Coupling of Black Box Solvers for the Gradient Based Optimization of a Thermo-Mechanical Problem

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ABSTRACT

Application of coupled optimization in industry continues to be a very challenging area. The complexity of the models used in industry requires weak forms of coupling to reduce computational expense. It also means specialist knowledge is required for the setup and analysis of the different physics models, with coupling of models thus containing an important human component where the interaction between different specialist groups must be considered. Any optimization method must therefore take such considerations into account in order to provide a method that can be readily utilized in industry. Previous work has been carried out regarding industrial applications of coupled optimization particularly in the aerospace industry, this work looks specifically at an application to a thermo-mechanical problem in the automobile industry.

Thermo-mechanical problems constitute a critical issue in engine design. Engine cooling prevents damage to the engine for both combustion and electric engines, and can be achieved through a water jacket which for a combustion engine is integrated into the cylinder block. With the water jacket typically manufactured as part of the main engine block the possible size and shape variations are limited due to manufacturability and integration in the engine bay. With a limited overall engine block size, any increase in the size of the water jacket directly results in the reduction of material in the engine block itself, and therefore also the engine block's strength. In such a problem it is therefore important to optimize for the coupled problem and not individual physics.

On this basis this work looks at applying gradient, node-based shape optimization, in the form of Vertex Morphing [1], to coupled thermo-mechanical problems using black box commercial physics solvers. Previous applications of vertex morphing to coupled problems have involved the application of coupled adjoint sensitivities derived according to a continuous adjoint formulation, in a fluid structure interaction context [2]. In an attempt to simplify the application in an industrial context the sensitivities from the full adjoint problem are not used and a simplification is made in the form of a substitute fluid objective. In the context of this work the combination of finite difference temperature sensitivities are combined with a custom temperature based objective function based on the conjugate heat transfer problem to provide a suitable replacement objective for the coupled adjoint sensitivities. Using these sensitivities an optimization is carried out and results compared to alternative single discipline objective functions as well as a discussion on the simplification with respect to the fully coupled sensitivities.

REFERENCES

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