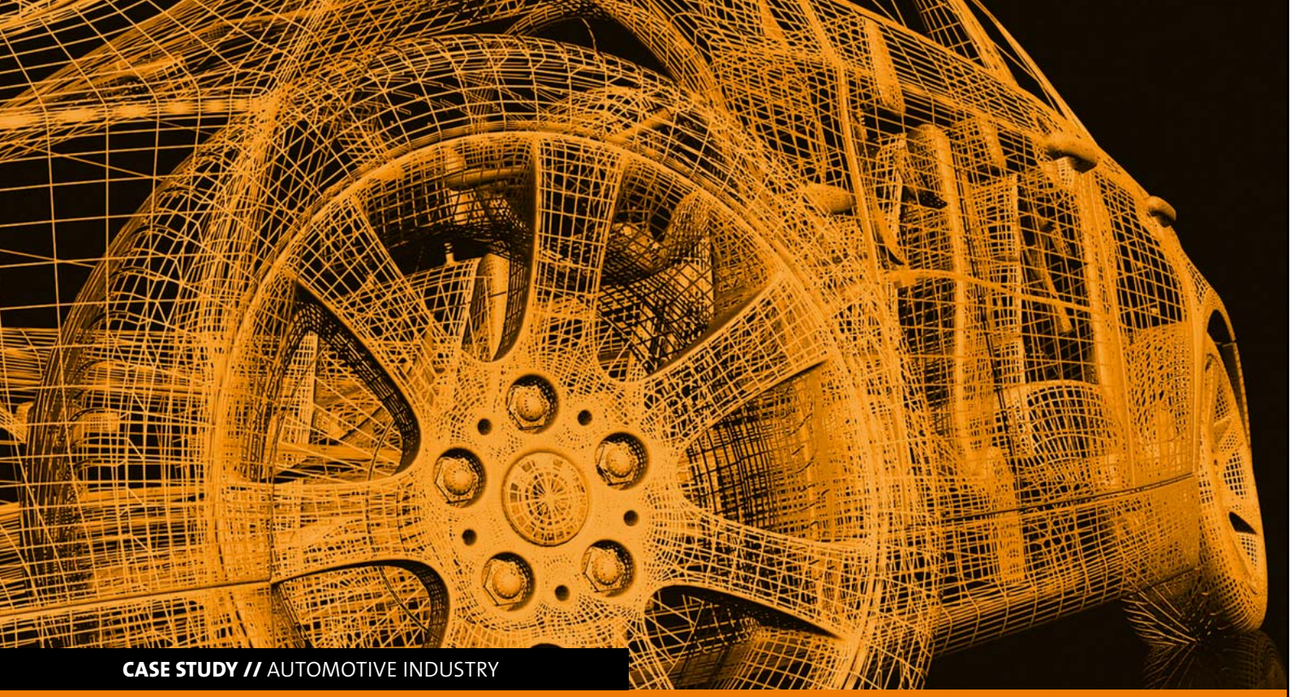

CASE STUDY // AUTOMOTIVE INDUSTRY

BRAKES WITHOUT SQUEAL

Most automobile companies are very aware of the unpleasant effect brake squeal has on driving comfort, drivers' fatigue, and thus customer satisfaction. Therefore, avoiding brake squeal is a requirement by drivers and car manufacturers. TRW relies on optiSLang® and ANSYS® to prevent brake squeal by simulations.

Brake squeal is a friction-induced vibration best explained by a simplified model of a brake assembly. Figure 1 shows a clockwise rotating brake disk and a very simplified brake pad in form of a beam. The beam touches the rotating brake disk with a frictional contact. Without rotation of the brake, any vibration ceases through dissipation at the contact between disk and brake pad. Under certain conditions, however, a rotating brake disk causes instabilities within the brake assembly leading to increasing vibration amplitudes, brake squeal. This moment is shown in Figure 2. The rotating brake disk vibrates upwards in the exact moment the brake pad moves clockwise and therefore within the direction of the rotating disk. The brake pad is picked up by the brake disk through the contact and receives additional energy from the disk. At the maximum deformation of the brake pad the brake disk will vibrate downwards and with loosing contact the brake pad springs back (Figure 3) and the cycle starts again.

Simulation Process

Development times in the automotive industry are short, and with growing design requirements, engineers need reliable simulations as well as efficient workflows. Simply modifying the design, materials, or testing new brake pad properties shouldn't require any work on the simulation workflow itself. ANSYS Workbench and ANSYS Mechanical allow these modifications in an excellent manner. The single solution steps are shown on the project page of ANSYS Workbench and simply combined to a solution workflow (Figure 4). The starting point for this workflow is given by the materials used in the simulation, a bidirectional CAD interface to import geometries and a robust meshing algorithm.

While classic solutions require a time consuming mesh generation in the contact area between brake pad and disk, ANSYS allows the use of simple nonlinear contact. This contact can not only replace the traditional matrix elements required to define contact between brake pad and disk, but also add more accuracy to the solution. ANSYS uses a nonlinear static contact analysis to solve the contact behavior between rotating brake disc and pads, and sends the pre-stress effects to a subsequent complex modal analysis. Keeping development times in mind, ANSYS allows engineers to choose between short solution times and higher accuracy by running brake squeal simulations as full nonlinear, partial nonlinear, or linear simulations. While being able to respond to needs in timeframe or accuracy by choosing between one of the three solution methods, engineers can also use different complex solvers to solve the complex modal analysis (QRDAMP, UNSYM and DAMP solver). Friction models to define friction between brake pad and disk as a function of brake pressure or rotating velocity of the disk provide the opportunity to add more accuracy to the simulation. In addition, stabilizing squeal damping, a specific brake squeal effect, the influence of gyroscopic effects, and mode tracking options are available within ANSYS Workbench.

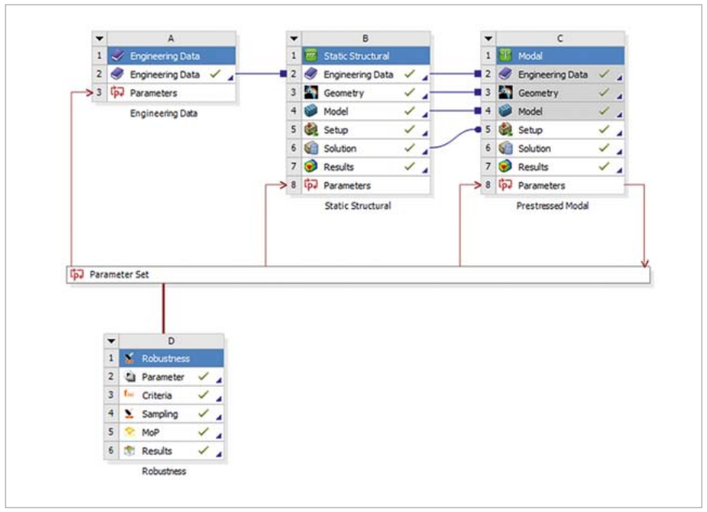

Figure 4: Brake squeal simulation process withANSYS Workbench and optiSLang.

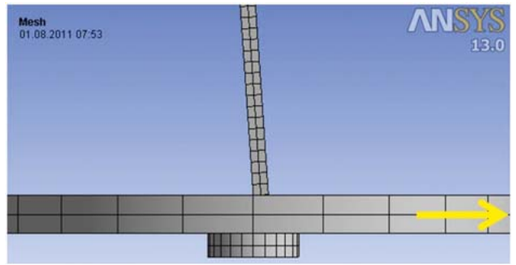

Figure 1: Rotating brake disk

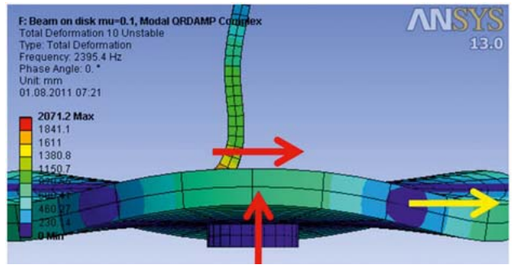

Figure 2: Brake disk picks up brake pad

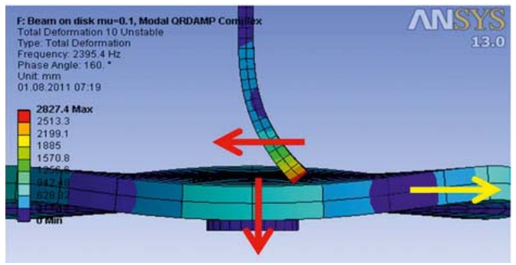

Figure 3: Brake pad springs back

While brake squeal simulations in ANSYS cover all areas from fast results to detailed and highly accurate solutions, ANSYS Workbench provides another important piece of the brake squeal puzzle. The parametric environment includes all important variables from friction coefficient to material properties and CAD design. The user simply defines a new set of material properties, a new friction condition, or brake pressure and updates the simulation.

Brake squeal is not simple to understand. Improving the design of a brake assembly, as well as analyzing the assembly with all uncertainties of its later working environment, is an important part of brakes squeal simulations. optiSLang inside ANSYS Workbench allows simulations including uncertainties as well as design improvements. Variations within brake friction and pressure, the material properties of the brake pad, or manufacturing tolerances are included in the simulation and provide new information to design engineers.

Eye-opener by unexpected brake squeal are avoided and brakes improved. The combination of efficiency and technology integrated within one environment leads to more comprehensive and reliable brake squeal simulations.

You see: That your brakes are not squealing is not just luck, it is a result of good and detailed engineering.

Author // M. Moosrainer (CADFEM GmbH)/
Image Title // © fotolia.com: 3ddock