Discrete Element Modeling of Additively Manufactured Particle Dampers with Variable Particle Packing Density

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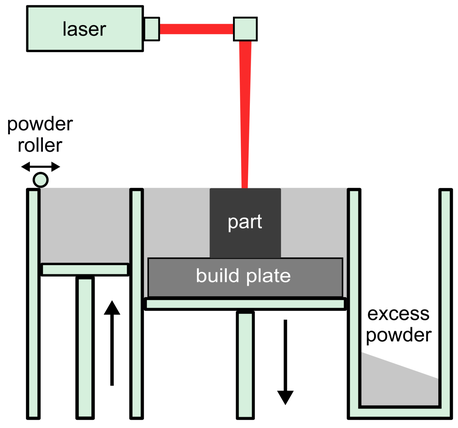
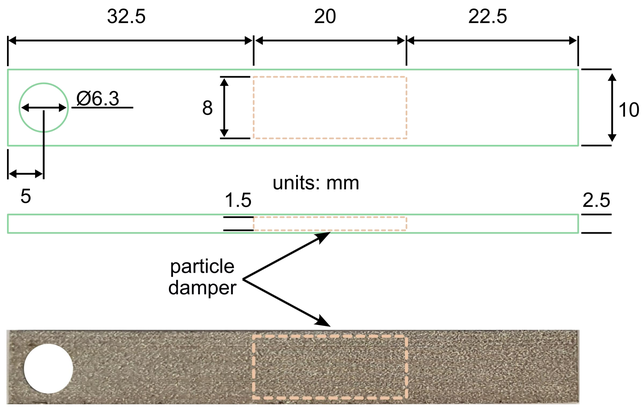
Introduction

- Laser powder bed fusion (LPBF) additive manufacturing
  - Capable of creating high-quality, complex parts
  - Can create fully-integrated particle dampers
- LPBF particle damper qualities can be influenced by changes in particle packing density via post-production indentation
  - Changes damping ability and frequency response
  - Costly to test
- Discrete element method (DEM) is used to simulate the behavior of large quantities of particles.
  - More time- and cost-efficient than experimental testing
  - Provides more insight into damper behavior/qualities



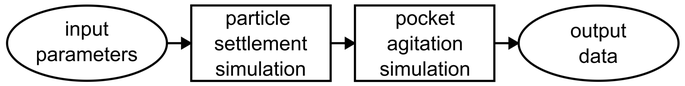
Laser powder bed fusion additive manufacturing process



Experimental beam dimensions used for simulations

Methods

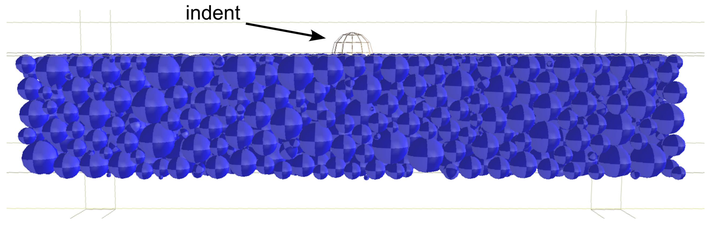
- YADE is used to simulate damper pocket
  - Free and open-source
  - Relatively simple Python front-end



Flowchart of simulation process

Particle settlement simulation

- Pocket is generated with extended walls and ~1300 particles.
  - Walls are extended to ensure particles do not escape
  - Particle count kept low to keep simulation time reasonable
  - Particles are sized according to a normal distribution centered at 25 μm
- Indentation is simulated by creating a small sphere and moving it partially into the damper
  - A spherical cap of specified volume is in contact with the particles, compressing them
  - Spherical cap size is tightly controlled to ensure full contact with particles
- Particles are left to settle under gravitational force
  - Ensures total particle kinetic energy does not change between simulations

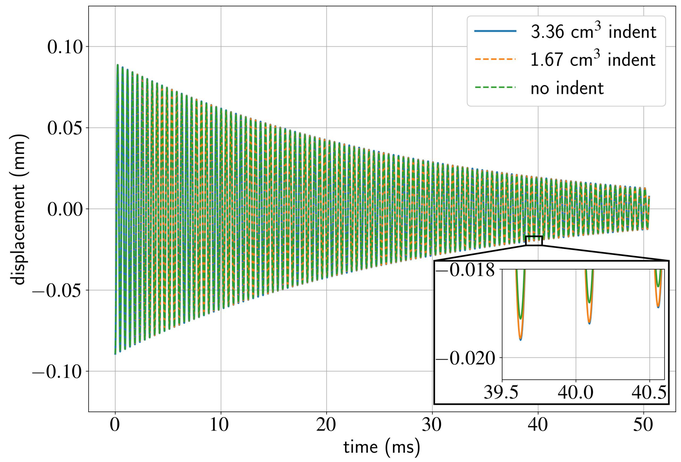


Particle damper in YADE with an indent

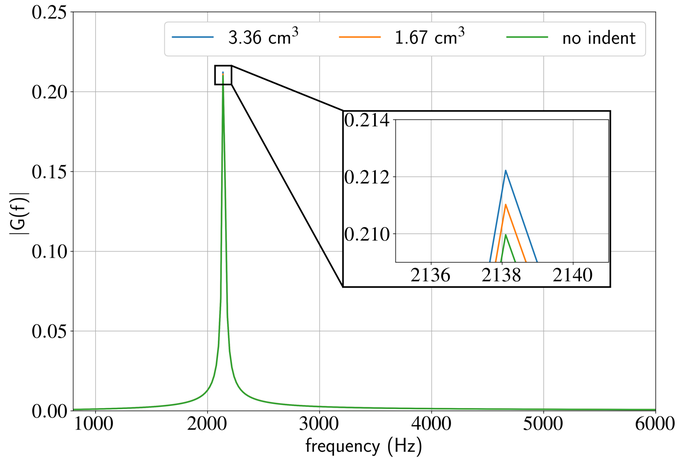
Particle agitation simulation

- New simulation using parameters and information from the previous step
- 14 N force is applied to the pocket to set it into motion
- Simulation is left to approach a steady state
- Data is collected on the displacement and kinetic energy of the pocket

Results



Displacement data for three different indent volumes



Frequency domain responses of three different indent volumes

- An increase in indentation volume is correlated with a decreased in damping ability
  - Matches expectations from experimental testing

Conclusions

1. The DEM can replicate key trends related to particle packing density observed in experiments.
2. The DEM can capture subtle changes in damper behavior that would be difficult to detect through physical testing alone.

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