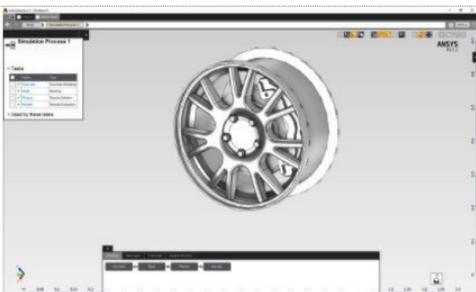


Analyzing Wheel Bolt Pretension with Ansys AIM

Wheel separations are a serious concern, with rear wheel separation presenting the greatest risk because a vehicle that loses a rear wheel is more likely to lose control and rollover. Wheel separations are also dangerous to other vehicles since when a vehicle separates it is often launched into the air when the weight of the vehicle is suddenly removed. The largest cluster of incidents came in 1991 when a series of wheel separations resulted in seven deaths. At that time, the United States National Transportation Safety Board (NTSB) studied the problem and concluded that about 750 to 1,050 wheel separations occurred each year. This number is probably on the low side since wheel separations that do not cause an injury often go unreported, and there is no central clearinghouse for wheel separation data. The NTSB concluded that one of the two leading causes of wheel separation was the loosening of wheel fasteners. Proper design of the bolted joint can reduce the risk of wheel separation. This application brief will introduce an Ansys AIM template that guides design engineers through the process of simulating a bolted wheel assembly to ensure a reliable, safe connection. The brief will demonstrate how AIM's immersive user environment guides the engineer through the workflows needed to get the design right the first time.



CAD model of wheel assembly



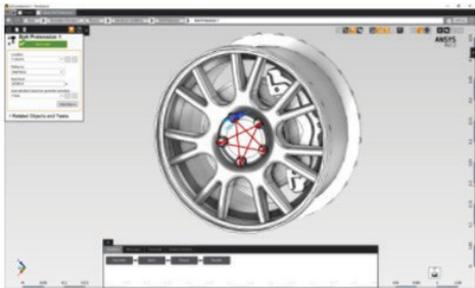
Finite element mesh

/ Introduction/Challenge

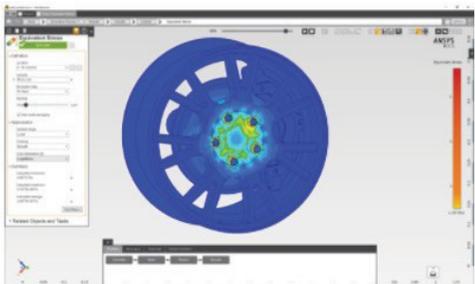
Tightening the lug nut on a wheel bolt stretches the bolt; the resulting pretension or preload applies compressive force, known as the clamp load, to the wheel and brake disk. Increasing pretension increases the clamp load, providing greater pretension and greater resistance to loosening of the bolt. On the other hand, excessive tension can stretch the bolt beyond its elastic range and cause the bolt to permanently stretch, which also can result in failure. The sequence in which the bolts are tightened can also have an important impact on the ability of the joint to withstand service loads. Finite element analysis (FEA) is required to address the complexities involved in wheel bolt pretensioning, but up to now this has required the services of a FEA expert who may not be available to the design team. When an expert is available, getting them involved in the project may involve considerable delays.

/ Solution

Ansys AIM enables design engineers to simulate wheel bolt pretension themselves, and also solve a wide range of engineering problems involving structural, electrical, fluid, thermal and electromagnetic physics. In this application, a structural template provides a task-based workflow that guides the engineer through the simulation process. The engineer begins by opening a template that presents them with a workflow consisting of the necessary simulation tasks. The first task is opening a computer-aided design (CAD) file containing the wheel assembly geometry. The next task is meshing, so the engineer clicks a button to generate the mesh at the default settings. He assigns structural steel as the material to the axle and bolts; stainless steel to the five lug nuts; aluminum alloy material to the wheel and brake caliper; and cast iron to the brake disk.



Adding bolt pretensioning structural condition in a specific order



Equivalent stress results produced by simulation

The engineer adds a support to the back face of the axle. Next, he adds a bolt pretension support to each bolt axle body. In this case, the engineer adds the structural conditions in a defined order to model a specific tightening sequence. He then runs the simulation and views the results. The engineer selects a displacement magnitude to display the contour plot and animates the results to visualize the effect of the bolt pretension sequence. Next, the engineer selects equivalent stress, views another contour plot and again animates the results to see the impact of the pretension sequence.

/ Results

This application provides a good illustration of how the AIM wheel bolt pretension template simplifies what would otherwise be a difficult analysis task. A template guides engineers through the process of simulating pretension in wheel bolts, demonstrating how AIM enables design engineers who are not simulation specialists to analyze the complete physics of a wide range of engineering problems. The simulation provides key insights, such as the effects of different tightening sequences. Although it was outside the scope of this example, engineers can easily go one step further and define parametric values for geometrical dimensions and boundary conditions and run sweeps to optimize the design.

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