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LES-Aided Shape Optimisation of U-Bend Channel

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Aerodynamic shape optimisation (ASO) affects the flow features by modifying bounding walls with aim to improve an objective function of interest. Adjoint methods are most effective in providing sensitivity of a given objective function w.r.t any number of input parameters at near-constant cost, they are widely used for steady-state RANS cases. Many complex flows, e.g., with severe flow separation, require LES turbulence modelling to improve accuracy, but if the chaotic turbulent motion is resolved, adjoint gradients blow up and practical regularisation methods are not available.

Alessi et al. [1] have fitted a frozen RANS eddy-viscosity to match a time-averaged LES solution and used the RANS adjoint to optimise the shape of the VKI U-Bend[2]. They recompute the LES after every design step, which indicates that while the LES flowfield can be matched with frozen turbulence, gradient accuracy is too poor for effective shape optimisation.

Our study will also investigate shape optimisation for the U-Bend, but following Singh et al. [3], we introduce a factor to the production term in the Spalart-Allmaras turbulence model. We then differentiate the S-A model with a frozen factor, but including the correct dependence of the model terms on the flow field. Results will compare gradient accuracy and optimised shapes for the U-Bend with frozen turbulence and differentiated turbulence with the frozen augmentation factor.

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