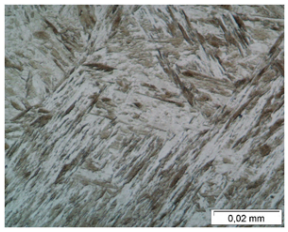
NITINOL

Nitinol is a nickel-titanium alloy that was discovered in 1958 by metallurgist William J. Buehler, working at the U.S. Naval Ordnance Laboratory, while he was seeking an alloy for missile nose cones that could better withstand reentry. The alloy, named Nitinol for ***Ni***ckel ***Ti***tanium ***N***aval ***O***rdnance ***L***aboratory, exhibits a shape memory effect, that is, it radically changes shape when subjected to a temperature change. Nitinol wire is soft at a low temperature and can easily be bent into simple shapes. At high temperature. the Nitinol wire becomes stiff reverting to its original shape.

Nitinol is an example of a "smart" material that undergoes changes between two solid phases, called the austenite and martensite phases, that involve rearrangement of its atoms within its crystal lattice. Nitinol is unusual in that it "remembers" its shape because the its crystal structure arrangement is not changed during a phase change.

The Martensite phase is named after the German metallurgist Adolf Martens (1850–1914), who, in the 1890s, studied samples of different steels under a microscope, and found that the hardest steels had a regular crystalline structure of plate shaped crystal grains. The martensite is formed by rapid cooling (quenching) of austenite which traps carbon atoms (in carbon steel) that do not have time to diffuse out of the crystal structure.



The Austenite phase is named after Sir William Chandler Roberts-Austen (1843-1902). In this high temperature phase, iron changes it crystal structure resulting in a softer and ductile form of iron.

The martensite and austenite phases occur in other metals in addition to iron.

One application of Nitinol is the Thermobile (see Figure 1), a device consisting of a wire loop around two pulleys, one brass and one plastic, that generates power without a motor or batteries. The Thermobile is manufactured by Innovative Technology International, Inc.

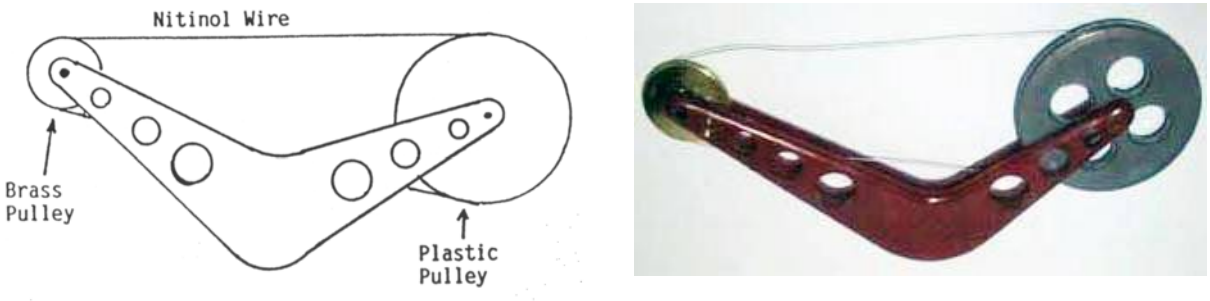


Figure 1. A Thermobile

The Thermobile works by immersing the bottom edge of the brass pulley into hot water between 50°C and 75°C. Within a few seconds, the Thermobile will begin to spin continuing as long as the bottom is at a temperature above 50°C. What takes place is that the Nitinol wire, bent around the metal pulley, will try to straighten itself out into its "remembered" straight shape, and, in the process, will cause the wheel

to spin. The effect can also be produced by using solar energy, with the aid of a magnifying glass, to heat the brass pulley.

An improved version of Nitinol wire, consisting of approximately 50% each of nickel and titanium is manufactured by Toki Corporation under the name BioMetal®. This alloy has been stretched and, when heated, will shorten to its original shape. BioMetal® wire is used in a device called Space Wings and a Kinetic Butterfly, butterfly types of devices which flaps their wings due to the contraction of the BioMetal® wire. The kinetic butterflies are occasionally seen in displays in stores.

Materials Needed

Nitinol wire
Tongs
Long nose pliers
Bunsen burner or small propane/butane torch
Wire bending plate
Screws with nuts and washers (stainless steel preferred)
Screw driver
Beaker of ice water
Beaker of hot water

Procedure

A. Observing the properties of Nitinol wire

Place the Nitinol wire in the ice water. Allow it to become thoroughly chilled.

Remove the wire from the water and bend it into any desired shape such as a coil, a spring, s-shaped, etc.

Holding the end of the wire with tongs, dip it into the hot water. What happens?

This process can be repeated many times without any damage to the wire..

B. Training Nitinol wire to remember a new shape

Obtain a piece of nitinol wire, at room temperature, a bending plate, screws with nuts and washers, a pair of needle nose pliers, and a screw driver.

Take some time to determine the type of shape you want to train your piece of nitinol wire. You can form letters, flowers, folded-ribbon shapes, etc. You do not want to overlap or twist the wire together.

Place a screw with washer into one hole of the bending plate with a nut on the bottom side of the plate. Use the pliers to wrap the end of the nitinol wire around the screw, below the washer. Tighten the screw to hold the wire securely.

Figure 2. A wire bending plate

Using additional screws with nuts and washers, bend the wire into the desired shape. NOTE: The wire must be bent snugly around the screws and tightened in place. The wire will not hold a free-form shape.

Once you have the desired shape, secure the end of the nitinol wire by wrapping the wire completely around a screw, washer, and nut. Tighten securely. (See Figure 3)

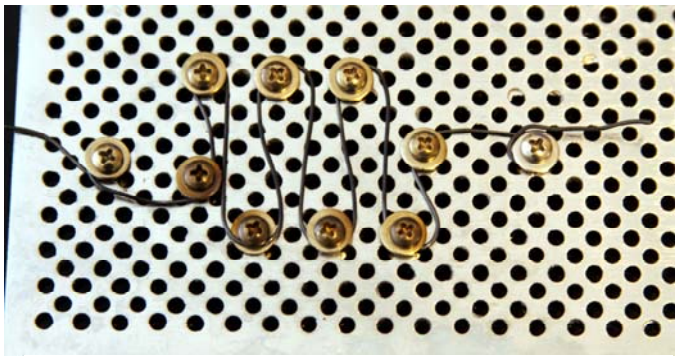


Figure 3. Nitinol wire secured in place for training.

Heat the wire with a Bunsen burner or small propane/butane torch flame (see Figure 4), to about 500°C, starting at one end, until it just slightly turns red, and continue slowly, heating it until you reach the other end. The wire will try to straighten out until it is trained. **Do not overheat the wire**, as it may become damaged.

Allow the wire and the bending plate to cool to room temperature. This will take a minimum of 10 minutes.

Carefully remove the wire from the bending plate. It should maintain the shape you made. Dip the cooled wire into ice water and allow it to become chilled.

Remove the wire from the ice water and straighten it out. Then dip it into the hot water. Does the wire “remember” its trained shape?

If the wire does not maintain the trained shape, you can reshape it and heat it again.

Figure 4. A micro butane torch