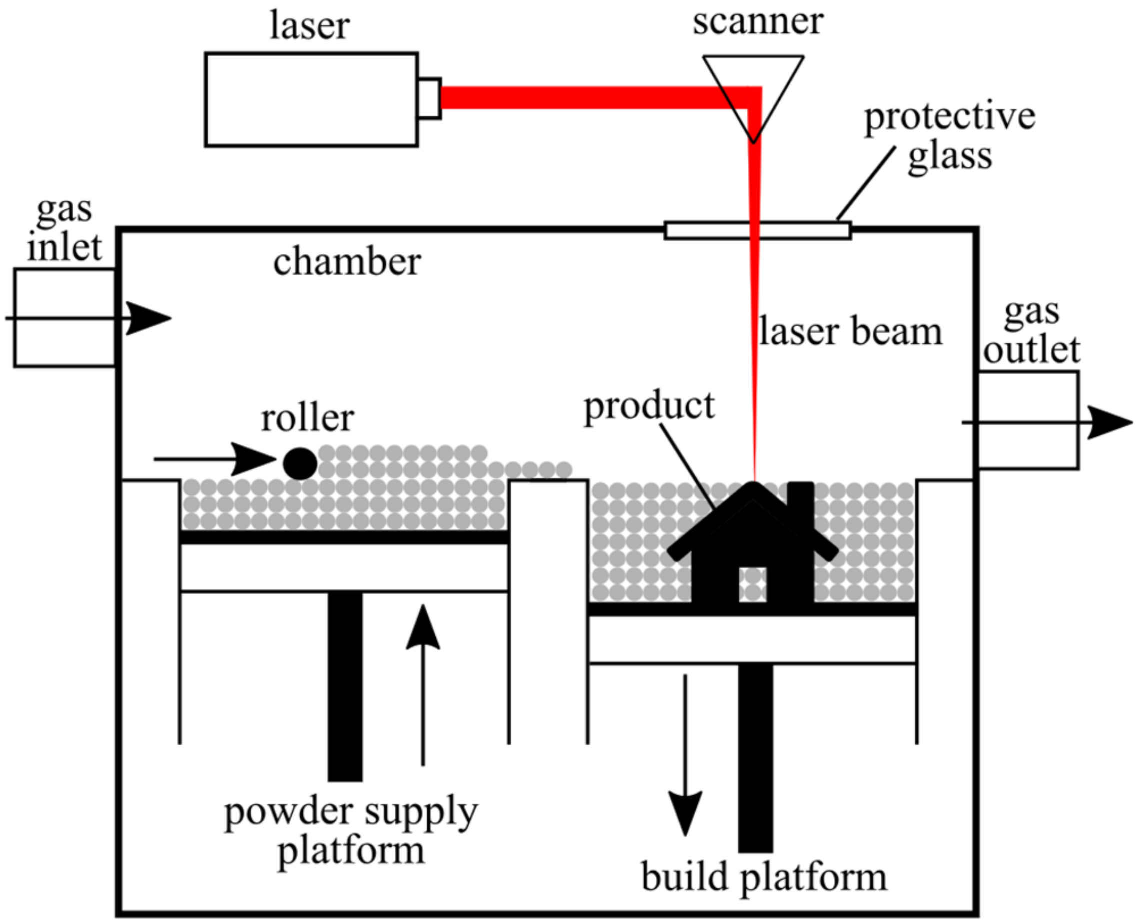
Investigating Compressing Particle Damper Pockets in Beams Manufactured by Laser Powder Bed Fusion Additive Manufacturing

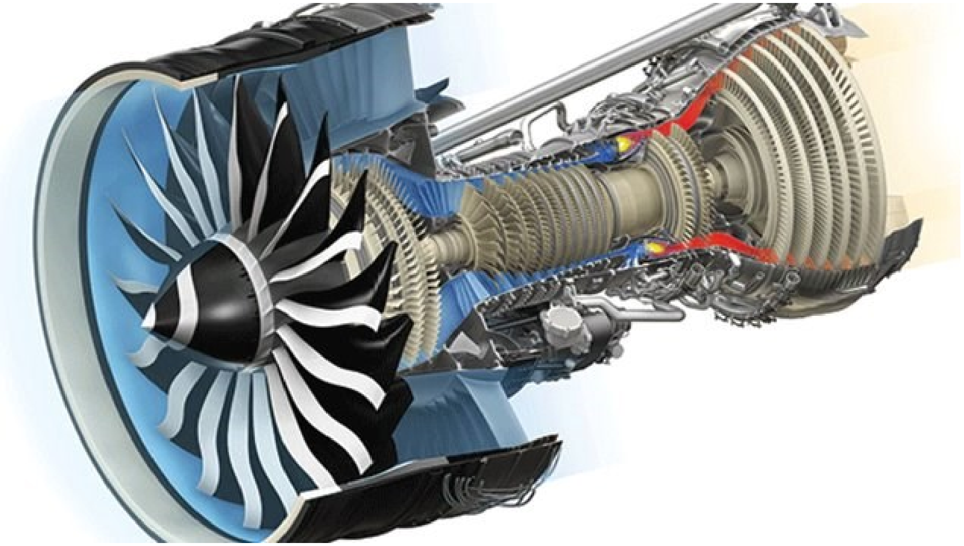
Presenter: Yanzhou Fu
Authors：Yanzhou Fu, Satme Joud, Austin R.J. Downey, Lang Yuan, Daniel Kiracofe
UNIVERSITY OF South Carolina

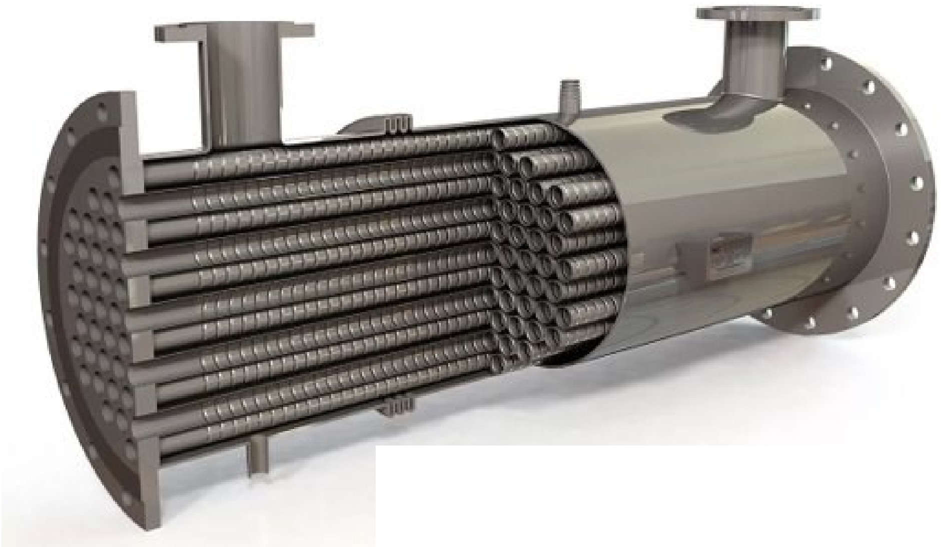
Contents

South Carolina

Introduction

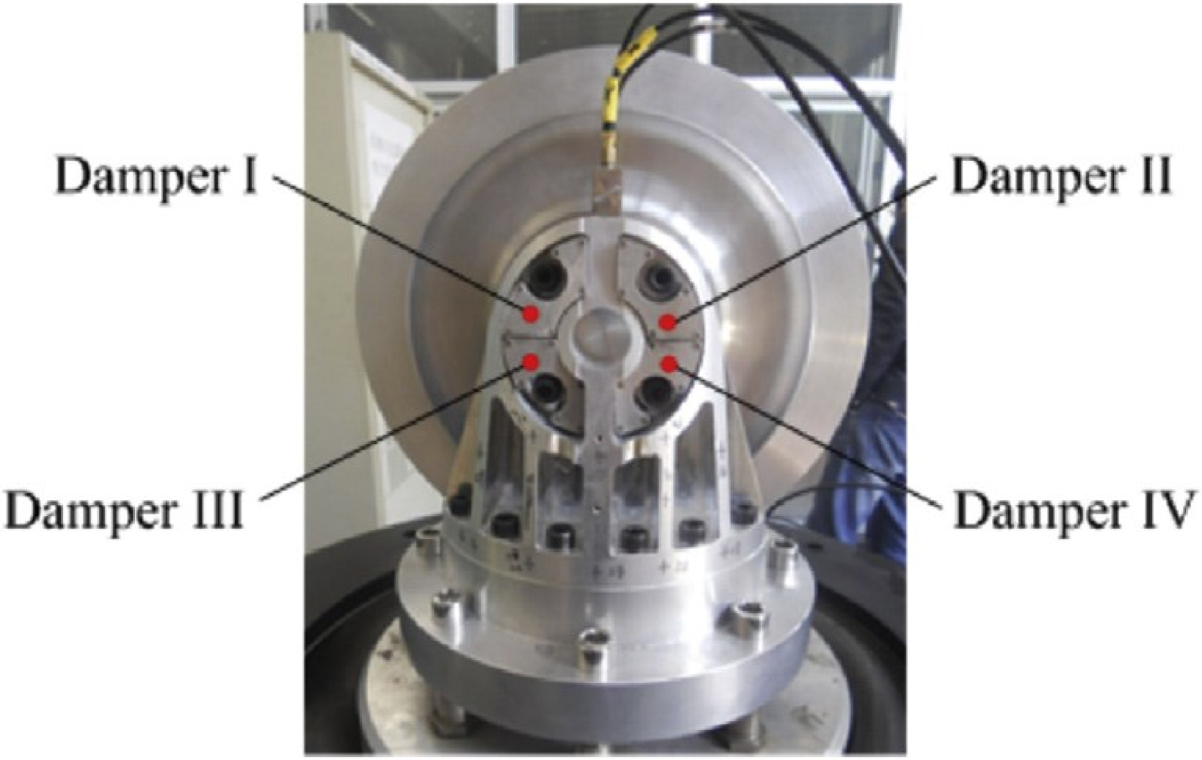






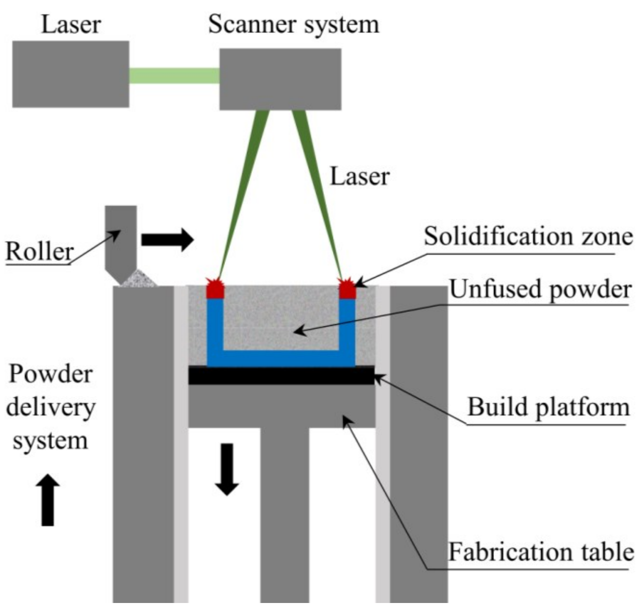
1. https://www.machinedesign.com/motors-drives/article/21832035/whats-the-difference-between-turbine-engines/
2. https://envirotecmagazine.com/2020/03/11/maximising-the-potential-of-exhaust-gases/

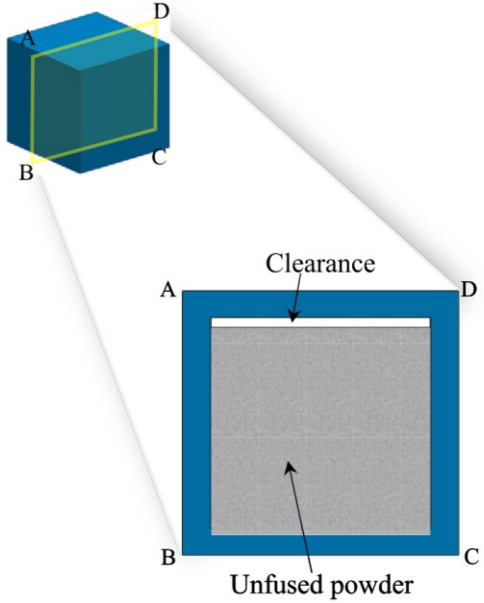
Introduction

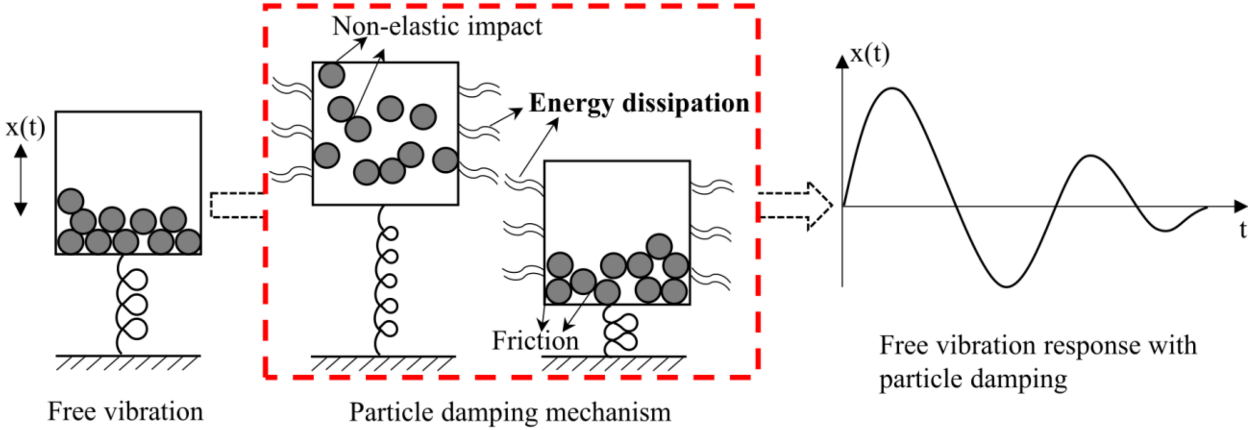


1. Yan W, Xu W, Wang J, et al. Experimental research on the effects of a tuned particle damper on a viaduct system under seismic loads[J]. Journal of Brid Engineering,2014, 19(3): 04013004.
2. X. Wang, X. Liu, Y. Shan, T. He, Design, simulation and experiment of particle dampers attached to a precision instrument in spacecraft, J. Vibroeng. 17 (4) (2015) 1605–1614. www.scopus.com.

Introduction

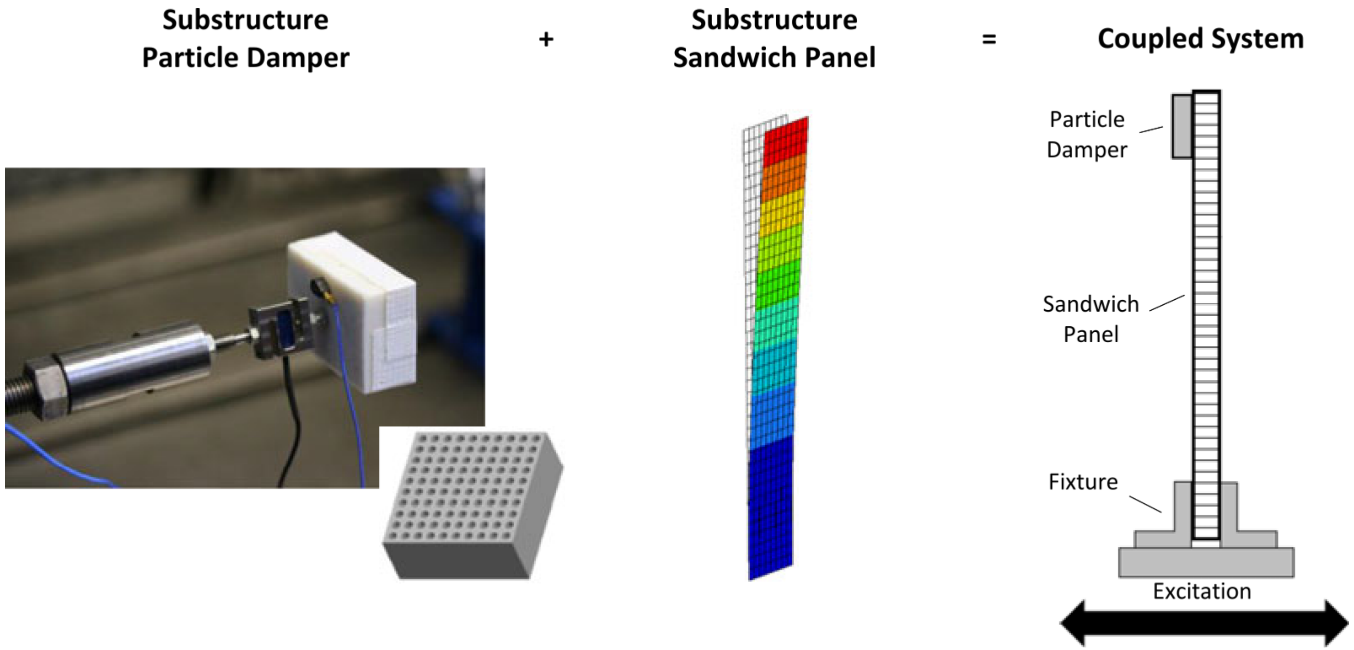


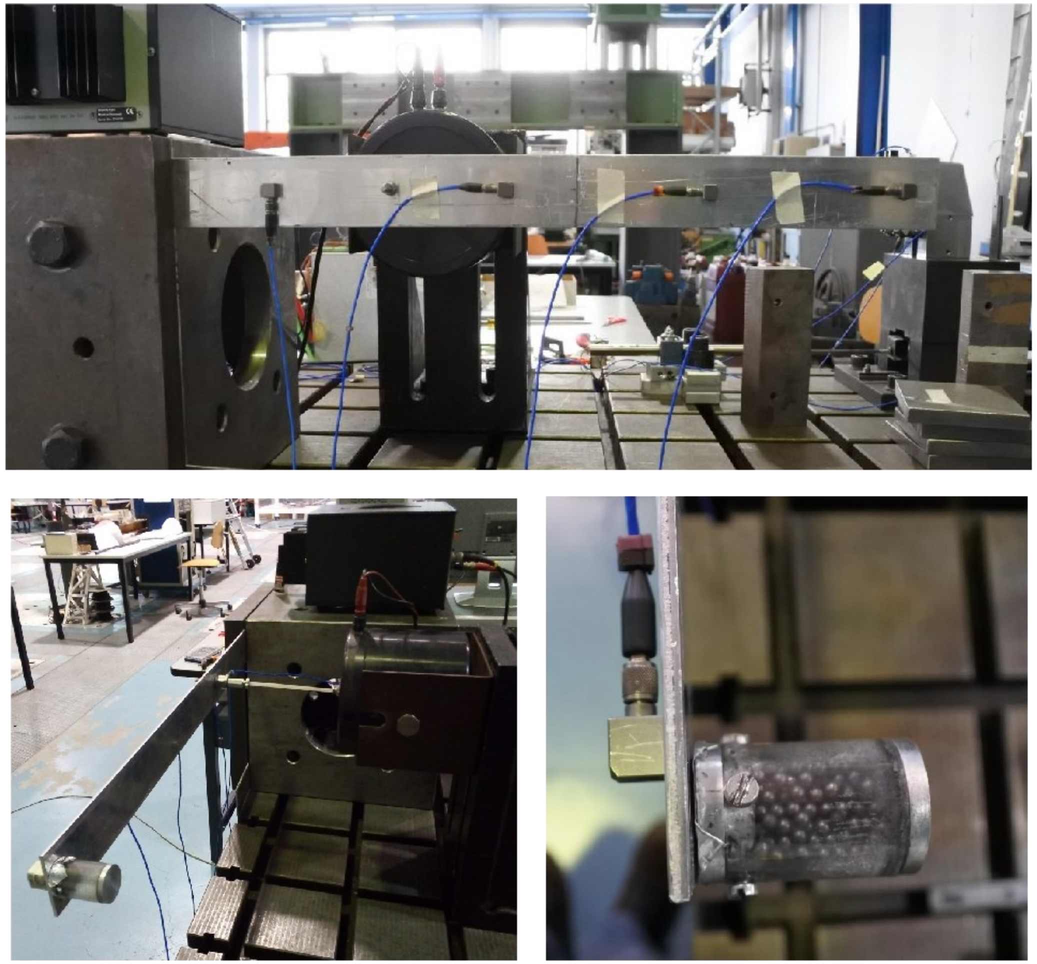




1. Guo H, Ichikawa K, Sakai H, et al. Numerical and experimental analysis in the energy dissipation of additively-manufactured particle dampers based on complex power method[J]. Computational Particle Mechanics, 2023: 1-15.

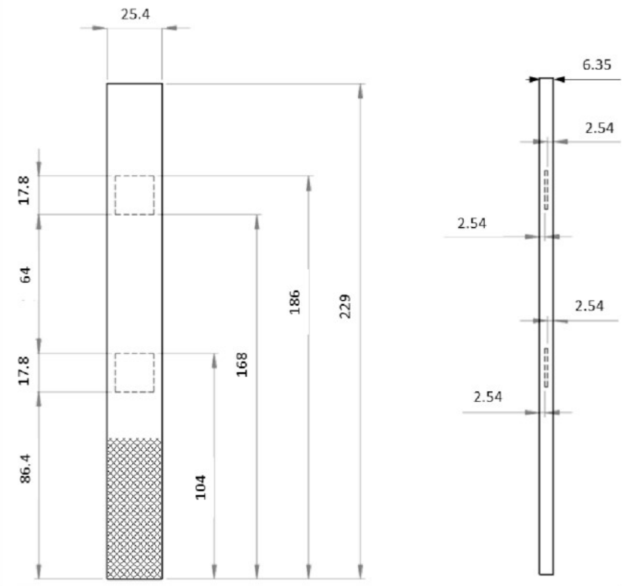
Introduction

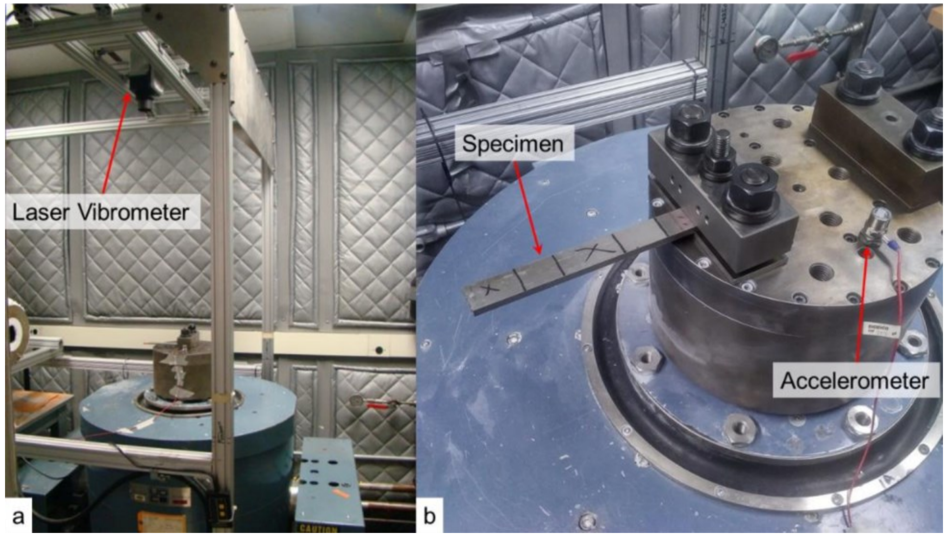




1. Oltmann J, Hartwich T, Krause D. Optimizing lightweight structures with particle damping using frequency based substructuring[J]. Design Science, 2020, 6: e17.
2. Biondani F, Morandini M, Ghiringhelli G L, et al. Efficient Discrete Element Modeling of Particle Dampers[J]. Processes, 2022, 10(7): 1247.

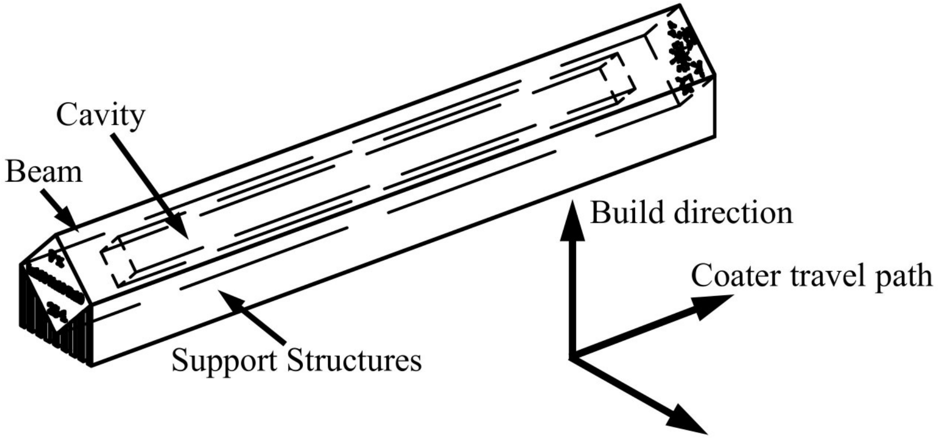
Introduction

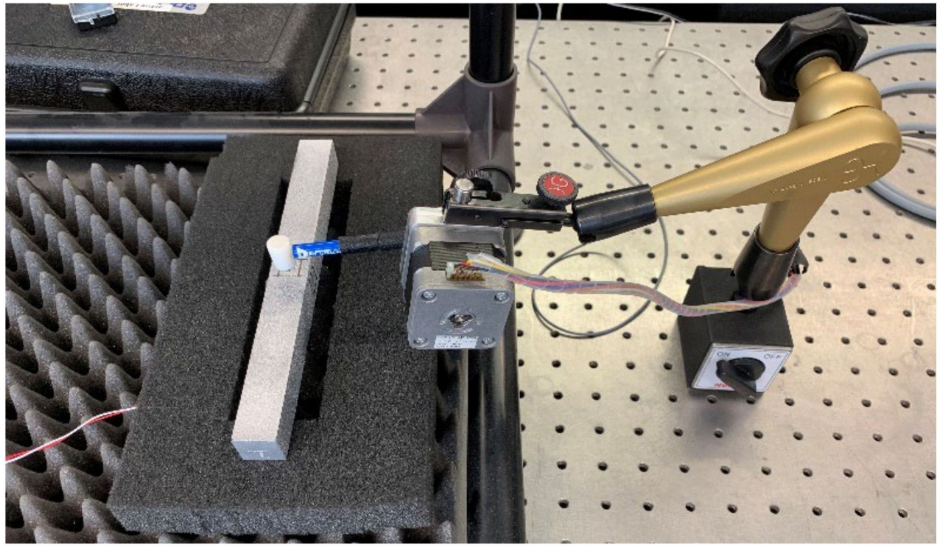


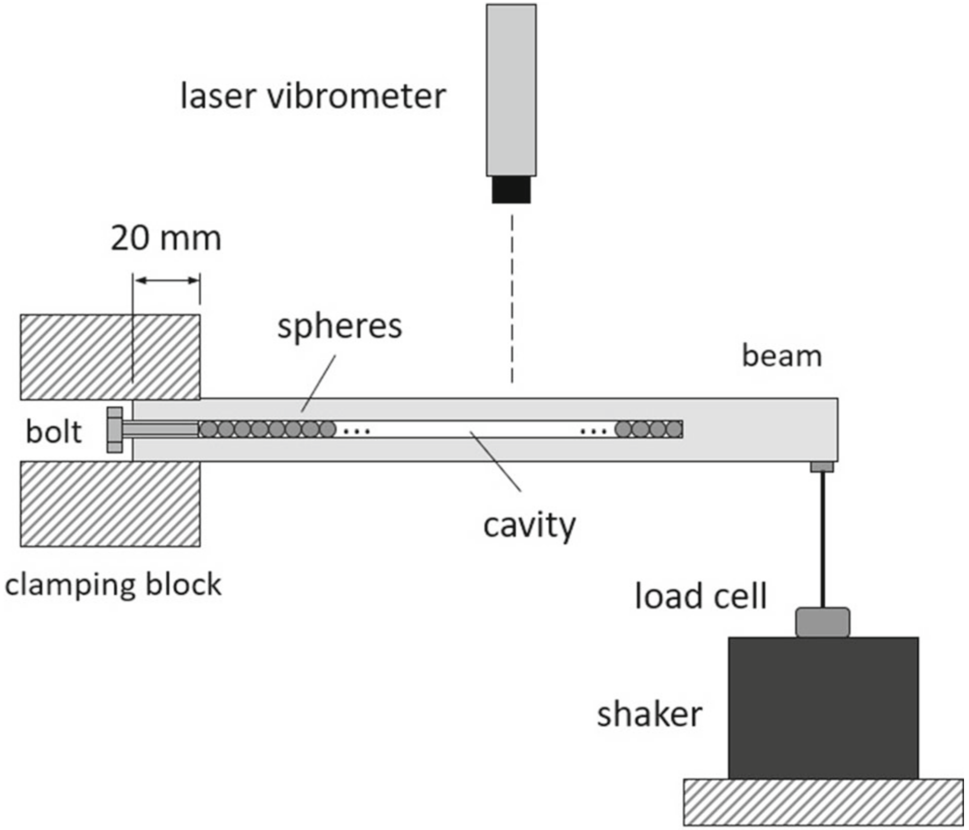


1. Scott-Emuakpor O E, George T, Beck J, et al. Inherent damping sustainability study on additively manufactured nickel-based alloys for critical part[C]//AIAA Scitech 2019 Forum. 2019: 0410.

Introduction







1. Ehlers T, Lachmayer R. Design of particle dampers for laser powder bed fusion[J]. Applied Sciences, 2022, 12(4): 2237.
2. Gorla F D, Nicoletti R. Dampening of a cantilever beam with large particles in a small cavity: model and experiment[J]. Archive of Applied Mechanics, 2021, 91(7): 2933-2942.

Contents

South Carolina

Methodology

Innovation:

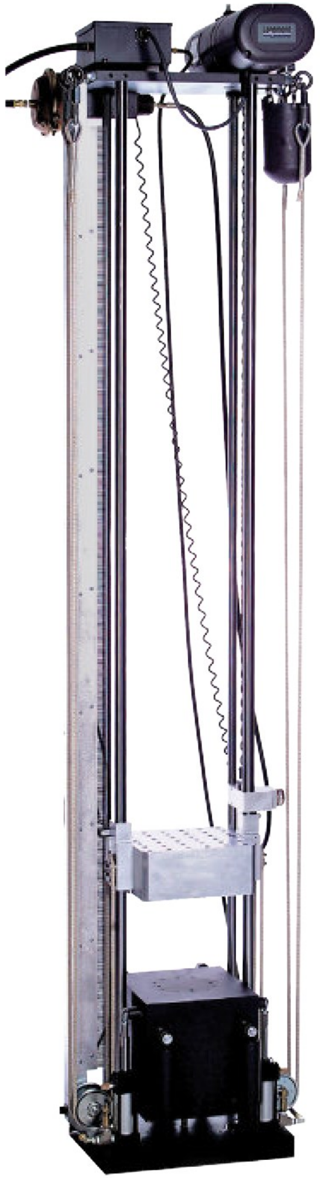
Lots of research focusing on particle damper performance. However, the effects changing the volume of the pocket post manufacturing has not been investigated. Therefore, this study reports preliminary investigations on the effects of energy absorption provided by changing the volume of the pocket.

Research purpose:

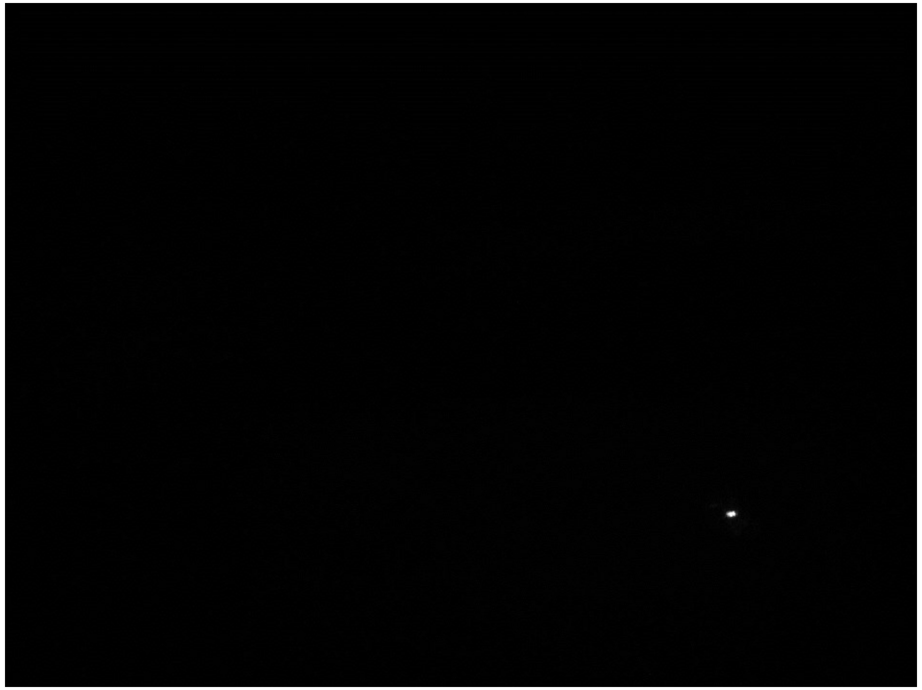
1. The effects of energy absorption are provided by indenting the volume of the pocket.
2. The unfused powder pocket's damping characteristics are assessed by observing the structure's response to various excitation.

South Carolina

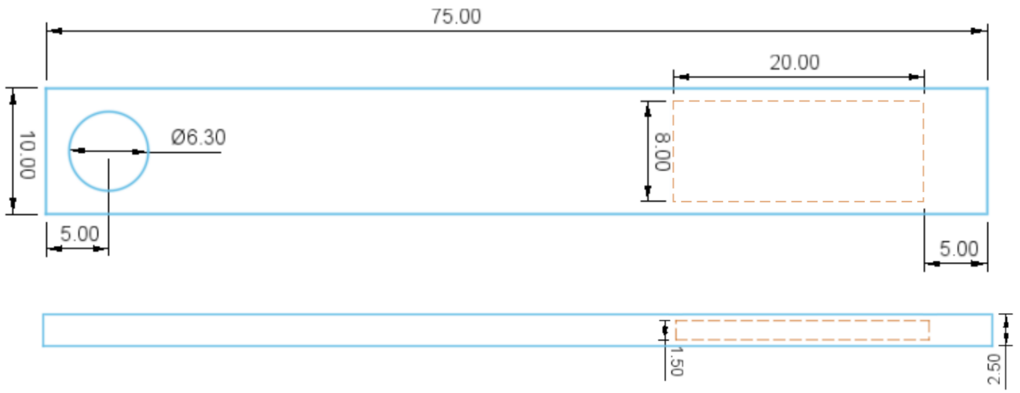
Methodology



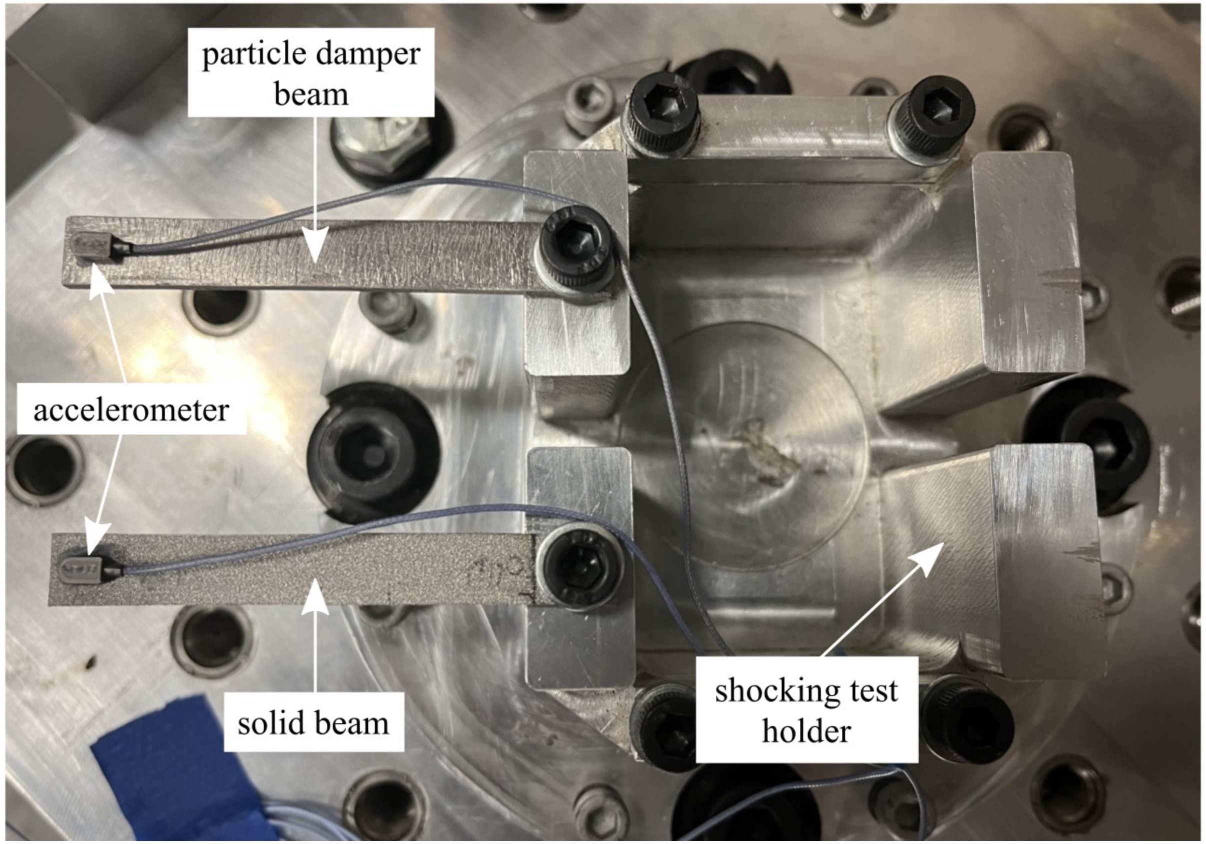
Methodology



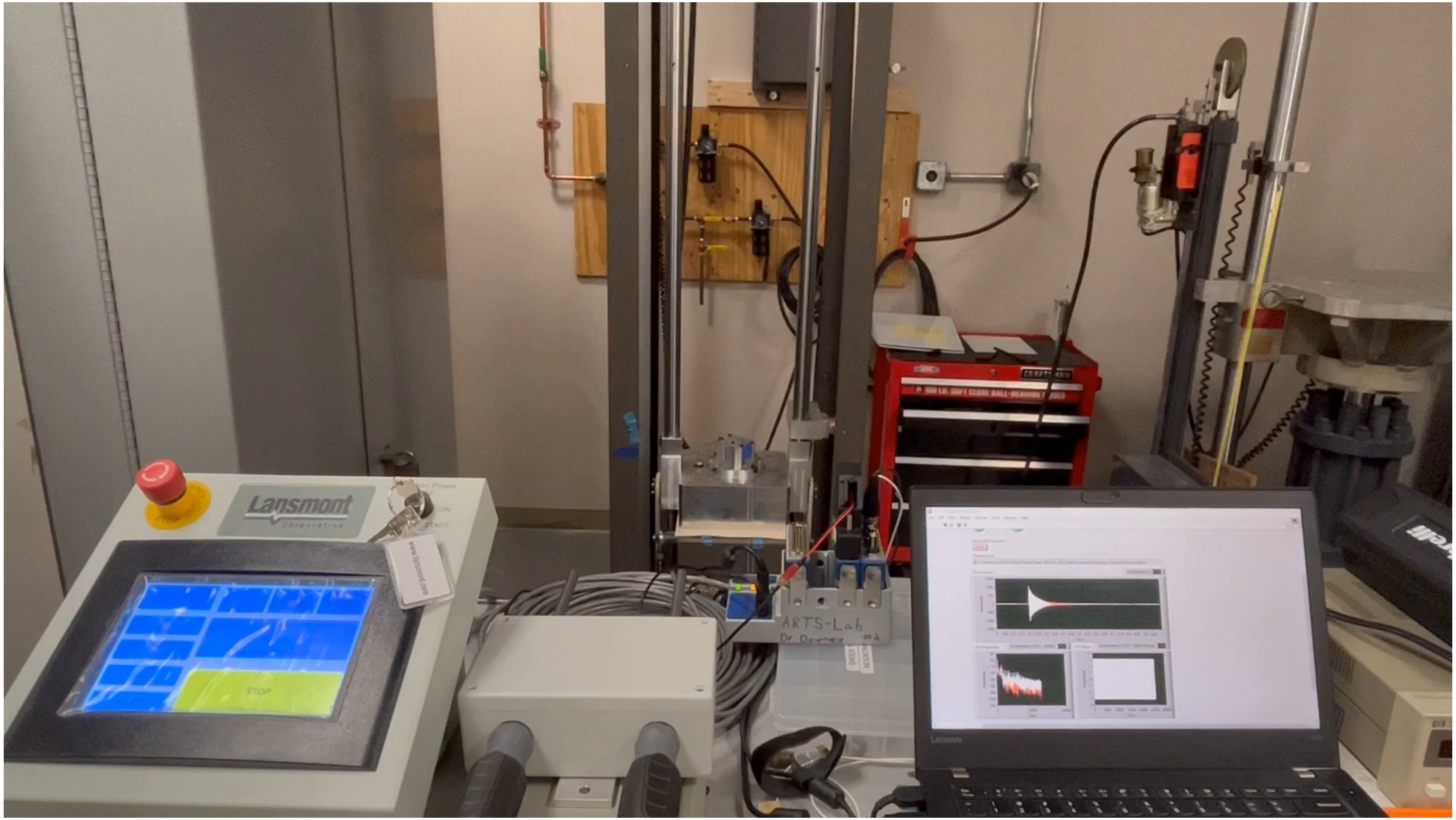
Methodology



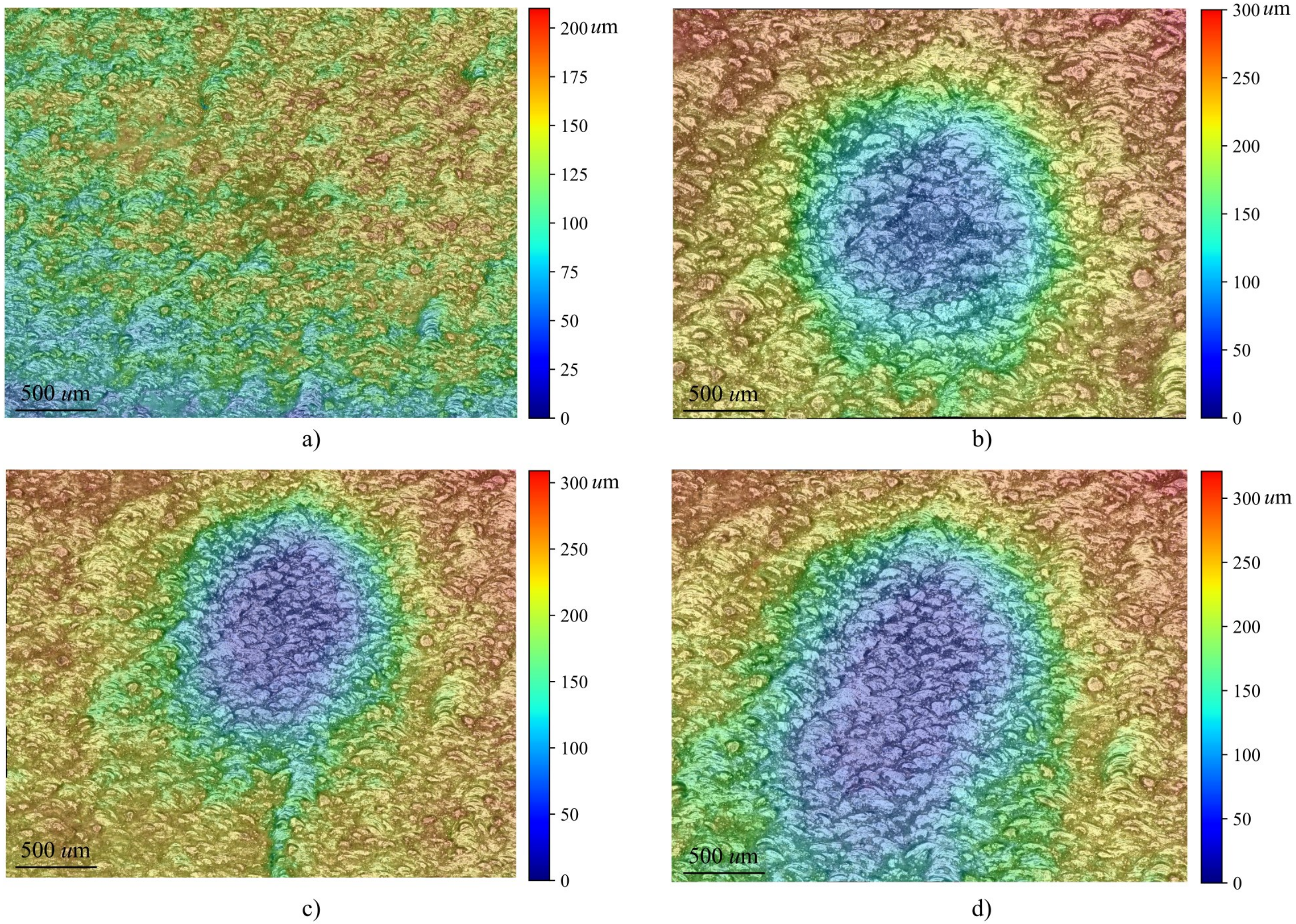
Power (W)	Speed (mm/s)	Hatch distance (um)
200	800	100



Methodology



Result



500 um
200 um
175
150
125
100
75
50
25
0
a)
500 um
300 um
250
200
150
100
50
0
b)
500 um
300 um
250
200
150
100
50
0
c)
500 um
300 um
250
200
150
100
50
0
d)

Result

Table 1. Surface height change of the particle damper beam.

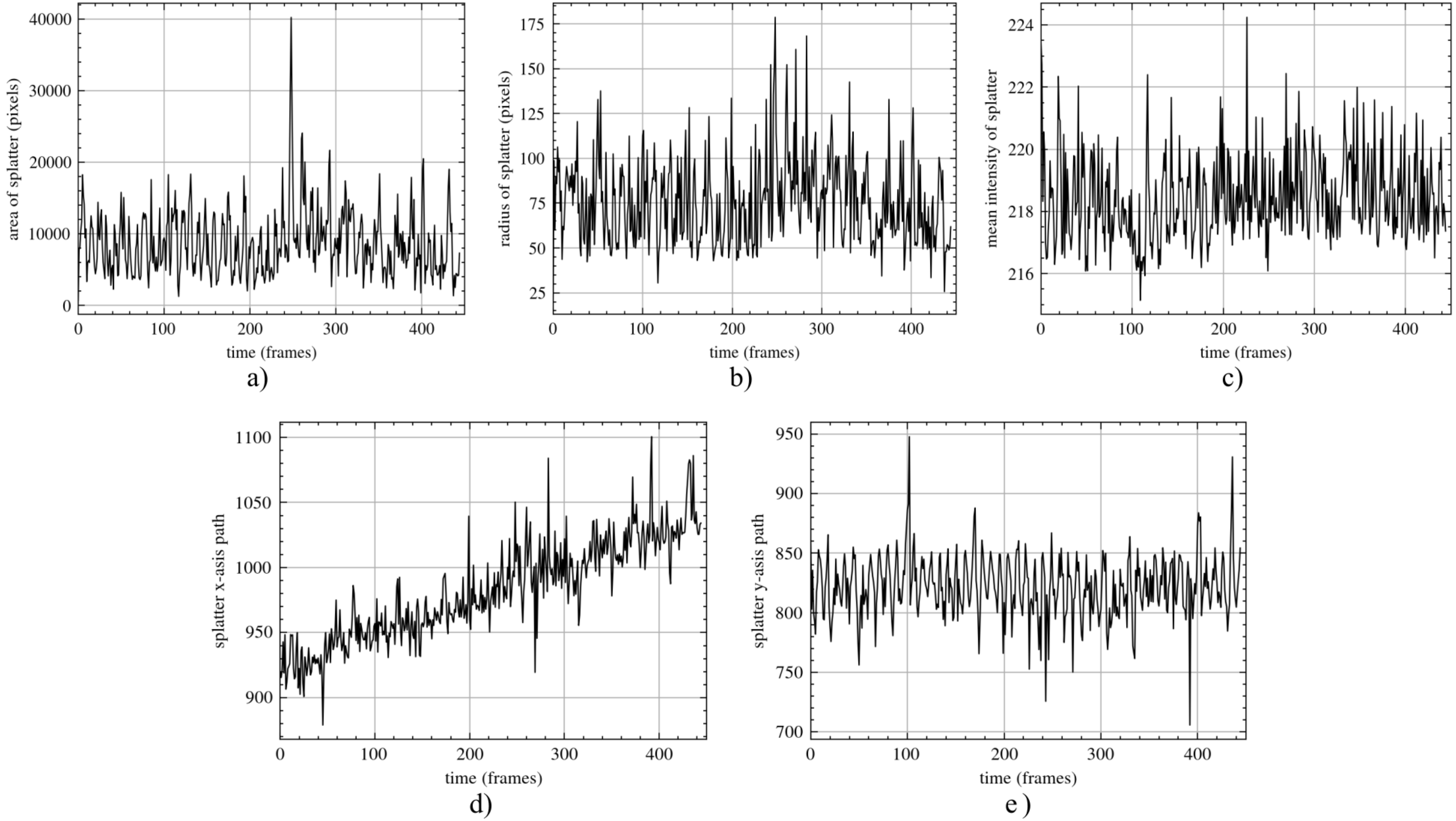
particle damper beam	min-height (μm)	max-height (μm)	surface height change (μm)
before indent	37.44	210.70	0
after first indent	0	301.77	91.07
after second indent	0	310.56	99.86
after third indent	3.93	322.08	111.38

Contents

1. Introduction
2. Methodology
3. **Result**
4. Conclusion and future work

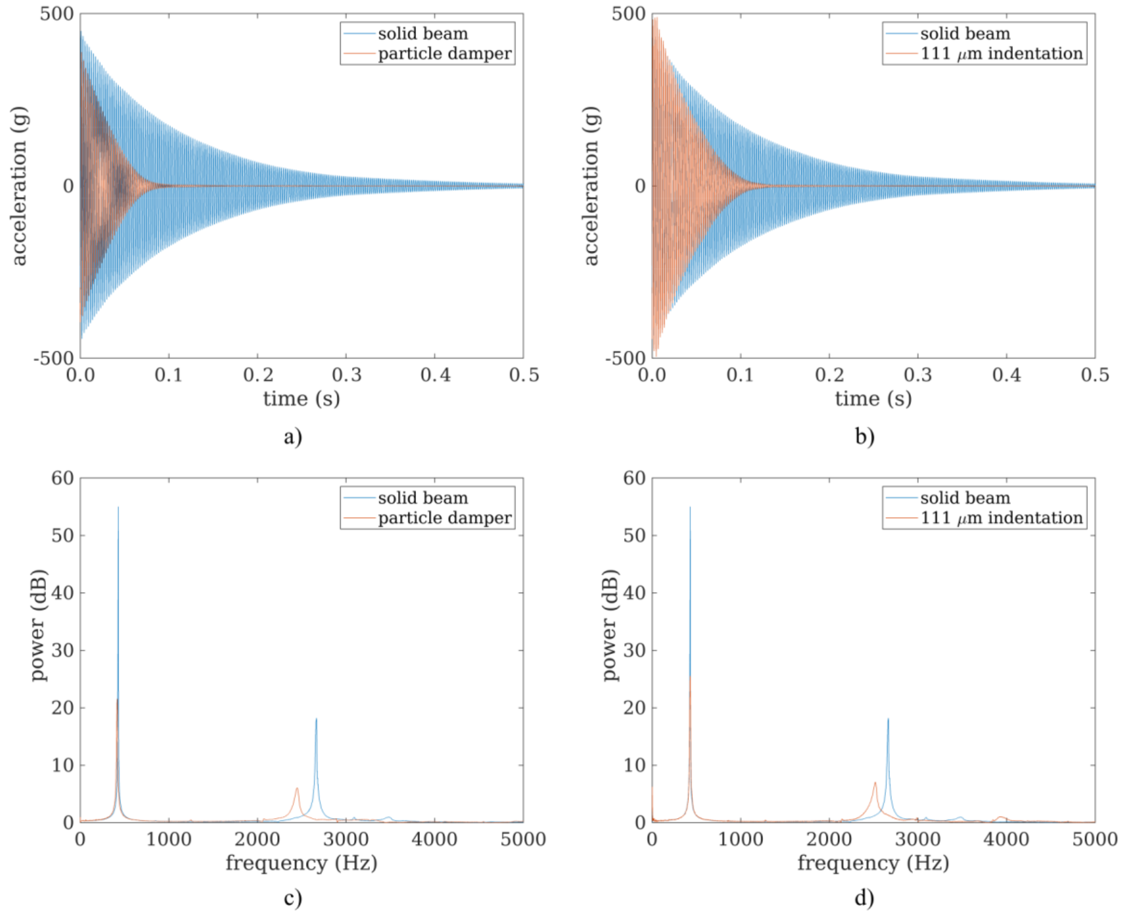
South Carolina

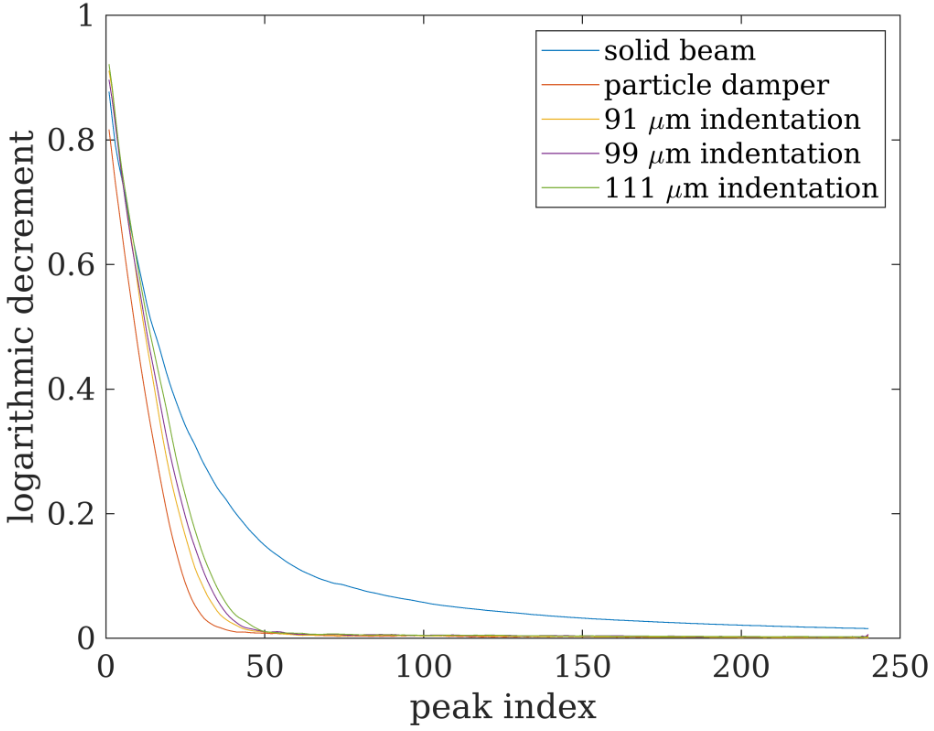
Result



area of splatter (pixels)
time (frames)
a)
radius of splatter (pixels)
time (frames)
b)
mean intensity of splatter
time (frames)
c)
splatter x-asis path
time (frames)
d)
splatter y-asis path
time (frames)
e)

Result


solid beam
particle damper
111 μm indentation
acceleration (g)
time (s)
power (dB)
frequency (Hz)
a)
b)
c)
d)


solid beam
particle damper
91 μm indentation
99 μm indentation
111 μm indentation
logarithmic decrement
peak index

Result

Table 2. Shock test result for the solid and particle damper beam.

test sample	max frequency (Hz)	damping ratio	Q factor	Q factor standard deviation
solid beam	428.7	0.00287	174.8	1.89
particle beam	416.0	0.00430	116.7	4.88
91 µm indentation	425.7	0.00420	119.4	4.52
99 µm indentation	425.8	0.00408	122.8	4.48
111 µm indentation	428.7	0.00401	124.6	4.17

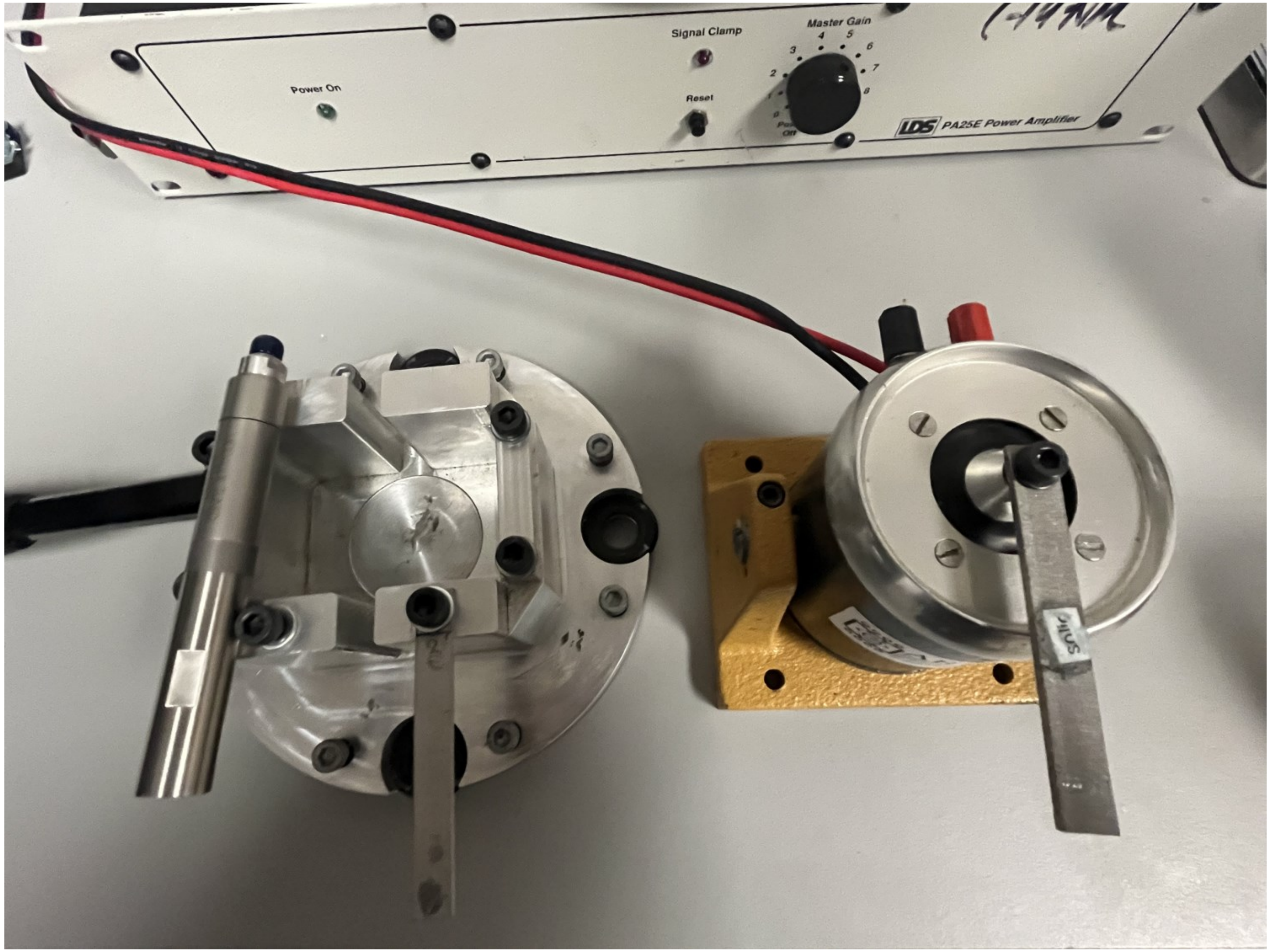
Contents

South Carolina

Conclusion and future work

1. This paper investigated the effect of pocket volume change on a cantilever beam damping.
2. The vibration curves, decay rate, and fast Fourier transform (FFT) analysis are obtained under different pocket volume change.
3. Results show that show the particle damper inside of the beam can dramatically reduce the beam vibration. With compressing the pocket volume, the particle damper density increases, which cuts down the unconsolidated powders' energy absorption capacity.
4. Future work will establish the relationship between powder density and damping performance.

Conclusion and future work



- Various pocket locations
- Shaker test
- Impact test
- Multi-modal analysis

Acknowledgement

This material is partially supported by the South Carolina Space Grant Consortium under grant 521179-RP-SC007. The support of the South Carolina Space Grant Consortium is gratefully acknowledged. Any opinions, findings, and conclusions, or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the South Carolina Space Grant Consortium.

THANKS!

NASA SC Space Grant Consortium

SCRA South Carolina Research Authority

UofSC South Carolina