STUDY ON ANTI-SLIP CRITERION OF PRE-TIGHTENED STRUCTURE WITH VISCOELASTIC MATERIAL IN VIBRATION ENVIRONMENT

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ABSTRACT

In order to study interlayer rotary slip property in transverse vibration, the multilayer axisymmetrical structure with viscoelastic material pre-tightened was designed and constructed. Then, the experiments of the structure with transverse vibration were carried out, and the influences of various pre-tighten force and vibration levels were studied. Finally, through the result of vibration tests, an criterion was proposed to evaluate the anti-slip effectiveness. These results will give the guidance for the practical design.

Keywords: vibration environment, pre-tighten, interlayer rotation, viscoelastic material.

INTRODUCTION

In military and civil products, there are lots of multilayer axisymmetrical structures with viscoelastic material pre-tightened. In the vibration environment, separation and relative slip or other instability phenomena may occur between each component of the structure contacted with viscoelastic material. The emergence of these phenomena will lead to the function of the product cannot meet the design requirements, and even the scrap of the entire product. In order to study interlayer rotary slip property in transverse vibration, the pre-tightened structure (as shown in figure 1) was designed and constructed. Based on that, the experiments of the structure in transverse sine excitation were carried out, the slip phenomena between the layers was obtained, Figure 2. And the influence of different vibration magnitude, pre-tightened load, excitation frequency was studied.

Fig.1 - The specimen under transverse sinusoidal excitation

Fig. 2 - Relative rotary slip test results of the specimen under transverse sinusoidal excitation
The experimental results show that the sine excitation drives the relative rotary slippage between the layers should be larger with the pre-tightened force increases. Under the same exciting, relative rotary slippage of the specimen under resonant frequencies is more likely to happen than non-resonant frequencies.

Based on the experimental results, according to the deformation energy friction theory, when the tangential deformation of material can be more than normal deformation, the rotary slippage will occur. So the anti-slip condition is: \[ \frac{1}{2} G y^2 < \frac{1}{2} E e^2 \]

As a whole, the structure with viscoelastic material is simplified as mass spring system. For cylindrical shell structure, under sinusoidal excitation, the motion differential equation is:

\[ J \ddot{\theta} + c \dot{\theta} + k \theta = M_t \sin \omega t \]

Therefore, with the dynamic torque \( M_t \sin \omega t \), the shear deformation amplitude as follows: \( \Theta = \beta \Theta_0 \). Where, \( \beta = \Theta / \Theta_0 \) is the amplification factor; \( \lambda = \omega / \omega_n \) is the frequency ratio; \( \Theta_0 = M_t / k \) is the shear strain amplitude.

Therefore, for per-tightened structure with viscoelastic material, the critical condition of slippage is: \( \Theta < \gamma_{\text{max}} = \frac{N}{SGE} \).

**RESULTS AND CONCLUSIONS**

For axisymmetrical pre-tightened structure with viscoelastic material, the anti-slip criterion was proposed based on the experiment. When the shear strain is greater than the critical value, the structure will slip. And from table 1, the criterion proposed in this paper can be used to evaluate the anti-slip effectiveness. The related experimental results can provide support for engineering design.

<table>
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<tr>
<th>No.</th>
<th>Pre-tightened force (N)</th>
<th>Excited state</th>
<th>Excitation frequency (Hz)</th>
<th>Amplification factor ( \beta )</th>
<th>Whether slippage or not</th>
<th>Eccentric load of the structure (g)</th>
<th>Torsion Angle of viscoelastic material (°)</th>
<th>Critical torsion Angle (°)</th>
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**REFERENCES**
