FLUTTER INSTABILITY IN ELASTIC STRUCTURES FROM FRICTION OR NON-HOLONOMIC CONSTRAINTS

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Non-conservative loads are advocated as sources of dynamic instabilities such as flutter and divergence. One of these loads is the tangential follower force considered by Ziegler [10] and another is a force constrained to act along a fixed straight line, as introduced by Reut [8], see also Bolotin [4].

The problem with these loads is their realization, which has been considered impossible during the last fifty years [5, 6]. Following Bigoni and Noselli [3], Bigoni et al. [1] and Bigoni and Misseroni [2] it is shown, both theoretically and experimentally, how to obtain the Ziegler's (Fig. 1) and Reut's (Fig. 2) forces by exploiting contact with Coulomb friction.

Viscosity was theoretically proven to have a detrimental effect on the stability with respect to flutter and Hopf bifurcations [7, 9]. In the limit of vanishing viscosity, the so-called Ziegler paradox was found, which corresponds to a discontinuity in the critical load occurring in the limit. Effects related to the viscosity remained so far not validated experimentally, so that an experimental campaign was performed to highlight these. Experiments are shown to provide positive evidence to the theoretical results.

Finally, it is shown that flutter, divergence instability and Ziegler paradox can be obtained in elastic structures loaded by conservative forces, as a consequence of the application of non-holonomic constraints [11].

Flutter and divergence instabilities, as well as the detrimental effect of viscosity on critical loads, are documented indisputably, thus bringing an end to a long debate and opening a new research area, with perspective applications to mechanical actuators, high-precision cutting tools, or energy harvesting devices.

References

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