e-Xstream engineering | **CASE STUDY**

Advanced anisotropic damping modeling for NVH optimization

Mastering the microstructure of composite materials for optimizing NVH performance

Overview

The Ford Motor Company uses glass fiber reinforced plastic materials for powertrain parts such as engine covers, air intakes and engine oil pans. These materials offer numerous benefits with regards to automotive component design including lightweighting and a better damping compared to metal. However, due to the complexities of the composite material microstructure which arise due to the manufacturing process, both the stiffness and damping of reinforced plastic materials are frequency dependent and locally anisotropic. The efficient design of such components from an NVH perspective requires the use of adapted techniques that can account for these specificities, from the material characterization stage up to the performance prediction of each design iteration.

PA6 GF Engine Oil Pan

Challenge

The challenge can be framed as follows:

- How to build a material model capable of capturing the correct local anisotropic stiffness and damping behaviors depending on the frequency and the local fiber orientation?
- How do the microstructure parameters influence the part's NVH behavior?

The Ford Motor Company can see a great opportunity to employ this technique not only as a predictive simulation methodology but also as a tool to fine-tune the parameters which drive a given part's microstructure. This brings 2 benefits:

- The part's NVH performance as well as weight will be optimized
- It reduces the need for corrective actions which typically increase component weight in order to meet acoustic targets

"I'm very impressed with the unique adaptive capabilities demonstrated by Digimat as part of our partnership methodology research project with e-Xstream. Use of this software will allow us to optimize the microstructure of design of composite materials in such a way that we can tune for specific NVH requirements. Automotive application of composites is essential for weight reduction, resulting in less fuel consumption and reduction of CO2 emissions. However, at times this may come with some level of degradation in NVH performance. Digimat will allow the engineer to properly model & design the material composition such the optimum damping tuning can be achieved to deliver the required NVH performance and refinement. This is a huge step forward in light weighting component design!

– Mario Felice, Manager , Global Powertrain NVH CAE, Ford Motor Company

Solution

The technology developed by e-Xstream engineering in Digimat has been applied on 2 components:

- An engine oil pan in order to:

- Apply the procedure to create a visco-elastic material model from DMA test data

- Demonstrate the accurate prediction of eigenfrequencies and acceleration peaks when applied on a FRF FEA compared to experiment.

- An engine bracket in order to:

- Estimate the extent to which fiber orientation, fiber mass fraction and fiber length can influence a component's NVH behavior

For each application, the fiber orientation distributions have been mapped onto the Nastran structural meshes. The effect of the manufacturing process on the prediction of the components behavior is taken into account via the mapped fiber orientations which have been associated with a multi-scale visco-elastic material model in FEA. For the engine bracket application, the mass fraction and the fiber length have been modified directly in the material file in order to gauge their influence on the simulation.

Results/Benefits

The engine oil pan case study has demonstrated a significant improvement in how frequencies and acceleration peaks are identified compared to the usual isotropic method applied by Ford Motor Company: see Fig. 1

The engine bracket case study reveals that each microstructure parameter (the fiber orientation, the fiber length and the fiber mass fraction) has a significant potential influence on the component's performance, enabling them to be considered as design parameters. Hence, by fine-tuning the material microstructure of the injected composite, a design engineer can optimize the component's performance in terms of damping and lightweighting: See Fig. 2

Key Highlights:

Digimat:
Digimat-MF, Digimat-RP/Fiber Estimator

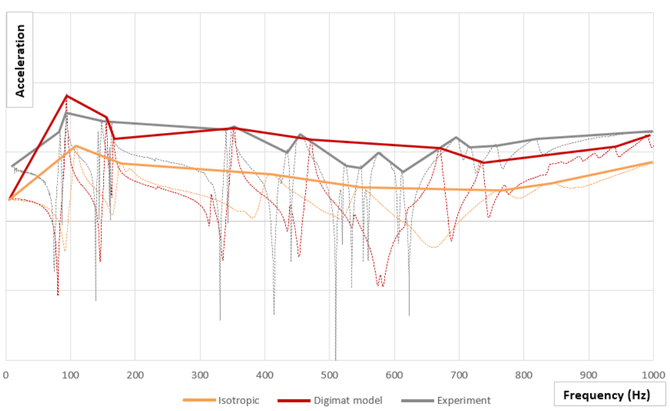
Industry:
Automotive

Application:
Engine oil pan, engine bracket

Performances:
NVH, frequency and acceleration peaks identification

Fig. 1

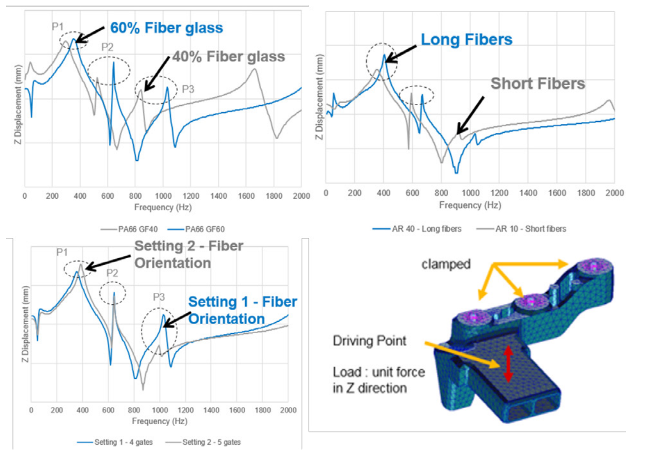
Gaps/experiment	Acceleration peak			Frequency		
	Average	Min	Max	Average	Min	Max
Isotropic	72%	65%	83%	11%	5%	18%
Digimat	29%	4%	83%	3%	0.5%	5%



Case 1 – Engine Oil Pan: Comparison of model predictions with experimental data reveal a significant improvement in using the Digimat technology compared to a usual isotropic method, which under-estimates the component's NVH performance over the whole frequency range.

Fig. 2

Influence on peak 1	Acceleration peak			Frequency		
Configuration	1	2	Influence	1	2	Influence
Mass Fraction	2	2.3	15%	300	360	20%
Aspect Ratio	2	5.6	180%	365	401	10%
Gates position	2.2	3.2	45%	370	395	7%



Case 2 – Engine Bracket: Fiber orientation, mass fraction and aspect ratio influence the component's stiffness and damping behaviors in such a way that the effect is dependent on the frequency and the eigenmode shape for each peak.

For more information on Digimat and for additional Case Studies, please visit www.e-Xstream.com

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