Abstract

Real motors are non-ideal drives due to power saturation behaviour. For a mechanical system driven by an electrical motor, the load dynamics and drive dynamics are intricately coupled, which can lead to complex energy interplay between the source and system. Therefore, if surpassing the resonance requires more input power than what the motor can supply, then the system gets stuck at resonance unless power is increased beyond some critical value. Such nonlinear behaviour is attributed to the so-called Sommerfeld effect, which is characterised by a sequence of prolonged capture at resonance for a range of input power, followed by a sudden release from there (i.e. a sudden jump-like transition from a resonant state to a non-resonant state). Characterisation of the Sommerfeld effect is considered essential to determine safe operating guidelines so that a vibrating system can make a smooth transition through resonance, without any negative consequences.

So far, Sommerfeld effect has been extensively studied in motor-driven vibrating systems with purely rotating unbalances. However, unbalances or eccentricities can exist in various forms within dynamical systems. In view of that, the present thesis deals with study of Sommerfeld effect in various motor driven machines or mechanisms, in which the excitations originate from sources other than rotating unbalances. In other words, the dynamics of the systems considered in this thesis deal with excitations of other kinds, such as residual reciprocating unbalances, base motions and also parametric excitations. For each of the considered systems, the source is a permanent magnet type DC motor, while, the load dynamics is selected from various mechanical vibrating systems with different eccentric loading conditions. Two different kinds of Sommerfeld effect has been investigated: the first kind, which denotes passage through resonance conditions, and the second kind, which denotes passage through parametric instability zones. Both analytical and numerical methods are used to characterize the Sommerfeld effect of the first kind, whereas, the same for Sommerfeld effect of the second kind is based on pure numerical study. Electro-mechanical source-load interactions are modelled using multi-energy domain bond graph models.

Keywords*:* Non-ideal drive, Sommerfeld effect, jump phenomena, reciprocating mechanism, cam-follower mechanism, scotch-yoke mechanism, geared rotor shaft, parametric instability, bond graph.