An Innovative Approach to Lighter and More Efficient Powertrains

Key Highlights

Industry
Automotive

Challenge
Develop a new, efficient and lightweight vehicle powertrain

Altair Solution
Design optimization methods used to create an innovative, minimum mass structural layout of material

Benefits
- Weight reduced by 8%
- NVH & fatigue improved by 30%
- Modeling efficiency improved by 60%

The majority of territories across the world have witnessed an almost continuous increase in the cost of fuel. Tighter regulations across Europe, US and Asia combined with a shift in consumer demand as drivers seek to reduce CO_2 emissions and minimize vehicle running costs, has ensured manufacturers must deliver ever more fuel efficient vehicles. Carmakers are investing heavily in the development of lighter vehicles and more economical engines that can go further on less fuel.

Renault is one of Europe’s largest automotive manufacturers and produces a wide range of passenger cars and commercial vehicles from its facilities located around the world. The company has been pushing the development of high performance, fuel efficient engines for many years and in 2009, Renault figured among Europe's three best-performing car manufacturers for average CO_2 emissions. Renault’s sights are now set on moving to the top of the order.

Renault’s powertrain division wanted to further decrease the weight and increase the performance of existing and in-development engines by redesigning key components to use a minimum amount of material. As an existing user of Altair's simulation solutions, Renault approached Altair to assist in the development of the required optimization design methods and processes for use at component and sub-system levels.

The collaboration involved Altair supplying Renault with extensive support for the design optimization technology within its HyperWorks simulation suite, as well as providing engineering expertise through its product development division, Altair ProductDesign.

Keywords: Powertrain, optimization, weight reduction

Renault Success Story

"Altair helped us to greatly increase the impact of optimization by applying it in the early development phase, with an ambitious scope, yet coping with real industrial time and resource constraints."

Dr. Anthony Hähnel
Powertrain NVH CAE Team Leader
Renault

This initial collaboration proved very successful, delivering light and efficient components on a range of different programs. However, the team felt that design optimization techniques were being used as a tactical tool to combat weight problems in the detailed design phase rather than a mechanism to drive an optimized design from the start. The ideal time to implement optimization technology is right from the start of the development process, where the cost implications of making structural changes are at their lowest. The project raised awareness of a potential barrier to optimization technology being used at this early stage. Since powertrain models are very complex and take a long time to create, suggesting changes to geometry, guided by optimization technology, could slow down the product development time if the modeling phase is not properly taken into account.

The Optimization Grand Challenge

In order to demonstrate the potential impact that optimization technology could have on the performance of the powertrains, Altair and Renault agreed to conduct a simulation 'Grand Challenge'. These unique projects involve Altair using new design methods and processes to rapidly develop an innovative solution to a defined engineering challenge. For Renault, the challenge was to develop a process to accelerate the creation of powertrain models and then deploy optimization technology across multiple powertrain components while accounting for a wide range of performance criteria. With Renault about to start the development of a new powertrain, the project was well timed to demonstrate the impact that optimization technology can have on weight, performance and manufacturability if used early in the development process.

The project included two main areas of focus, namely the noise, vibration and harshness (NVH) performance of the global powertrain assembly and the fatigue

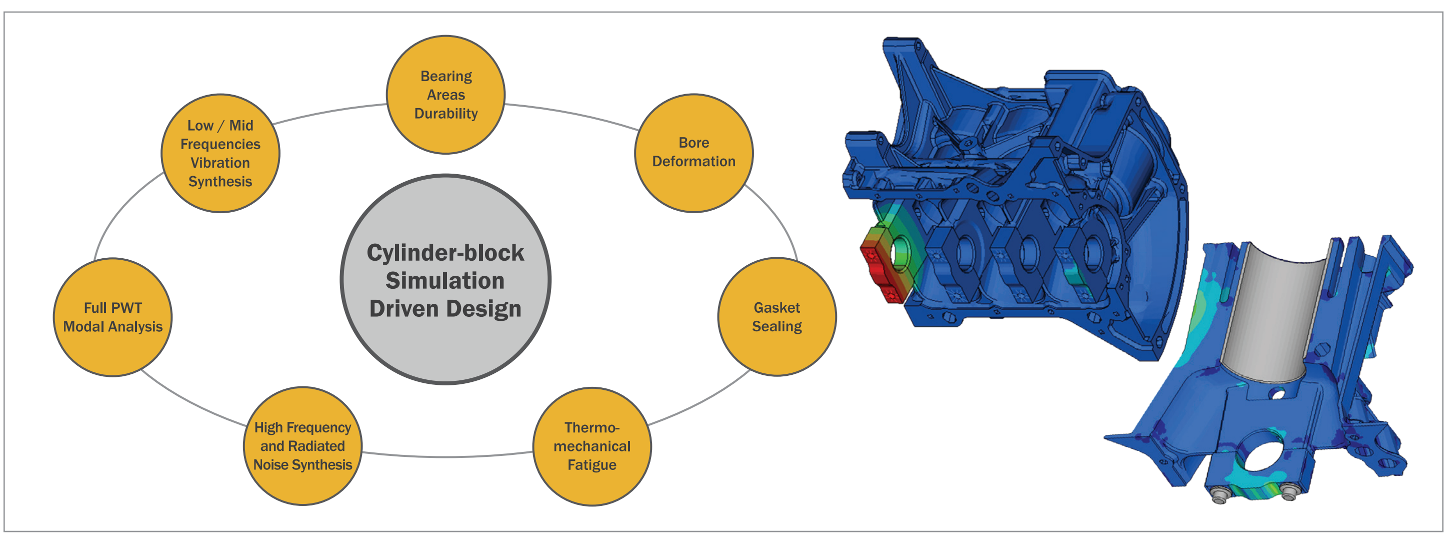

Fig1: Simulations investigated by the powertrain team

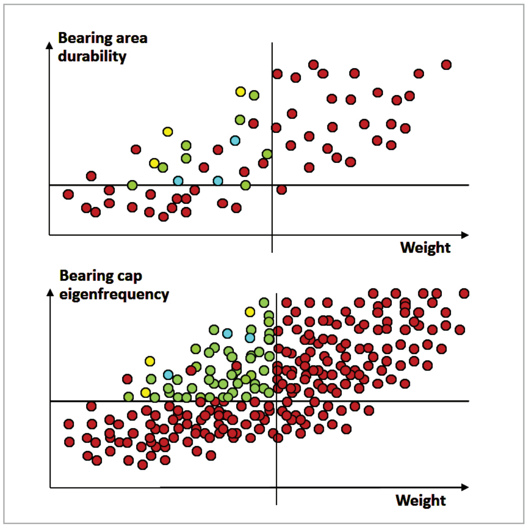

Fig 2: Design of Experiments Studies

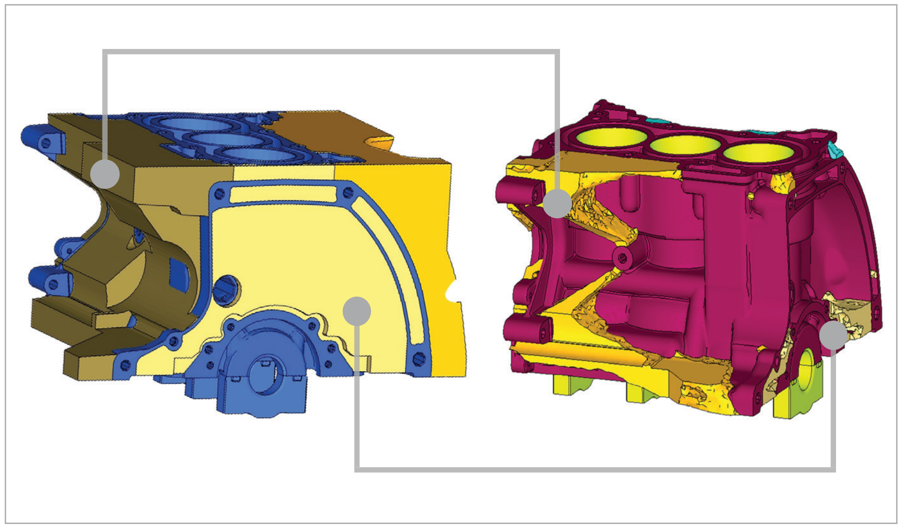

Fig 3: Topology optimization to define the external rib network for NVH performance

performance of the engine's bearings. The different durability and NVH loadcases (Fig 1) were executed using HyperWorks' optimization solution, OptiStruct. OptiStruct excels at handling these large models and is able to simulate complex physics including bolt tensioning, gaskets, highly non-linear materials and contact.

The first step in the process was to parameterize the model in the CAD environment, identifying design spaces and parametric design variables such as wall thickness and rib height that could later be used as design considerations for the optimization process.

Altair's SimLab finite element modeling environment was deployed to automate the build of these complex structures based on the concept CAD models. Using custom meshing, boundary conditions and contact templates, SimLab managed to improve the productivity of the model build process by 60% compared to Renault's standard approach, while maintaining strict quality criteria of the model. By automating this process, any future changes to the model geometry could be re-meshed, ready for optimization and analysis within just a few minutes. In order to find the best trade-off between NVH and durability performance, weight targets and manufacturability criteria, design of experiments (DOE) processes were conducted using HyperWorks' HyperStudy (Fig 2). This process automatically explored multiple design variables and quickly identified design variations that could meet the overall performance and weight goals.

To further enhance the NVH performance of the structure, OptiStruct was employed in parallel to perform topology optimization on the external rib network for the global powertrain assembly (Fig 3). By identifying the design space areas within the model and applying the known loads and constraints, OptiStruct was able to suggest the ideal material layout for the rib network, removing any material that was not required to meet the NVH targets.

Accelerating Powertrain Development

The new product development process proved to be extremely effective for Renault. Using optimization technology upfront in the development cycle allowed the powertrain team to rapidly experiment with hundreds of design variables that an engineer would not typically consider, while still allowing the team to use their judgment in choosing the best solution. The process allowed the team to concentrate on added value tasks rather than occupied with time consuming modeling activities.

The final design of the new powertrain achieved an 8% reduction in weight while improving in-house NVH and fatigue cumulated performance indicators by 30%. When compared against the other powertrains in the market, this improvement made the performance of the new Renault engine the best in its class.

Since the grand challenge proof of concept activity took place, Renault has identified that using the same process and targeting a smaller weight reduction of 5%, could result in a performance increase of as much as 90%. Conversely, if the performance of the powertrain was already on target, this simulation driven design process could be applied solely to reduce mass resulting in a significantly larger impact on weight.

The grand challenge activity demonstrated that using optimization technology early in the development process can help to reduce the development time by shortening costly design loops and minimizing the effort required for product validation.

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