World Academy of Science, Engineering and Technology
International Journal of Mechanical and Industrial Engineering
Vol:12, No:04, 2018

Steady State Rolling and Dynamic Response of a Tire at Low Frequency

Authors : Md Monir Hossain, Anne Staples, Kuya Takami, Tomonari Furukawa

Abstract : Tire noise has a significant impact on ride quality and vehicle interior comfort, even at low frequency. Reduction of tire noise is especially important due to strict state and federal environmental regulations. The primary sources of tire noise are the low frequency structure-borne noise and the noise that originates from the release of trapped air between the tire tread and road surface during each revolution of the tire. The frequency response of the tire changes at low and high frequency. At low frequency, the tension and bending moment become dominant, while the internal structure and local deformation become dominant at higher frequencies. Here, we analyze tire response in terms of deformation and rolling velocity at low revolution frequency. An Abaqus FEA finite element model is used to calculate the static and dynamic response of a rolling tire under different rolling conditions. The natural frequencies and mode shapes of a deformed tire are calculated with the FEA package where the subspace-based steady state dynamic analysis calculates dynamic response of tire subjected to harmonic excitation. The analysis was conducted on the dynamic response at the road (contact point of tire and road surface) and side nodes of a static and rolling tire when the tire was excited with 200 N vertical load for a frequency ranging from 20 to 200 Hz. The results show that frequency has little effect on tire deformation up to 80 Hz. But between 80 and 200 Hz, the radial and lateral components of displacement of the road and side nodes exhibited significant oscillation. For the static analysis, the fluctuation was sharp and frequent and decreased with frequency. In contrast, the fluctuation was periodic in nature for the dynamic response of the rolling tire. In addition to the dynamic analysis, a steady state rolling analysis was also performed on the tire traveling at ground velocity with a constant angular motion. The purpose of the computation was to demonstrate the effect of rotating motion on deformation and rolling velocity with respect to a fixed Newtonian reference point. The analysis showed a significant variation in deformation and rolling velocity due to centrifugal and Coriolis acceleration with respect to a fixed Newtonian point on ground.

Keywords : natural frequency, rotational motion, steady state rolling, subspace-based steady state dynamic analysis
Conference Title : ICSV 2018 : International Conference on Sound and Vibration
Conference Location : Boston, United States
Conference Dates : April 23-24, 2018