

DESCRIPTION FOR THE GENERAL PUBLIC

The goal of this project is the determination of the conditions of the synchronization phenomena of the beams or pendulums attached to a rotating hub. Intention of the author is to pay attention for two types of rotors. Firstly, a rotor composed of two or three pendulums attached to a hub, where each pendulum has a massless rod treated as a solid body and a lumped mass attached at the end of the rod. The offered lumped mass system might be seen as a simplification of a structure composed of a hub with attached blades, reduced for example to a single mode, by the modes projection. Pendulums are fixed to the hub by a flapping hinge. Secondly, the study will be extended taking into account rotors with two or three flexible beams attached to the non-deformable hub. In both cases of rotors, it is assume that the hub may rotate with a non-constant angular velocity. Dynamics of the mentioned structures will be studied considering the torque supplied to the hub as a harmonic function or a chaotic function of time. The response of the hub-blades system will be studied also if one or more blades are forced by regular or chaotic external force (or torque).

The elaborated mathematical model will be solved and treated by analytical and numerical methods. The analytical results will be determined for regular vibrations and a weakly nonlinear system, while the numerical approach will be applied for strongly nonlinear problems and chaotic oscillations. Various kinds of synchronization between rotating beams (pendulums) will be studied including a fully symmetric and a slightly detuned system. Moreover, beams will be treated as Euler-Bernoulli or Timoshenko model. Results from the analytical and numerical calculations will be compared with the experiment. In the experimental tests the response of the beams, attached to the hub will be performed considering various kinds of excitations. It is planned to supply torque to the hub by imposing voltage to the DC motor given by a defined function: constant, periodic, chaotic or combination of these signals. The second option is direct excitation of the blades by an embedded active MFC element (Macro Fiber Composite). Then the exited beam (or beams) may synchronize due to the fact they are attached to the hub. The MFC elements will be activates by periodic or chaotic signals and then the synchronization of regular and chaotic attractors will be observed.

Pendulums synchronization effect was discovered in the seventeenth century by the Dutch scientist Huygens, who had noticed that between the pendulum clocks hanging on the same wall, synchronization take a place. The same effect is well described for parametric, double pendulums etc. Unfortunately, most scientific publications mention the movement of the pendulum in the horizontal plane, which was one the motivation to study pendulums/beams synchronization in a horizontal plane. Moreover, the project is closely connected to the rotating models, which are very popular in aviation especially in the helicopters engineering. The results of the calculations planned in the project can be useful in designing new rotors for helicopters, wind turbines, rotor blades of jet engines, etc.