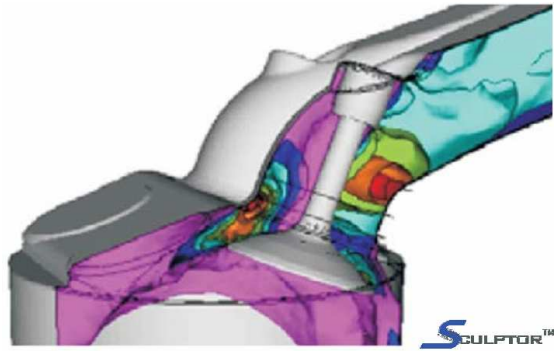
Rapid improvement of an engine intake port design with Sculptor™: overview



MASS AIR FLOW:	-18%
PRESSURE DROP:	CONSTANT
SHAPE CONSTRAINTS:	OK

Why an engine intake port?

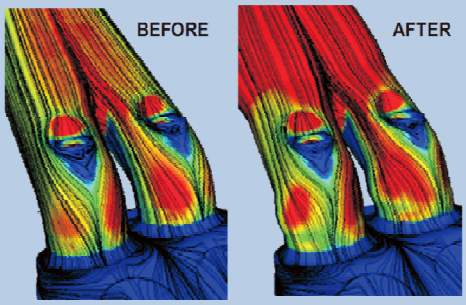
In internal combustion engines, the intake port shape is crucial to control the air flow entering the cylinder, and hence emissions and performances. Usually, it has to deliver an adequate mass flow to the valve passage, while containing the pressure losses. Intake port geometry is also exposed to tight shape constraints, since it's located in a compact and critical zone of the engine.

So What?

The geometry of an existing intake port had to be changed in order to achieve performance and efficiency improvements without expensive engine layout changes. The main goal was to increase the air mass flow in the intake port, while respecting the prescribed pressure loss. Also, any geometry variation had to respect precise shape constraints. Finally, design cost and time had to be minimized.

Did They Succeed?

Sculptor™, coupled with a CFD code, enabled the users to find an improved and feasible inlet port geometry in just one week, while with only CFD it would have taken several weeks or months. With subtle shape modifications, a 1.9% increase of the mass flow rate was achieved without any compromise on the pressure drop. The new configuration respects all the shape constraints and represents a cheap manufacturing solution. Sculptor™ avoided time consuming operations on the Computer Aided Design (CAD) model and on the computational grid, since its morphing took place on the CFD model directly.

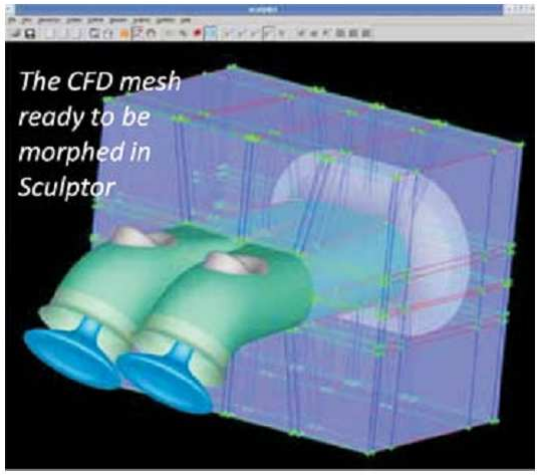


Rapid improvement of an engine intake port design with Sculptor™: details

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

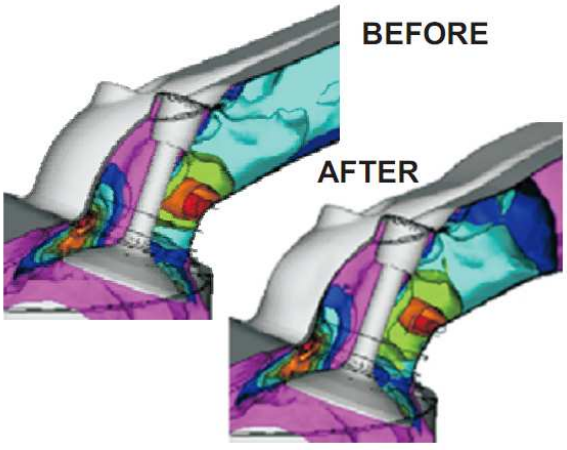
Sculptor™ enables the user to easily parameterize a complex engine intake port, respecting the assigned shape constraints. It also removed the need to re-CAD, re-mesh and pre-process the CFD for each new design iteration, by modifying the shape of the CFD model directly.

The original engine intake port geometry had to be refined while respecting constraints on some cross-sections: a maximum of 15% of variations was allowed for the area. The mass air flow through the port had to be increased, without affecting the pressure drop.



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

Using Arbitrary Shape Deformation (ASD) volumes, one hundred and twenty three configurations were instantly generated by changing the parameter values, without the need of re-creating the mesh. Such new configurations were then submitted to a CFD analysis code and evaluated. Finally, the best configuration was selected.



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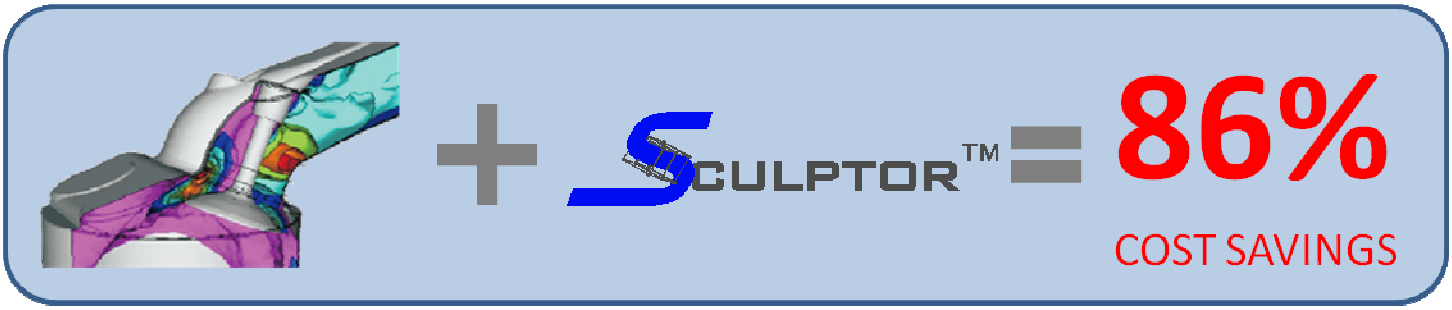
CFD and Sculptor™: faster and cheaper design



Sculptor™, coupled with a CFD code, allowed finding the optimal engine inlet port geometry in just one week. With only CFD code, it would have taken several weeks or months. The total costs were 86% less with respect to the traditional design method. In the table below the breakdown of the costs is presentd, 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		COSTS	
	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	123 h	0 h	$12,392	$0
Time / Cost to re-set Boundary Conditions for all designs	12.3 h	0 h	$1,239	$0
Time / Cost to set up the case in Sculptor™	0 h	15 h	$0	$1,511
Total Time / Cost	140.3 h	20 h	$14,135	$2,015

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

to save more than $12,000 and 120 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 research team has expended thousands of man-hours in designing and refining the SculptorTM software program to its present 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 prevent the efficient use of digital simulation.

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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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