



BIG WHEEL

The North American commercial trucking industry is challenged by many factors, including the continual need to be more efficient by carrying more load at lower cost and higher fuel economy. One way some trucking fleets address this need is to utilize wide-base wheels that offer weight savings and lower rolling resistance compared with traditional dual-wheel configurations. Accuride has enhanced the savings that truckers can achieve by using ANSYS simulation tools to reduce the weight of its Duplex® wide-base wheels by more than 23 percent in recent years.

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Most commercial trucks ride on sets of two 22.5-by-8.25-inch wheels with two tires on both drive and trailer axles. Commercial truck owners needing weight and fuel economy savings are considering the benefits of a single 22.5-by-14.0-inch wide-base wheel instead of the traditional dual-wheel configuration. Wide-base wheels reduce rolling resistance by about 30 percent, resulting in up to 10 percent fuel savings. Wide-base wheels are also substantially lighter than the two dual wheels that they replace. Further weight savings come from using one wide-base tire compared with two of the standard size. Accuride has provided truckers with further savings by using ANSYS simulation tools to reduce the weight of their forged aluminum wide-base wheels from 71 pounds to 55 pounds in current designs – an additional savings of 128 pounds on a typical tractor trailer.

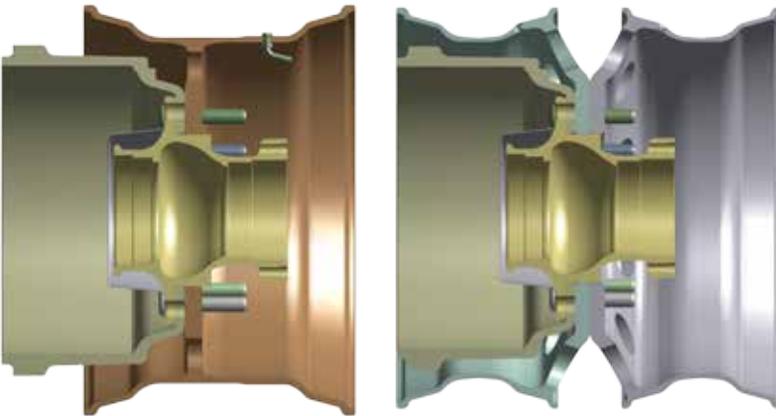
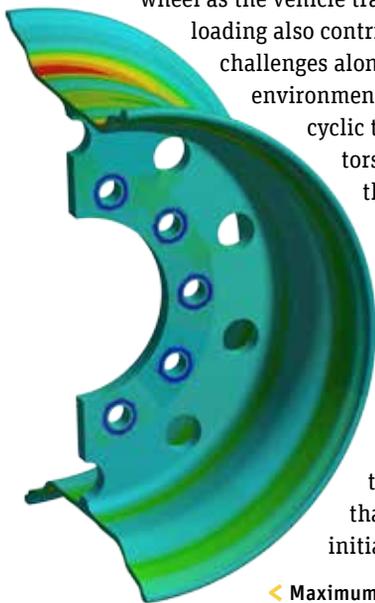


Optimized Designs for Fatigue Using
ANSYS nCode DesignLife
[ansys.com/fatigue](https://www.ansys.com/fatigue)

“Commercial truck owners needing weight and fuel economy savings are considering the benefits of a single wide-base wheel.”

Commercial truck wheels are typically constructed from steel or forged aluminum. The materials and processes are relatively basic, but the minor details of the material and processes make all the difference in achieving a long-lasting and durable product. To ensure that these

wheels are reliable, engineers are faced with structural challenges like metal fatigue and fracture, including standard cyclic fatigue, fretting fatigue, weld fatigue and crack growth. Primary loads on wheels come through the tires, which exert very high axial and radial loads just from tire inflation of up to 131 psi. Additionally, each 14-inch-wide wheel must carry 12,800 pounds of load generated from the vehicle weight, and cycle around the wheel as the vehicle travels. Side and impact loading also contribute to metal fatigue challenges along with eventual environmental factors.



▲ New wide-base wheels (left) and a conventional set of two wheels (right)

changes in design or processing can have a significant influence on actual wheel performance.

ENSURING RELIABILITY

Accuride does not release wheel designs for use until high test standards are met. Commercial wheel

designs are generally tested against SAE standards. These test standards include straight rolling of a wheel and tire assembly, and a rotating bending test of just the wheel at elevated loads to a specified number of cycles. Due to the potential variability in testing, Accuride significantly exceeds industry standards to ensure reliability. Physical testing is very expensive and time-consuming. For every prototype design that is tested, custom-built tooling and manufacturing processes must be developed to generate sufficient samples for design validation. Prototype builds and testing can take weeks and even months. If all samples do not pass the qualification testing, then a new design iteration is started and the clock is reset for samples and testing, thus prolonging product release. Therefore, minimizing design iterations is critical to managing development costs and time-to-market goals.

As part of the design process, it is critical to validate that the manufacturing process can repeatedly create the same product with minimal variation. The potential variations that must be controlled include both geometry and all aspects of the manufacturing process. The manufacturing process has a significant influence on actual wheel performance. These processing effects must be considered during the early design phase. Failure to attain manufacturing control will mean process changes or, potentially, product redesign.

Accelerated cyclic testing and safety factors can more than double the load for which the wheel must be designed. Predicting fatigue life is very challenging because the relationship between fatigue life and material stresses is nonlinear, and there are many factors that influence crack initiation. Often small

◀ Maximum principal strain contour for straight rolling using analytical tire load model

“By taking advantage of the **ANSYS Workbench environment**, workflows can be set up so that only the input **geometry needs** to be changed for each analysis iteration.”

PREDICTING FATIGUE PERFORMANCE

Continually improving a safety-critical component subject to fatigue loading requires advanced knowledge of the product loading and the effects of manufacturing processes. An Accuride engineer starts by constructing standardized finite element models (FEM) using ANSYS Mechanical within ANSYS Workbench to provide an initial evaluation of stresses and strains for different load cases. Integration with a parameterized CAD model makes it easy to evaluate multiple designs at this preliminary stage. As the design progresses, the analyses begin to include predictions of crack initiation using ANSYS nCode DesignLife. The ANSYS stress and strain predictions flow directly into a custom fatigue analysis template setup in nCode DesignLife. The nCode DesignLife component is critical because fatigue problems are governed by the stress history and other factors besides the maximum stress values.

After preliminary design work is complete using fatigue life predictions, Accuride engineers may begin more advanced optimization methods to further reduce weight while trying to maintain minimum levels of predicted fatigue performance. The optimization process is similar to the preliminary design work except that ANSYS Workbench systems are parameterized, including input and output variables. Tables of multiple parameter combinations are set up and solved in a batch



▲ Accuride 22.5 x 14.0 Duplex® wide-base wheel

mode to evaluate the sensitivity of each parameter. Once key parameters are identified, ANSYS DesignXplorer tools can be used to further refine the design using design of experiment (DOE) methods.

The Accuride wheel analysis process has multiple phases. Evaluating and optimizing different designs potentially could take a significant amount of time. By taking advantage of the ANSYS Workbench environment workflows can be set up so that only the input geometry needs to be changed for each analysis iteration. Additionally, ANSYS ACT enables Accuride to further enhance the analysis process so that more time is spent reviewing results than building models.

The final design proposal is validated with simulation focusing on model quality and design details. Advanced meshing controls and quality checks ensure mesh quality in critical areas. Submodeling techniques enable even higher levels of detail at locations such as contact edges.

RESULTS

Using ANSYS and the analysis methods developed in-house, Accuride engineers have reduced the weight of their standard 22.5-by-8.25-inch forged aluminum wheel by 25 percent and the 22.5-by-14.0-inch wide-base Duplex® design by 23 percent in recent years.

Besides meeting customer lightweighting goals, thereby contributing to increased fuel economy and larger loads, weight reductions help Accuride maintain competitiveness by offsetting increasing production costs with raw material savings.

As the complex structural and design challenges of commercial truck wheels continue to increase, Accuride engineers are developing even more advanced analysis methods using the capabilities of the ANSYS Workbench environment and integration with specialty codes such as ANSYS nCode DesignLife. With these new tools, Accuride will continue to improve its design methodology to develop innovative and reliable truck wheel technology at an even faster pace. ▲