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Roller chain drive vibration analysis based on a string model with boundaries moving non-smoothly

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A general kinematic analysis of roller chain drives is presented. We analyze the inherent non-smooth properties of chain drives, which causes impact loading of the drive components. Chain span vibrations are then analyzed by considering the chain as a string, forced by boundaries moving non-smoothly as determined by the kinematic analysis. Resonance phenomena are identified, and conclusions about critical operation parameters such as pretension, axial velocity, and impact frequency are presented.

General kinematic analysis of roller chain drives

Chains wrapped around sprockets form polygons rather than circles. This introduce several effects, collectively known as *polygonal action*. Some of these effects are less desirable, e.g. non-smooth transfer of torques between sprockets, and impact between chain rollers and sprockets during meshing. By modeling the sprockets as polygons, and the chain drive as a four-bar mechanism, the configurations are determined for which a) a roller loses contact with the driven sprocket, and b) a roller gets in contact with the driving sprocket. It is shown how the span endpoints move discontinuously in time, leading to impulsive loading as rollers are released into- or removed from the free span. When the driver sprocket rotates at constant speed, the driven sprocket speed and acceleration is shown to generally vary discontinuously in time, leading to a non-smooth excitation of the drive system. The analysis is carried out analytically, and main parameters are shown to be shaft center distance and pitch fraction.

Vibrations of axially moving strings supported by moving boundaries

Vibrations of a chain span are analyzed approximately by modeling the chain as an axially moving string, supported by boundaries moving as prescribed by the above mentioned kinematic analysis. The equation governing transverse string vibrations is nonlinear due to axial stretching with gyroscopic terms, and parametric as well as external excitation. By employing a single-mode approximation in terms of velocity dependent mode shapes, the response is approximated using The Method of Multiple Scales. The external loading is described as a temporal Dirac pulse train. This makes it possible to describe analytically the response of the string subjected to periodic impact loading.

Currently work is in progress to include the effects of modal coupling, internal resonance and dissipation of impact energy into higher modes, using a two-mode approximation. Furthermore, we intend to study the case where excitation frequencies are much higher than the underdamped natural frequencies, which is relevant for chain drives operating at high speeds of revolution. This analysis will be carried out using The Method of Direct Partition of Motion; it should give insight into how system properties such as stiffness, natural frequencies and stability change under this type of excitation.

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