Tire performance evaluation for severe snow traction

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Abstract: Snow traction is an important tire performance parameter for product applications in markets where snow is present for several months during the year. It is very difficult to perform multiple tests because proving grounds and consistent test conditions are available only for limited periods of time and due to prototyping and test expense. This paper deals with the simulation aspects of the snow traction test using Abaqus. The first part of this paper describes the chosen test method and offers a review of the available simulation technology. A modeling methodology for realistic snow interaction is examined using small-scale simulations, in order to evaluate its applicability to snow traction simulations. Next, simulations of snow traction are developed for a tire rolling over a snow surface. The tire models employ fine-resolution tread patterns so that a better approximation is obtained to the real-world event of tire/snow interaction. Physical phenomena such as snow shear, digging and friction are taken into account by an adaptive-explicit FEA. The proposed analytical procedure is validated through comparison with test data.

Keywords: Tire, snow, traction, adaptive-explicit FEA.

1. Introduction

Tire traction refers to the ability to transmit traction force from vehicle to ground in order to move that vehicle forward. Snow traction is an important tire performance parameter. Tires sold in North America must pass a certain traction test known as ASTM F1805 (ASTM, 2001) in order to bear the US Rubber Manufacturers Association snowflake-on-mountain symbol (RMA, 2008), shown in Figure 1, which rates the product as suitable for severe snow usage. In tire development programs, special attention is paid to snow traction because it is a critical OEM requirement. However, it is very difficult to have snow testing performed during three quarters of the year because the test grounds are not available. These tests are also time and resource consuming. Hence, there is need to help screen tires and tread patterns for snow traction through the application of FEA. In this way, the development curve can be shortened and costs associated with test, tire manufacturing and product qualification could be saved.

In order to perform a computer simulation, one has to carefully examine the test procedure so that the FEA can replicate the exact conditions while allowing for reasonable simplifications. A snow traction test in progress is depicted in Figure 1. The test tire is mounted on an instrumented vehicle and the desired load is applied by adjusting the ballast weight. The vehicle maintains a constant speed of 5 mph while the driver applies a driving torque on the test tire at a constant rate. The tire starts slipping on the snow surface when the applied traction force exceeds that of tire-snow interaction. In practice, when the tire starts spinning, there is visible trail of snow thrown behind the tire, which sometimes is referred to as “rooster tail”. When the spinning speed exceeds a prescribed value, the maximum torque transferred to the tire is found. The ratio of this torque to its