An automated approach to speed up concept creation and validation based on flow optimization

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Article originally published in Newsletter EnginSoft Year 12 n°4, Winter 2015,
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EnginSoft Newsletter: http://www.enginsoft.com/newsletter.html

Volvo Car Corporation aims to decrease the vehicle production time to 20 months by 2020. It is therefore necessary to automate the process of evaluating new concept designs. In this MSc. thesis project a CFD analysis of an engine cover is automated in modeFRONTIER using the mesh-morphing methodology in ANSA. The objective of the study is to maximize the cooling air at 3 probe locations close to the engine.

A design of an existing engine cover concept is used as a baseline design. The advantages of using mesh-morphing is that mesh nodes are repositioned by the morphing tool without processing the CAD model which gives more degrees of freedom and the possibility of new concept designs which were not obvious for the Concept Engineer.

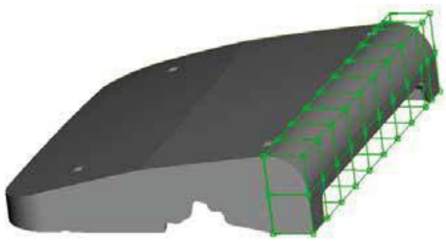

Fig. 1 - Morph box location on the engine cover

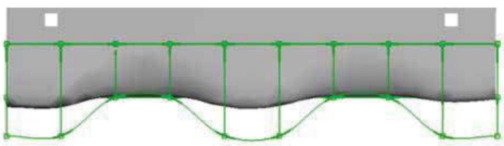

Fig. 2 - Illustration of morphing 6 out of 10 points in x direction

In the modeFRONTIER workflow, 9 input parameters are controlling the boxes to morph. The initial DOE is a Uniform Latin Hypercube table of 96 design. MOGA-II is chosen as the optimization algorithm, with 20 generation and 20 designs in each generation.

The mesh morphing is done in ANSA, the simulation in OpenFOAM and the extraction of the probe velocity is done within the Shell node.

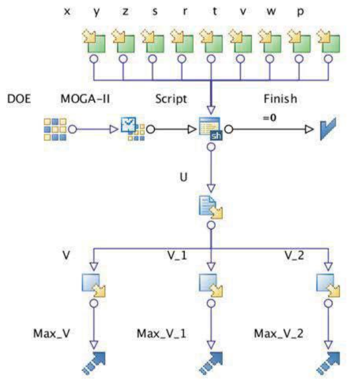

Fig.3 - modeFRONTIER workflow with the mesh-morphing input parameters and the probe values to maximize in the OpenFOAM simulation of the engine cover

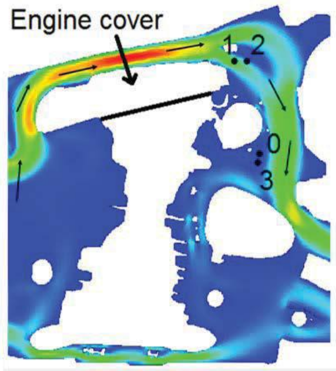

Fig. 4 - Cross section view under the car hood for a typical mid-size vehicle

In figure 4 the velocity field of the air flow can be seen around the engine cover and bay for one design configuration. Between the engine cover and the car hood the velocity of air can be seen to increase rapidly (red colored) due to the small passage. Probe 1, 2, and 3 are the locations where the velocity should be maximized in the shape optimization of the engine cover.

Each simulation takes about 10 minutes so the designs from DOE + optimization can be obtained in 3-4 days. The result of the modeFRONTIER optimization can be seen in figure 5 where the 3 probe values are plotted. Pareto designs are colored red and located at the very up-right corner.

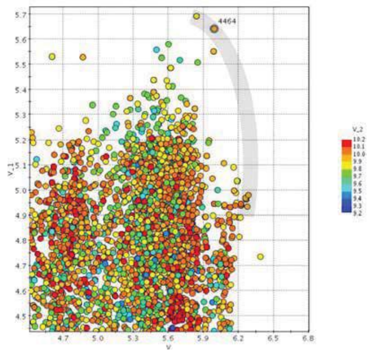

Fig. 5 - Results from DOE + Optimization of velocity at probe locations 1, 2, and 3

In table 1, a design proposal is presented with the highest improvement in velocity. Not surprisingly the greatest increase in velocity can be seen in probe location 1 (Max_V) since it is positioned close to the engine cover.

Fluent Simulation Results - Done by VCC Thermodynamics Department						
Simulation	Probe 1	%	Probe 2	%	Probe 3	%
Base case Low Car (LC)	2.05 m/s		3.23 m/s		1.64 m/s	
Optimized LC	5.32 m/s	160.3%	3.38 m/s	4.7%	1.66 m/s	1.6%

Table 1 - Results from DOE + Optimization of velocity at probe locations 1, 2, and 3

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