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Mechanical Testing and Design of the Magnetic Linear Test Apparatus

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Abstract

In order to further understand the fatigue and electrical properties of multifunctional magnetic shape memory alloys (MSMA), such as nickel-manganese-gallium (Ni-Mn-Ga), it is often necessary to modify existing machinery or design unique devices. The existing linear test apparatus has accomplished the goal of straining specimens by applying linear compression in a static magnetic field. The data acquired by this apparatus has been useful, but is limited by the device's lack of magnetic field strength variability and closed loop control, as well as its data acquisition speed. The proposed study seeks to design and test a linear test apparatus that performs the same functions as the existing test equipment with the addition of a variable magnetic field, closed loop control and data acquisition rate of up to 1 μHz. The creation of a device with these additional capabilities will result in a broader range of actuation frequency, control of actuation strain, and the production of higher quality data. Advancements in the understanding of the fatigue behavior of MSMAs will foster the reliability of magnetic shape memory alloys. These improvements and the exploration of the energy harvesting capacity will promote the development of technological applications utilizing magnetic shape memory alloys.

Keywords

fatigue, magnetic shape memory alloys, Student Machine Shop, Magnetic Linear Test Apparatus (MLTA)

Disciplines

Mechanical Engineering

MECHANICAL TESTING AND DESIGN OF THE MAGNETIC LINEAR TEST APPARATUS

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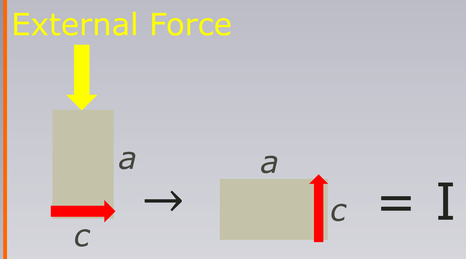
PURPOSE

The Magnetic Linear Test Apparatus (MLTA) is used to test and study the fatigue and electrical characteristics of magnetic shape memory alloys (MSMA).

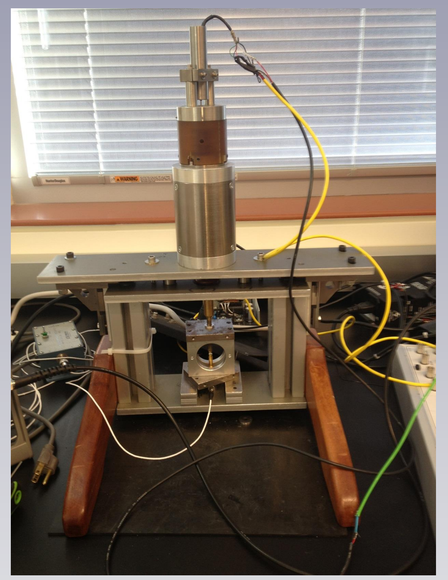


DESIGN REQUIREMENTS

- Stable platform able to withstand constant vibration
- Provide a controlled, variable magnetic field of up to 1 Tesla confined to a small space
- Easily accessible sample stage
- Precision fixed compression displacement of sample (± 0.002 mm)
- Utilize as much of existing apparatus as practical in order to reduce cost
- Closed-loop control system and 1 μHz data acquisition

EXISTING DEVICE

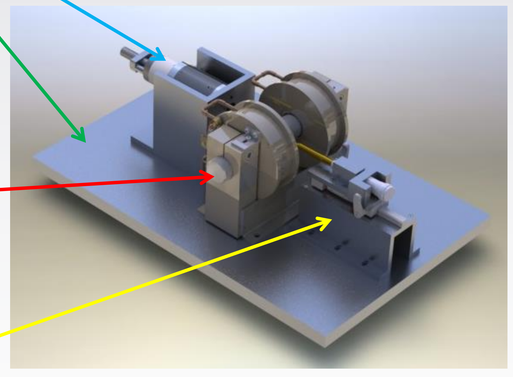
- Design has functioned well and produced useable data
- Magnets must be removed to access the sample stage
- Sample mounting takes place in a difficult to access area
- Limited to fixed magnetic field strength
- Stability issues caused by vibration



FINAL DESIGN

Design completed entirely by COEN undergraduate students

1. Linear actuation motor
2. Heavy MIC6 aluminum base plate with rubber feet
3. Variable field electromagnet
4. Linear compression stage with micrometer compression adjustment



DESIGN BUILD

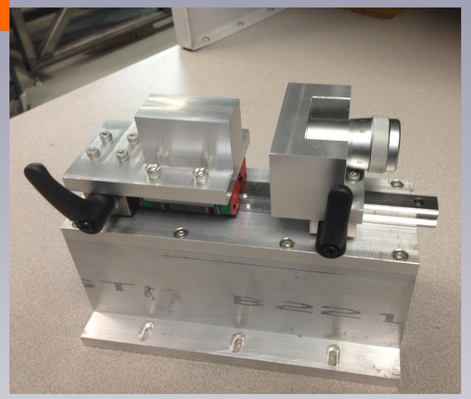
Design completed using Dassault Systemes Solidworks Modeling software

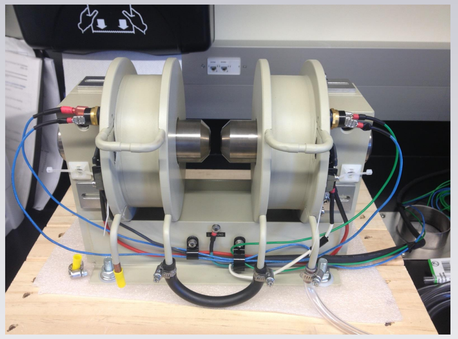
Parts fabricated in COEN Student Machine Shop by undergraduate researchers

Electromagnet characterized and prepared in COEN Magnetic Materials Lab

Electromagnet wired with temperature sensitive switches to prevent overheating

Electromagnet plumbed for process cooling water to sustain large magnetic fields





FUTURE WORK

- Complete fabrication/assembly
- Mechanical integrity/data acquisition testing
- Sound level safety testing
- Conduct tests on MSMA samples
- Data analysis
- Design and installation of sound proofing cabinet

ACKNOWLEDGEMENTS

COEN Machinist Phil Boysen for his design and fabrication advice, COEN Student Machine Shop Manager Chris Davis for his fabrication help, and financial support of the US Department of Energy, Office of Basic Energy Sciences (BES) through project DEFG-02-07ER46396.