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# SIMULATION OF A VIBRATORY SYSTEM WITH SHAPE MEMORY ALLOY UNDER ROTATING UNBALANCE EXCITATION

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## ABSTRACT

This paper presents a numerical simulation of the non-linear dynamic presented by a mechanical vibratory system (MVS) under rotating unbalance and dumped by shape memory alloy (SMA). To do so, a Matlab code was used to solve the respective equations. The results made clear the dissipative capability of this material due its hysteretic behavior.

***Keywords:*** shape memory alloys, rotating unbalance, vibration.

## INTRODUCTION

Though structural integrity is a major request in civil engineering, the exact time prediction of a component catastrophic fracture remains as one of the oldest unsolved mystery for large-scale engineering structures building and design (Radu, Sedmak, and Băncilă, 2017) (Beaumont and Soutis, 2016). Because of this, even the wind force, seemingly harmless, has been causing many failures of metallic structures due to fatigue (Klinger, 2014). However, this problem is not particular to huge metallic constructions. Namely, unbalanced masses is very common in rotating machinery and may lead any structure to high vibration levels, which make them prone to fatigue-failure (Morais, Der Hagopian, Steffen, and Mahfoud, 2013) (Mršnik, Slavič, and Boltežar, 2017). A way to dissipate mechanical vibrational energy is the use of the hysteretic stress- strain behavior presented by SMA (Pinto, 2011). On the other hand, the non-linearity promoted in the system by theses alloys becomes a critical part for computational mechanics (Michel, Piccirillo, and Andrade, 2017). Thus, the present paper exhibit a theoretical numerical study of a MVS under rotating unbalance dumped by SMA (its features are exposed on Table 1). To do so, a unidirectional single degree of freedom approximation, as well as the material properties and model proposed by Brinson (1993) were used.

Table 1 - Features of the mechanical vibratory system

| m (Kg) | r (m) | ω (RPM) | $A_{SMA}$ ($mm^2$) | C ($Nsm^{-1}$) | M (Kg) | $L_{SMA}$ (m) | T (°C) | g ($ms^{-2}$) |
|---|---|---|---|---|---|---|---|---|
| 0.3 | 0.32 | 1000 | 2.5 | 36 | 27 | 0.55 | 61 | 9.8 |

## RESULTS AND CONCLUSIONS

Figure 1 shows two distinct results. The picture on the left side represents the stress-strain behaviour of the SMA; the lower region (compressive field) was greater than the upper one (tensile), because the mass of the system worked as an initial load on the material and made it behaves anisotropically, which would not happen for a linear material. Simply put, the SMA component deformed more while forced downwards. The right graph exhibits a comparison between the SMA's strain and the strain expected for a linear material having Young's Modulus equal to 67 GPa under the same conditions.

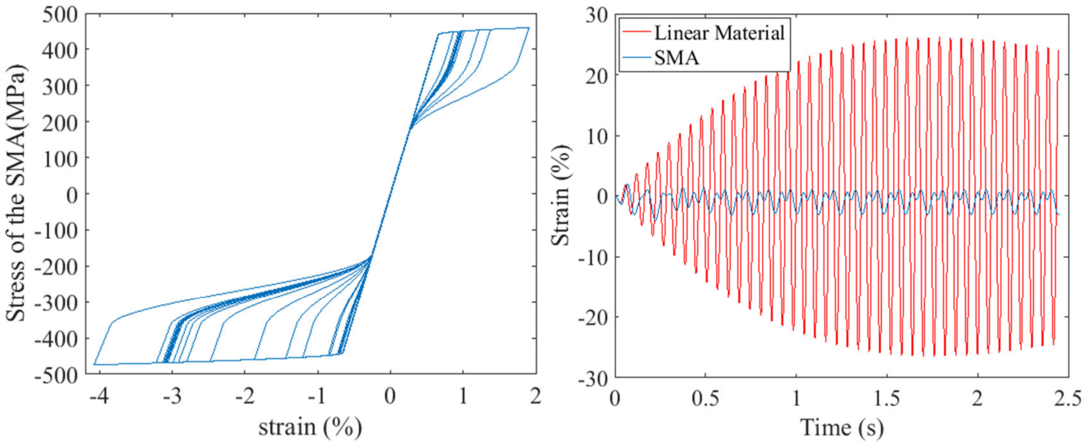


Fig. 1 - SMA's stress-strain behavior (left) and strain profile for SMA and linear material (right)

## REFERENCES

[1] Beaumont, P. W. R., and Soutis, C. (2016). Structural integrity of engineering composite materials: a cracking good yarn. Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences, 374(2071), 20160057.

[2] Brinson, L. C. (1993). One-Dimensional Constitutive Behavior of Shape Memory Alloys: Thermomechanical Derivation with Non-Constant Material Functions and Redefined Martensite Internal Variable. Journal of Intelligent Material Systems and Structures, 4(2), pp. 229-242.

[3] Klinger, C. (2014). Failures of cranes due to wind induced vibrations. Engineering Failure Analysis, 43, pp. 198-220. https://doi.org/10.1016/j.engfailanal.2013.12.007.

[4] Michel, A., Piccirillo, V., and Andrade, C. A. R. (2017). Pseudoelastic behavior of shape memory alloys under different loads da. In V Encontro de Jovens Investigadores do Instituto Politécnico de Bragança (pp. 1-2). Bragança.

[5] Morais, T. S., Der Hagopian, J., Steffen, V., and Mahfoud, J. (2013). Optimization of unbalance distribution in rotating machinery with localized non linearity. Mechanism and Machine Theory, 72, pp. 60-70. https://doi.org/10.1016/j.mechmachtheory.2013.09.012.

[6] Mršnik, M., Slavič, J., and Boltežar, M. (2017). Vibration fatigue using modal decomposition. Mechanical Systems and Signal Processing, 98, 548-556.

[7] Pinto, A. alves. (2011). Estudo teórico e numérico de modelos constitutivos de ligas com memória de forma e associação com sistemas vibratórios (master dissertation, UFU).

[8] Radu, D., Sedmak, A., and Băncilă, R. (2017). Structural integrity of a wind loaded cylindrical steel shell structure. Procedia Structural Integrity, 5, pp. 1213-1220.