EVALUATING THE DESIGN OF AN AUTOMOBILE SILENCER THROUGH FEA METHODOLOGY FOR MINIMIZING THE VIBRATIONS GENERATED DURING ITS OPERATION

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INTRODUCTION
The sole purpose of an automotive muffler is to reduce engine noise emission. If you have ever heard a car running without a muffler you will have an appreciation for the significant difference in noise level a muffler can make. If vehicles did not have a muffler there would be an unbearable amount of engine exhaust noise in our environment. Noise is defined as unwanted sound. The down side to reactive mufflers is that larger backpressures are created, however for passenger cars where noise emission and passenger comfort are highly valued reactive mufflers are ideal and can be seen on most passenger vehicles on our roads today. Sound is a pressure wave formed from pulses of alternating high and low pressure air. In an automotive engine, pressure waves are generated when the exhaust valve repeatedly opens and lets high-pressure gas into the exhaust system. These pressure pulses are the sound we hear. As the engine rpm increases so do the pressure fluctuations and therefore the sound emitted is of a higher frequency.

SPECIFICATIONS OF SILENCER:-
1. Material used:- CRCA/ SS
2. Thickness :- 1 to 2 mm
3. Weight: - Approx. 6–10 Kg.

OBJECTIVES: -
• Identify and study using software tools (for simulation/ analysis), the nature and characteristics of vibrations
• Evaluate the influence of the vibrations over the design of the silencer
• Review the existing design and consider improvement for negating the harmful influence of the vibrations

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.

APPROACHES, TECHNIQUES, AND METHODOLOGY
1) 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 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
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.

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 typical equipment used for vibration analysis is a general purpose single channel spectrum analyzer that most of the cases is not well suited for the specific task and lacks from the capability of simultaneous multiple channel analysis and it is not specifically designed for vibration analysis. Low-cost FPGA based 3-axis simultaneous vibration analyzer can be employed. The vibration analyzer has three stages: vibration monitoring with a MEMS accelerometer as sensor, three parallel 1024-point FFT cores and one post-processor for the analysis of the specific vibration related failure, which can be reconfigured to attend the specific task. Other vibration analysis can be performed by the three channel FFT cores with the reconfiguration of the post-processing unit to detect or enhance a specific characteristic under study. A suitable instrument would be employed for the experimentation. Experiment could be performed on a ‘live’ two-
The Engine could be kept running on three levels –
- Level 1 - Idling (1000–1500RPM)
- Level 2 - 2000–3000RPM
- Level 3 - 3500–4500RPM

The frequency reading would be recorded as displayed over the FFT analyzer connected to the head/ tail end of the silencer.

As for the Design parameters influencing the phenomena, the geometry of the silencer would be modified and the effects would be noted. Typically, the following changes are being considered:
- Length of the tube connected to exhaust port of the engine
- Diameter to be changed for the extended length
- Number of perforations and/or size of holes to be modified

A good match of the analytical readings with the Experimental readings would validate the thesis work for Design.

**LITERATURE REVIEW**

A.G. Antebas, F.D. Denia, A.M. Pedrosa, F.J. Fuenmayor, in this paper, a finite element approach for modeling sound propagation in perforated dissipative mufflers with non-homogeneous properties. The spatial variations of the acoustic properties can arise, for example, from uneven filling processes during manufacture and degradation associated with the flow of soot particles within the absorbent material. A detailed study is presented to assess the influence of the heterogeneous properties and the perforated duct porosity on the acoustic attenuation performance of the muffler. A finite element approach has been developed to predict the acoustic behavior of perforated dissipative mufflers with non-homogeneous properties. A study has been presented to assess the influence of the heterogeneity, the filling density and the porosity of the perforated duct on the sound attenuation of the dissipative mufflers.

Michal Paškar, Peter Bigoš are presented the results from measurement of a high-powerful racing combustion engine. These results are obtained by means of the system EwaC, which is operating as the data-recording process. That is such measuring equipment, which is sensing and recording information during the engine current operation under the real conditions and real operational loading. In this paper there are presented the analytical relations and experimental measurements obtained and performed during testing of the various configurations of the inlet and exhaust system specified for the racing engine.

Jingxiang Li, Shengduin Zhao, Kunihiko Ishihara presented a novel approach to study the acoustical properties of sintered bronze material, especially used to suppress the transient noise generated by the pneumatic exhaust of pneumatic friction clutch and brake (PFC/B) systems. The transient exhaust noise is impulsive and harmful due to the large sound pressure level (SPL) that has high frequency. In this paper, the exhaust noise is related to the transient impulsive exhaust, which is described by a one-dimensional aerodynamic model combining with a pressure drop expression of the Ergun equation. This paper presents a simple and general method coupling the flow field and the sound field to predict the properties of sintered bronze materials for the transient exhaust noise reduction. A one-dimensional aerodynamic model with adynamic equation of piston is derived from thermodynamics and presented to analyze the exhaust process. The mass flow rate of air through the sintered bronze is established from the pressure drop described by the Ergun equation. This mass flow rate is related to the monopole source of impulsive exhaust noise.

V. Maciàna, A.J. Torregrosa, A. Broatch, P.C. Niven, S.A. Amphlett in this paper a multi-load method has been used to extract source characteristics from gasdynamic simulation results. The details of the method, in which the resulting over-determined system is solved by fitting the values of the source parameters in a least-squares sense, are described, and different approaches are used in order to check the internal consistency of the source presentation: the identification of pressure and velocity sources, and the application of the least-squares criterion to the modulus or to the real and imaginary parts separately.

With the purpose to check the internal consistency of the representation of an engine exhaust as a linear time-invariant acoustic source, a least-squares extension of the two-load method for source identification has been developed. As velocity fluctuations are considered.

A. Kierkegaard, S. Boij, G. Efraimsson, in this paper scattering of acoustic plane waves at a sudden area expansion in a flow duct is simulated using the linearized Navier–Stokes equations. The aim is to validate the numerical methodology for the flow duct area expansion, and to investigate the influence of the downstream mean flow on the acoustic scattering properties. A comparison of results from numerical simulations, analytical theory and experiments is presented. It is shown that the results for the acoustic scattering obtained by the different methods gives excellent agreement. This paper concerns the scattering of acoustic plane waves at a flow duct area expansion. The investigation is performed by means of a linearized Navier–Stokes approach. Simulations with a realistic base flow have been conducted, and the numerical approach has been validated for simulations of the scattering matrix of the area expansion, and show excellent agreement with experimental data and with calculations with an analytical model.

G. Montenegro, A. Onorati, A. Della Torre, describes the development and application of different nonlinear models: a coupled 1D-multiD model and a coupled 1D-quasi-3D model, to predict the silencer behavior in the time and frequency domains. Second order time and space discretization were adopted in the 3D and quasi-3D approaches, whereas specific coupling strategies were developed to realize the interface between them and the 1D model. In this paper the development and application of two different hybrid 1D-multiD non-linear models has been described, in order to predict the silencer behavior in the time and frequency domains.

**REFERENCES**

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exhaust system on brake mean effective pressure.

Michal Puškar, Peter Bigol

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