Memory-Metalle GmbH

INFO-SHEET No. 13

NiTinol Alloy Types, Conditions and Surfaces

A. Chemical Composition

NiTinol alloys are mainly use due to their specific functional properties. These properties are related to the martensitic phase transformation, which is controlled by two independant parameters: the mechanical stress and the temperature. This means, that a NiTinol alloy can transform from the austenitic high temperature phase into the martensitic low temperature phase due to the following reasons:

- an increasing mechanical stress exerted on the specimen
- a decreasing temperature below the martensitic transformation temperatures.

or a combination of both. Usualy, the transformation behaviour of NiTinol is characterized at a stress level of zero by measuring the characteristic transformation temperatures A_s, A_f or A_{peak}. The chemical composition of a intermetallic compound can certainly be measured, but it has shown to be very critical to bring chemical composition and transformation temperatures in relationship to each other. The reasons for this is:

- The most precise method to analyze composition of NiTinol is the wet chemical analysis. This method shows the Ni and Ti composition with a tolerance of 0.2 wt-%.
- The whole range of commercially available alloys is covered by a composition range of less than 2 wt-% of Ni content changes. With this composition window, the NiTinol alloys cover as much as -100°C up to +100°C for the A_s temperatures.

As a consequence, we can derive that a small change in chemical composition (such as we find in the tolerance window of the chemical analysis) leads to a wide window of transformation temperatures. Therefore, this pure measurement of chemical composition is considered to be unsuitable for the specification of NiTinol. Today, the specification of the alloy types by transformation temperatures which are measured in a well defined thermo-mechanical condition (annealing at 800 to 850 °C/15 min.) is widely accepted.

B. Classification of Alloy Types

As a consequence of the said, NiTinol alloys are classified Austenite transformation temperatures in the so-called ‚fully annealed condition‘ at zeron stress rather than by chemical composition. We basically distinguish between 6 different alloys and a seventh alloy that is derived from the others:

- Alloy N (superelastic standard alloy) with an A_f temperature around -10 to -15°C. This alloy is used widely e.g. in guidewires, medical instruments and implants. The measured compositional average is around 51.0 at-% Ni. The alloy is very sensitive to effects of so-called thermo-mechanical treatments.
- Alloy S (superelastic standard alloy) with an A_f temperature around 0°C (slightly ‚warmer' than alloy N). This alloy is used widely medical instruments and implants. The measured compositional average is around 50.8 at-% Ni.
- Alloy C (Cr-doped superelastic alloy) with an A_f temperature around -10 to -20°C. This alloy is used for applications where a slightly higher stiffness or torqueability is required, such as guidewires and other medical instruments or implants. The measured Cr content is around 0,25 wt-%.
- Alloy B (standard alloy for body temperature shape memory applications) with an A_f temperature around +25 to +35°C. This alloy is used in applications, where a shape change due to changes in temperatures around body temperature is required. The measured compositional average is around 50.2 to 50.4 at-% Ni.
- Alloy M (standard alloy for intermediate temperature actuation) with an A_f temperature around +55 to +65°C. This alloy is used in applications, where a shape change due to changes in temperatures is required. The measured compositional average is around 50.0 to 49.8 at-% Ni.
- Alloy H (standard alloy for higher temperature actuation) with an A_f temperature around +95 to +110°C. This alloy is mainly used in actuator applications, where an electrical current (or boiling water) are used as actuation energy. The measured compositional average is around 49.6 to 49.4 at-% Ni.
- Flexinol™ wire: this is a special actuator alloy generated by a proprietary process from either alloy M or alloy H exclusively for use in straight wire actuators with maximum performance.

C. Thermomechanical Conditions

NiTinol materials are typically supplied in two different thermomechanical conditions:

- straight annealed: this is the standard condition, with which the alloy is annealed to a well defined straight shape using a standard process with a certain furnace temperature (around 500 °C), for a certain period of time under a defined tensile load. This process leads to a good average of functional properties and is suitable for a multitude of applications.
- shape annealed: the Nitinol alloy is shape-set by a certain heat treatment to a custom specified shape (e.g. expanded to a stent or coiled to a spring). This is done with steel fixtures or tools in different types of furnaces or salt baths.
- as cold worked: material is supplied in this condition is neither straight (or flat) nor does it have good functional properties. Customers typically order this material when they want to apply their own heat treatment to the wire. However, it is recommended to order NiTinol in the shape annealed condition, which gives Memory-Metalle GmbH the chance to carry out the heat treatment under tightly controlled conditions.
- actuator optimized: this process can only be applied to thin wire and is done by using a proprietary process, which Memory-Metalle GmbH has exclusively licenced from its partner company Dynalloy, Inc. The special trade name of this kind of material is Flexinol™.

D. Surfaces

A multitude of surface finishing procedures can be applied to the different shapes. However, the standard surface quality is the grey/black oxide, which forms during heat treatment in air. This oxide layer can also appear as shiny blue surface, if the black oxide was removed prior to the final heat treatment. It can also be removed by pickling, grinding and polishing procedures, which lead to shiny bright metallic surfaces.
On finished components Memory-Metalle can also apply more advanced polishing processes like e.g. electropolishing or mechanical polishing in tumble grinders (this is difficult due to the necessary mechanical impact on the alloy).