Abstract

Unbalanced inertia forces, moments, and torques in slider-crank and Scotch-yoke mechanisms negatively affects performance, causing stress, vibrations, and accelerated wear. This risks system reliability and durability which compromise overall energy efficiency. This dissertation presents the strategic application of mechanical resonance as a solution to mitigate these drawbacks. Modelling and investigations are carried out using multibody simulations involving both rigid and flexible bodies. The scope covers the detrimental effects of unbalanced forces, moments, and torques, the potential benefits of mechanical resonance, and an investigation of resonance utilization in diverse scenarios. Synthesis section defines the technique for generating resonance, achieving optimal reciprocating body positioning, gravity compensation, and configuring systems with multiple sliders. Analysis section highlights the impact of factors such as reciprocating body mass, spring element stiffness, damping, and external loads on resonance performance. Findings reveal substantially improved dynamics under resonance conditions for both mechanisms. In the absence of dissipative forces, resonance conditions in the slider-crank mechanism result in a significant reduction of up to 79.99% for peak joint reaction force, 76.74% for the RMS value, 81.6% for peak inertia torque, and 82.2% for RMS torque. Resonance in the Scotch-yoke mechanism entirely eliminates torque fluctuation due to the harmonic nature of slider motion, practically eliminating reaction forces at key kinematic pairs. Both mechanisms experience substantial reductions in strain energy under resonance—91.9% in peak and 94.5% in average for the slider-crank crank, and 99.1% in peak and 99.2% in average for the Scotch-yoke crank and connecting rod.

Keywords: slider-crank, Scotch-yoke, mechanism, linkage, resonance, dynamic, balancing.