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Study and Vibration Analysis of Two Wheeler Silencer

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***Abstract*—The vibrations of silencer are affecting the performance of silencer and it is uncomfortable to operators. So it is necessary to reduce the vibrations. Modal analysis is a technique which is used to find natural characteristics of structure like natural frequency and mode shapes. In this paper, three silencers having different material properties are taken and modal analysis is carried out using finite element analysis (FEA) method by using ANSYS 16.0 software and these results are compared with reading taken on experimental modal analysis by using FFT analyzer, so as to analyze the working frequency from natural frequency and avoid resonating condition. Also we can choose better material for silencer which has minimum vibrations.**

Keywords—Modal analysis, Silencer, Finite element analysis (FEM), FFT analyzer.

I. INTRODUCTION

The silencer is main part of exhaust system of internal combustion engine. The exhaust gases leave from the engine at very high speeds. During each cycle of combustion the exhaust valves opens and closes simultaneously so that exhaust gas pressure changes continuously from high to low causing a vibration and noise. The basic function of silencer is to reduce noise and vibrations produced by exhaust gases. The silencer vibration contributes the total vibrations of two wheeler. Due to vibrations it is subjected to several stresses. When working frequency matches with natural frequency then resonance happens, so it is necessary to reduce vibrations and avoid resonating condition. It is therefore to study the behavior of silencer by analyzing the vibration modes and response of vibrations by its sources, also to minimize crack, improving life and efficiency of silencer. Aminudin Abu [1] studied the dynamic properties of silencer like natural frequency and mode shapes. These properties were calculated by using Transfer matrix method and Finite Element Method. Also the hanger location of the exhaust system is determined by estimation of the normal mode of the total exhaust system. Vinay Gupta et al. [2] designed exhaust system with the specified properties of different materials in solid works. The deformation of silencer parts was calculated for the same exhaust thrust. Sidharam Ambadas Basaragi [3] modeling the exhaust system by using a FEM package with specified properties of material. Also the readings of natural frequencies were taken experimentally by FFT analyzer. It was useful for the design of silencer to avoid the resonance. Mr. Amit Asabe and Prof. Pravin P Hujare [4] were done modal analysis of existing silencer and modified silencer theoretically by FEM method and experimentally by FFT analyzer. He found that, the modified silencer gives better dynamic performance as compared to existing silencer. Saurabh Jadhav and Apoorv Prem [5] studied the noise and pollution performance of a 100cc motorcycle of conventional silencer and new designed Helmholtz silencer. They found that, the new designed silencer were more efficient than conventional silencer in terms of flow rate, pressure drop, heat dissipation capacity and packaging constraints. Krishnal Bhangale et al. [6] studied the different design configurations by using transfer matrix method to find out transmission losses and compared with numerical predictions. Key Fonseca de Lima et al. [7] studied the application of shape and parametric optimization techniques in the reactive silencer with extended inlet and outlet ducts. Parametric optimization used to calculate the approximate size of the inlet and outlet ducts. Shape optimization used to design the proper profile of the ducts which improves the features of muffler. T. Pride [8] determined the noise produced by various major elements of vehicles. Jian-Hua Fang et al. [9] designed the exhaust noise measurement system especially for the excavator. The exhaust engine noise from an excavator produced by a construction machinery corporation was measured and analyzed. Then seven mufflers with different structures were designed. After analyzing the frequency spectrums of seven impedance mufflers of different structures respectively, we selected the one muffler which was of best noise elimination performance among the seven mufflers. Takashi Yasuda et al. [10] studied the noise from the tail pipe experimentally and numerically under the condition of open throttle acceleration. Hongiun Liu and Shuyahi [11] modeled exhaust system in solid works and then makes its finite element analysis of frequency to research the relationship between lugs hanging position and amplitude. They found that to change the hanging position can reduce the maximum amplitude.

II. MODAL ANALYSIS USING FEA

Silencers of three different materials are modeled using CATIA V5 software and file is saved in IGS file format. This file is imported into ANSYS software and modal analysis is performed on the silencer by using ANSYS 16.0 workbench software. Silencer is fixed at one end to the L-shaped bracket so that it acts like a cantilever beam. Initially, material properties of silencer were assigned then geometry was imported into ANSYS 16.0 software and meshing was done on imported silencer model. For meshing tetrahedron element was selected. After meshing nodes and elements obtained. The nodes and elements for silencer of material SUS436j1L are 27496 and 12256 respectively. The nodes and elements for silencer of material SUS409L are 19304 and 39870 respectively. The nodes and elements for silencer of material SUS436L are 14239 and 30739 respectively. Finally, modal analysis was performed to find out natural frequency and mode shapes of silencer. Table I shows the material properties of three different silencers.

TABLE I. MATERIAL PROPERTIES OF THREE SILENCERS

MATERIAL PROPERTY	SUS436J1L	SUS409L	SUS436L
Young's modulus	2.03 x 10^5 MPa	2.86 x 10^5 MPa	2.06 x 10^5 MPa
Poisson's ratio	0.2	0.25	0.24
Mass density	7740 Kg/m^3	7730 Kg/m^3	7740 Kg/m^3

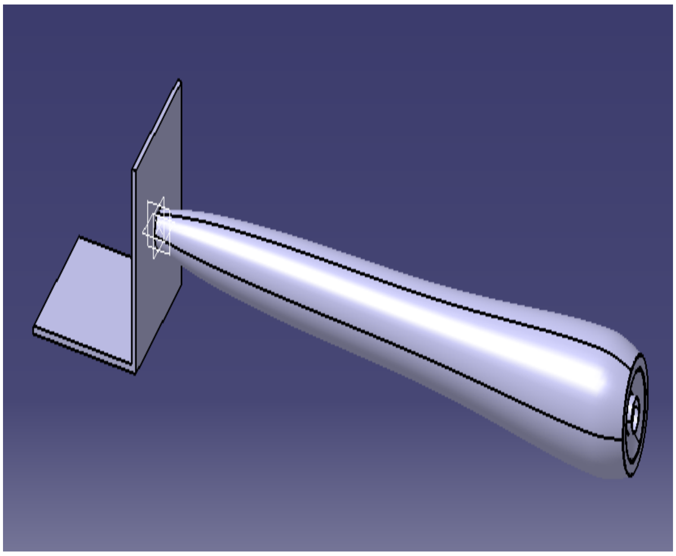

Fig.1 Catia model of silencer of material SUS436j1L

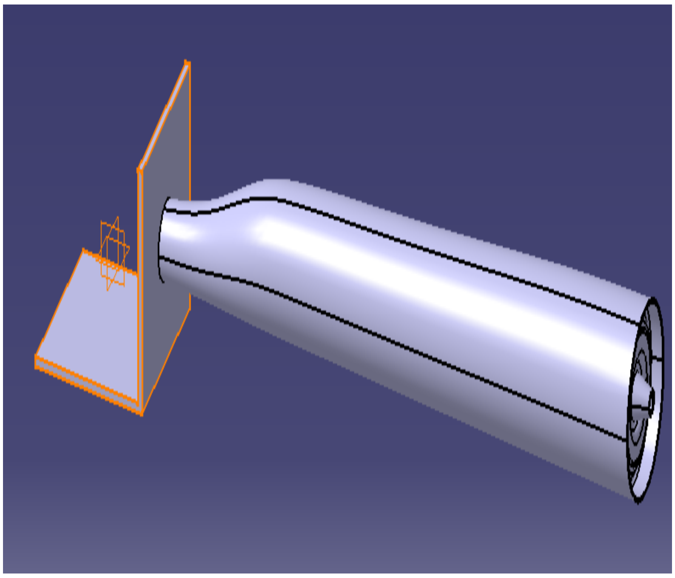

Fig.2 Catia model of silencer of material SUS409L

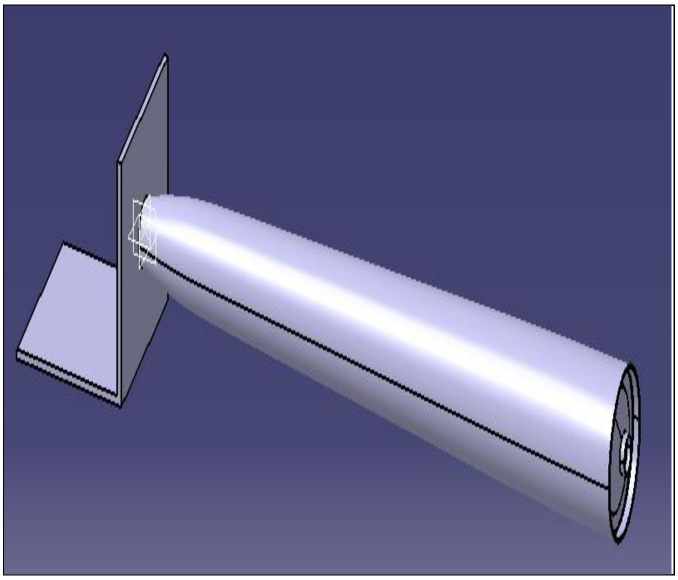

Fig.3 Catia model of silencer of material SUS436L

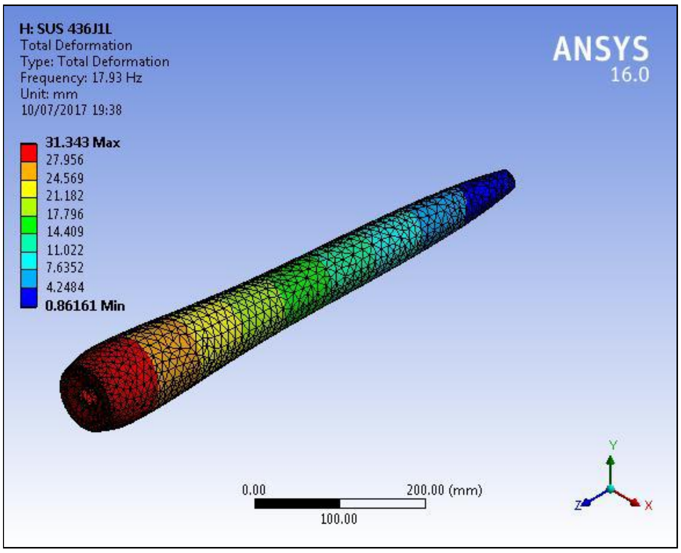

Fig. 4 First mode shape of Silencer of material SUS436j1L

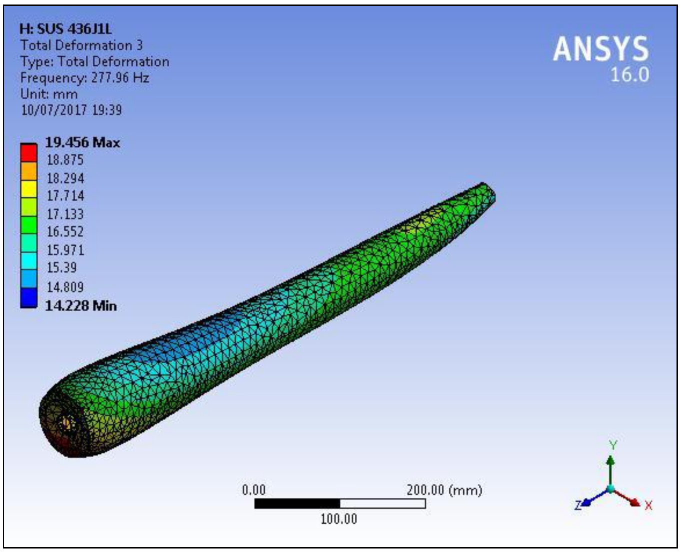

Fig. 5 Second mode shape of Silencer of material SUS436j1L

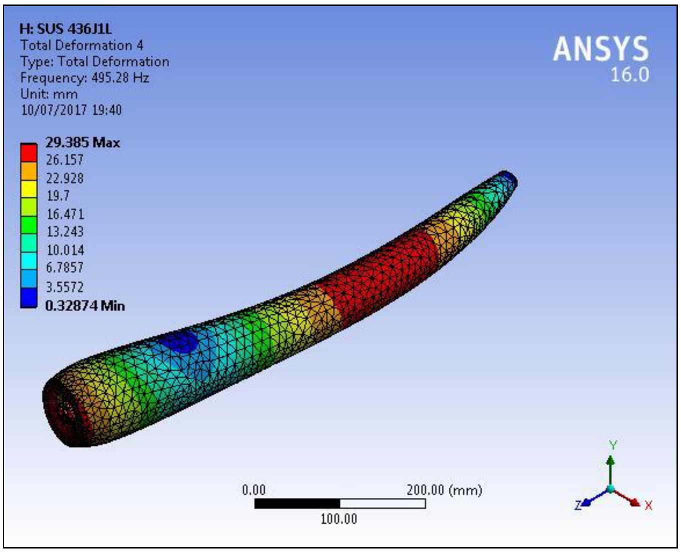

Fig. 6 Third mode shape of Silencer of material SUS436j1L

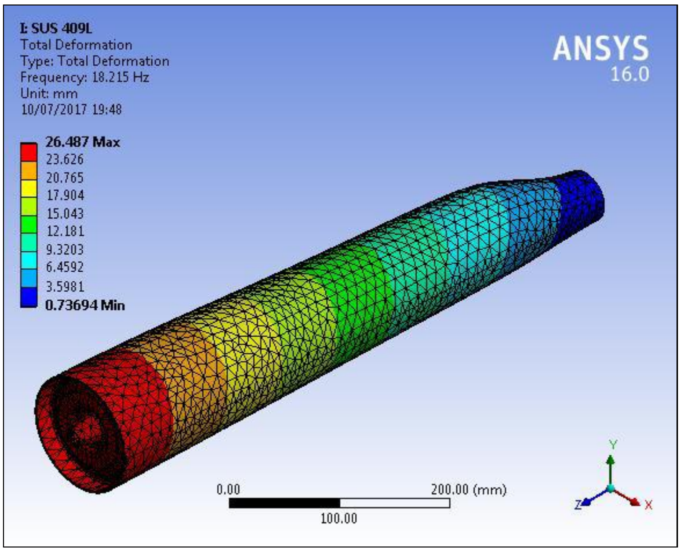

Fig.7 First mode shape of Silencer of material SUS409L

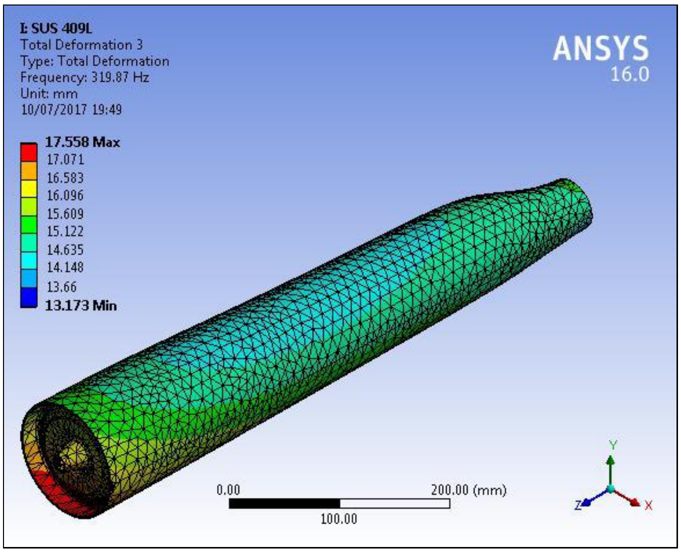

Fig.8 Second mode shape of Silencer of material SUS409L

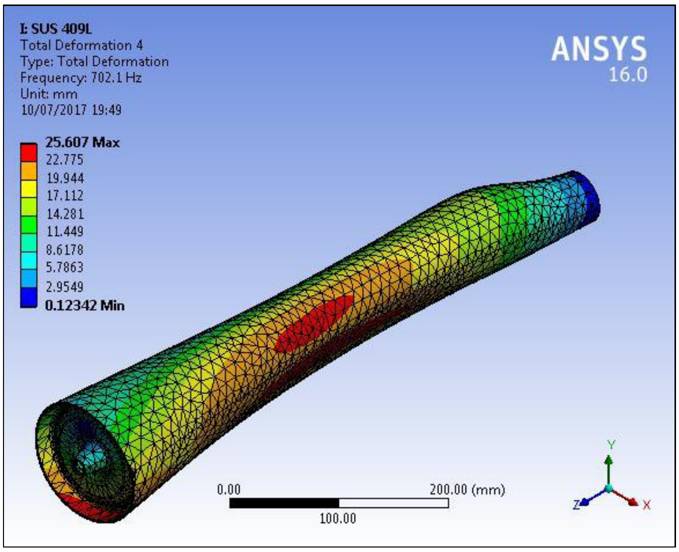

Fig. 9 Third mode shape of Silencer of material SUS409L

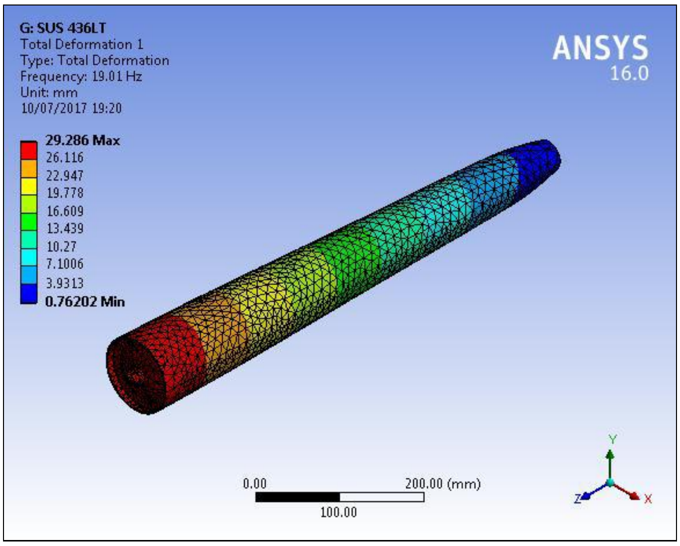

Fig.10 First mode shape of Silencer of material SUS436L

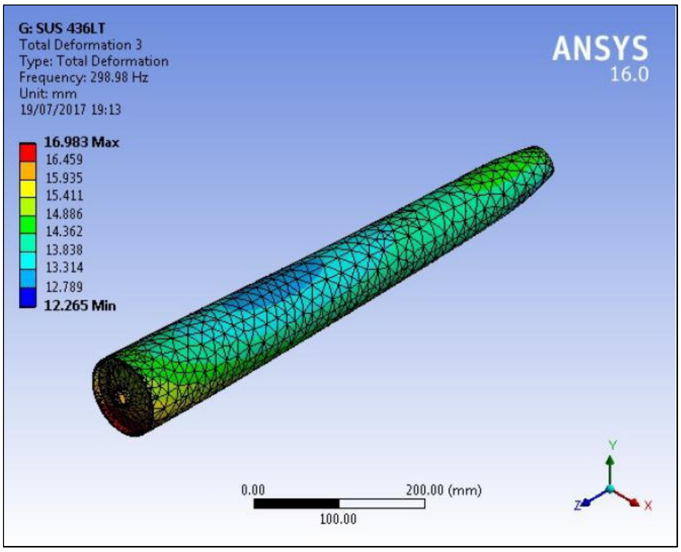

Fig. 11 Second mode shape of Silencer of material SUS436L

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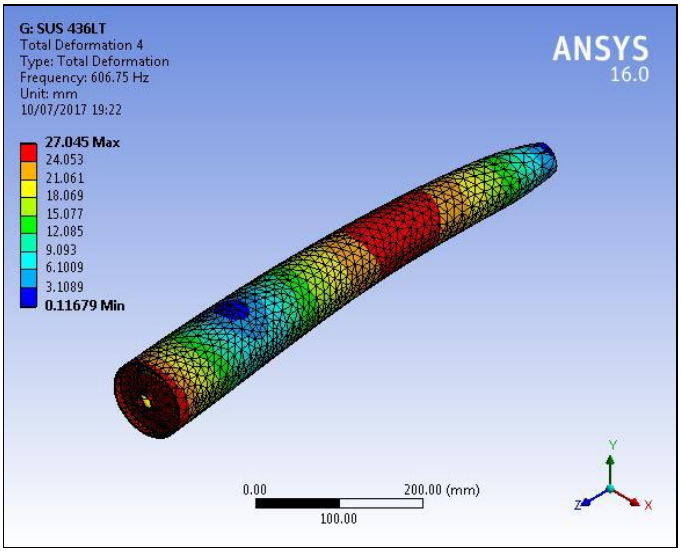

Fig. 12 Third mode shape of Silencer of material SUS436L

TABLE II. NATURAL FREQUENCIES BY ANSYS

MODE NO.	FREQUENCY (HZ)		
	SUS436j1L	*SUS409L*	*SUS436L*
1	17.93	18.215	19.01
2	277.96	319.87	298.98
3	495.28	702.1	606.75

III. EXPERIMENTAL MODAL ANALYSIS

In experimental modal analysis, the natural frequencies and mode shapes of silencers of different materials are obtained by measuring and analyzing the input and output response signals by using FFT analyzer. In this experiment, silencer is fixed at the one end with the help of L-shaped bracket and other end is free so that silencer acts as a cantilever beam. The accelerometer is placed on the surface of the silencer at different positions to sense the response signal. Silencer was excited with the help of impact hammer and input-output response is recorded by means of FFT analyzer. Fig. 13 shows schematic diagram of experimental setup.

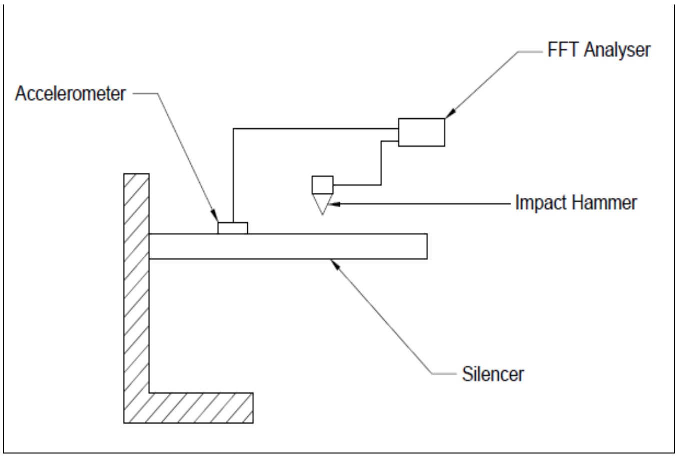

Fig.13 Schematic diagram of experimental setup

Fig. 14 Experimental Setup

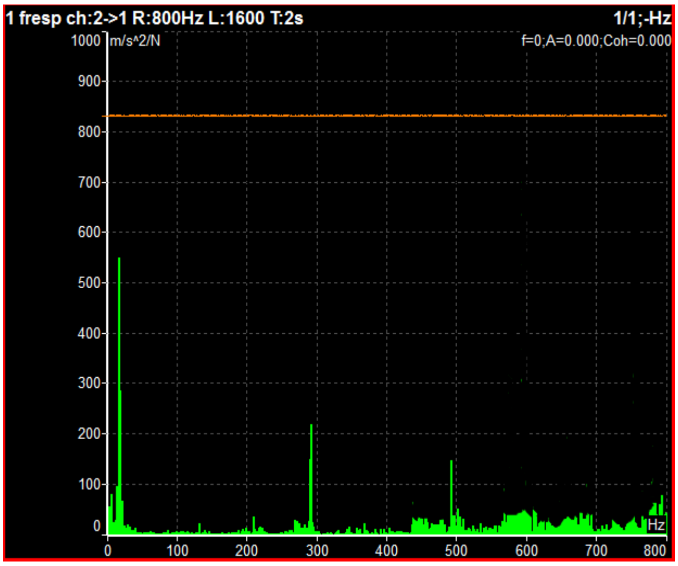

Fig. 15 Graph of frequency v/s acceleration of silencer of material SUS436j1L

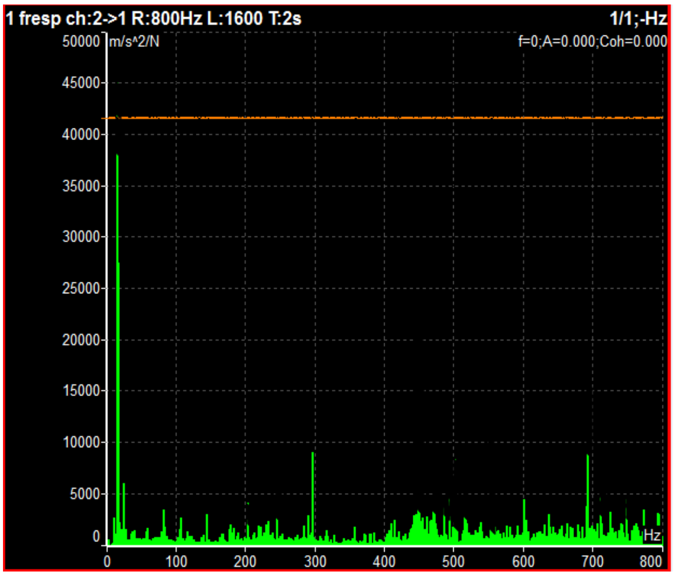

Fig. 16 Graph of frequency v/s acceleration of silencer of material SUS409L

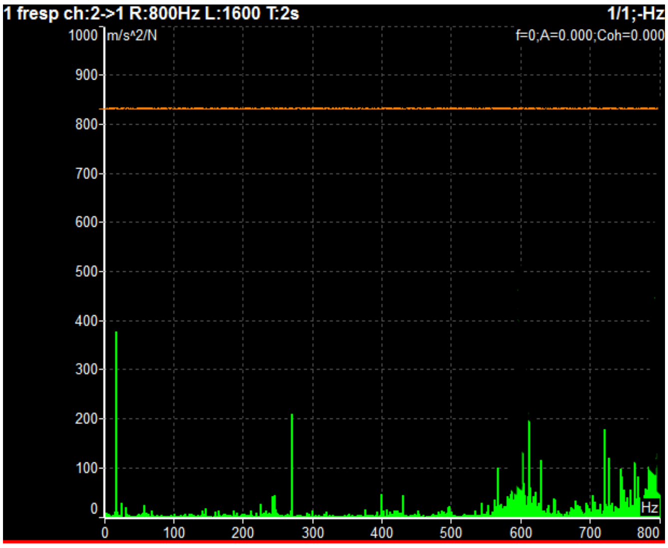

Fig. 17 Graph of frequency v/s acceleration of silencer material SUS436L

TABLE III. NATURAL FREQUENCIES BY FFT ANALYZER

MODE NO.	FREQUENCY (HZ)		
	SUS436j1L	SUS409L	SUS436L
1	16.25	20.01	18.27
2	286.5	300.11	279.13
3	490.31	692.11	621.35

IV. RESULTS

The results obtained by finite element analysis method and experimental analysis method of three different silencers are given in table below.

TABLE IV. COMPARISON OF MODES FOR SILENCER OF MATERIAL SUS436J1L

Mode No.	Natural frequency by FFT (Hz)	Natural Frequency by ANSYS (HZ)	Error (Hz)	% Error
1	16.25	17.93	1.68	9.36 %
2	286.5	277.96	8.54	2.98 %
3	490.31	495.28	4.97	1.00 %

TABLE V. COMPARISON OF MODES FOR SILENCER OF MATERIAL SUS409L

Mode No.	Natural frequency by FFT (Hz)	Natural Frequency by ANSYS (HZ)	Error (Hz)	% Error
1	20.01	18.215	1.795	8.97 %
2	300.11	319.87	19.76	6.17 %
3	692.11	702.1	9.99	1.42 %

TABLE VI. COMPARISON OF MODES FOR SILENCER OF MATERIAL SUS436L

Mode No.	Natural frequency by FFT (Hz)	Natural Frequency by ANSYS (HZ)	Error (Hz)	% Error
1	18.27	19.01	0.74	3.89 %
2	279.13	298.98	19.85	6.63 %
3	621.35	606.75	14.6	2.34 %

TABLE VII. COMPARISON FOR SILENCERS OF MATERIAL SUS409L AND SUS436J1L (BY ANSYS)

Mode No.	SUS409L	SUS436j1L	Increase in Natural frequency (Hz)	% increase in Natural frequency
1	18.215	17.93	0.285	1.26 %
2	319.87	277.96	41.91	13.10 %
3	702.1	495.28	206.82	29.45 %

TABLE VIII. COMPARISON FOR SILENCERS OF MATERIAL SUS409L AND SUS436L (BY ANSYS)

Mode No.	SUS409L	SUS436L	Increase in Natural frequency (Hz)	% increase in Natural frequency
1	18.215	19.01	-0.795	- 4.18 %
2	319.87	298.98	20.89	6.53 %
3	702.1	606.75	95.35	13.58 %

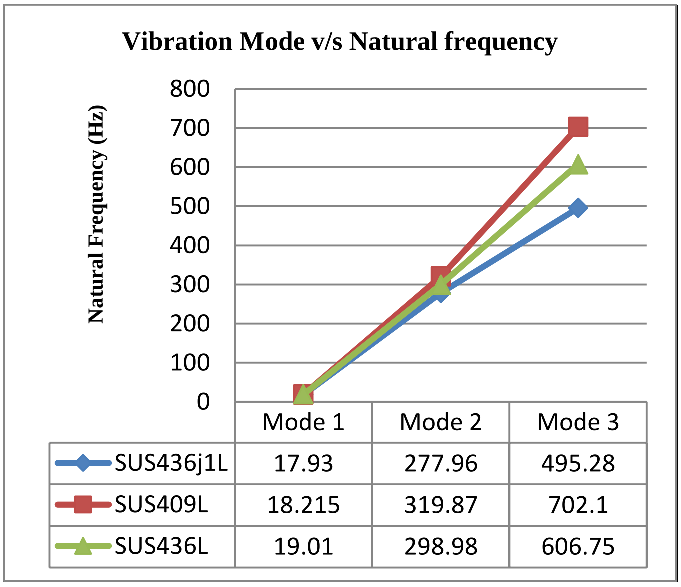

Fig. 18 Vibration Mode V/S Natural Frequency for three different silencers

TABLE IX. COMPARISON FOR SILENCERS OF MATERIAL SUS409L AND SUS436J1L (BY FFT)

Mode No.	SUS409L	SUS436j1L	Increase in Natural frequency (Hz)	% increase in Natural frequency
1	20.01	16.25	3.76	18.79 %
2	300.11	286.5	13.61	4.53 %
3	692.11	490.31	201.8	29.15 %

TABLE X. COMPARISON FOR SILENCERS OF MATERIAL SUS409L AND SUS436L (BY FFT)

Mode No.	SUS409L	SUS436L	Increase in Natural frequency (Hz)	% increase in Natural frequency
1	20.01	18.27	1.74	8.69 %
2	300.11	279.13	20.98	6.99 %
3	692.11	621.35	70.76	10.22%

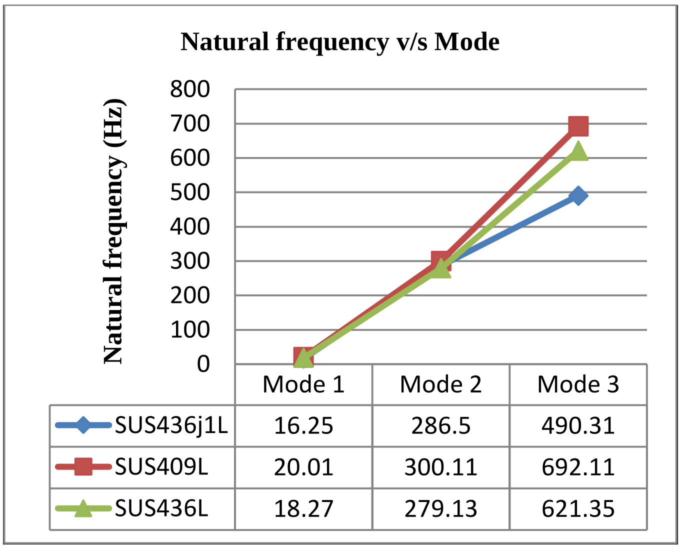

Fig. 19 Vibration Mode V/S Natural Frequency for three different silencers

V. CONCLUSION

The natural frequencies of silencers having different materials properties are calculated by finite element method (FEA) using ANSYS software and experimentally by using FFT analyzer. Also the deformations of three silencers having different material properties are calculated by ANSYS software. By comparing the results of both the methods, it shows that,

The increase in natural frequencies for silencer of material SUS409L is more than other two silencers of materials SUS436j1L and SUS436L. Therefore, the silencer of material SUS409L has more stiffness as compared to other two silencers, so it has minimum vibrations.

The natural frequencies calculated by FEA method and experimental method are nearly same. Therefore, the FEA results are verified with experimental results, so it is useful for design the silencer to avoid resonating condition.

Therefore, we choose the SUS409L material for manufacturing because of its high stiffness and it gives better dynamic performance.

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REFERENCES

[1] Aminudin Abu, “On the theoretical vibration analysis of the exhaust system” Journal Meckanikal, Jilid, Vol.1, 1996, pp. 61-75.
[2] Vinay Gupta, Dhananjay Kr. Singh, Dhirendra Kr. Singh, Madan Mohan Mishra, Satish Kumar Dwivedi, Ajay Yadav, “Vibrational Analysis of Exhaust Muffler” International journal of scientific and engineering research, Vol. 4(6), 2013, pp.1890-1893.
[3] Sidharam Ambadas Basargi, “Design and Development of Automobile Silencer for Effective Vibration Control” International journal of latest trends in engineering & technology, Vol. 5(1), 2015 pp.230-239.
[4] Mr. Amit Mahadeo Asabe, Prof. Pravin P Hujare, “Performance Enhancement of Automotive Silencer Using Finite Element Analysis” International journal of engineering science invention, Vol. 3(8), 2014, pp. 2319-6726.
[5] Saurabh Jadhav, Apoorv Prem, “A Comparative Study on performance parameters of a conventional silencer versus Helmholtz silencer implemented on a 100cc motorcycle” International Journal of Engineering Research & Applications, Vol. 4, Issue 6 (5), 2014, pp. 127-133.
[6] Krishnal Bhangale, Prof. Rajkumar Shivankar, Prof. P.K. Sharma, “Vibration Analysis of an automotive Silencer for Reduced Incidence of Failure” International journal of engineering & technical research, Vol.3(3), 2015, pp.79-84.
[7] Key Fonseca de Lima, Arcanjo Lenzi, Renato Barieri, “The study of reactive silencers by shape and parametric optimization techniques” Applied Acoustics, Vol. 72, 2011, pp.142-150.
[8] T. Pride “Origins of automotive vehicle noise” Journal of sound vibration, Vol.15 (1), 1971, pp. 61-63.
[9] Jian-HuaFang,Yi-Qi Zhou , Xiao-Dong Hu & Li Wang, “Measurement and analysis of Exhaust noise from Muffler on an Excavator” International journal of precision engineering & manufacturing, Vol. 10, No. 5, 2009, pp.59-66.
[10] Hongjun Liu, Shuya zhi, “Exhaust system finite element analysis and optimizing design” Advanced materials research, Vol. 538-541, 2012 pp. 590-594.
[11] V.P. Patekar, R.B. Patil, “Vibrational analysis of Automotive Exhaust silencer Based on FEM and FFT analyzer” International journal on Emerging Technologies, 2012 Vol.3(2), pp.1-3.