Stress Relaxation Of Superelastic Shape Memory Alloy Under Bending And Torsional Load

Sakib Tanvir, Dr. Md. Ashiqur Rahman

Abstract: Stress Relaxation of Superelastic Shape memory (NiTi) Alloy under bending and torsion is uncommon in literature. Therefore, experimental set up has been devised and test results are obtained for superelastic SMA.Unlike the other common engineering materials superelastic SMA it gives dramatic reduction in stress. In this paper, therefore, results of stress relaxation of superelastic shape memory alloy under bending and torsion are presented graphically and interpreted in terms of stress induced martensitic transformation.

Keywords: Stress relaxation, superelastic SMA, NiTi alloy Tube, Viscoelastic Response, Bending Load, Torsional Load, Testing Device

1.1 Introduction

Bending stress relaxation of NiTi alloy is a important behavior of SMA.It is a time dependent behavior of NiTi alloy to relax stress under constant strain. It is an experimental analysis of NiTi alloy under bending. It reveals the prospect of NiTi alloy to be used as actuator and spring under bending load. NiTi alloy can exhibit stress relaxation unlike the traditional materials. Tensile stress relaxation is a common phenomenon.[1,2] However bending stress relaxation of NiTi alloy is also a possible case of interest. Using this bending stress relaxation behavior uses of NiTi can be increased to far extent. Stress relaxation is a time dependent behavior of some metal or alloy to relax stress under constant strain. Commonly metals don't show this behavior or show in a very negligible range. But SMA (shape memory alloy) shows this behavior. [1], [2]

1.2 Motivation of the Present Work

Most of the application and researches on NiTi have been centered to its shape memory effect and super elasticity. Recent focus is made on SIMT too. The factors related with SIMT are stress, strain, volume fraction and temperature. Study with time dependant behavior is not common with NiTi SMA. But Viscoelastic response is important to know because without knowing this we cannot have real idea about how much stress the material is relaxing. So preloading cant be done perfectly also. Though some researches have been done in tensile and compressive loading, not much work is done with NiTi in bending and torsional loading to observe its time dependant behavior. But as a matter of fact, for using NiTi as a actuator, stress relaxation in bending and torsional loading should be observed carefully. The above mentioned facts motivated the author to investigate experimentally the stress relaxation of NiTi in bending and torsional loading.

1.3 Experimental Setup for Bending Load

In our test of stress relaxation our main objective is to observe the time dependent stress reduction of NiTi alloy. We used NiTi alloy tube (Ti 49.3 at %, Ni 50.2 at %, V 0.5 at %).The dia of the tube is 2 mm.In both bending and torsional test measuring force at constant load was the primary challenge. We did that with a force sensor. A wooden block was made to keep the NiTi tube at constant strain. Clamping on both ends is made with steel plates with bolting. At one end was the sensor to measure the change in load to observe the stress relaxation.

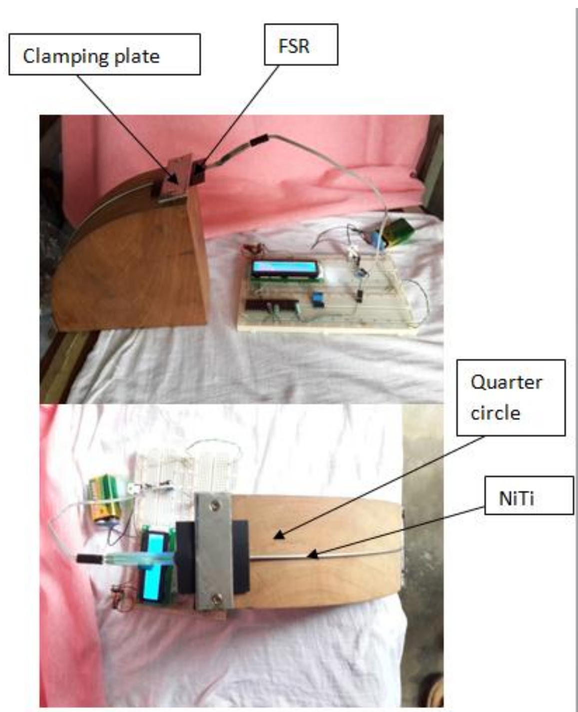

Figure 1.1: *images of bending stress relaxation test*

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1.4 Test Results for Bending Load

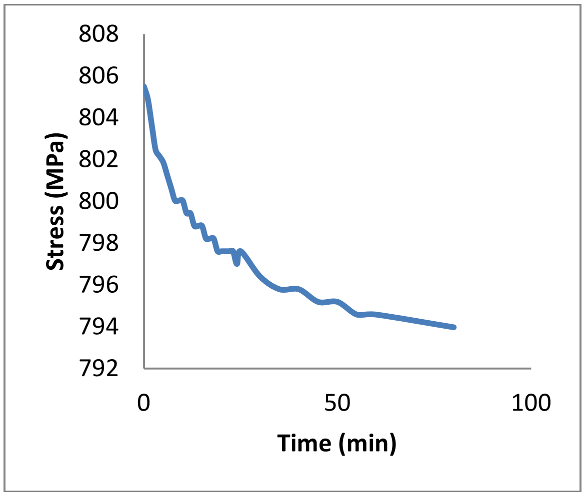

Fig 1.2: Stress Vs time for SMA rod under bending load at constant strain

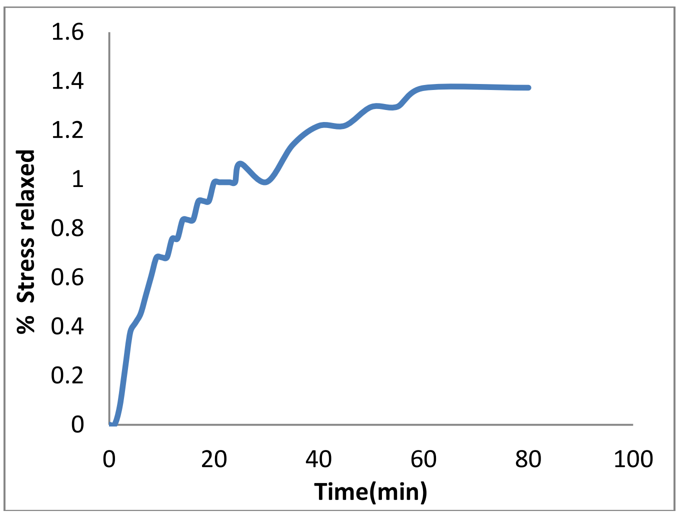

***Figure 1.3:** % stress relaxation Vs time for SMA rod under bending load*

2.1 Experimental Setup For Torsional Stress Relaxation Test

In torsional loading the slippage of the SMA specimen is a big problem [2]. Again keeping the twisting angle constant is another issue. For this reason an innovative structure is made with wood to confirm the constant twisting angle. The figures below will show how twisting angle can be kept constant and how they can be varied.

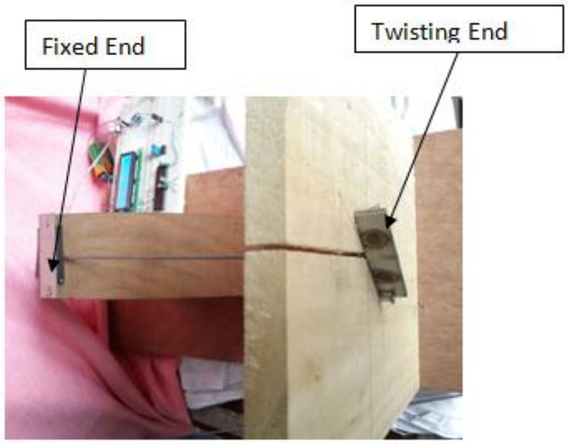

***Figure 2.1:** image of set up for torsional load*

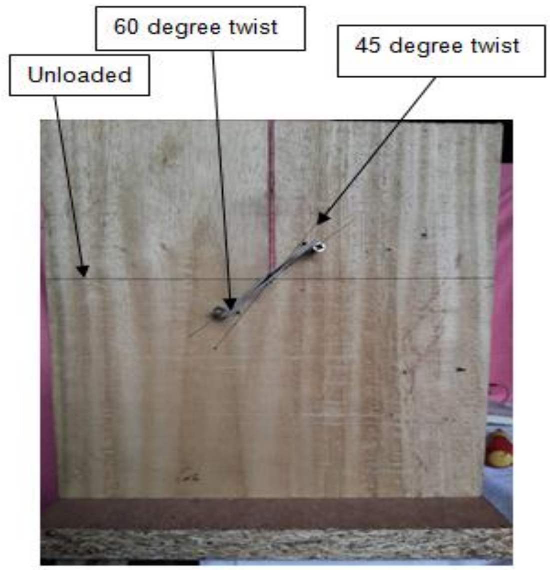

***Figure 2.2:** image of how twisting angle was kept constant*

2.2 Test Results for Torsional Load

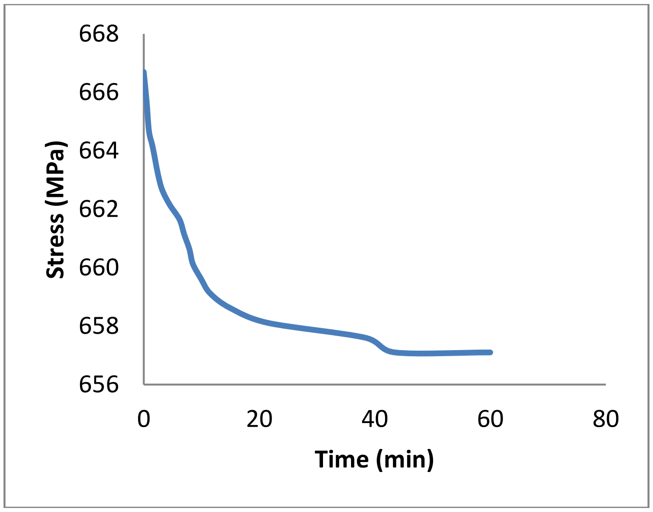

***Figure 2.3:** Stress Vs time graph for torsional load at twisting angle 45 degree*

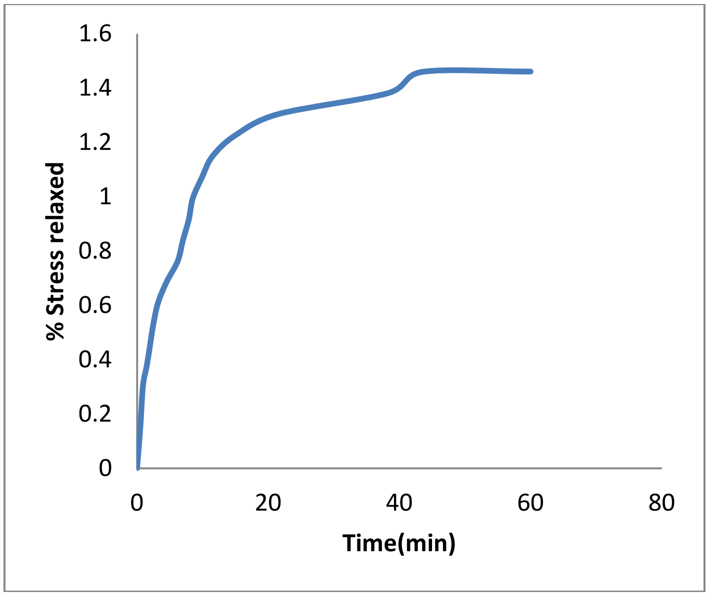

Figure 2.4: *% stress relaxed Vs time of SMA rod for torsional load at 45 degree twisting angle*

Conclusions

For both bending and torsional load, NiTi tube reduces its stress with time under constrain strain. Fig 1.2 and 1.3 shows reduction of stress under bending load. Fig 2.3 and 2.4 shows reduction of stress under torsional load. It exactly matches with the Viscoelastic model of Maxwell. This paper was mainly concentrated with the invention of test setup for stress relaxation under bending and torsional load. Further improvement can be done to make the test setup fully automated for using as a standard for stress relaxation test.

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