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STABILIZATION OF A CANTILEVER PIPE CONVEYING FLUID USING ELECTROMAGNETIC ACTUATORS OF THE TRANSFORMER TYPE

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We consider a cantilever pipe discharging fluid with electromagnetic devices attached at a selected position along the pipe's length. When the flow velocity reaches the so critical value, the straight equilibrium position becomes unstable, and self-excited lateral vibrations appear [1]. We are interested in increasing the critical flow velocity as well as improving the behavior of the system for near-critical flows by the action of the actuators.

Supplying the voltage to the actuators yields two opposite effects. First, each of the actuators pulls the pipe, thus introduces the effect of the negative stiffness which destabilizes the middle equilibrium. On the other hand, lateral vibrations change the gap in magnetic circuits, which leads to oscillations of the magnetic field in the cores, and consequently the electromagnetic phenomena of induction and hysteresis that are impeding the motion. The combination of these two non-linear phenomena exerts an ambiguous effect.

It was shown theoretically that such actuators can increase the critical flow in a cantilever pipe [2] and increase the critical load of a similar non-conservative system with the follower force, i.e. Becks column [3]. The main goal of this work is to investigate the dynamics experimentally. We will show that the action of the actuators significantly improves stability of the system in a wide range of flow velocities – from zero up to the over-critical ones – and increases the value of the critical flow. This positive effect can be observed also for a wide gap in the magnetic circuits that allows the system to vibrate with high amplitudes.

The results might be applicable in another systems. Such actuators are used in active magnetic bearings, where they stabilize the magnetic levitation of the rotor within the gap [4].

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