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Optimizing a Passive Tracking Solar Panel System

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Abstract

For a solar panel to function efficiently, it must turn to face the sun throughout the day. Usually, an electronic device rotates a solar panel. In this experiment, hourly rotation of the panel was achieved through contraction of a shape memory alloy (SMA) and a gear system. A Fresnel lens directed the sun's rays onto the SMA causing it to contract. A delayed reset system was built to turn the panel from west to east at the end of the day. In addition, this project investigated different materials to properly heat and cool the SMA within the plexiglass housing apparatus. The overall goal for the project was to automatically power an appliance on campus with solar energy.

Introduction

<u>The benefits of solar energy</u>

- Inexhaustible
- Available in most parts of the world
- Virtually no pollution

<u>The benefits of the OBU Prototype</u>

- Increased sunlight absorption
  - Follows the azimuth angle of the sun
- Low maintenance
- Passive tracking with a shape memory alloy (SMA) spring
  - The austenite phase is rigid and programmable.
  - The martensite phase is elastic.
- Single axis - the seasonal axis is adjusted manually

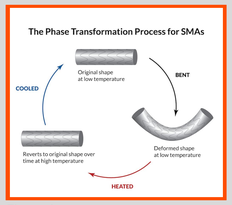

Figure 1.

General Outline of Design and Function

1. Each hour the Fresnel lens focused sunlight on the SMA.
2. The SMA contracted and rotated the gears which turned the panel and lens 15°.
3. The SMA cooled below the transition temperature and lengthened because the ray was not directed on it, but the gears did not rotate because of the nature of the sprag gear.
4. The sun moved 15° through the sky over 1 hour, and a ray was once again focused on the SMA; the cycle continued seven more times in the day.
5. The hammer trigger released the energy of the spring which both disengaged the sprag gear axle and rotated the all other gears in the reverse direction moving the solar panel to face the east for the next day.

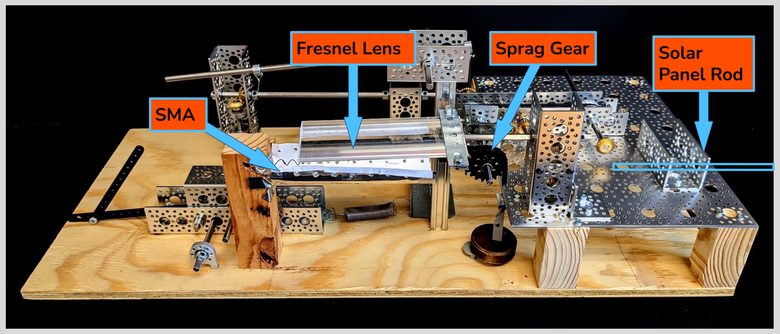

Figure 2. Side view of rotor system (housing not included)

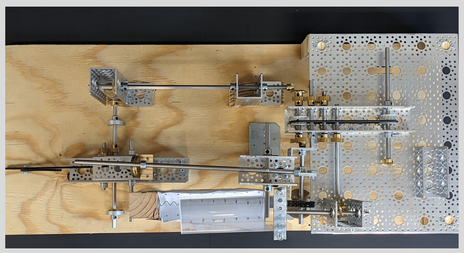

Figure 3. Top view of rotor system

Focusing The Fresnel Lens

- <u>Goal</u>: To investigate the intensity of the light ray through the lens at different angles.
- <u>Procedure</u>: A beam of light was focused 4.75 cm (focal length) below the lens on the black surface. The width of the focused ray was measured after each 5° tilt of the lens.

Figure 4.

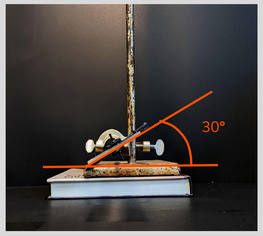

Figure 5. Angle of lens depiction

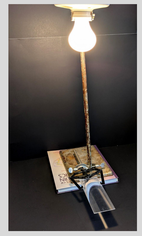

Figure 6. Experimental setup

- <u>Result</u>: There is a positive correlation between the width of light ray and angle of lens. There is no light ray with an angle greater than 30°.

Delayed Trigger Reset System

Primary functions:

- Rotate the panel to the morning position
- Disengage the sprag gear axle

1. As the day progressed, energy was stored in the spring and a plastic arm was cranked towards the trigger.

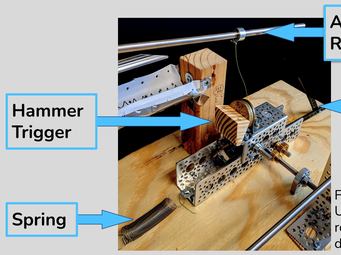

Figure 7. Unactivated reset system diagram

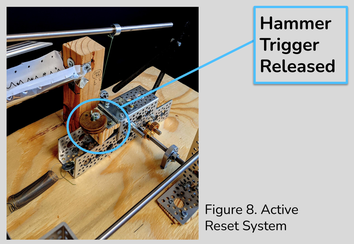

Figure 8. Active Reset System

2. At the end of the day, the arm tripped the trigger and the gear lock was released
   a. The stored energy in the spring was used and rotated the panel and Fresnel lens back to the east.
   b. The aluminum rod disengaged the sprag gear axle from the system, so that the SMA did not prevent the reset motion.

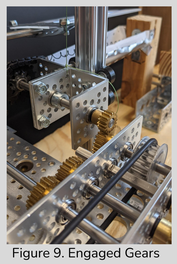

Figure 9. Engaged Gears

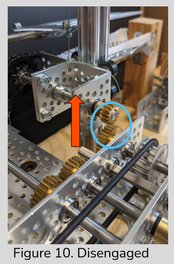

Figure 10. Disengaged Gears

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Temperature Control with Plexiglass Housing

- The rotor housing and heating trough were used to maintain a temperature just below the SMA transition temperature of 70°C, while the Fresnel lens was used to regularly bring the temperature of the SMA above 70°C .
- An average summer day in Arkadelphia was 90-95°F/ 32.2-35°C.
  - This was much too cool to contract the SMA which has a transition temperature of 158°F/70°C without the housing, trough, and lens.

<u>Plexiglass Housing Temperature</u>

- Insulated (3-in. recycled plastic insulation):
  - Average temperature: 75°C
  - Not recommended in summer
- Non-Insulated:
  - Average temperature: 55°C
  - Optimal for summer conditions

Temperature Control with Heating Trough

- Three trough lining materials were tested. Each material has absorptive, reflective, and emissive capabilities which heated the SMA differing amounts as shown below.

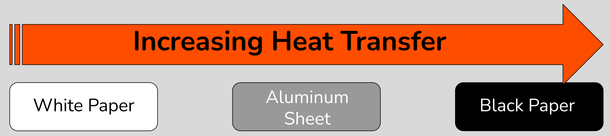

Figure 11. Heat diagram

<u>SMA Heating and Cooling in Varied Trough Materials</u>

- <u>Heating</u>: All materials heated the SMA above the transition temperature resulting in contraction.
- <u>Cooling:</u>
  - Black: Never below the transition temperature.
  - Aluminum: Below the transition temperature; no expansion of the SMA.
  - White: Below the transition temperature; allowed expansion of the SMA.

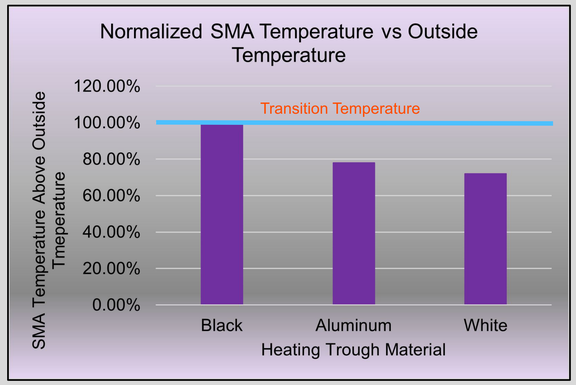

Figure 12.

Future Work

- Test the reset system outdoors.
- Attach a lid to the rotor housing and ensure weather resistance.
- Continue research on temperature control.
- Find ways to operate system in other seasons.
- Attach solar panel and mount the rotor housing to a stand with a seasonal axis.
- Replace the plywood and pine blocks with higher quality material.
- Replace the locking gear with one that has more teeth for precise increments.
- Optimize counterweight system with suitable materials.
- Replace the braided line with a metallic, non-fraying cable.

Acknowledgments

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