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Damping and Stability Evaluation for the Dynamical Hunting Motion of the Bullet Train Wheel Axle Equipped with Cylindrical Wheel Treads

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Abstract : Classical matrix calculus and Routh-Hurwitz stability conditions, applied to the snake-like motion of the conical wheel axle, lead to the conclusion that the hunting mode is inherently unstable, and its natural frequency is a complex number. In order to analytically solve such a complicated vibration model, either the inertia terms were neglected, in the model designated as geometrical, or restrictions on the creep coefficients and yawing diameter were imposed, in the so-called dynamical model. Here, an alternative solution is proposed to solve the hunting mode, based on the observation that the bullet train wheel axle is equipped with cylindrical wheels. One argues that for such wheel treads, the geometrical hunting is irrelevant, since its natural frequency becomes nil, but the dynamical hunting is significant since its natural frequency reduces to a real number. Moreover, one illustrates that the geometrical simplification of the wheel causes the stabilization of the hunting mode, since the characteristic quartic equation, derived for conical wheels, reduces to a quadratic equation of positive coefficients, for cylindrical wheels. Quite simple analytical expressions for the damping ratio and natural frequency are obtained, without applying restrictions into the model of contact. Graphs of the time-depending hunting lateral perturbation, including the maximal and inflexion points, are presented both for the critically-damped and the over-damped wheel axles.

Keywords : bullet train, creep, cylindrical wheels, damping, dynamical hunting, stability, vibration analysis
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