Project Title:	Ferroelastic Test Rig for Elastocaloric Performance Testing
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Area:	Mechanical Engineering
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Fort Wayne Metals Research Products is known for producing medical grade wire. This wire comes in many different forms: ultra-fine wire, high strength tungsten cables, hollow wire strands, composite wires composed of multiple materials, crimped cable assemblies, and much more. Fort Wayne Metals is also an industry leader in nitinol production, which is an alloy composed of nickel and titanium featuring super-elastic and shape-memory properties.

A new application for nitinol is emerging: solid-state heat pumps. This application takes advantage of the elastocaloric properties of nitinol. An elastocaloric alloy is capable of undergoing a stress-induced crystalline phase change, which releases or absorbs heat energy. In this application, the nitinol will originally be in its austenitic high-energy phase. When the nitinol is stressed, it will undergo a phase transition to the martensitic low-energy phase. This transition from the high energy phase to the low-energy phase results in the release of the difference between the two energy states. This released energy is the latent heat of transformation. When the stress is released from the nitinol, it returns to its high-energy phase, drawing thermal energy from the surroundings in the process. Therefore, mechanical work can be used to pump heat from one thermal reservoir to another by stressing and releasing an elastocaloric alloy.

Elastocaloric heat pumps are a potential market opportunity, as they would not require refrigerants that are hazardous to the environment. Many predict that they could operate with minimal maintenance, have a compact profile, and be safe and easy to recycle. Therefore, Fort Wayne Metals is looking to expand its capabilities to supply nitinol to the companies developing elastocaloric heat pumps. To determine which nitinol alloys are best for this application, Fort Wayne Metals must perform tests on each alloy to determine the latent heat of transformation between the two phases, the fatigue characteristics, and the long-term effect of repetitive stresses on the elastocaloric properties.

Fort Wayne Metals has submitted a request to develop a test rig to test for these factors. This test rig will be capable of the performing the following: a rapid application of strain to a nitinol wire to initiate phase transformations, a continuous measurement of the temperature of the wire, a continuous measurement of strain and force on the wire, and an application of joule-heating to the wire. To determine the properties of the wire, the wire will be rapidly strained to a specified amount while monitoring the resulting temperature increase in the wire. The strain on the wire will then be released while the resulting temperature reduction is monitored. To replicate the previously measured temperature differences, a joule-heating system will then be used to heat the wire using a known amount of electrical energy. These energy values will be used to determine the latent heat of transformation between the two phases. To determine the long-term elastocaloric behavior and fatigue characteristics of the material, the device will be capable of repeating the stress-release cycle at least 100 times.