Modal Analysis of an Electric Motor Casing- In Comparison with FFT Analyzer

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Abstract--**Motor casing is an indispensable component of an electric motor which reduces the noise level in the machine. Assuming that the casing is designed within the mechanical limits of its construction material, even though one of the most common causes of casing failure is vibration. Electric motor casing is also responsible for providing damage protection from external sources as well as prevention from dust particles. A vital component playing key role in optimized working of electric motor, the casing however is provided with notches, to provide ventilation to fan blades. This paper primarily focuses on modal analysis and investigates the mode shape frequency by FEM and experimental techniques. The results obtained by Finite Element Analysis are co related with the results obtained by FFT Analyzer on the motor casing, deviation of 9% is seen from natural frequency.**

Keywords- Motor Casing, FFT Analyzer, Modal Analysis, Natural frequency, Mode Shape

I. INTRODUCTION

In industrial applications Electric motor is involved in power driving. In an electric motor, the fan cover is having an aerodynamic design, which results in a significant reduction in noise level and an optimized airflow between the frame fins for heat exchange improvement [1]. By carrying out Modal analysis, we meet the objective of reliable and stable design of an electrical motor casing. The Finite Element Analysis which comprises of Numerical Modal Analysis helps us to determine the vibration characteristics of the motor namely natural frequencies, mode shapes as well as impact characteristics [2].

The modeling was done for Electric Motor Casing using commercially available software CATIA. The developed CAD model is meshed using FEM software. Subsequently element selection for the model is done from the element library and the respective figure is as shown.

II. FINITE ELEMENT ANALYSIS OF ELECTRICAL MOTOR CASING

The material properties of electric motor in brief are Structural Steel model of Solid 187 element (a 3D 10 Node Quad Element). The meshed part consists of total 1587 elements and 1639 nodes. The program defined technique is used to extract first 8 natural frequencies and mode shapes using ANSYS 14.5®.

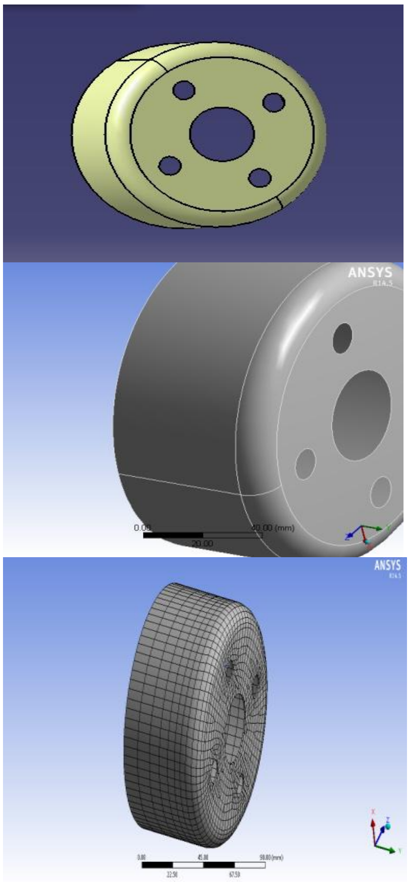

Fig. (1) 3D CAD Model of Electrical Motor Casing

Using the numerical method, the model was subjected to Modal Analysis using ANSYS Workbench 14.5®. During the Modal Analysis the generated model involved in ANSYS software was incorporated & the Analysis was carried out. [4] After the Analysis the eight natural frequencies and mode shapes were obtained for electrical motor casing. From the result obtained we were able to estimate structural deformation of the material with respect to their excitation natural frequency and the results are as shown.

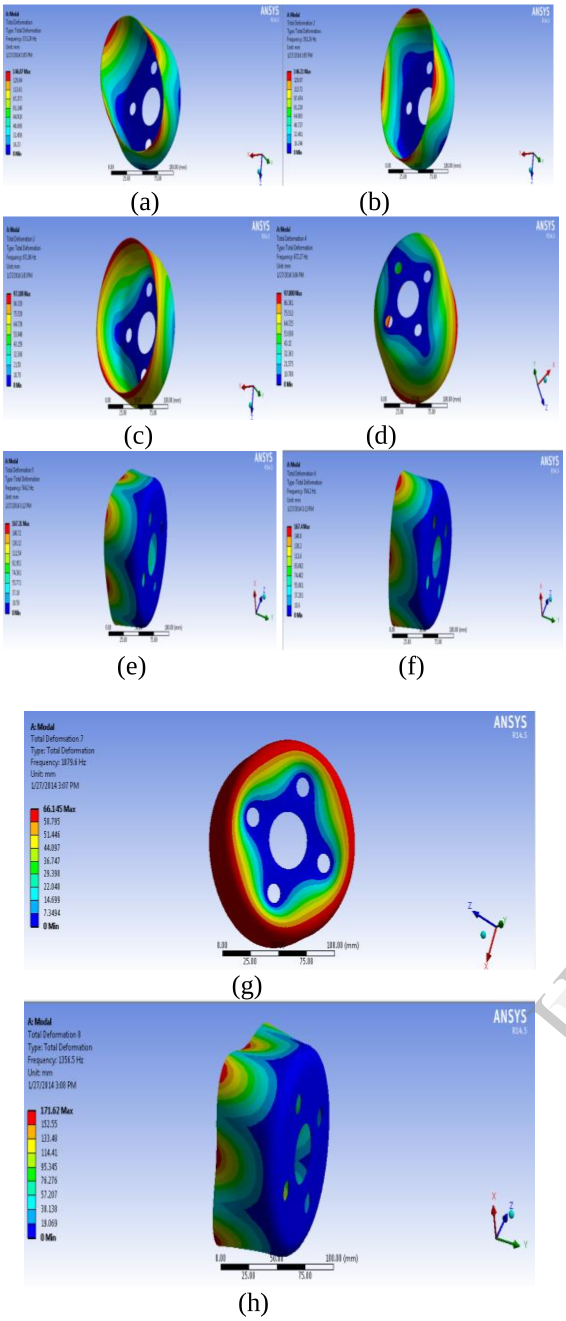

Figure 2. (a) - (h) - Mode shapes of Electric Motor

IV. EXPERIMENTAL TESTING

In the experimental setup, first the positions at which the readings of natural frequencies were to be taken were marked, and then accelerometer sensors were attached to the electric motor casing. As the setup suggests, it was connected to Data Acquisition Unit to collect vibration measurements. Fast Fourier Transform (FFT), a technique used to obtain real-time measurements of the vibration characteristics of an electric motor. Fast Fourier Transform (FFT) is advancement in the Discrete Fourier Transform (DFT).Which basically cancels out the duplicated terms in the mathematical algorithm, which moreover reduces the number of operations involved [5]. Therefore, it is possible to get large samples without compromising the speed of transformation of data involved.

Fig.4 Marking Positions for Accelerometer

(i) Modal Analysis Results obtained from FEA and experimental results:

EXPERIMENTAL DATA:-

In the experimental analysis we have used the setup of OROS (OR34 VS-4) which is a 4 Channel FFT Analyzer Data Acquisition System. The unit comprises of following:-

- DYTRAN Impact Hammer - 1pc
- Uni-axial Accelerometer Sensors- 2 pc
- Microphone - 1pc

(a)

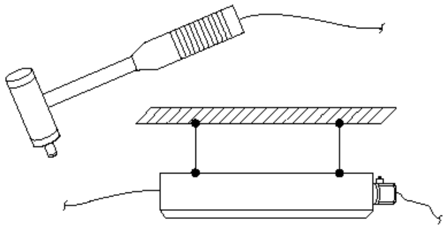

Figure 5. (a) OR34 VS-4 Data Acquisition system (b) Line diagram of FFT Setup

(ii) Experimental Setup:
The data extracted from the Data Acquisition System and respective software NVGATE. The acceleration v/s frequency data i.e. frequency domain data is obtained and shown below.

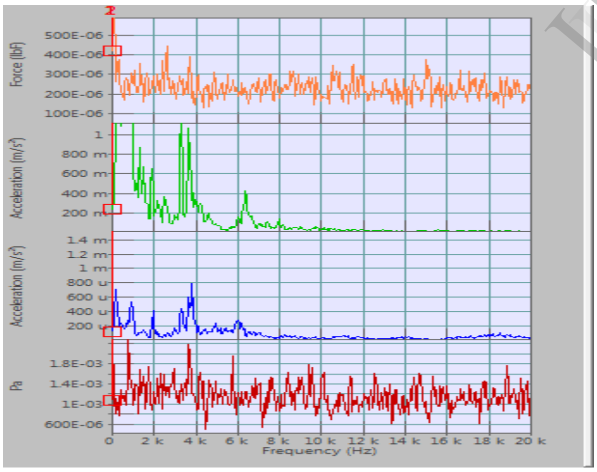

Figure 6.(a)Frequency Domain Measurements

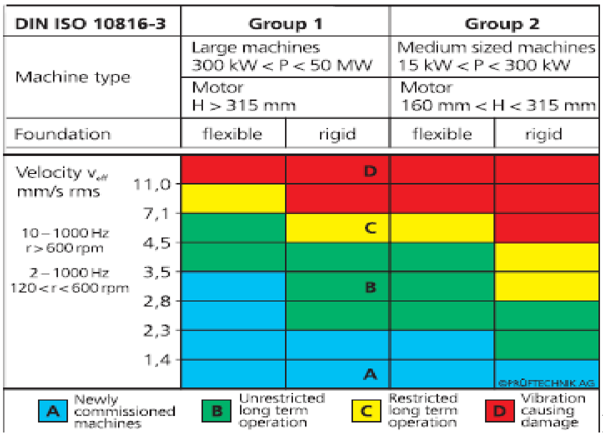

Fig. 6 (b) Graph of ISO prerequisites

Number of modes and natural frequencies obtained by experimental setup and FEA:

Modes	Frequency [Hz] FFT Result	Frequency [Hz] ANSYS	Mode Shape
1.	361	331.28	Mode 1
2.	405	391.26	Mode 2
3.	691	671.06	Mode 3
4.	698	672.27	Mode 4
5.	720		
6.	745	764.2	Mode 5
7.	770	764.2	Mode 6
8.	805		
9.	830		
10.	865		
11.	895		
12.	910		
13.	940		
14.	970		
15.	1005		
16.	1025		
17.	1055		
18.	1080	1079.6	Mode 7
19.	1105		
20.	1136		
21.	1162		
22.	1189		
23.	1209		
24.	1246		
25.	1279		
26.	1298		
27.	1305		
28.	1325		
29.	1362	1356.5	Mode 8
30.	1392		
31.	1403		

Figure 7. Chart of Comparison between FFT and ANSYS results. (Element analysis values at only predefined nodes were taken in order to get satisfactory results.)

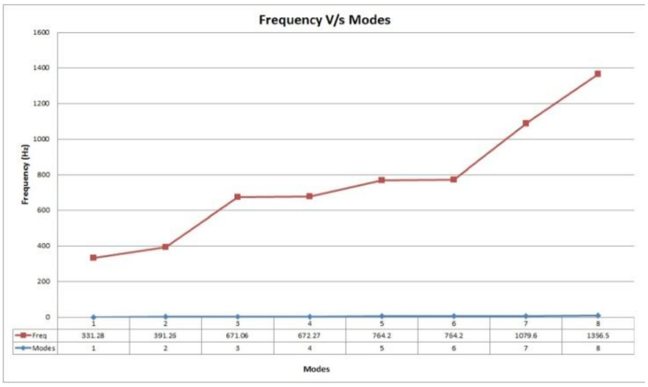

Figure 8. Plot of Frequency v/s Modes using the ANSYS workbench 14.5®

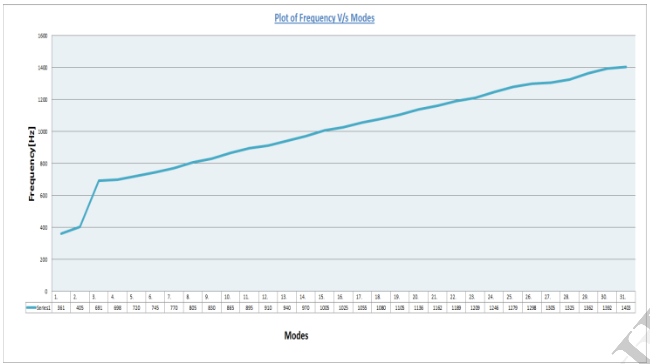

Figure 9. Plot of Frequency v/s Modes using the Experimental Analysis (FFT Analyser)

V. RESULT & DISCUSSION

The values of natural frequencies by FEA are then compared with frequency obtained by FFT analysis and it is found that the deviation of frequencies was found to be within the required limits i.e. 9%. It is found that these values are as per ISO standards. The difference in the experimentation results and FEA results may be mainly because of difference of material properties especially density, Poisson's ratio, young's modulus etc and uneven thickness of the casing. In addition, the patterns of the predicted mode shapes are similar to the experimental mode shapes. It can be concluded that the FEA results for of Electrical Motor Cover shows close agreement with the experimental modal test data.

A comparison of the obtained is made with the ISO standards (DIN-ISO 10816-3) which help in setting up a safe limit for machine working conditions. Analysis has been carried out to examine in detail the vibration characteristics of the top casing of Electrical Motor Cover using ANSYS 14.5®.

VI. CONCLUSIONS

In this paper, Generally, Modal analysis is carried out using Finite Element Methods but nowadays companies are already trying out new techniques for analysis so we tried to compare both the analysis techniques ANSYS and Experimental setup (FFT Analyzer). From experimental setup we were able to find results in both time-domain and frequency domain. The plots of the output are studied and the Natural Frequency, Modes are calculated from it. From the experimental FFT Data we have compared the values those obtained from the ANSYS Workbench 14.5®, and came to conclusion that the values from both the methods are varying by 9% and which is in desirable limits.

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