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SIMULATION OF A MECHANICAL VIBRATORY SYSTEM UNDER ROTATING UNBALANCE EXCITATION AND DAMPED BY SHAPE MEMORY ALLOY

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ABSTRACT

This work presents a numerical simulation of mechanical vibratory systems (MVSs) under rotating unbalance and damped by a shape memory alloy (SMA) element. Due to pseudoelastic hysteretic behaviour, SMAs can dissipate energy and provide damping capabilities to the structure, which leads to a passive structural vibration control. The algorithm utilizes was implemented in Matlab, based in Helmholtz free energy deduction that results in a cosine constitutive model. The results made clear the dissipative capability of SMAs due to their hysteretic behavior.

Keywords: shape memory alloys, rotating unbalance, vibration, structural integrity.

INTRODUCTION

In an industrial environment, there are a lot of different rotating machines that are subject to unbalance due to an unsymmetrical mass distribution. The vibration analysis field is responsible to study this behavior, and technicians do the maintenance of this machines over the operating time. However, to prevent structural damage between the balancing, other techniques to easy vibration ought to be considered.

Several authors have been researching ways to dissipate mechanical vibratory energy. One of those ways is the use of smart materials, in particular the SMAs that present the pseudoelastic hysteretic behavior. For Brinson (1993), the main goals where the development of a constitutive model to simulate the behavior of SMA elements.

Since there is a high cost involved with the fabrication of different damping element's prototypes, the development of mathematical models able to simulate the behavior of these elements are essential. This work presents a study of a MVS solved by a numerical model based in a method that come from Helmholtz free energy using cosine constitutive model implemented in Matlab to obtain the dynamic behavior presenting qualitative comparations with literature, Machado (2007).

The material properties and system features are exhibited in Table 1, being utilized as input in the developed algorithm to obtain the stress-strain and displacement-time diagrams.

RESULTS AND CONCLUSIONS

Figure 1 shows the literature data and the result obtained with the algorithm implemented. Both cases consider the same MVS, however the properties from the alloy are different. Thus, a qualitative comparison of the graphical shape exhibits a similar behavior, showing the energy loss over the time of the vibration cycle.

Table 1 – System features and material properties

m (Kg)	r (m)	ω (RPM)	A_{SMA} (mm²)	C (Nsm⁻¹)	M (Kg)	L_{SMA} (m)	T (°C)	g (ms⁻²)
0.3	0.32	1000	2.5	36	27	0.55	51, 61 and 71	9.81

Young's modulus (GPa)	Transformation temperatures (°C)	Transformation constants (MPa °C⁻¹)	Transformation stress (MPa)	Maximum residual deformation
$D_A = 67$ $D_M = 26.3$	$M_f = 9$ $M_s = 18.4$ $A_s = 34.5$ $A_f = 49$	$C_M = 8$ $C_A = 13.8$	$\sigma_s^{crit} = 100$ $\sigma_f^{crit} = 170$	$\varepsilon_L = 0.067$

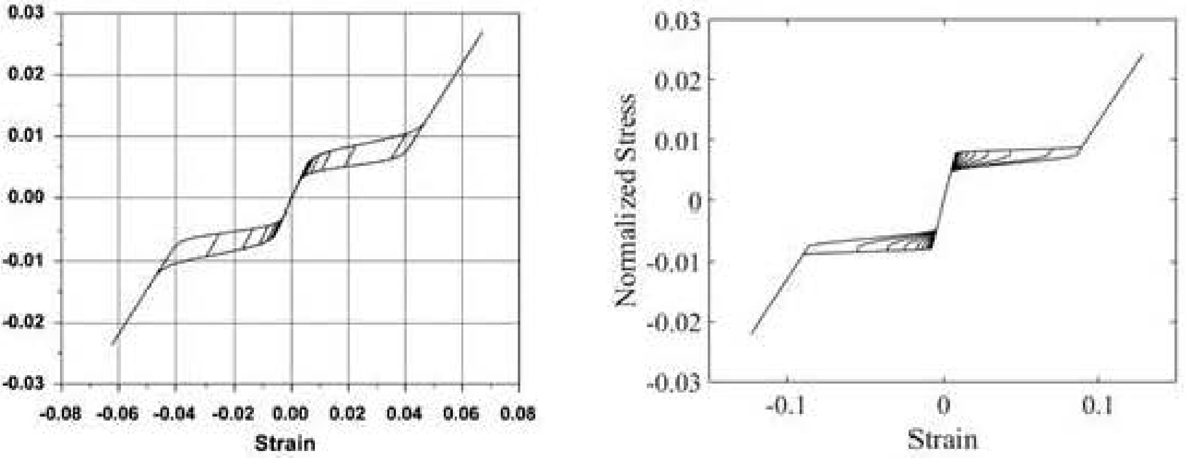

Fig. 1 – a) literature's result and b) obtained result for a free vibration case of a MVS.

This study shows that, by a qualitative analysis, the implemented algorithm presents an acceptable behavior of the MVS with SMA for a free vibration case. Future research aims to expand the analysis to forced vibration case and comparison with other authors to see the influence in the results of the different constitutive models developed over the years.

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