MOGA-II for an Automotive Cooling Duct Optimization on Distributed Resources

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Abstract. In this paper a procedure for the multi-objective optimization of an automotive cooling duct is described. The two objectives considered are the minimization of the pressure drop between the inlet and the outlet of the duct and the maximization of the outlet flow velocity. Since there is no a single optimum to be found, the MOGA-II was used as multi-objective genetic algorithm. The optimization of the duct was obtained employing a parametric model, performing flow analysis with an open source suite and using a multi-objective optimization product. The distributed optimization search exploited the parallelization capabilities of the MOGA-II algorithm which allowed the evaluation of several designs configurations by running concurrent threads of the flow analysis solver. The results obtained are very satisfactory, and the procedure described can be applied to even more complex problems.

1 Problem Description

The present work deals with designing the optimal shape of a duct in order to minimize the pressure drop between the inlet and the outlet of the duct and to maximize the outlet flow velocity (see Fig. 1). This process is normally complex, time-consuming and relies heavily on engineering experience. In order to reduce the product development time and satisfy the growing design requirements to stay competitive in the market, designers are giving more and more importance to the quality of their work complying with the principle of finding the best solution with the minimum effort. In this context, the designer can take full advantage of efficient optimization algorithms that allow concurrent designs evaluation on distributed computational resources.

The duct geometry in this example is located in the underbonnet of a vehicle, and is responsible for channelling air from the side-grill (see Fig. 2) towards the transmission for the purpose of cooling. Like most underbonnet regions in modern vehicles there is a very compact and crowded compartment with complex paths for air movement. Providing convective cooling with a side-duct is considered beneficial for the reduction in the transmission surface and oil temperatures.

The optimization procedure consisted of generating a parametric model of the duct, performing a *Computational Fluid Dynamics* (CFD) analysis and using

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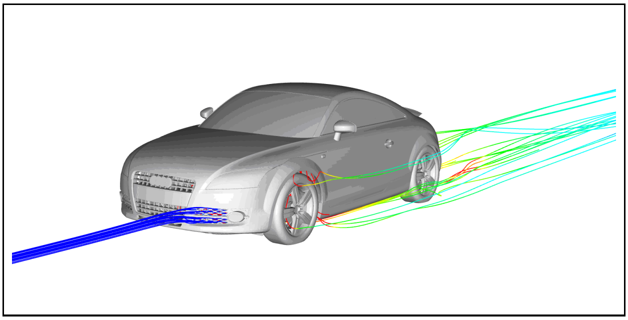

Fig. 1. Side grill inlet on a typical production car (Image courtesy of Audi AG)

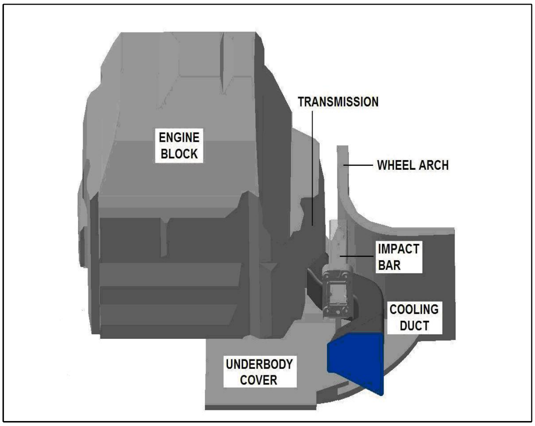

Fig. 2. Underbonnet components included in the duct optimization model (Image courtesy of Audi AG)

the multi-objective optimization software modeFRONTIER [4] to describe the optimization process and find the optimal design layout.

Steps to perform the cooling duct optimization can be enumerated as follows:

1. Retrieve data and generate the parametric model
2. Create automatically a polyhedral mesh of the flow domain
3. Setup of CFD analysis running on a multi-CPUs cluster
4. Setup an automatized optimization strategy using modeFRONTIER
5. Perform automatic multi-objective optimization
6. Multi-Criteria Decision Making (MCDM) tool usage
7. Robust Design analysis
8. Final selection of best solution

The first stage in the work was to retrieve all the available data for the full underbonnet simulation, which also included the baseline duct geometry. The final geometry is presented in Fig. 2.