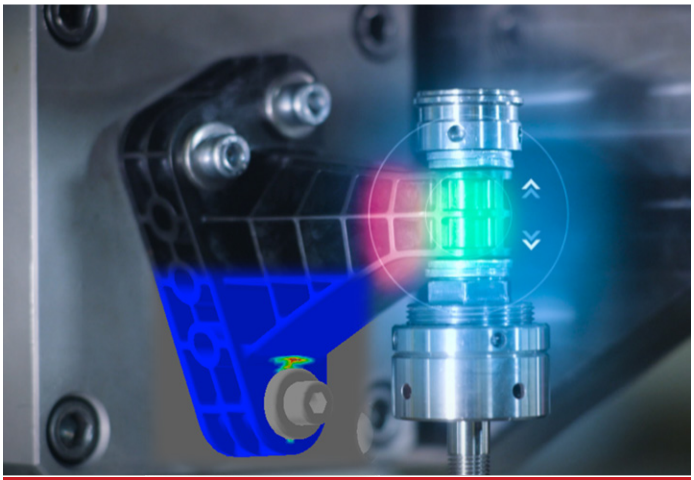
Case Study: Fatigue lifetime prediction of short fiber reinforced plastics (SFRP)

More accuracy from material card calibration to FEA simulation results post-processing

Summary

SFRPs are increasingly used, especially in the automotive industry.

Metal replacement for assembly reduction and light weighting are the first drivers. But after having tackled the spatially varying stiffness and anisotropy and more recently the failure prediction, more advanced performances have to be addressed such as durability.



DSM load bracket, real testing and digital twin fatigue weak spot

"DSM is pleased to collaborate with e-Xstream team to provide to the industrial community material cards and a dedicated workflow to reach accurate SFRP lifetime predictions at part level."

- Lucien Douven, Senior Design Engineer, DSM

Key Highlights:

Digimat:
Digimat-MX, Digimat-RP

Industry:
Automotive

Performances:
Durability

Challenge

Lifetime prediction of SFRP parts is a challenge due to several aspects among which:

- The spatially varying microstructure related to the injection molding process
- The local stress ratio which differs from the macroscopic load ratio due to boundary conditions and part geometry
- The load nature is depending on the mean stress sensitivity which involves different failure mechanisms such as crack growth and plastic strain accumulation.
- The numerical description sensitivity, both from mesh size and material modeling sides

Solution

To overcome this challenge, DSM collaborated with e-Xstream to build a suitable workflow in order to reach accurate SFRP part lifetime prediction.

An integrative approach involving injection molding process effect has been deployed starting with

I) the injection molding process simulation relying on Moldflow,

II) the material modeling for any microstructure involving an advanced calibration workflow with Digimat-MX,

III) the part fatigue load case simulation with Abaqus and

IV) the post-processing of the FEA simulation results in Digimat-RP (Figure 1).

To perform the last step, Digimat-RP has been upgraded with a post-processing environment specifically for FEA simulation fatigue results. It involves different post-processing workflows and combines several lifetime computation methods including plasticity correction, lifetime averaging and stress gradient correction.

Results

By deploying this integrative approach, DSM accounted for the effect of local stress, local fiber orientation in high detail, stress concentrations, and local stress ratio.

The load bracket made out of Akulon S223-HG0, a 50% glass fiber reinforced PA66, has been subjected to a cyclic load covering different load ratios -2, -1, -0.5, 0.1, 0.5 and multiple load amplitudes. Comparison of test data and lifetime predictions relying on the described workflow are presented herein.

Conclusion

This effort leads to very good part-lifetime predictions, for different load ratios and with multiple load amplitudes, within 1 decade margin with respect to test data. The deployed approach also appears to be robust to mesh size (Figure 2).

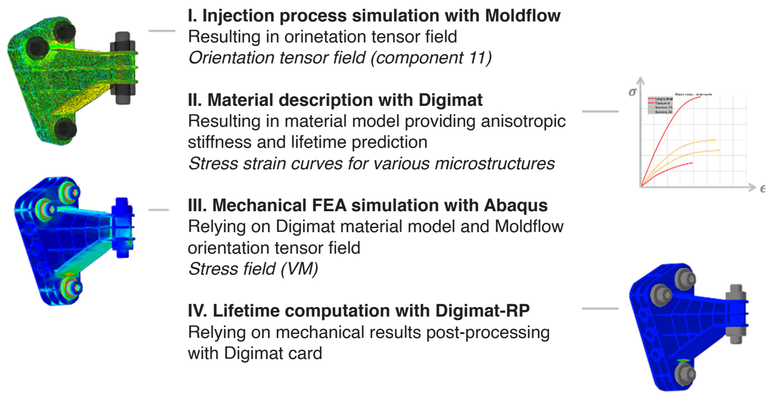


Figure 1: Integrative approach deployed by DSM to reach accurate lifetime prediction of SFRP parts

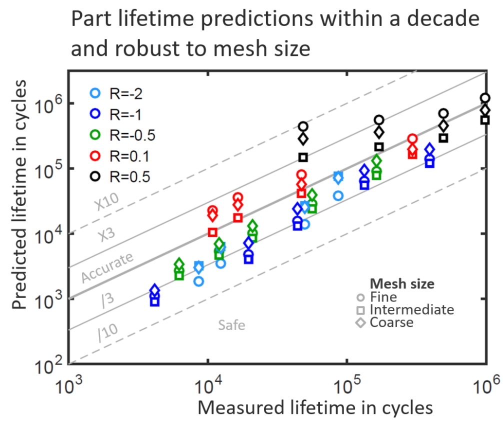


Figure 2: Correlation of predicted lifetime with test data covering different load ratios and multiple load amplitudes

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

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