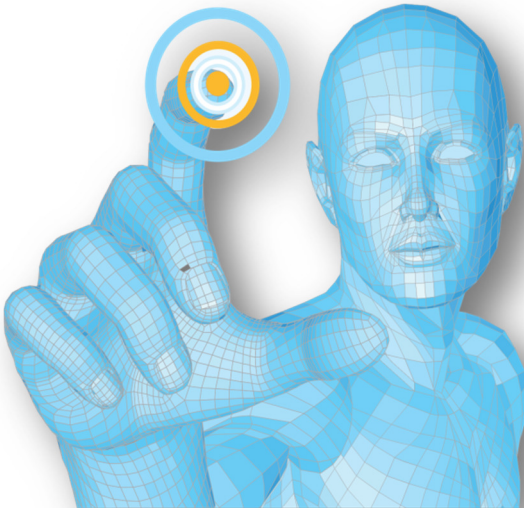# Shape and topology optimization of a cylinder head and block, using a minimalistic design approach

About the Client

The client is a leading automotive OEM in North America.

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www.depusa.com

The Challenge

The client wanted to explore the weight saving opportunities on the cylinder head and block. The delivery deadline of the project was short, and the client wished to achieve a reasonable amount of weight reduction from the component, while still meeting performance targets. In addition, the client wanted to do both shape optimization and topology optimization for higher mass savings. De-featuring of ribs on block and head, design space creation and running topology optimization for stiffness and PT Bending frequencies done as well.

The Solution

Since time was of the essence, the DEP team used the 'minimalistic design approach'

to execute the project. Minimalistic design approach involves pushing the design to the minimum possible limits, keeping in mind the manufacturing constraints.

Shape Optimization:

Shape optimization involved the following steps:

• The baseline model was evaluated for NVH and durability in their respective solvers

• The model was parameterized in DEP MeshWorks, achieving minimum mass design with the performance same as the baseline design

• In consultation with the manufacturing team, the constraints involved for casting

of the cylinder head and block was identified for the following parameters- wall thickness, rib thickness, flange thickness, rib & boss height

• In keeping with the manufacturing constraints, parameters are modified, yielding the most optimized design, meeting all targets

The load cases analysed were:

1) Block Durability Analysis – FSF evaluation

2) Bore Distortion Analysis

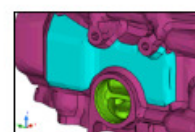3) NVH Load cases - PT Bending/Mount Mobility and Excursions, Accessory accelerations and Radiated noise

Few of the shape parameters on head
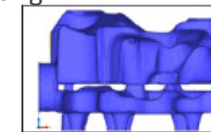
Head Water Jacket thickness | Rib thickness | Wall thickness

The DEP Edge

- Using the minimalistic approach by DEP, resulted in 60% time savings compared to the DoE approach

- Using MeshWorks for de-featuring of ribs on block and head and design space creation saved 70% time compared to the conventional approach

- Due to CAD Morpher used, an optimized CAD model could be given directly to the design team

The Result

A mass saving of 10% was achieved on the cylinder head and block, while still meeting all the performance targets.

4) CHT analysis on Cylinder Head – confirmation check.

Rib thickness   Rib & Boss height

Flange thickness
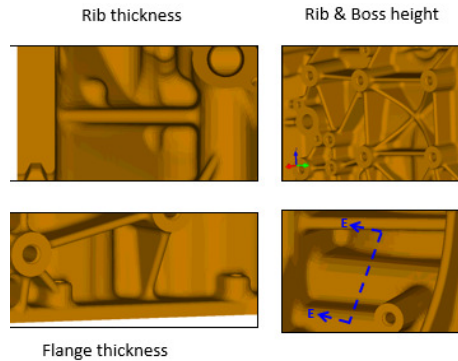
Bulk Head Depression

Vent Window

The same parameters as the optimized FEA model were put in a CAD level using the CAD Morpher from DEP MeshWorks. CAD Morpher generated the final optimized CAD, which was given directly to the design team as a parasolid model.
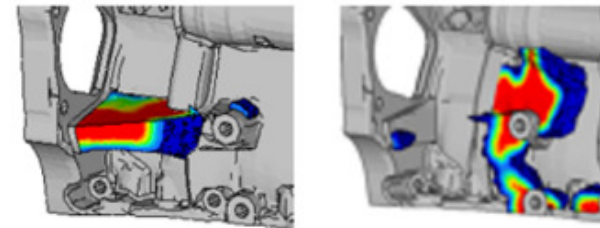
Topology Optimization:

The de-featuring of ribs on block and head, design space creation and running topology optimization for stiffness and PT Bending frequencies was performed using MeshWorks of the load path and subsequent creation of the ribs was done directly using MeshWorks. As compared to the manual method of deleting and de-featuring, the quick tools in MeshWorks were a significant time saving.
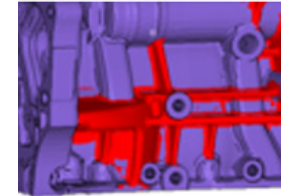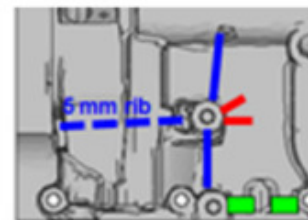

Baseline rib pattern

Rib de-featuring and design space creation using MeshWorks

Topology results – Strain Energy Density contour

Load path Interpretation from Topology Optimization results

Rib creation using MeshWorks