Stability and robustness assessment of self-synchronizing vibrating screens

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Abstract

Since the early 20th century scientists have noticed the inclination of machines driven by two or more eccentric rotors towards self-synchronization. This means that rotors that are not otherwise connected mechanically, for example through gears, chains or drive belts, tend to synchronize their motion through the weak coupling of the machine body. One of the prime examples of industrial machines showing this phenomenon are linear vibrating screens, which have two unbalanced shafts rotating in the opposite direction, theoretically creating a unidirectional force excitation on the sieve body. Concerning this type of machine, the main goal of the present study is to investigate the global stability of the synchronized motion with respect to the difference between the driving torques acting on the rotors. In literature various analytical methods for the local stability estimation of the synchronized regime have already been established, from which the stability boundary of the system with respect to the driving torque can be obtained. The results from these analytical methods exhibit an excellent agreement with numerical simulations of the system dynamics. However, numerical simulations show a large regime where synchronous and non-synchronous motions for the same driving torque difference coexist, which indicate that the basin of attraction for the stable, synchronous motion is finite. To assess the safety of this region, the dynamical integrity of the synchronous state was computed; in particular, we estimated its local integrity measure by exploiting the algorithm proposed by Habib (Nonlinear Dynamics, Vol. 106, issue 3, (2021) p 2073-2096). Results indicate that a significant part of the investigated region has too small dynamical integrity for being of practical use. Which would mean that in practice, the driving torque difference of the two unbalanced rotors cannot be as large as previously calculated for the vibrating screen to retain its synchronous operation.

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