Shape Optimization for Isogeometric Contact Problems using Bundle methods

Benjamin M. Horn*, Stefan Ulbrich*

* Research Group Optimization, Department of Mathematics,
TU Darmstadt, Dolivostr. 15, 64293 Darmstadt, Germany

ABSTRACT

We consider three dimensional shape optimization of mechanical connectors with respect to fatigue strength or stiffness calculations.

In contrast to the standard procedure in algorithm based product development, where the CAD model is approximated by a finite element model which is then optimized in the next step, we use a combined model for the shape optimization. To ensure the consistent model representation during the product development process, we choose an isogeometric approach to model the contact problem within the shape optimization method.

The contact conditions are handled using the Mortar method with dual basis functions and the resulting contact problem is solved with a semismooth Newton method. This leads to a shape optimization problem governed by an linear elastic contact problem.

To measure the fatigue strength of the mechanical connection we present two different objective functions. The first one is the failure probability based on non-parametric regression estimation and the second is based on the damage parameter of Smith, Watson and Topper, also called PSWT. To determine the PSWT we calculate the approximated elasto-plastic strains and stresses using the von-Neuber hypothesis and the Ramberg-Osgood material law. The structural stiffness of the considered connectors is measured by the compliance.

The resulting shape optimization problem is nonconvex and due to for example the contact conditions nonsmooth. We solve this optimization problem with a Bundle Trust Region algorithm, which is modified to ensure a feasible design in each iteration. The design subgradients required by the bundle method can be calculated efficiently with the adjoint approach.

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