VISUALIZATION OF TIRE VIBRATION AND SOUND RADIATION AND MODELING OF TIRE VIBRATION WITH AN EMPHASIS ON WAVE PROPAGATION

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16. Abstract

It is now known that tire/road interaction noise is the major contributor to exterior automobile noise and establishes the background noise level in many environments. Thus, the reduction of tire/road noise is a major environmental noise issue today.

Among the numerous tire noise mechanisms, tire vibration has been established as the primary source: i.e., a tire's tread block hits the road surface, and then the underlying reinforcing belts vibrate owing to the force transmitted through the tread block, resulting in sound radiation from the vibrating tire surface.

In an attempt to identify the dominant tire noise sources, a sound field visualization procedure referred to as Nearfield Acoustical Holography was applied to a rolling tire: it has been shown that sound radiation originates close to the contact patch of a tire.

An experimental procedure has also been introduced to identify the main characteristics of tire vibration. In the latter procedure, a tire is driven radially at a point on its treadband and measurements of the resulting radial treadband vibration are made around the treadband circumference by using a laser Doppler velocimeter. By performing a circumferential wave number transform of the measured data, the dispersion relations can be obtained that quantify the multi-modal wave propagation characteristics of a tire, specifically the wave propagation speeds and attenuation rates.

For the purpose of identifying tire design parameters that can control tire vibration components that are responsible for sound radiation, various tire models have been developed. In particular, for the purpose of modeling a tire at low computational expense, a hybrid two-dimensional finite element model was developed in which the cross-section of a tire is approximated by two-dimensional finite elements while an analytical wave-like solution is assumed in the circumferential direction of the tire.

Finally, the vibration of an inflated, circular cylindrical shell, rotating about a fixed axis has been considered in an attempt to understand the effects of rotation on wave propagation within a tire's treadband. It is suggested that a stationary tire analysis may be used to predict the characteristics of a rotating tire after performing a simple kinematic compensation.

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