Mechanical characterization of NiTi wires under pure bending

G.Antherieu[1], N.Connesson[1], D.Favier[1], Y.Payan[1] and P.Mozer[2]

[1] *Laboratoire TIMC/IMAG, UMR CNRS 5525, Faculté de Médecine Domaine de la Merci, La Tronche, France*
[2] *ISIR/service d'urologie, hôpital la Salpêtrière, 37, boulevard de l'Hôpital, 75013 Paris, France*

1. INTRODUCTION

This work presents results about the development of an innovative stent composed of NiTi wires. During the stent expansion, the wires are mainly loaded in bending. A section of the wire is thus compressed while the opposite side is pulled. If tensile behaviour of NiTi samples is well documented in the literature, only few studies about compressive behaviour were made [1]. Moreover, NiTi materials present tension-compression asymmetry [2], which makes bending behaviour difficult to predict [3]. In this study, various samples of NiTi wires were tested using a specific pure bending apparatus allowing curvature radius as low as 1cm. The tests were performed at different temperatures and for different thermal treatments. Obtained results enabled a better understanding of NiTi bending behaviour and also provided insights about its mechanical behaviour under compression.

2. BENDING DEVICE

2.1. Description

A specific pure bending apparatus based on a universal joint has been developed. Using this apparatus, a wide range of radius of curvature (from a linear geometry to 1cm radius of curvature) can be applied on wire samples (diameter less than 1mm). This device also allows the loading of specimens in pure torsion: this feature will be used to validate the moment measurement on a controlled torsion spring.

2.2. Validation

The bending device performances were experimentally validated. Two validation tests were performed:

- Validation of the moment measurement during torsion tests on a torsion spring
- Validation of the curvature and moment measurement during pure bending tests on steel wires (Figure 1)

Bending moment/load measurements were performed using a 25N load cell. A picture of the specimen was taken for increasing bending moment. Curvature was estimated using these pictures: an in-house program fitted a least mean square circle on each specimen, providing thus the global radius of curvature. The order of moment magnitudes was of about 10^{-3} N.m; the minimum reached radius of curvature was about 1.5cm. Results of a bending test on a steel wire are presented Figure 1.

3. BENDING TEST ON NITI WIRES

NiTi wires of diameter 0.5mm and length 2.5cm were then tested in pure bending. The minimum reached radius of curvature was about 1.5cm. Bending moment and curvature were measured as previously described. The specimen temperature was controlled in an insulated oven. Various thermal treatments and testing temperatures were tested, providing results for different crystallographic states: cold-worked, austenitic and martensitic. Results of a bending test on a steel wire are presented Figure 2.

4. CONCLUSION

An innovative pure bending apparatus has been developed and used to perform tests on NiTi wires on a wide range of radius of curvature [1cm, ∞]. These tests provided a first characterization of the NiTi behavior under pure bending for a wide range of local strain [-5%;5%]. Knowing the tensile NiTi behavior during pure tensile tests, the compressive NiTi behavior will be estimated in further work.

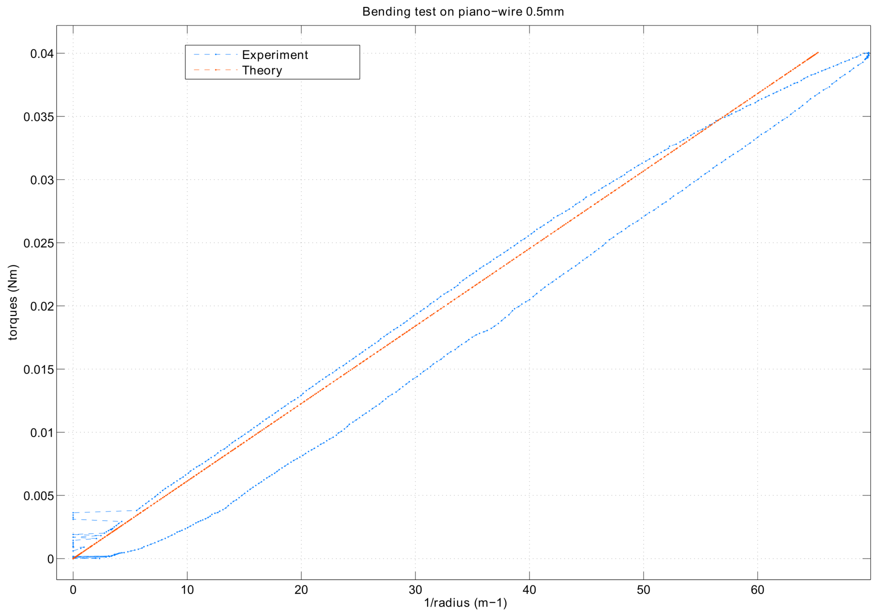

Figure 1. Bending test on steel wire (piano-wire type), 0.5 mm diameter

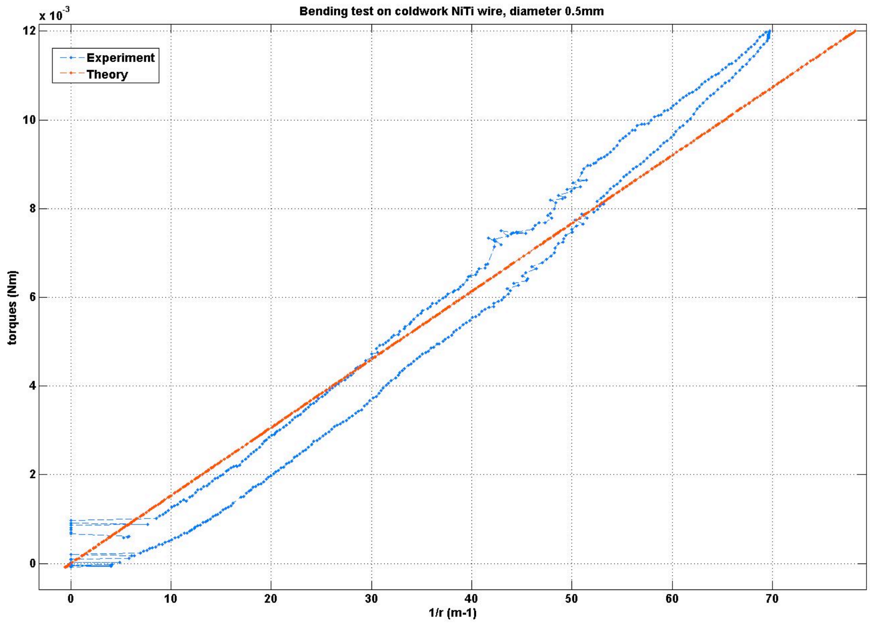

Figure 2. Bending test on NiTi wire (cold-worked), 0.5 mm diameter

References

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