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 these 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

<table>
<thead>
<tr>
<th></th>
<th>m (Kg)</th>
<th>r (m)</th>
<th>(\omega) (RPM)</th>
<th>(A_{SMA}) (mm²)</th>
<th>C (Ns/m¹)</th>
<th>M (Kg)</th>
<th>L_{SMA} (m)</th>
<th>T (°C)</th>
<th>g (ms²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.3</td>
<td>0.32</td>
<td>1000</td>
<td>2.5</td>
<td>36</td>
<td>27</td>
<td>0.55</td>
<td>61</td>
<td>9.8</td>
<td></td>
</tr>
</tbody>
</table>

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.

![Figure 1 - SMA's stress-strain behavior (left) and strain profile for SMA and linear material (right)](image)

**REFERENCES**


