Periodic and quasi-periodic oscillations of fixed and rotating self-excited structures with time delay

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Self-excited vibrations may occur due to different reasons in many mechanical or aero-space systems. Self-excitation may be generated by two main mechanisms, (a) by specific nonlinear properties of the system e.g. nonlinear dry friction, or flutter phenomenon which are modelled by nonlinear functions often as van der Pol or Rayleigh models or (b) by time delay which can be a natural phenomenon of the studied problem e.g. regenerative chatter in machining or intentionally added delay input signal in order to control the system response.

Thus important question arises how time delay affect the system with self-excitation already included in the model in terms of vibration control. Analysis of periodic oscillations of a self-excited system driven by external force and time delay signal has been presented by former author paper [1] and then extended for quasi-periodic oscillations in [2]. The solutions and bifurcation points have been determined by multiple time scale method and verified numerically.

Vibrations of the system, induced by driving external torque supplied to the rotor or forces acting directly on the blade, for various control strategies, but without time delay control, have been studied in [3] and on [4]. Effectiveness of the proposed linear or non-linear control methods have been tested taking into account the dynamic properties of the full system composed of the beams and hub subsystem. The solutions have been obtained by numerical and analytical methods. For selected cases experimental tests have been performed as well.

The present contribution is a continuation of the former analysis but now with the main focus on time delay influence on a composite beam structure excited by fluid flow under flutter condition. The flutter phenomenon is modelled by van der Pol equation for two variants, a fixed beam or a beam rotating as a structural element of a hub-beam rotor. The delay input signal is used to suppress vibrations of the beam. Furthermore, the impact of external or parametric excitations which may occur in the structure is also taken into account.

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Acknowledgements: The work is financially supported by grant 2016/23/B/ST8/01865 from the National Science Centre, Poland.