STUDY OF MECHANICAL PROPERTIES, FATIGUE AND CORROSION PROPERTIES OF NI-TI SUPER-ELASTIC ALLOY

Project Reference No.: *45S_BE_3398*

College ***:*** *Smt. Kamala and Sri Venkappa M Agadi College of Engineering, Gadag*
Branch ***:*** *Department of Mechanical Engineering*
Guide(s) ***:*** *Dr. M S Tattimanni*
Student(S) ***:*** *Mr. Abhishek Mokashi*
Mr. Shekhargouda Patil
Mr. Mohammedabrar Khatib

Keywords:

Ni-Ti alloy, Fatigue strength, corrosion resistance, super-elasticity

Introduction:

Material is a substance or mixture of substances that constitutes an object. Materials can be pure or impure, living or non-living matter. Materials can be classified on the basis of their physical and chemical properties, or on their geological origin or biological function.Nitinol (pronounced night-in-all) is a metal alloy with unique properties and uses. This amazing metal alloy can “remember” or change shape depending on temperature. Before you decide whether to use nitinol in your product design, here are some things you should know about it.Nitinol originated in 1959 by mistake. Scientists were developing a heat and corrosive resistant alloy and during that process, created an alloy made of 55% nickel and 45% titanium. The name represents its elemental components and place of origin. The “Ni” and “Ti” are the atomic symbols for nickel and titanium and the “NOL” stands for Naval Ordinance Laboratory, the lab that discovered it.

Nitinol (NiTi) exhibits well-known shape memory and pseudo elastic effects that are due to a first-order cubic (B2) to monoclinic (B19') martensitic transformation [1, 2]. This temperature- or stressinduced transformation is fully reversible, whereby strains as great as 10% may be fully recovered. Consequently, Nitinol has become the material of choice for many medical devices that undergo repetitive strain excursions, such as self-expanding, endovascular stents [3, 4] and endodontic dental files [5, 6, 7].

Beside shape memory properties and super elasticity, nitinol exhibits good corrosion resistance, an unusual combination of high strength and high ductility, a strong tendency toward self-passivation, paramagnetic properties, high fatigue strength, low Young’s modulus and excellent biocompatibility [8–10]. Such a unique combination of properties has enabled its use [11], especially for biomedical purposes, first in orthodontic treatments; and later on, in cardiovascular surgery for stents, guide wires, filters, etc.; in orthopaedical surgery for various staples and rods; and in maxillofacial and reconstructive surgery [12,13]. Moreover, nitinol is used in aerospace, automotive, marine and chemical industries, and civil and structural engineering [14–18].

Objectives:

1. To study mechanical properties of Nitinol Alloy.
2. To study Fatigue properties.
3. To study Corrosion characteristics.

Mechanical properties like tensile property of Ni-Ti alloy are observed under UTM. Tensile testing is a destructive test process that provides information about the tensile strength, yield strength, and ductility of the metallic material. It measures the force required to break a composite or plastic specimen and the extent to which the specimen stretches or elongates to that breaking point.Fatigue tests are performed to measure the reduction in stiffness and strength of materials under repeated loading and to determine the total number of load cycles to failure. Fatigue tests are performed by repeated tension–tension, compression– compression, tension-compression or other combinations of cyclic loading.Corrosion tests are used to study the release of waste form components into solution during waste form degradation.

Methodology:

The following methodology processes are divided into four steps.

1. **Selection of Material.** Nitinol is a metal alloy of nickel and titanium with unique properties, including super-elasticity or pseudo-elasticity and “shape memory” properties. That means nitinol can remember its original shape and return to it when heated. It also shows great elasticity under stress.
2. **Preparation of specimen.** After selecting the material, we required to study, the material is need to be prepared or given required shape to conduct the tests.

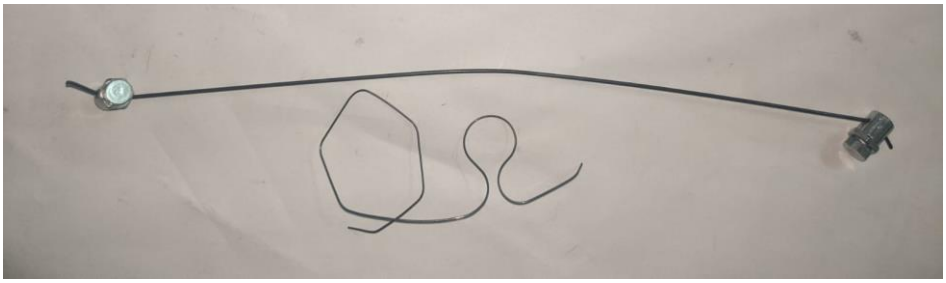

Figure 1: Sample specimens with 0.25 mm and 1 mm diameter wire

3. **Experimentation**.
   Tensile and Fatigue Test:

   1. Tensile and Fatigue testing was conducted using a hydraulic servo feed controlled Universal testing machine (UTM).
   2. Prepare the sample as per ASTM standard
   3. Mark the gauge length at round or round threaded & flat sample
   4. Mount the sample using suitable grips & wedge
   5. Calibration the load cell & strain gauge as per the shunt value

6. Select the crosshead speed as per required strain rate
7. Select the temperature as per the required test conditions
8. Set the test speed rate &DAQ Hz speed rate as per the test required
9. Test the sample up to failure
10. Remove the failed specimen from the gripes after test is over.

Figure 2: UTM machine

For Computer Data& Chart:

1. Select the DAQ report test file open the raw data
2. Open the raw data in excel sheet & make arrange the chart and data
3. Excel file save in correct computer location

4. **Corrosion Test:**

A primary testing method is Salt Spray testing, which as its name indicates, evaluates how resistant a part or material is to corrosion when exposed to a salt spray for extended periods of time. Effective Salt Spray testing must be performed in a controlled environment, such as a closed salt fog tank.

Conclusion:

The ultimate tensile strength of 1 mm Nitinol alloy was 1650 MPa and in this test, samples are fatigued at 0.8% strain until failure or 80,000 cycles.

Scope for future work:

In the near future, many other SMA-based applications will be identified and conceived in which the actuation due to the shape memory effect or the pseudo-elasticity will be based on.