Optimal Shape Design of Air Ducts in Combustion Engines: Design a General Shape Optimization Framework

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Abstract

In order to optimize the shape design of air ducts in combustion engines, we consider a shape optimization problem subject to an instationary incompressible viscous Navier-Stokes equations in 3D with appropriate physical boundary conditions in the duct geometry. An inflow profile is given at the inlet, a no-slip boundary condition is imposed on the wall, and a do-nothing boundary condition on the outlet. To find optimal shapes, we choose a mixed cost functional to achieve the flow uniformity at the outlet and minimize the dissipated power of our fluid dynamics device in a well balanced way.

In this talk, we try to design a general shape optimization framework via the continuous adjoint approach for the problem proposed, especially replacing Navier-Stokes equations by some widely used turbulence models, for high Reynolds number flows, to be able to capture turbulence phenomena. Their adjoint PDEs and the first-order shape derivatives of the chosen mixed cost functional and a general one have been computed and will be presented in this talk as the first step to design a gradient descent algorithm and develop CFD shape-optimization software packages.

Keywords: Shape optimization, Navier-Stokes equations, turbulence models, adjoint-based method.

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