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A Finite Element Based Predictive Stone Lofting Simulation Methodology for Automotive Vehicles

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Abstract : Predictive simulations are one of the key focus areas in safety-critical industries such as aerospace and high-performance automotive engineering. The stone-chipping study is one such effort taken up by the industry to predict and evaluate the damage caused due to gravel impact on vehicles. This paper describes a finite elements based method that can simulate the ejection of gravel chips from a vehicle tire. The FE simulations were used to obtain the initial ejection velocity of the stones for various driving conditions using a computational contact mechanics approach. To verify the accuracy of the tire model, several parametric studies were conducted. The FE simulations resulted in stone loft velocities ranging from 0–8 m/s, regardless of tire speed. The stress on the tire at the instant of initial contact with the stone increased linearly with vehicle speed. Mesh convergence studies indicated that a highly resolved tire mesh tends to result in better momentum transfer between the tire and the stone. A fine tire mesh also showed a linearly increasing relationship between the tire forward speed and stone lofting speed, which was not observed in coarser meshes. However, it also highlighted a potential challenge, in that the ejection velocity vector of the stone seemed to be sensitive to the mesh, owing to the FE-based contact mechanical formulation of the problem.

Keywords : abaqus, contact mechanics, foreign object debris, stone chipping
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