Review Article

ASSESSMENT OF DESIGN ALTERNATIVES WHILE CONDUCTING CAE ANALYSIS FOR SILENCER AND THE AUXILIARY COMPONENTS IN ITS SUB-ASSEMBLY

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INTRODUCTION

Silencer has to muffle the vibrations of the exhaust gases, reduce their velocity and thus reduce the amount of noise emitted from the engines. The pulsating flow from each cylinder's exhaust process of an automobile petrol or diesel engine sets up pressure waves in the exhaust system-the exhaust port and the manifold having average pressure levels higher than the atmospheric. This varies with the engine speed and load. At higher speeds and loads the exhaust manifold is at pressures substantially above atmospheric pressure. These pressure waves propagate at speed of the sound relative to the moving exhaust gas, which escapes with a high velocity producing an objectionable exhaust boom or noise. A suitably designed exhaust silencer or muffler accomplishes the muffling of this exhaust noise. This, along with other factors, induces vibrations in the exhaust system. Since silencer happens to be at the tail end with limited scope for supporting along its length, the influence of vibrations could be more prominent over this component.

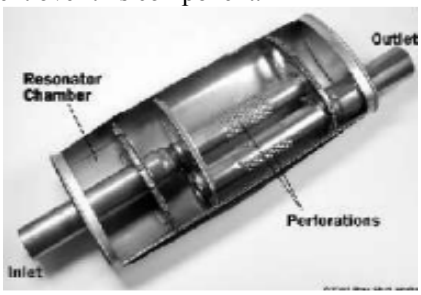

Figure: Typical automotive muffler

NEED FOR ANALYSIS:-

The Automobile silencer under study belongs to a popular 2- Wheeler manufacturer in India with the rated HP of the engine upto @13.5HP. The exhaust gases coming out from engine are at very high speed and temperature. Silencer has to reduce noise, vibrations. While doing so it is subjected to thermal, vibration and fatigue failures which cause cracks.

OBJECTIVES: -

- Select a suitable geometry for benchmark study
- Identify using CAE tools the nature and characteristics of natural frequencies (mode shapes)
- Revise the geometry in an effort to reduce the unfavorable effects (resonance or stress concentration)
- Analyze the revised geometry for Modes and Structural strength (of bracket)
- Any auxiliary effects of temperature or flow could be included in the study, if required
- Recommend the best design alternative

INDUSTRIAL RELEVANCE:-

Every exhaust system of an industrial or automobile system where hot gases discharge from the combustion chamber into the surrounding atmosphere at relatively high velocities has a silencer as an integral part of the system. The Automotive silencer attempts to reduce the audible noise levels in the proximity of the system to acceptable limits for human comfort. While doing so, it has to withstand stresses induced due to heat and other factors such as vibration, fatigue etc.

As such, any improvement made to the silencer would directly enhance the function of silencer with marked improvement in its effective life-span.

Generic Approaches, Techniques and Methodology:-

1) Mathematical/ Numerical approach

This is global approach, based on the loading definition, the modeling of the constitutive law and of the damage and a failure criterion. This approach is applied on cylinder heads and on exhaust manifolds submitted to transient thermal loading and permits to predict the cracked area as well as the lifetime.

2) Computational/Analytical approach

This presents a computational approach for the lifetime assessment of structures. One of the main features of the work is the search for simplicity and robustness in all steps of the modeling, in order to match the proposed method with industrial constraints. The proposed method is composed of a fluid flow, a thermal and a mechanical finite element computation, as well as a final fatigue analysis.

The CAE software has intuitive graphical interface with direct access to CAD geometry, advanced meshing, integration with other compatible software for solving. It is optimized for large scale systems, assemblies, dynamics and NVH simulations. It has graphical interface with direct access to CAD geometry, most suitable for fatigue analysis.

3) Experimental set up (Physical Testing)

With the use of experimental set-up we can analyze the fatigue and vibrations for silencer. In lab silencer would be tested to give results required. Of above approaches computational approach will give results more close to practical values through simulation/ analyses. The technique would deploy any of the following software tools: Abaqus, Patran/ Nastran, ANSYS, MSC fatigue or any compatible CAE software

For this work, the Analytical approach (CAE software) and the Physical experimentation would be explored for finding solution

STEPS FOR ANALYTICAL METHODOLOGY:-

- Creation of Geometry for silencer.
- Importing the geometry for meshing.
- Solving for the meshed model with constraints and boundary conditions.
- Viewing the results during post-processing.
- Interpretation over the results.
- Recommendations.

EXPERIMENTATION/ VALIDATION

The experimental validation is done by using FFT (Fast Fourier Transform) analyzer. The FFT spectrum analyzer samples the input signal, computes the magnitude of its sine and cosine components, and displays the spectrum of these measured frequency components. The advantage of this technique is its speed. Because FFT spectrum analyzers measure all frequency components at the same time, the technique offers the possibility of being hundreds of times faster than traditional analog spectrum analyzers.

LIERATURE REVIEW

1. *"A material and gauge thickness sensitivity analysis on the NVH and crashworthiness of automotive instrument panel support." K.P. Lam, K. Behdinan, W.L. Cleghorn,* this paper provides a finite element analysis of the effects of using alternative materials and gauge thickness on the weight and structural performance of the VN127 instrument panel support. Two types of analyses were performed, NVH and crashworthiness. The NVH analysis was used to determine the structure's natural frequencies, whereas the crashworthiness analysis was used to examine the structure's crash behavior under two different impact conditions. According to the results obtained from the crash simulations, the thickness of the Al model must be increased by 40% in order to achieve a crashworthiness performance that is comparable to that achieved by the baseline model.

2. *"A new technique based on traditional wavelet transform used in NVH application of internal combustion engine." Guo-Xi Jing, Zhi-Yong Hao*

In this study a new technique that is based on traditional wavelet transform and has many advantages over traditional spectrograms is proposed in this study. The sound and vibration signal of internal combustion engine (ICE) is typically unsteady and very complex. Recently the wavelet transform, we see, is being widely used as a time–frequency representation. The performance of the new technique is validated by applying it to a numerical simulation and test signals. It is shown that the new technique is suited for complicated signals that contain multiple impacts and/or dynamic changes in time and frequency domain.

3. *"Comparison and implementation of the various numerical methods used for calculating transmission loss in silencer systems." S. Bilawchuk, K.R. Fyfe*

Today, most silencer design is performed by simply modifying existing designs without full confidence of the new performance characteristics. Due to the size and expense of these silencers, it would be beneficial to have means to predict the insertion loss (IL) or transmission loss (TL) characteristics at the design stage. To properly accomplish this, many factors such as geometry, absorptive material properties, flow effects, break out noise, and self-generated noise must be considered. The conclusions were that the FEM is better suited for this kind of application and that the 3-point method was the fastest method and was easier to use than the 4-pole method.

4. *"Field measurement of the acoustical and airflow performance of interior natural-ventilation openings and silencers" Chris Bibby, Murray Hodgson**

This paper discusses measurements of the acoustical and airflow performance of interior natural ventilation openings and silencers ('ventilators') in existing buildings. It reviews the characterization of ventilator performance, and methods and theory for measuring it. Performance measures for sixteen ventilators in five buildings are presented and discussed. This paper reviewed the characterization of natural-ventilation opening and silencer ('ventilator') performance, including the definition of a new overall combined sound and airflow performance-optimization metric (the open area ratio). It then summarized methods for measuring ventilator performance and the supporting theory based on the results.

5. "*Numerical simulation of the flow field of a diffused pneumatic silencer" X.W. Zhang, Z.H. Yao, F. He*

The detailed structures of the inner and outer flow fields of the diffused pneumatic silencer were obtained. The simulation results displayed the characteristics of the flow in the silencer. The nature of the flow outside the silencer, comparable with the experimental data, was also obtained. Results of the simulation showed the characteristics of the inner flow field and the distribution of the external velocity of the silencer.

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4. Field measurement of the acoustical and airflow performance of interior natural-ventilation openings and silencers" Chris Bibby, Murray Hodgson* Acoustics & Noise Research Group, University of British Columbia, 3rd Floor, 2206 East Mall, Vancouver, BC V6T1Z3, Canada article i n f o Article history: Received 1 April 2013 Received in revised form 24 May 2013 Accepted 25 May 2013
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