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Vibration Isolated Workplace

The paper presents the concern of the authors to realize a vibration-isolated workstation for own use. In this mean the authors have both modelled and experimented small scale devices, usable in vibration damping and control. The theoretical models use the spring(s)-damper(s)-mass model. The results of simulations were compared whit experiments made using Ni-Ti alloys with different shapes. The used theoretical model present sufficient accuracy for practical issues. The authors concluded that: regarding the device's shapes the best results were obtained for semi-cylindrical elements; the mass of the stiff plate and equipment placed on it has also an important role in the damping system.

Keywords: *isolated workplace, shape memory alloys, dampers*

1. Introduction

Buildings are normally not sensitive to vibrations. However, they can be affected; light to strong damages can appear, depending on the vibration parameters. More than that, optimal functioning of sensitive equipment depends on low level of vibrations. Regulations are different in various counties [1].

Shape Memory Alloys have the ability to change their shape, stiffness, natural frequency, damping coefficient and other mechanical characteristics in response to a change in temperature and/or stress [2]. SMA' s show two phenomena, known as: shape memory effect, and superelasticity or pseudoelasticity.

These characteristics are a result of a phase transformation between two crystallographic structures of the materials: the martensite and austenite phases. A SMA is easily deformed in its low-temperature martensitic condition and is returned to its initial shape by heating above the austenite start temperature A_s. At temperatures above the austenite finish temperature A_f pseudoelastic behaviour is observed [3]. This makes SMAs proper to be used as passive damping devices due to their inherent energy dissipation, resulted from the hysteretic phase transformation between austenite and martensite.

2. The effect of pseudoelasticity

The pseudoelastic behaviour is defined as forming detwinned martensite from austenite by thermo-mechanical loading. A simplified model representing martensitic to austenitic transformation and vice versa is presented in figure 1.

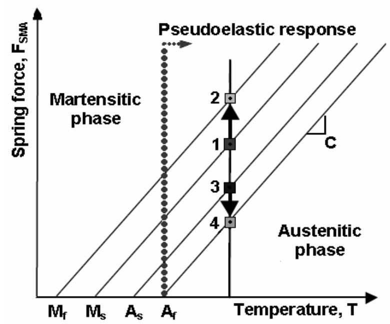

Figure 1. SMA spring element force-temperature diagram with pseudoelastic loading path

In addition to the change in material properties and large recoverable strain during pseudoelastic transformation, hysteresis is also an indicator for energy dissipation during the transformations. This energy dissipation is proportional to the degree of transformation completed during a loading cycle for both complete and incomplete, or partial transformations. These partial transformations are referred to as minor loop hysteresis cycles (figure 2.a) and complete or full transformations are referred to as major loop hysteresis cycles (figure 2.b).

The hysteresis behaviour (represented by points 1 to 4 in figures 2) along with the stiffness change (represented by k_F and k_R in figure 2 and k_{A-M} , k_M , k_{M-A} and k_A, characteristic for each state phase, in figure 2.b) of the material during the pseudoelastic phase transformations confirm the availability for our SMA spring-mass system to be used as damping and vibration isolation device [2].

3. Vibration isolated workplace

Sensitive equipment, for proper use and avoid of defects, needs a good isolation against vibrations. Classical solutions are: the use of tables with heavy plates or implementation of dumpers in the table's structure. These solutions are inadequate because of the high weight or expensive.

The authors have developed for the use in the own university a workstation, schematic illustrated in figure 3, based on the pseudoelastic behaviour of SMAs. The structure is a rigid one, on which are placed two mobile plates assigning a pre-compression of the SMA elements placed between the two mobile plates and the structure. We have tested elements with three different forms: spring, cylinder and semi-cylinder, the last providing the best isolation. Finally we placed them parallel to the long side of the plates, with the open side orientated to the stiff mounting plate.

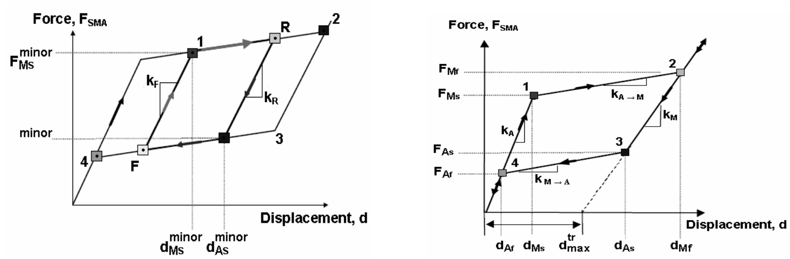

Figure 2. Force - displacement path for a) minor loop loading; b) major loop

To determinate the natural frequencies a simplified mechanical model was used (figure 3), where linear springs, frictional and slip elements are used to describe the behaviour in austenitic or martensitic domains or during the austenitic to martensitic respectively martensitic to austenitic transformations. In the figure 5, $d \geq 0$ represents the load cycle, $d<0$ the unload cycle. The four stiffness values k_A, k_M, $k_{A\text{-}M}$ and $k_{M\text{-}A}$ can be determined experimental, the values for k_I, k_{II} and k_{III} for load and unload cycles by calculus.

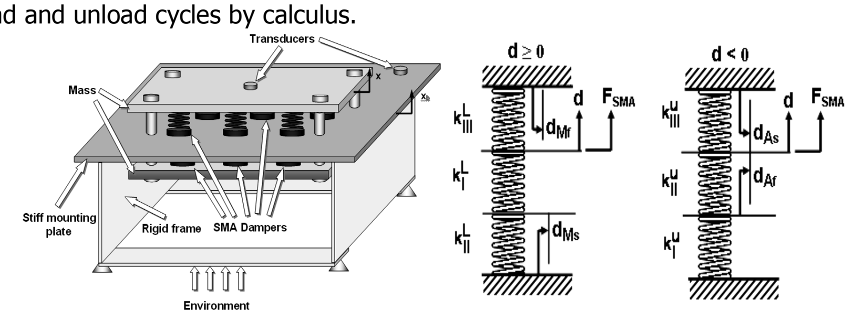

Figure 3. Isolated workstation for sensitive equipment and simplified mechanical model of SMA behaviour

Experiments regarding the influence of pre-compression have been made to find a good isolation. Tri-axial transducers placed on the structure and the upper mobile plate have determined the transmissibility of vibrations. We obtained good results in isolation in vertical field, but worst in horizontal field.

Next approaches will be focused to find out shapes which permit isolation in all directions, or if the results are unsatisfying, constructive solutions for integration of SMA elements designed to isolate in all directions. Meantime, theoretical background will be improved, in order to permit accurate design of this kind of isolating workplaces.

4. Conclusion

Elements from SMA are proper devices for vibration damping/isolation. The authors have developed a work station for sensitive equipment for own use, for which the best results where obtained for semi-cylindrical elements, having the open side orientated to the stiff plate. The excitation level defines the type of the loop: a high level determines a major loop (favourable situation), a low level determines a minor loop (the behaviour of the SMA element is close to them of a linear spring). A global conclusion is that the performance of the damping system is given by a combination of four parameters: form of the SMA, excitation level, mass and pre-compression. As future research the authors intend to develop specific form-dependent models for the SMA elements.

References

[1] Bratu, P. & Gillich, G.R. (2006). Reference Values in Evaluating Effects of Vibrations on Buildings and Persons. *Annals of "Eftimie Murgu" University Resita. Engineering Fascicule,* Vol XIII, Nr. 1, October 2006, pp. 111-116, ISSN 1453-7394

[2] Amariei D., Gillich G. R., Frunzăverde D., Micloşină C., *Study on the behavior of Ni-Ti Shape Memory Alloys in order to highlight the Memory Effect* - 2008 IEEE International Conference on Automation, Quality and Testing, Robotics AQTR 2008 - THETA 16th edition - May 22-25 2008 Cluj-Napoca, Romania

[3] Graesser, E.J. & Cozzarelli, F.A. (1991). *Shape-Memory Alloys as New Materials for Aseismic Isolation*, Journal of Engineering Mechanics, 117(11), November 1991, pp. 2590-2608, ISSN 0733-9399

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