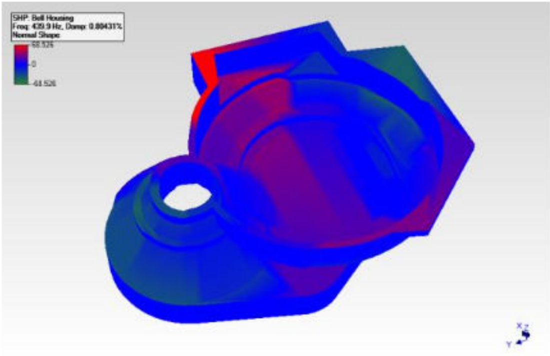

Fig. 6. Experimental method mode shape 2

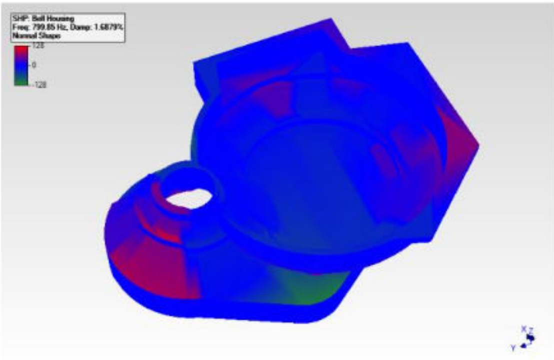

Fig. 7. Experimental method mode shape 3

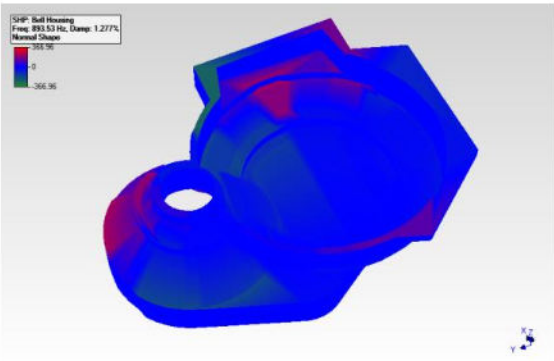

Fig. 8. Experimental method mode shape 4

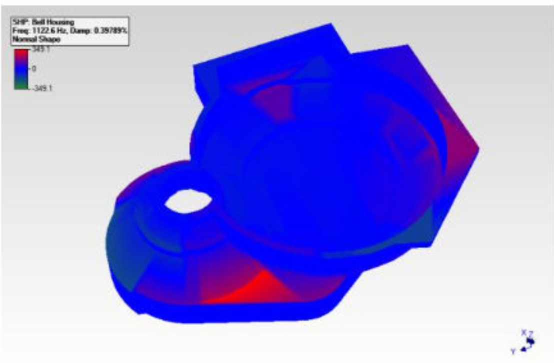

Fig. 9. Experimental method mode shape 5

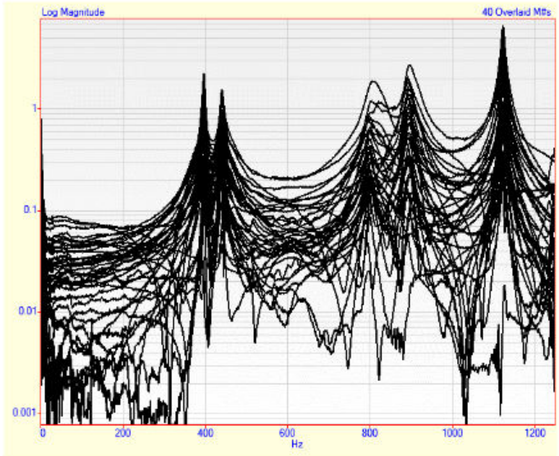

Fig. 10. Combination of frequency occurring at different points

B. *Numerical Results*

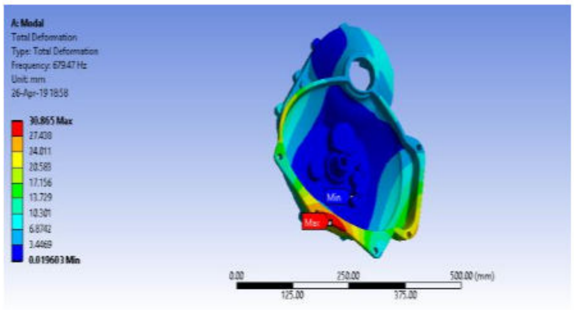

Fig. 11. Numerical method mode shape 1

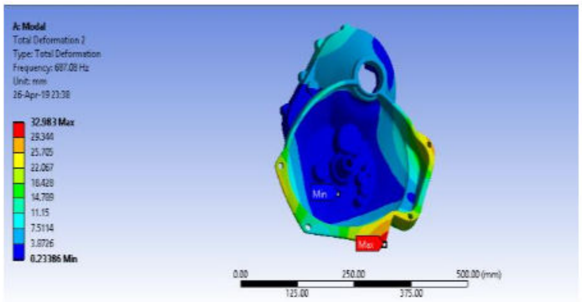

Fig. 12. Numerical method mode shape 2

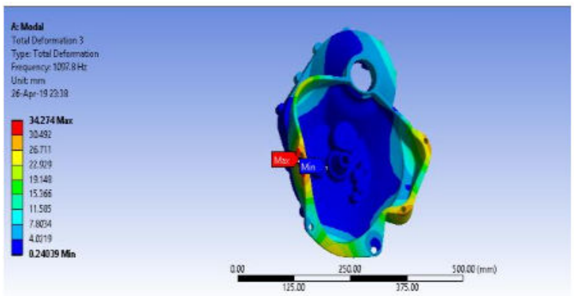

Fig. 13. Numerical method mode shape 3

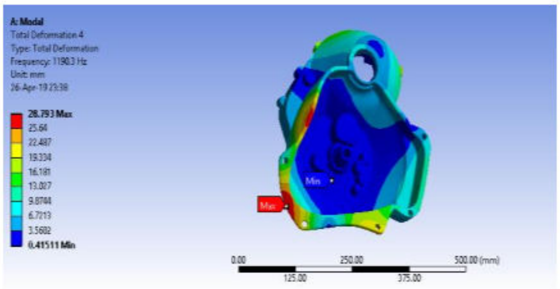

Fig. 14. Numerical method mode shape 4

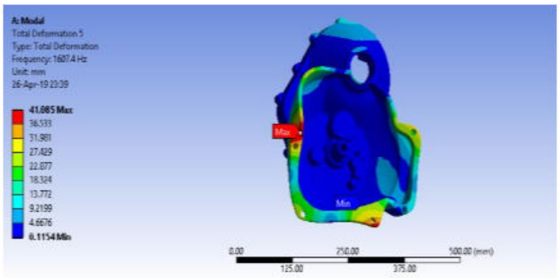

Fig. 15. Numerical method mode shape 5

Tabular Data

	Mode	Frequency [Hz]
1	1.	0.
2	2.	0.
3	3.	1.9484e-004
4	4.	7.3231e-004
5	5.	1.4672e-003
6	6.	2.2067e-003
7	7.	679.47
8	8.	687.08
9	9.	1097.8
10	10.	1190.3
11	11.	1607.4

Table 4. Frequencies from FEA testing

IV. CONCLUSION

After the results have been validated, development of a new bell housing can be carried out in reference to the results obtained to further modify the design depending on the required characteristics. Experimental and numerical methods are both incorporated to better understand the design and dynamic behavior of bell housing and also to validate the results.

V. REFERENCES

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