Faster and cheaper design of automotive HVAC ducts with Sculptor^TM: overview

Panel Duct

Console

SCULPTOR^TM

FLOW TO REAR SEATS: +250%

PRESSURE DROP: -9%

**PACKAGING Constraints:**   OK

What are HVAC Ducts?

The automotive Heating, Ventilation and Air / Conditioning (HVAC) unit supplies air to the vehicle cabin interior through the panel duct and the consoled duct systems. These duct geometries should respect the packaging constraints imposed by devices and structures contained in the instrument panel and in the console frame: this turns the HVAC duct system shape design into a challenging task.

So What?

Geometry of an existing HVAC duct system had to be improved in a Ford vehicle, aiming at a substantial increase of the flow reaching the rear seats through the console duct, while respecting all the packaging constraints. Besides that, the reduction of the pressure drop would have been beneficial to reduce the vent energy consumption. Finally, design cost and time had to be minimized.

Did They Succeed?

Sculptor^TM, coupled with a Multi-Objective Optimization code, allowed finding an optimal and feasible duct system shape over a few days, with only CFD the same optimization would have taken several weeks. With subtle shape modifications, a 250% increase of the console duct flow rate was reached. At the same time, pressure drop was decreased by 9%. This approach allowed to completely define the design in a few days. Moreover, Sculptor^TM avoided time consuming operations on the Computer Aided Design (CAD) model and on the computation grid, since its morphing took place over the CFD model directly.

OLD   NEW
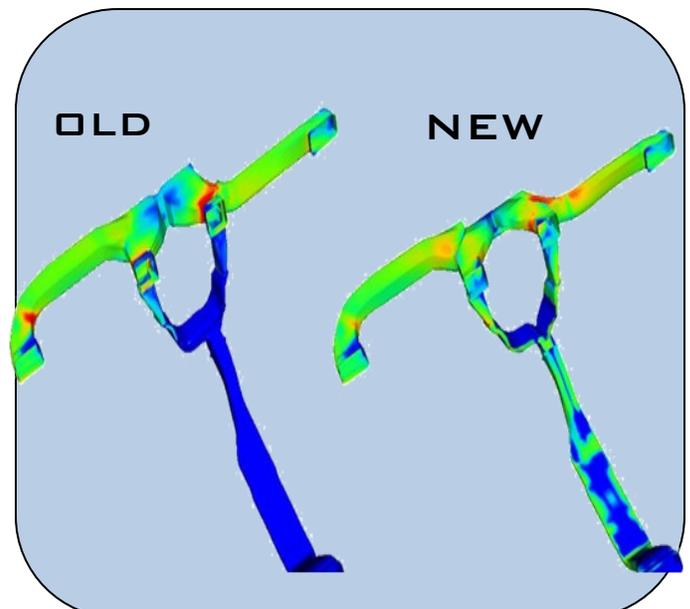
Faster and cheaper design of automotive HVAC ducts with Sculptor™: details

| Re-Cad	Re-Mesh	CFD Pre

| Mesh Morph | * | 89 % time saving with Sculptor™ |

Time advantage in creating any new configuration after the initial one.
*"Exports to CFD"

Sculptor™ enables the user to easily parameterize a complex duct system, respecting the packaging constraints. It also remove the re-CAD, re-mesh and pre-process operations for each new design iteration, by modifying the shape of the CFD model directly.

The original HVAC ducts had to be shaped respecting the existing packaging constrains, imposed by devices and structures contained in the instrument panel and in the console frame. In particular, the rear seats' mass flow had to be substantially increased. Also the maximum pressure drop had to be decreased in order to downsize the volume of the vent.
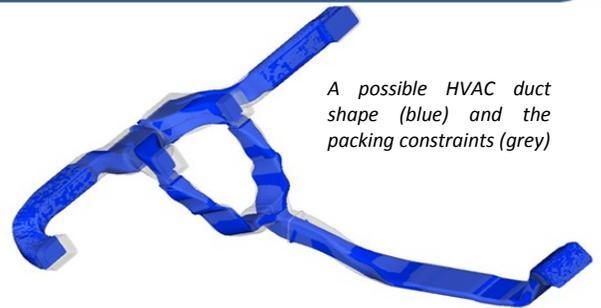
A possible HVAC duct shape (blue) and the packing constraints (grey)
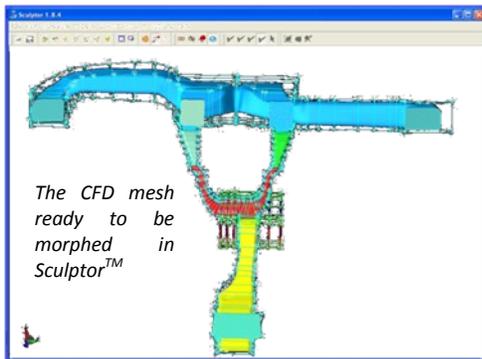
The CFD mesh ready to be morphed in Sculptor™

Sculptor™'s technology was applied over the Computational Fluid Dynamic (CFD) model of the duct system, to define its optimal shape. The original mesh was imported and prepared for morphing. Twelve parameters controlling the shape of crucial areas were defined and set in a way that took into account the mentioned constraints.

Shape Deformation (ASD) volumes, different feasible configurations were instantly generated by changing parameter values, without the need of re-creating the mesh. Such new configurations were then submitted to CFD and evaluated. Finally, the configuration giving the best results was exported back as a CAD file, and constructed by stereo lithography. This part was tested on the real HVAC unit, confirming the predicted improvements.

OLD   NEW
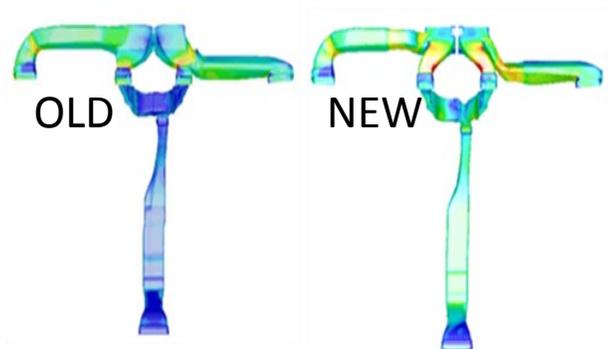
CFD and Sculptor™: faster and cheaper design

Sculptor™, coupled with a CFD code, allowed finding the optimal HVAC duct system shape in a few days, while CFD only would have taken several weeks. The total costs were 90% less with respect to the traditional design method. In the table below the breakdown of the costs is presented, based on the estimation of man-hour cost of ($90 / hour), CFD code hourly cost ($10.75 / hour) and a Sculptor™ hourly cost of ($10.75 / hour). 80 designs needed to be evaluated.

	Time		Cost	
	Without Sculptor	With Sculptor	Without Sculptor	With Sculptor
Time / Cost to mesh the first design	5 h	5 h	$504	$504
Time / Cost to re-CAD and re-mesh designs after initial	120 h	0 h	$12,090	$0
Time / Cost to re-set Boundary Conditions for all designs	20 h	0 h	$2,015	$0
Time / Cost to set up the case in Sculptor™	0 h	10 h	$0	$1,008
Total Time / Cost	145 h	15 h	$14,609	$1,512

On this project, the use of Sculptor™ enabled the user

to save more than $14,000 and 130 hours

About Sculptor™

SculptorTM is developed by Optimal Solutions Software LLC, based in Idaho, USA. The Optimal Solutions Management team is comprised of some of the most experienced CFD-based shape optimization personnel in the business. Since 1990, the re-search team has expended thousands of man-hours in design-ing and refining the SculptorTM software program to its pre-sent form. Through the development of the SculptorTM world-class, patent-pending product family, Optimal Solutions has been able to effectively address the current barriers that pre-vent the efficient use of digital simulation.

www.optimalsolutions.us

Apply Sculptor to your model for free

The team at Optimal Solutions Software is happy to perform a no-cost initial design assessment on your model. Contact us today and we will obtain the deformation constraints from you and demonstrate how Sculptor can save you time and money. We have worked with all sizes of companies and have NDA's in place with most major firms and can quickly get to work on your model.

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