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Adjoint-Based Shape Optimization for Industrial Heat Exchangers

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Power electronics as used in electric cars derate their performance above certain temperatures, if not sufficiently cooled. Residential gas/hydrogen boilers require careful design for optimal efficiency and minimal emissions. In both application fields, a free-shape optimized design of the heat exchanger and surrounding components promises substantial performance gains that are relevant to fulfil the regulator's and customer demands.

The discrete adjoint method using automatic differentiation to compute shape gradients for CHT problems [1] will be outlined together with an efficient way to evaluate a pin-shape performance, essential in many heat exchangers, using streamwise periodic flow. Validation of the discrete adjoint gradient against finite differences shows excellent agreement for all tested configurations. These sensitivities are used in a shape optimization process using FFD-boxes and competing objective functions (system pressure drop and surface temperature or similar). Beyond shape optimization, the value of accurate shape sensitivities on its own for industry will be highlighted, as suitable shape parameterization with an effective enforcement of geometry constraints are not a trivial step.

In addition to the results of steady state simulations, validated gradients for a simple unsteady CHT setup using the discrete adjoint method are implemented and available. The unsteady multizone adjoint requires additional care [2] in terms of implementation and especially objective function definition.

The implementations that were used to produce the results are available to the public via the open-source C++ code SU2 [3]. The contributions are embedded in a code framework that encourages collaboration between academia and industry to extend features and usability.

REFERENCES

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