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Analysing Vibration attenuation characteristics of Al 6061 metamaterial structures

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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. Effective configuration of metamaterial structures can possibly attenuate excitation frequencies which matches to the natural frequencies of resonators employed. In this work Al 6061 alloy with neoprene combination is analysed for strength and stiffness characteristics and is proposed as an alternative to MS structures. Attenuation characteristics are validated using FRF comparison,and mode shape analysis.

Keywords: Metamaterials, Mode shape analysis, Vibration attenuation.

1.Introduction

Metamaterial structures employing,geometrically non-linear local resonators with cubic and quadratic restoring forces are very effective compared to linear systems employed for vibration isolation[1]. Studies on piezoelectric materials is done by Robillard et al[2],wherein it is observed that electric field can affect stiffness and meta-damping of the structure. Floquet-Blosch theory provides the fundamentals for deriving the transfer matrix which relates the state variables (displacement and force) at the left of a unit cell to the right of it[3]. Al alloy (Al 6061) has comparably low non-linear damping characteristics with high stiffness making it suitable for attenuation applications. The metamaterial structure (Fig1) has neoprene with VEM properties embedded periodically to act as resonators. The holes housing the resonators have aspect ratio near to 1.66. The longer edge is kept parallel to longitudinal side of the beams of the structure, since the material coverage envelope bounding dimensions should match with low-frequency high wavelength signals. The filleted corners are to reduce stress concentration and to improve the adhesiveness of the VEM. The experimental readings were taken at a sampling frequency of 10000 Hz and over a time window of 10s.

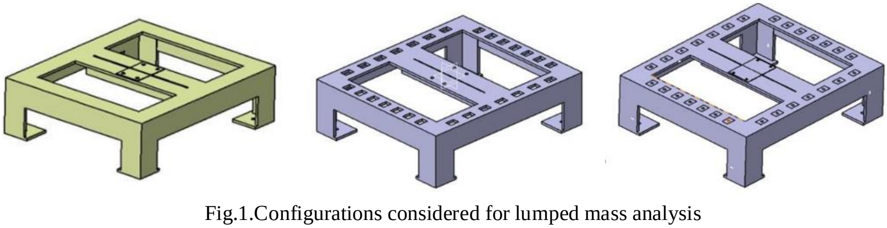

Fig.1.Configurations considered for lumped mass analysis

2.Results and Discussion

From simulation results it is found that a band gap is observed at near 900-1100 Hz, where the air holes and with neoprene structure,damping the frequencies in that range,at comparable magnitudes. Mode shapes (Fig 2) do reveal higher out-of-plane excitation, implying a mode excitation, establishing a pass band as inferred from FRF.

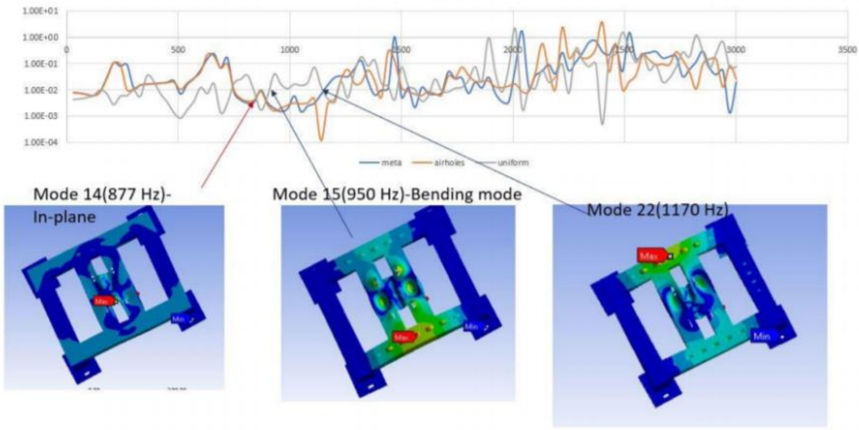

Fig.2, Mode shapes analysis

3.Concluding Remarks

In this work, vibration attenuation characteristics of different metamaterial structural configurations with Al 6061 as base material is analysed .An attenuation band spanning a magnitude of 75 Hz centered around 350 Hz corresponding to 3rd mode is observerd from experiment and is well captured from simulation also. A frequency sweep analysis upto 3000Hz ,revealed a stop band region (900-1200 Hz). The mode shapes inside this band are all flexural modes with wavelengths comparable to resonator dimensions.FRF along mode shape analysis do underline attenuation characterisitics of Al alloy-neoprene metamaterials,and the ineherent damping properties and comparable strength parameters do make it an alternative to conventional MS metamaterial structures.

References

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