Self Deploying Nitinol LHP Radiator for Small Spacecraft

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Nitinol - Shape Memory Alloy

• Nickel Titanium Intermetallic Compound
  – Near Equi-Atomic (49.0-50.7 at% Ti)

• Low Temperature - Martensite
  – Twinned monoclinic structure
  – Very flexible - 8% elastic limit

• High Temperature - Austenite
  • Cubic B2 structure

• Shape Memory
  – Temperature or Stress
Concept – Self Deploying

- LHP condenser tubing is Nitinol so it self deploys as it warms up.

![Diagram showing LHP Condenser Tubing as coiled (Martensite) and passively deployed (Austenite).]

The LHP Condensers passively extend to their trained memory shape when they reach the phase transition temperature of the Nitinol tubing. (Austenite)
Coiling Constraints

- LHP Ends are Constrained

\[ \text{Radius}_{\text{min}} \approx 7 \times \text{Dia}_{\text{tube}} \]

Memory Shape

Roll it Up

Ends don’t move
Coiling

• Two Shapes were tried

“V” Form Memory Shape

V Form Coil as Received

“U”-Form Nitinol Coil

“U” Form Memory Shape
Deployment Tests

• Learn how SMA works when Heated by Internal Vapor Condensation
  – Water Loop Thermosyphon (LTS)
    • Safety while learning
  – Ammonia Loop Heat Pipe (LHP)
    • Proof of Concept

• Try Different Coil and Mechanical Arrangements
Deployment Tests

• First Test
  • Water LTS
  • Surface Mount

1. Center Curve Moves First
2. Center Curve runs into support
   Upper Coil begins to change
3. With ends constrained, upper coil
   moves in haphazard directions
   Lower Coil has not reached transition
   temperature
4. Final Shape
Deployment Tests

- Test of 6/4/09 (Rebuilt water LTS)

  \[ T = 0 \]
  \[ T = 51 \text{ sec} \]
  \[ T = 170 \text{ sec} \]
Deployment Tests

- Test of 6/22/09 (Ammonia Loop Heat Pipe)

At start of Test

Full Deployment
Deployment Tests

• Demonstration 7/7/09

“U” Form Coil around AeroCube-Style Nanosat (4 inch cube)
Conclusions

• Phase 1 Demonstrated Feasibility

• Need Mission Application for Phase 2