Ford Motor Co.

Accelerates powertrain design with CATIA and SIMULIA

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Jeffrey Bautz
Ford Motor Co.
Powertrain ADSS Manager

Challenge

Ford Motor Company's powertrain team sought to accelerate product development by enhancing collaboration among engineers, designers, and analysts.

Solution

Ford leveraged SIMULIA's Abaqus for CATIA solution to tighten integration of CAD geometry and CAE analysis models, and by developing CAD and CAE templates to standardize and accelerate processes.

Benefits

Ford is rolling out the solution globally to take advantage of substantial time savings plus better workload balancing of analysts and designers and improved design validation efficiency.

DASSAULT SYSTEMES

Ford Motor Company's North America Engine Engineering Organization has more than 100 CAD designers and CAE analysts in its Powertrain Analytical Design and Six Sigma (ADSS) department. This team designs all of the powertrain components, including the cylinder block and head, connecting rods and crankshafts, pistons, turbo chargers, and valvetrains.

To develop the most robust designs to Six Sigma quality levels in the shortest amount of time is a challenge that requires precise inter- and intra-departmental coordination, robust engineering tools, and well-tuned processes. Ford therefore created a global Product Lifecycle Management (PLM) program to improve product development efficiency, increase throughput, and deliver 100% geometric compatibility. As part of this effort, Ford implemented a series of digital innovation initiatives; one of these – Digital Vehicle Engineering (DVE) – includes development of multiple intelligent CAD templates with tight integration of computer-aided engineering (CAE) and optimization modules. The goal is to promote enhanced collaboration among engineers, designers, and analysts in a virtual product design and verification environment.

CAD and CAE integration

About five years ago, Ford decided to migrate all CAD modeling to CATIA, the Dassault Systèmes' brand for virtual design and product innovation. "What made the difference for the management team was the capability of CATIA to integrate CAE tools," says Jeffrey Bautz, Ford's ADSS manager. "They recognized that the resulting efficiency improvements would be significant."

The ADSS team saw the potential benefits and was one of the first groups inside Ford to use the integrated CAD/CAE solution for production. The team choose Abaqus for CATIA, a solution from the Dassault Systèmes' SIMULIA brand that brings the FEA capabilities of Abaqus into the CATIA environment through two CATIA workbenches: nonlinear structural analysis and thermal analysis.

Using Abaqus to integrate CAD and CAE within CATIA, the ADSS team greatly accelerated the analysis process. The CAE model and the CAD geometry were easily accessible in one interface, eliminating the need for data translations. The workbenches enabled multiple iterations quickly. Using an integrated platform also creates associativity between the geometry and analysis models, eliminates delays between steps, and streamlines workflow.

Template development

The ADSS team next focused on automating the CAD and CAE processes by developing software templates to facilitate process automation. "With integrated CAD/CAE templates as part of our Digital Vehicle Engineering strategy, we are able to accelerate the initial geometry and analysis generation

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Sassan Khoubyari
PLM Strategy and Implementation Manager, Ford Motor Co.

process," says Sassan Khoubyari, PLM strategy and implementation manager. "This allows CAE to drive design upfront, rather than validating later in the design process."

Since an analysis is only as good as an analyst's assumptions, team members spend significant time developing and validation their methodology with multiple iterations between physical test data and the model. Once assumptions are validated, capturing their value for re-use ensures consistency and eliminates the need to recreate the methodology for each new model. Templates provide the capture mechanism, standardizing the conditions and variables for a model or simulation.

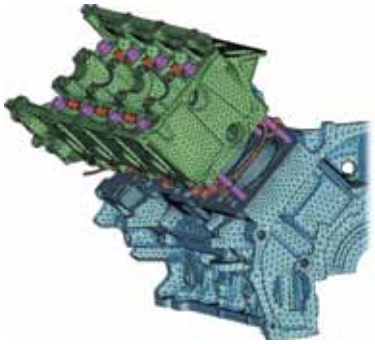
Once a method for building a complicated model has been developed, the analyst must still apply numerous boundary conditions, contact elements, and loads. A single model can have 250 to 300 different types of boundary conditions. Before templates, most of that work was done manually. With hundreds of components in the powertrain and multiple iterations for many analyses, significant time was spent cross-checking designs. Templates eliminate this time investment and minimize the potential for human error.

The ADSS team used a Six-Sigma-style approach, developing value stream maps for all major engine components. The maps were used to set priorities for component template development, giving precedence to those templates that could improve the product development cycle most dramatically.

The team started with an oil filter adaptor analysis because it was relatively simple, could be completed quickly, and could serve as a template proving ground. They also chose a cylinder head lift deck rigidity analysis, a more complicated project, to test CATIA's ability to handle complex CAE templates. This analysis template included automatic setup of 51 contact pairs and 71 constraints; creation of parameterized components; elastic-plastic material property of head bolts; geometry partition and grouping of a combustion chamber surface to define the mesh boundary for a cylinder pressure application; five analysis steps, including press-fit of valve seats, bolt-down of a cylinder head with steel plates, and peak combustion pressure application in each cylinder head. Both analysis templates were attractive candidates because they are current production programs and fall in the early phases of development, where multiple iterations are common.

The CAD template defines the geometry. The CAE template includes the basic information for the simulation, including mesh, load, and boundary condition requirements. Because the templates are linked, a CAE analyst can easily change the key parameters, which automatically updates the geometry as well as the mesh in the analysis model.

Model for an oil filter adaptor NVH (noise, vibration, and harshness) analysis.



Model of engine block and cylinder head for a cylinder head deck lift analysis.

Benchmarking efficiencies and savings

Two years into the CAD/CAE integration, the ADSS team has created CAD templates for all major components and has begun to actualize the return on investment, with significant projected long-term impacts. For example:

- According to John Norcut, CAD template development manager, the oil filter adaptor analysis has been greatly improved. "By eliminating the CAD-to-CAE-to-CAD handoffs, we have saved three to four weeks overall in product development cycle time," Norcut says.

- "For the cylinder head deck lift analysis," says Alex Tang, CAE technical specialist in charge of the CAE template development effort, "it used to take an analyst one to two days to set up the model. But with the template and a CAE-ready model, setup time has been reduced to less than 30 minutes."

- Improvements are equally dramatic for other components. To mesh the connecting rod for a dynamic analysis, it used to take an experienced analyst as much as four to eight hours. With templates, it can now be done in as little as 10 minutes if the CAD model is clean. For an intake manifold burst analysis, mesh generation has been collapsed from three weeks to only about two hours. For a connecting rod durability analysis, a mesh time that would have required 1.5 work weeks has shrunk to minutes.

Future

The template initiative's results are perfectly aligned with Ford President and CEO Alan Mulally's ONE Ford plan to accelerate development of new products that customers want and value, so the advancements are being deployed throughout Ford's operations globally.

As a result of these gains, the ADSS team is looking at ways of integrating additional analysis tools inside CATIA, including SIMULIA's Isight optimization software.
This tool provides a visual and flexible process to automate the exploration of design alternative and identify optimal performance parameters.

Quality on the road

The CAE integration and template effort will have a number of long-term impacts, including streamlined workflow. CAD designers and D&R engineers, rather than CAE analysts, will be able to handle many of the simple analyses. As a result, analysts will be freed up to tackle more difficult problems, including higher-end analyses and new methods development that require their advanced level of training and expertise. This workload balancing will further improve design validation efficiency; every new method will allow the team to eliminate a hardware test, which generates substantial cost savings.

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Images courtesy of Ford Motor Co.

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