Numerical Optimization of a Intake Duct with Adjoint Topological Methods

Markus Towara, Uwe Naumann

LuFG Informatik 12: Software and Tools for Computational Engineering, RWTH Aachen University, Germany, in cooperation with Volkswagen AG, Kassel, Germany

In times of a shrinking availability and rising costs of resources and increased customer awareness regarding fuel consumption and compliance with strict emission standards, the optimization of fuel and energy consumption as well as lowering the weight becomes more important in automotive applications. Due to the increasing number of power consuming devices, the efficiency of the components has to be enhanced. In this thesis ways to decrease the pressure loss in a oil intake-duct in the mechatronic unit of a direct-shift-gearbox developed by Volkswagen AG are presented. The geometry of a already planned out duct is redesigned by numerical optimization to determine the possible reduction in pressure loss. Adjoint topology optimization is chosen as the optimization method and an extension written for OpenFOAM [1], kindly supplied by Volkswagen AG, is used to obtain the optimized geometries.

The optimization is carried out by adding a porous term to the governing Navier-Stokes equations to allow punishment and thus effectively removal of contraproductive cells in the computational domain. To obtain those contraproductive cells the sensitivity of a certain cost function with respect to a variation in the porosities is needed. In this solver a continuous approach is used to determine the adjoint information needed to calculate the desired sensitivities. The inclusion of adjoint variables leads to an increased runtime, but with a time per increment of roughly two times compared to the normal execution without optimization the calculation of large scale problems remains possible.

In order to judge the behavior and quality of the optimization method a test case created by Olesen et. al.[2] with a different implementation is recreated and the obtained results are discussed.

[1] C. Othmer, A continuous adjoint formulation for the computation of topological and surface sensitivities of ducted flows, Int. J. Num. Meth. Fluids, 58.8 (2008)

[2] L. Olesen, F. Okkels and H. Bruus. A high-level programming-language implementation of topology optimization applied to steady-state Navier-Stokes flow. Int. J. Num. Meth. Engin., 65.7 (2006),