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Vibration isolation in metamaterial structures embedded with neoprene resonators

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Abstract: Metamaterial structures provide a passive mode of vibration isolation by forming band gaps using a resonator mass and a viscous elastic membrane (VEM) material embedded at in it. Irrespective of the frame structure configuration (1D, 2D or 3D) the metamaterials with periodic elements are meant to attenuate vibrations in transverse direction to the plane of propagation. Moreover, if employed in desired configuration metamaterial helps in attenuating the vibrations along structural elements in a desired frequency band (Floquet-Bloch theory). In the present investigation, a motor frame assembly is designed incorporating the meta-material properties and it ability to attenuate vibrations produced by the motor in the frequency range of interest is analysed. Experimental results are compared to FEA simulation for validation

Keywords: Metamaterials, Passive vibration isolation.

1.Introduction

Attenuating drive vibrations to a proper level for a preferred frequency band (called band gap) using a metamaterial structure, has attracted the attention of industrial experts and researchers in recent times[1-3]. Advancement of continuum mechanics saw the development of theories like Floquet-Bloch and Bernoulli mathematical models, which are generally used for analysing periodicity in beam elements. Employing a metamaterial like structure helps in attenuating the vibrations along structural elements in a desired frequency band without increasing the compliance of the joints.

In this work, a uniform frame made of mild steel is considered as the base frame. For obtaining the second configuration, periodic air-holes are introduced in the uniform frame, whereas the third configuration is obtained by incorporating resonators in the periodic holes embedded with visco-elastic membrane (VEM). Here, Neoprene is used as VEM and central resonators are in turn made of mild steel.

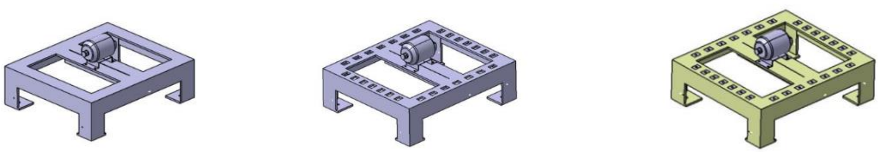

Fig.1.Structural configurations considered (i)uniform(ii)With VEM resonators (iii)With VEM+central mass resonators

The frames are excited with a shaker. The time domain data were obtained and analysed using NI LabVIEW software. The acceleration response from output points are measured using a tri-axial accelerometer and the input acceleration is recorded using a uni-axial accelerometer attached opposite to the shaker excitation point.

2.Results and Discussion

From the simulation of the MS structure it is observed that 2 predominant flexural modes are occurring in the 0-500 frequency range. Attenuation band of 75 Hz is centered around 350 Hz and corresponding 3rd mode is observed from experiment as well as the simulation. From a frequency sweep simulation performed in a range of 10-3000Hz, significant band gaps are visible near 670-840 Hz, 930-1050 Hz and 1480-1590 Hz. The inherent compliance of the structure with airholes could be seen as causing high transfer function, in 500-700 Hz and 1200-1450 Hz region. Metamaterial effectively damps these modes to a level comparable with that of uniform structural configuration.

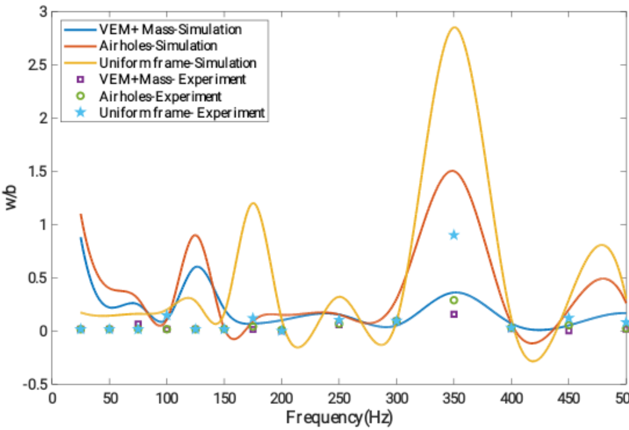

Fig.2.Comparison of FRFs from experiments and simulations

3.Concluding Remarks

In this work, vibration characteristics of different metamaterial structural configurations are determined and compared its inherent attenuation characteristics with that of a uniform structure. It is found that metamaterials can be employed for effective vibration isolation as a passive measure.

References

[1] J. Robillard, O.B. Matar, P. Deymier, M. Stippinger, A. Hladky-Hennion, Y. Pennec, B. Djafari-Rouhani, Tunable magneto elastic phononic crystals, *Appl. Phys. Lett*. 95 (12) (2009) 1–10.

[2]. Mahmoud I. Hussein, Michael J.Frazier. Metadamping: An emergent phenomenon in dissipative metamaterials. *Journal of Sound and Vibration*, Volume 332, Issue 20, 30 September 2013.

[3] M. Nouh , O. Aldraihem , A. Baz. Wave propagation in metamaterial plates with periodic local resonances. *Journal of Sound and Vibration*, Volume 341, 14 April 2015, Pages 53-73