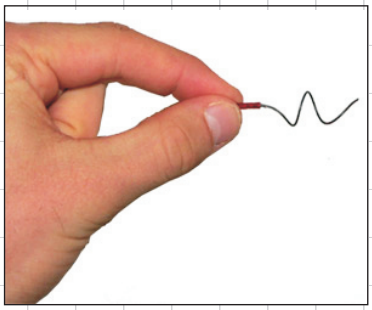
Nitinol Memory Wire

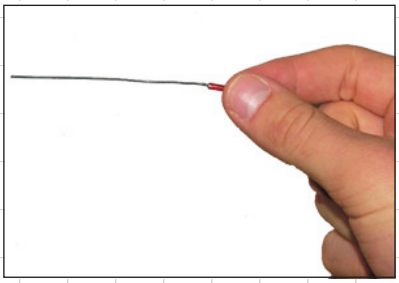


Nitinol wire is a shape memory alloy that will, when heated, magically return to a predefined shape that it has been "trained" to remember. Twist it or bend it and then heat it with hot water or an electrical current to see it return to its original shape – a strange kind of self healing.

What is Nitinol?

Nitinol (pronounced "night-in-all") is a generic trade name for NiTi alloys, which stands for Nickel (Ni), Titanium (Ti) and US Naval Ordinance Laboratory (NOL) where the alloy was discovered in the early 1960s by William Beuhler.

Nitinol wire properties
Nitinol belongs to a class of materials called Shape Memory Alloys (SMA).
It has interesting mechanical properties:



It contracts when heated (Muscle wire)
Nitinol's physical function resembles biological muscle; when activated it contracts. Notice that this effect is the opposite of standard metals that expand when heated and Nitinol does so with a 100 times greater thermal movement. To activate Nitinol it is heated above its transition temperature (typically 70°C). An electric current may be passed through the wire to heat it electrically as the wire's resistance is 2.5 ohm/m. When the material cools it can be stretched back to its original shape.

It has a Shape Memory Effect (SME)
The alloy can be made to remember a particular shape. Once the memory is established, it can be bent out of shape. Heating the alloy above its transition temperature will return it to its memorized shape. In ordinary metals, deformations cause the delocations of the molecular structure into new crystal positions. There is no "memory" in the crystal of where the atoms were before they moved.

Applications

The contraction movement may be applied to any task requiring physical movement with low to moderate cycling speeds.
The small size, light weight, ease of use and silent operation allow Nitinol to replace small motors, stepper motors or solenoids. Braille display devices, spacecraft antennas, robotic arms, spectacle frames, orthodontic alignment material, coronary stents and artificial limbs are just a few of the hundreds of applications.

What to do

A. Demonstrate its memory effect
Hold onto the beaded end and curl the wire around a pencil or bend it into any shape you want.
Place it in hot water (above 65 °C) or connect two AA batteries to the wire and the wire magically unfolds itself.
CAREFUL with hot water as the reverting process is quick and surprisingly strong. (The memorized shape is set at 'straight' when sold)
When the metal has cooled, it may be deformed again.

B. Make it memorize a new shape
You can modify the "memory" shape by annealing the wire.
Bend the wire to its new shape and hold it with two pairs of pliers while heating it in a candle or bunsen burner's flame. Do this until you feel a release of tension. Do not heat more than is necessary. Then dip the wire into cold water. It now has a new memory shape.

What is happening?

The physical movement of Nitinol is attributed to internal molecular restructuring. And as the movement is generated on a molecular level, it is quite strong. Nitinol alloy has three distinct temperature phases:

Martensitic Phase. Low temperature phase.
The crystal structure is aligned and cubic. The alloy may be bent or formed easily. Bending deforms the crystalline structure of the alloy producing internal stress.

Austenite Phase. Temperature is above transition temperature.
The movement generated in this phase is caused by the crystalline structure returning to its non-stress state (cubic). The exact transition temperature varies depending upon the exact composition of the nitinol alloy. (A 1% difference in the Ni and Ti ratio varies the transition temperature from -100 to +100 C). The strength with which the material returns to its original shape is considerable: 35,000 to 70,000 psi (241 000 to 482 000 kPa). Ten muscle wires the thickness of a human hair (100 microns) can lift 1.5 kg !

Annealing Phase. High temperature phase.
The alloy will reorient its (cubic) crystalline structure to "remember" its present shape. The annealing phase for the nitinol wire in this pack is approximately 540°C.

References
Muscle Wires Project Book, R G Gilbertson, 1994, Mondo-Tronics Inc.
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