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Investigation of light weight closed cell metallic foam for noise reduction in automobile application

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Abstract

This study aims to develop a multilayer hybrid passive material for noise control in automobile by coupling of open pore polyurethane foam and closed pore aluminium metallic foam. As a preliminary study the proposed configuration were tested in two microphone impedance tube method to quantify sound absorption coefficient as per ASTM E-1050. Subsequently, the five useful input parameters used for Finite Element (FE) study is predicted by means of inverse characterization technique using Genetic Algorithm (GA). From the predicted values, equivalent porous material is modelled and coupled to test bench car model to evaluate the noise reduction capability in terms of overall sound pressure level. The results are made to compare with and without porous material conditions, also it indicate noise suppression of 5–20dB in one-third octave band.

Introduction

Metal foams are natural-inspired, lightweight cellular materials extensively applied in various engineering applications due to strength to weight ratio. Some well-known examples of these structures are wood, bones, and marine sponges. The foam can be classified as open-cell and closed-cell depending on the connection between the cells. Closed-cell foam is the most common type of aluminum foam seen in commercial applications. The acoustic property of that closed-cell foam performs well only at higher frequency regimes [1]. This rigid metallic structure is stiffer than air surrounded, so the thermal and viscous losses inside the foam material are limited by closed-cell. The following factors that influence the sound absorption characteristic are porosity, closed pore size, shape, and structure. Polymeric foams are widely used, and extensive research on this material for acoustic properties [2], [3]. At the same time, the range of acoustic properties of polymeric foams depends on poroelastic nature, size, and reticulation rate. Acoustic properties of open-cell and partial reticulated foam possess good sound absorption coefficient (SAC), where the viscous and thermal losses occur in the narrow cell region. To outwit this drawback of aluminum foam, research reported combining high-density and low-density material for improved acoustic properties as multilayer material [4], [5], [6]; the stated configuration acts as a typical spring-mass system for better sound attenuation. There are five parameters needed for the successful development of the FEM model, which can be predicted by the various algorithm, for example, particle swarm optimization (PSO) algorithm [7], Genetic algorithm (GA) [8] using inverse characterization technique. This work proposes a multilayer foam that combines open-cell polymeric with closed-cell metallic foam as a hybrid absorber to show the use of closed-cell metallic foam in acoustic applications. The proposed arrangement was tested in an impedance tube, and numerical results confirmed it. Furthermore, using the COMSOL Multiphysics acoustic module, the optimum arrangement is combined with a test bench car to analyze sound pressure levels.

Section snippets

Metallic aluminum foam

The closed-cell aluminum (Al) foam was sourced locally whose dimension ranges $0.1 \times 0.1 \times 0.01\,mm^3$ and cut into impedance diameter 96mm. Table 1 shows the characteristics of Al foam.Table 2....

Polyurethane foam

Isocyanate and polyol are used to make flexible polyurethane, and these chemicals are provided by Manali Petrochemicals Limited (Chennai). As a polyol, EMPEYOL WSF 300/10(S) is utilized, a pre-mixture of all additives such as a chain extender, catalyst, stabilizer, water, surfactants, and an isocyanate –…

Experimental sound absorption(SA) result

Fig. 7 shows the experimental SAC of the multilayer construction; the Aluminum foam sample of 40mm only has strong SA at higher frequencies. This is owing to the material's reduced viscosity losses, which occur only on the surface of Al foam, implying a more substantial barrier to sound propagation. In comparison to AL 40, PU 40 foam sample open-cell in nature also displays poroelastic characteristics, resulting in higher thermo-viscous losses and more excellent sound absorption. This research …

Conclusion

The multilayer foam was created by mixing PU (open-cell) reticulated foam and Al (closed-cell) metallic foam in a layered structure. The Genetic algorithm was used to forecast the non-acoustic characteristics based on the measured Acoustic absorption of different layer configurations. A basic fem model was constructed in COMSOL Multiphysics to analyze acoustic absorption using expected parameters. The numerical results obtained accord well with the experimental results. Furthermore, combining…

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.…

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