USE OF SIMULATION IN COMMERCIAL TRUCK WHEEL DESIGN

Michael McLeod

Senior Project Engineer / FEA – Accuride Corp.

Aushutosh Srivastava

Technical Support Engineer – ANSYS Inc.

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ABSTRACT

The wheel has been a critical component of the transportation industry dating back to the Stone Age. By combining a wheel and axle, a very simple tool is created that provides the mechanical advantage to move large masses over long distances. For centuries the wheel has evolved to meet the efficiency requirements needed for each period of time. In modern times, what once was a very simple mechanical tool, has become a significant engineering challenge.

Today's modern commercial wheel design is driven by the need of efficiency to carrying the maximum weight for the least amount of mass. This drive to lower masses is also encouraged by the relationship of weight to fuel economy. Since raw materials make up a significant portion of the cost of a wheel, minimizing mass is also a critical motivator in a competitive market. Although styling can be a consideration in commercial wheels, obtaining optimized designs is the primary goal.

One of the challenges of optimizing a design is to fully understand the objectives that drive the design. There are many objectives in the design of a commercial truck wheel. Wheels are designed to meet accepted industry testing standards, but this is just the start. Wheels must interact with various hubs and tires to work as a system. Wheels are exposed to a variety of environmental and loading scenarios. Safety

is a critical objective due to the large mass, speed, and energy involved with the wheel end system. An integral part of wheel design is to work with existing manufacturing methods and materials as well as evaluate potential innovations. A wheel design must also meet all objectives throughout its life cycle.

This paper is divided into two parts. First, a summary of some of the common engineering analysis problems which are incorporated in a wheel problem are summarized. The analysis of commercial wheels revolves around the basic fatigue problem. Strain histories combined with material characterization are critical for predicting wheel performance. Being able to accurately predict strain histories and local material properties is the key to optimization of wheel designs. However, fatigue is not the only engineering problem in a wheel assembly. The local effects of the bolted joint at the hub mounting is important as well. Frictional contact between the wheel and hub is another area that must be evaluated. Steel wheels involve an assembly press fit and welding process that can greatly influence wheel performance. Steel wheels also have several pierce and coining operations that provide ideal locations for crack initiation.

The second part of this paper will highlight the specific engineering analysis problem of determining tire to rim flange interface loading. There are many methods of dealing with how to apply loading to wheels. One common method of load application is to use an approximate load distribution on the rim flange interface of a wheel-only FEA model. Various methods of correlation can be used to develop confidence that loading will provide sufficient accuracy to meet the design goals. Another approach to applying loads on a rim is to actually create a model of a tire and wheel system. This approach allows direct ground forces to be applied and the distribution of loading through the system to be determined by the simulation model. The method of incorporating a tire model with a wheel model is extremely complex and computationally expensive. Recent tire modeling approaches have been proposed that create an equivalent tire structure that mimics the tire stiffness but does not require full knowledge of the tire design details. Using a simplified tire model, it is more practical to model tire-wheel systems where the detailed modeling can be focused on the wheel features.