Impact of Particle Packing Density on the Frequency Response of an Additively Manufactured Particle Damper

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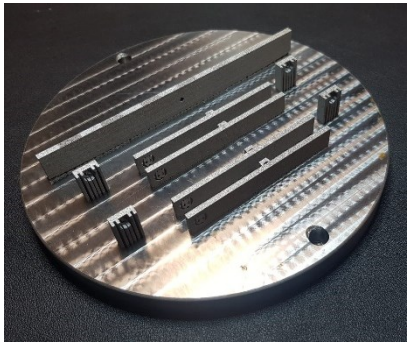
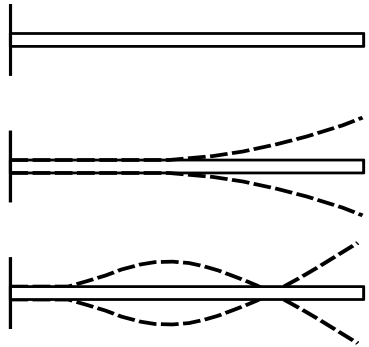
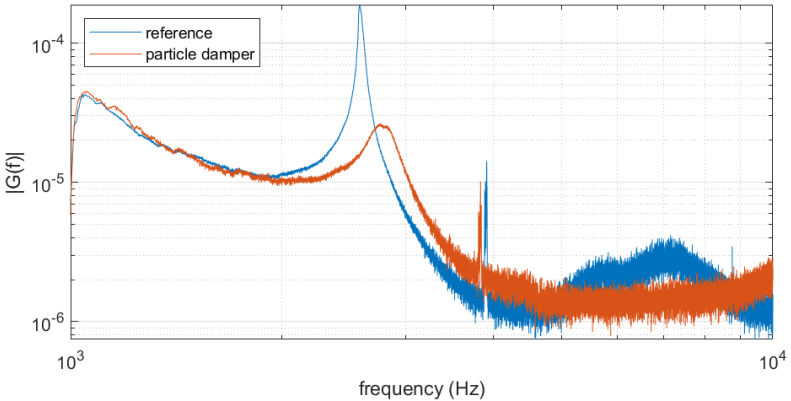
Outline:

- Methodology:
  - laser powder bed fusion
  - particle damper packing factor
- Experimentation:
  - frequency response of particle damper
- Results and Discussion:
  - time and frequency domains
  - transfer function modeling
- Future work:
  - study particle behavior
  - investigate pocket shape and location

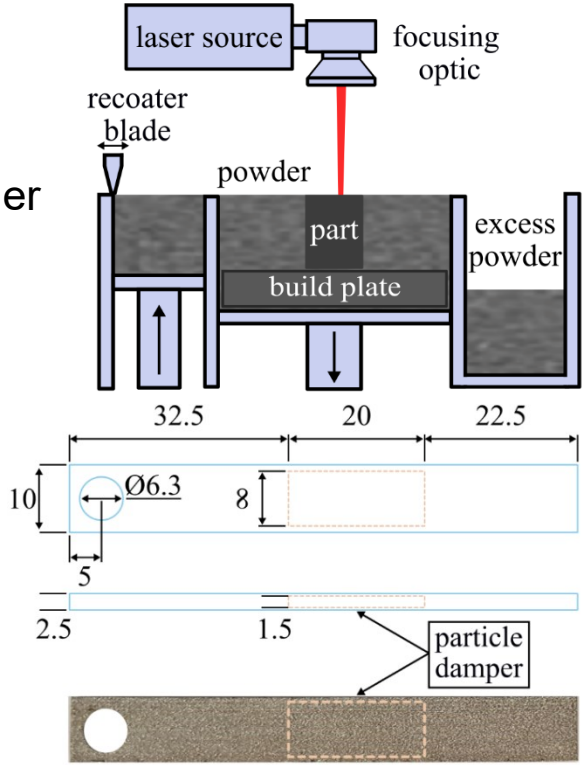


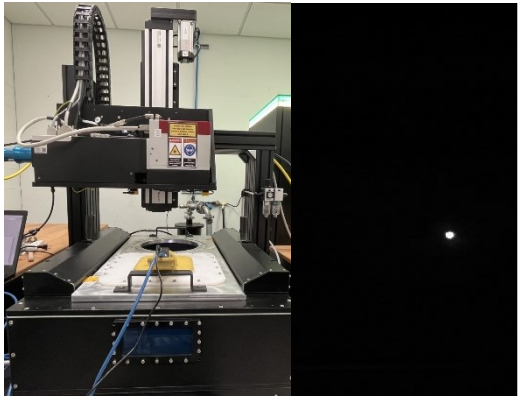


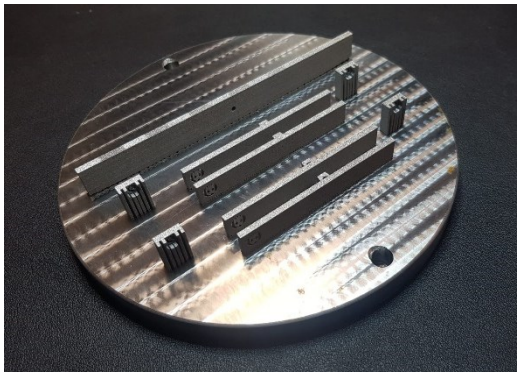


Laser Powder Bed Fusion (LPBF):

- part: cantilever beam
- material: 316L stainless steel powder
- printing parameters:
  - power: 200 W
  - speed: 800 mm/s
  - laser spot: 100 μm
  - hatch distance:100 μm

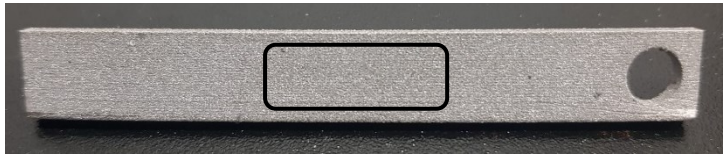


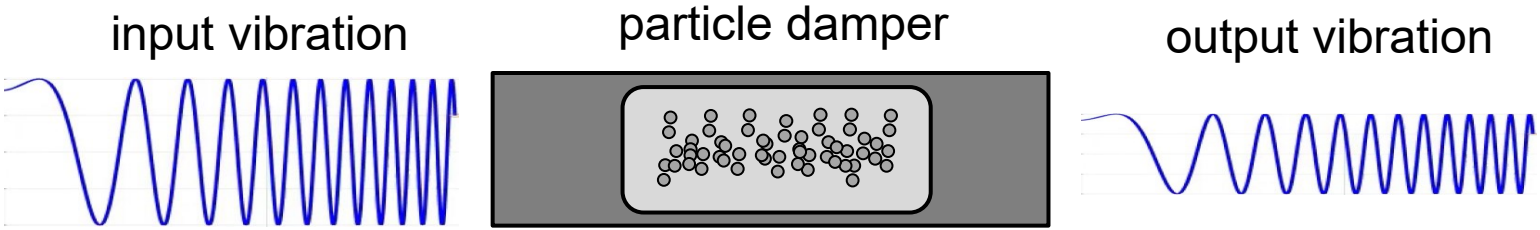




Particle damper packing factor:

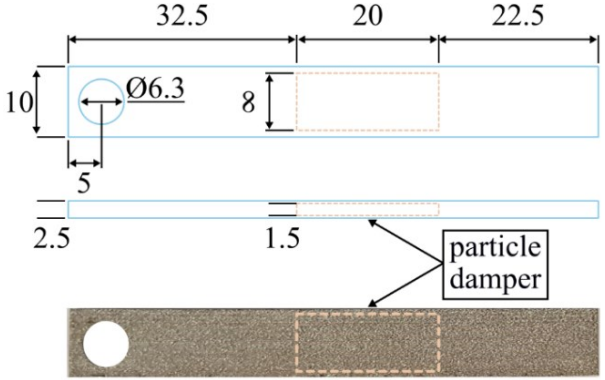
- pocket with loose particles
- particles dissipate energy
  - relative motion between particles
  - heat due to friction
- packing factor altered by changing pocket volume

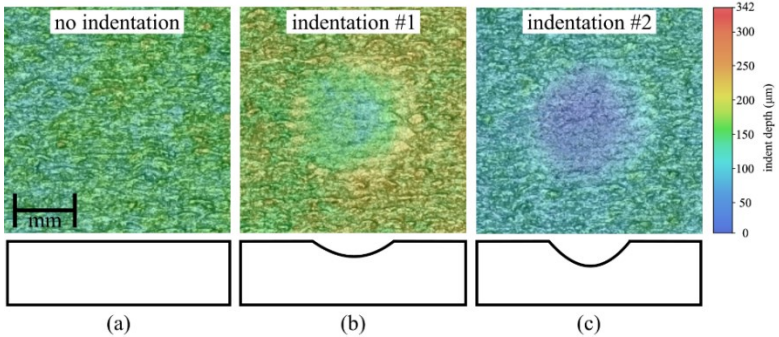


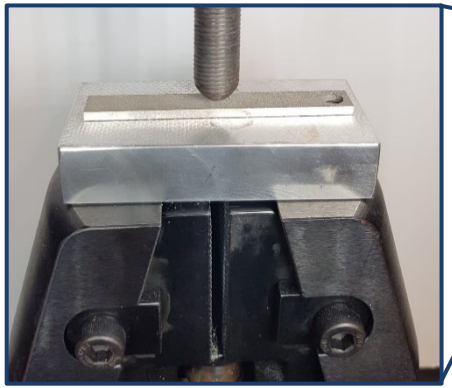


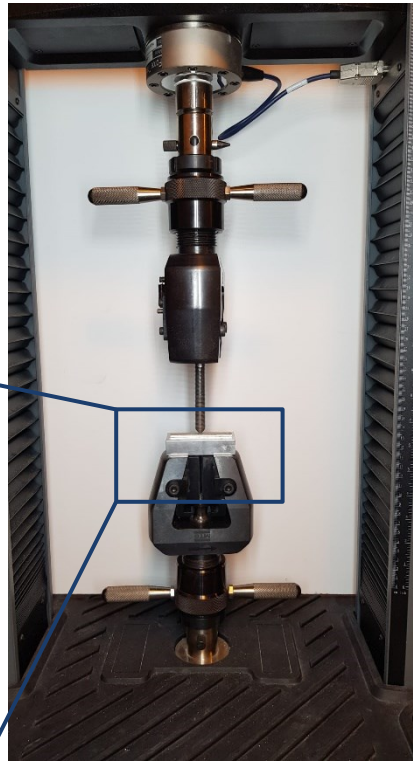
Particle damper packing factor:

- solid beam printed for reference
- indented using a round surface press
- pocket volume cases:
  - 240 mm^2, 239.74 mm^2, 239.64 mm^2





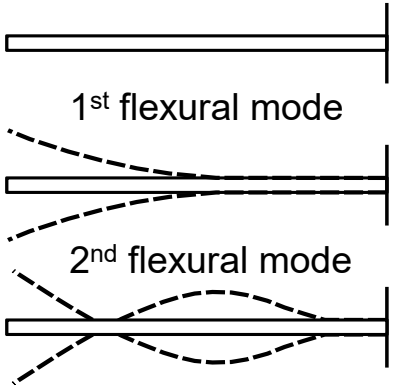


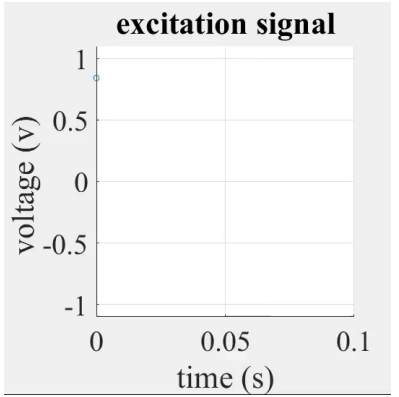


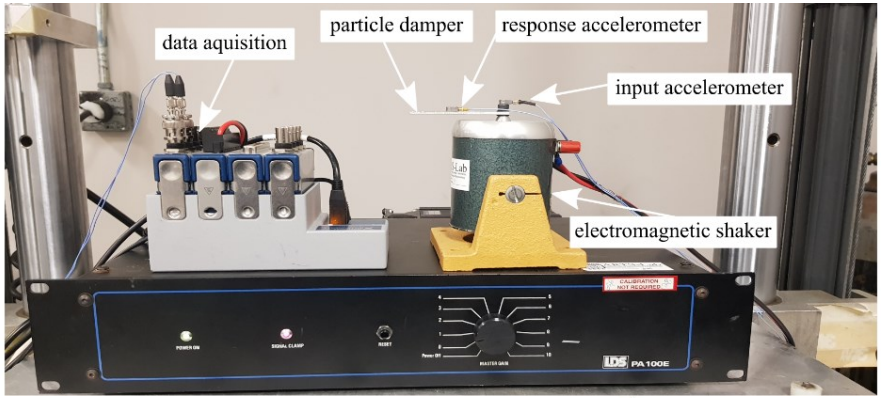
Frequency response of particle damper:

- cantilevered beam configuration
- frequency sweep excitation
  - frequency range: 1-8 kHz
- second flexural mode
- acceleration frequency response observed

$$x(t) = \sin\left(2\pi\left(\frac{f_{\text{end}} - f_{\text{start}}}{2(\text{test time})}t^2 + f_{\text{start}}t\right)\right)$$

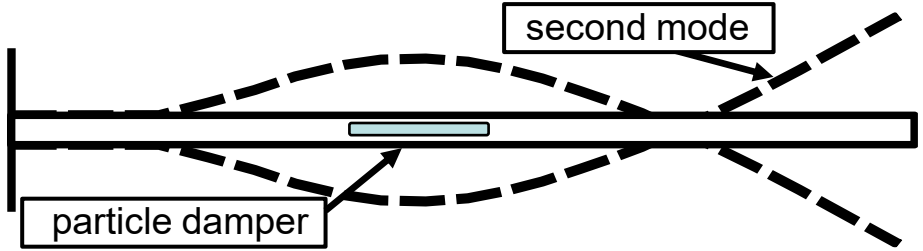


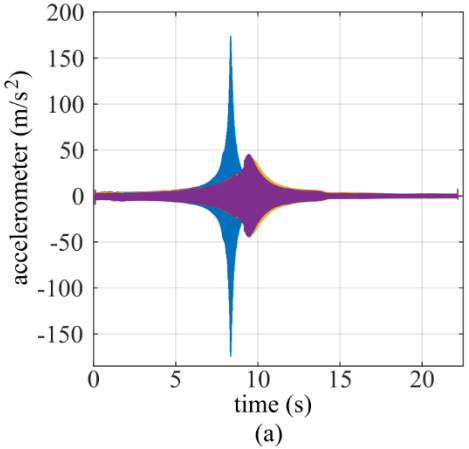


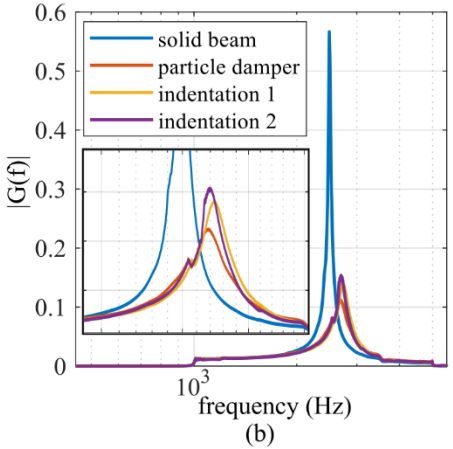


Time and frequency domains:

- solid beam vs. three damper cases
- particle dampers can mitigate vibrations at targeted modes
- increasing packing density reduces damping magnitude
- shift in natural frequency observed
  - unfused powder reduces part mass



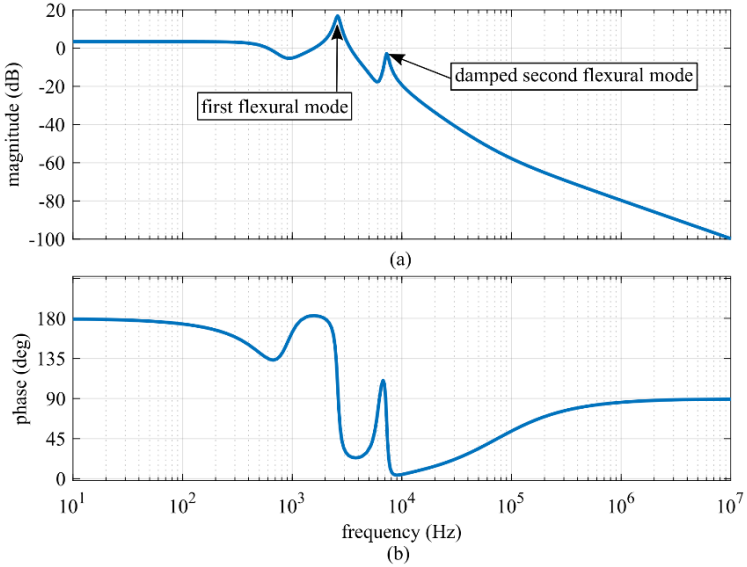




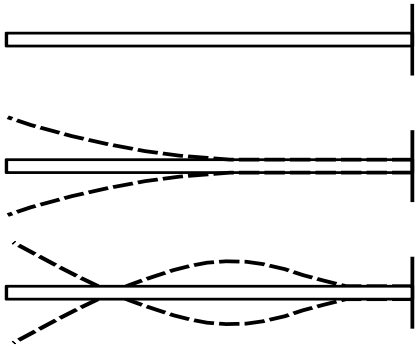
Transfer function modeling:

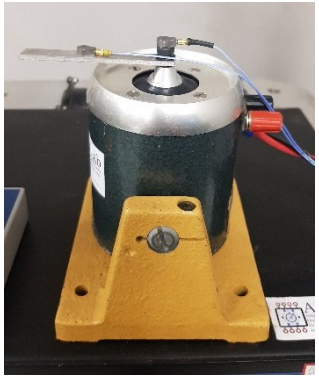
$$G(s) = \frac{-648.5s^5 - 3.071e08s^4 - 4.595e12s^3 - 4.736e17s^2 - 1.563e21s - 1.436e25}{s^6 + 9929s^5 + 2.397e09s^4 + 1.577e13s^3 + 6.18e17s^2 + 2.737e21s + 9.733e24}$$

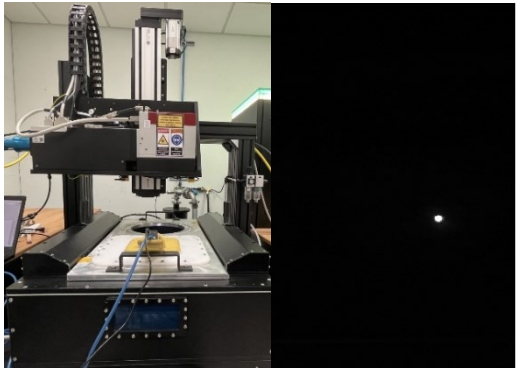
- input output relationship is utilized
- grid search of transfer function order is conducted
- training parameters:
  - number of iterations: 100
  - tolerance: 0.001
- transfer function model
  - dimensions: 6 poles, 5 zeros
  - precent fit: 88.97%

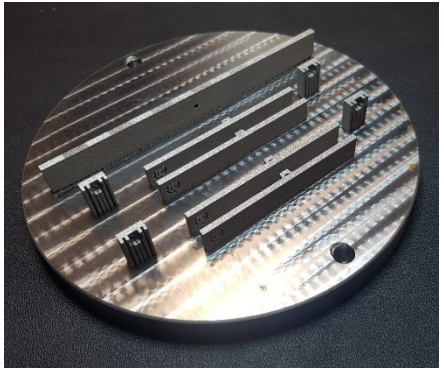


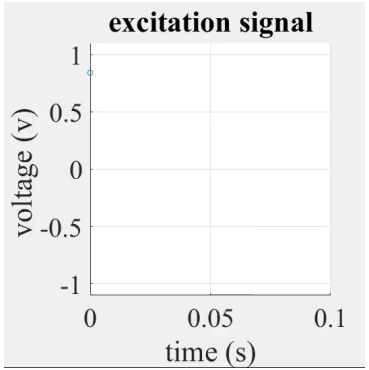
- study particle behavior within the pocket
- investigate pocket shape and location for targeted damping of complex modes











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Thank you for listening

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