AdCo Engineering^{GW} GmbH: Consultant and Developer for Market-Leading CAE Software Vendor ANSYS, Inc.

Collaboration with Global Market Leader

Since 2014, AdCo Engineering^{GW} GmbH proudly collaborates with ANSYS, Inc. as a consultant and developer for their Computer-Aided Engineering (CAE) software products. ANSYS, Inc., headquartered in Canonsburgh, PA, USA, is the global market-leading vendor for CAE software. This long-term collaboration covers various fields of CAE and currently focuses on mortar-based finite element methods (FEMs) for contact mechanics. The collaboration was initiated with the help of CADFEM GmbH, headquartered in Grafing, Germany, long-term sales partner of ANSYS, Inc. and ANSYS Elite Channel Partner. In the CADFEM Journal 02/2014, among others, it was reported on the collaboration between AdCo Engineering^{GW} GmbH and ANSYS, Inc.; see article as pdf here.

Mortar-Based Finite Element Methods: Cutting-Edge Approaches to Contact Mechanics

Contact phenomena are frequently observable in nature as well as biological systems, and they are part of a variety of technical systems and machine components. To name but a few technical examples, contact plays a major role when considering gears, bearings, shafts, seals and car tires (see Fig. 1). In fact, there is merely an astoundingly low number of non-linear mechanical problems in which contact does not play any role at all. Contact may occur as tied or unilateral, and issues such as adhesion and frictional sliding may be present.

In many cases, there are further physical phenomena appearing in combination with pure contact and friction, for example,

- wear,
- thermal effects such as heating,
- lubrication,
- multiphysics, and
- complex materials.

Just to provide two examples, (substantial) heating may occur as a result of frictional contact for brake discs such as the one depicted in Fig. 2, and hydrodynamic lubrication effects usually become prevalent for a tire as shown in Fig. 1 as soon as roadways get wet ("aquaplaning").

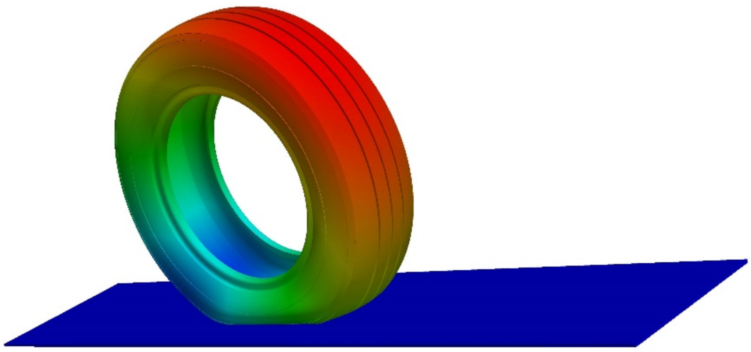

Fig. 1: *Simulating contact of rolling tire and roadway surface.*

All of the aforementioned physical complexities of contact problems render their numerical solution particularly challenging. Traditionally, approaches such as node-to-segment (NTS) or Gauss-point-to-segment (GPTS) methods have been used for simulating contact in the framework of FEMs. However, even rather simple contact scenarios (e. g., so-called contact patch tests) cannot always be represented consistently when using these traditional methods. Mortar methods, on the other hand, which are one of the fields of expertise of AdCo Engineering^{GW}, always ensure a consistent load and motion transfer for any interface discretization, that is, in particular, also for non-matching meshes. They were originally introduced as a domain decomposition technique for spectral elements. Nowadays, however, mortar methods are also widely considered in academic research as a non-conforming discretization technique within FEMs for various single-field applications, such as solid and fluid mechanics, and multi-field applications, such as fluid-structure interaction (FSI).

From Academia to Industry

Meanwhile, computational methods based on the mortar approach are state-of-the-art methods for numerically solving the present problems of contact mechanics as well as mesh-tying. Recent research on mortar methods has proven that they outperform traditional methods for various academic setups, and AdCo Engineering^{GW} now transfers this performance to industrial applications. In fact, besides the aforementioned consistent load transfer for non-matching interface discretizations, several further advantages of mortar methods compared to traditional methods when simulating contact problems can be identified, for instance,

- the improved robustness of non-linear solution schemes, including the search for active and non-active contact zones,
- the accurate representation of secondary mechanical quantities such as contact stresses / tractions,
- the accurate treatment of sliding contact scenarios such as dropping-edge contacts, and
- a natural compatibility with various novel discretization paradigms such as NURBS-based isogeometric analysis (IGA).

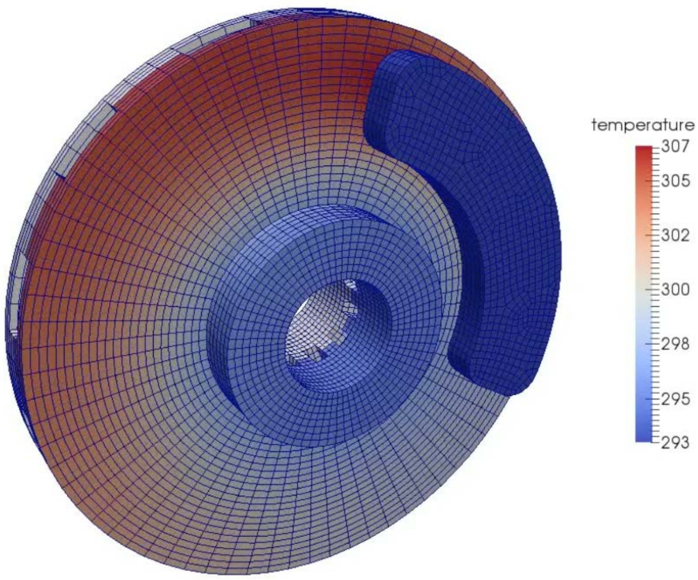

Fig. 2: *Brake disc: contact with frictional heating.*

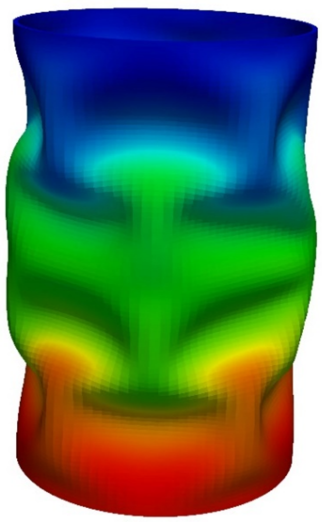

Fig. 3: *Example for self-contact: bulging can.*

Fit for HPC

Large-scale contact problems can be coped with, too: mortar FEMs are designed for being used on high-performance computing (HPC) systems. In general, the required parallel distribution on a large number of CPUs is accomplished by overlapping domain decomposition. Such a rather standard domain-decomposition process is not necessarily optimal for the interface of the problem, though. To improve this non-optimal situation, AdCo Engineering^{GW} has advanced technology available in form of an independent parallel re-partitioning of all mortar elements at the interface, allowing for excellent parallel scalability over a broad range in terms of the number of CPUs. Mortar FEMs are also readily applicable to large-scale simulations of complex multiphysics and multiscale problems, one of the core competences of AdCo Engineering^{GW} (see also our webpages on multiphysics and multiscale problems). Based on the aforementioned parallel repartitioning and dynamic load balancing, a first-rate parallel scalability is always ensured, even when simulating large-scale problems containing many million degrees of freedom.