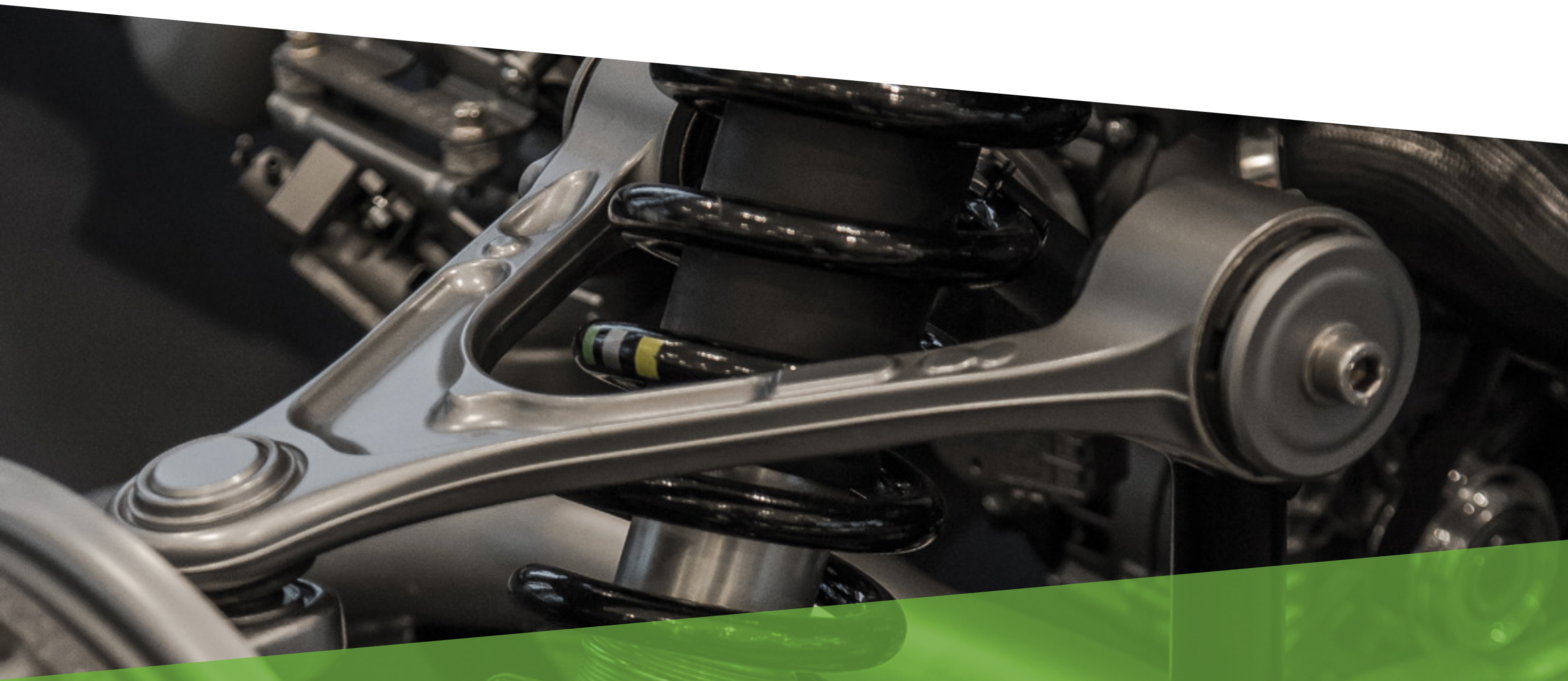
Digimat-RP Helps Reduce Time to **Market for Fiber Reinforced Plastic Control Arm**

Based on an interview with **Fabio Pulina, Magneti Marelli**



Industry Challenge

Magneti Marelli's suspension systems group was tasked with redesigning a steel control arm into injection molded fiber reinforced plastics to reduce weight and improve fuel economy. The function of the control arm is to connect the wheel side to the cross member; this connection is made by two elastic bushings, which filter the vibrations that come from the wheel. The subject matter of this metal replacement project was a steel control arm belonging to the B-SUV segment; so its loads, and its design space have been considered. Magneti Marelli engineers selected a polyamide fiber resin with short glass fiber reinforcements because this material is good for the control arm's primary mechanical requirements, which are strength and endurance. Optimizing the design required predicting the ultimate strength and failure location for multiple mass fractions. The manufacturing process also needed to be optimized because of its impact on fiber orientation which in turn affects the mechanical properties of the part.

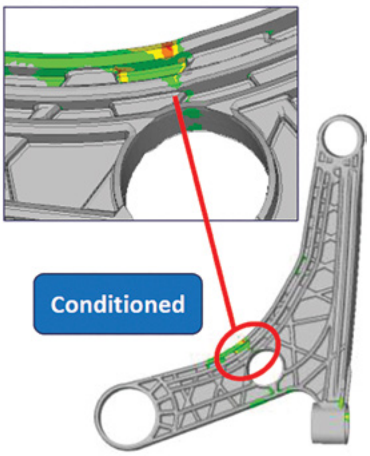
Using the traditional build and test method to design the part would have required a long and expensive product development schedule. "We needed an accurate finite element model of the part that we could use to evaluate different design configurations against a large number of potential load cases," said Fabio Pulina, Innovation Composite Engineer from Magneti Marelli.

The failure point predicted in the simplified approach, that is isotropic material plus a knockdown factor, did not let us able to achieve a correlation with the experimental results, in terms of either failure location, or collapse load level.

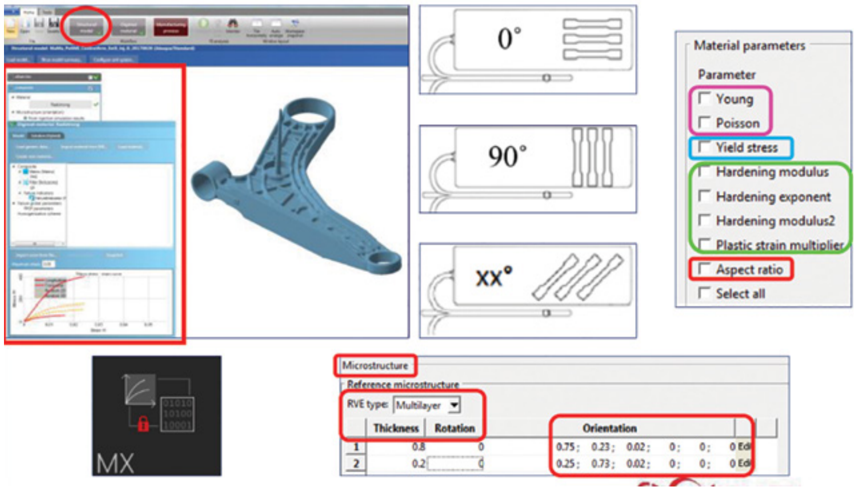
Different configurations have been tested; the material has been considered both dry and conditioned, and two typologies of constraints have been evaluated (rigid and soft attachment to the test bench). These results indicated that the original isotropic model could not be reliably used as a design tool.

"We clearly needed to take the effect of local fiber orientation on the material properties of the part into account In order to accurately simulate its performance," Pulina said.

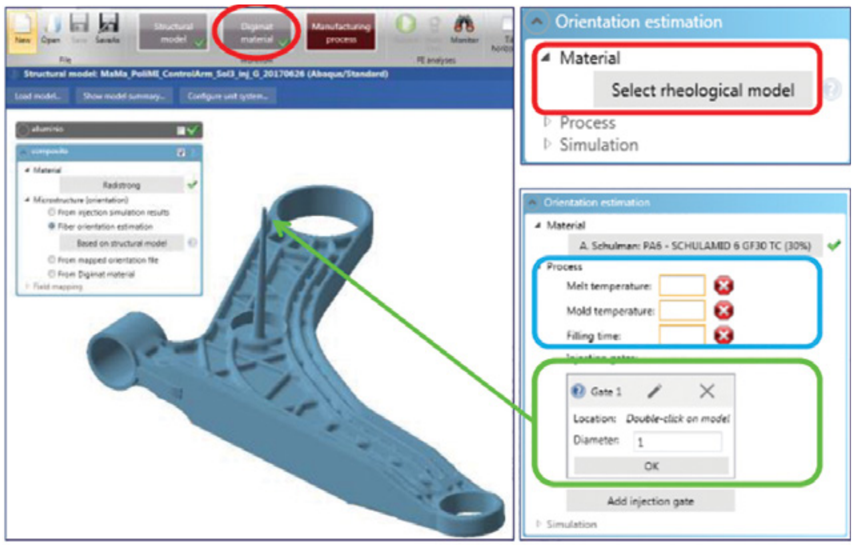
Original steel control arm



Failure point predicted by homogeneous isotropic simulation for conditioned reinforced plastic part with bushings did not match physical testing



Evaluating effects of fiber orientation on material



Determining fiber location and orientation in molded part

“The ability to optimize the design with a software prototype and manage the entire design process from within a single software package saved us 20 to 30 percent of the time that would have normally been required to design the new control arm.”

Fabio Pulina, Innovation Composite Engineer, Magneti Marelli

MSC Digimat-RP Solution

1. Determining Material Properties with Different Fiber Orientations

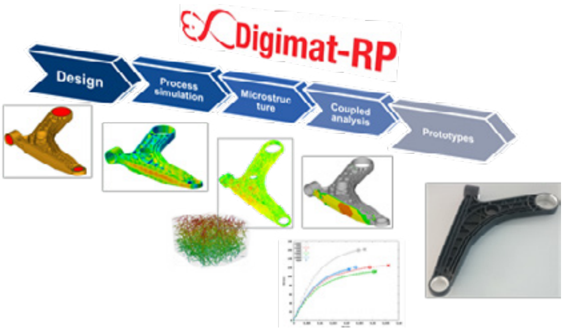
Pulina began by using Digimat-RP to compute the anisotropic composite properties based on the properties and microstructure of the underlying constituents in the multi-phase material. The result was a micro-scale material model capable of capturing the effects of different fiber orientations on material properties. The elastoplastic properties of the resin were automatically calibrated by loading test data provided by the resin manufacturer based on 0-, 30-, 45- and 90-degree fiber orientations.

2. Simulating the Injection Molding Process to Determine Local Fiber Orientation

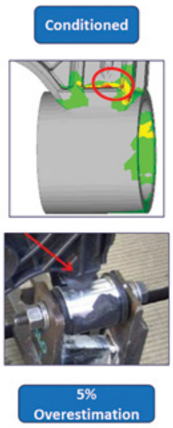
Pulina addressed the local fiber orientations in the part produced by the injection molding process. He entered the current injection molding parameters including gate location and size, mold temperature, melt temperature and filling time in Digimat-RP. Digimat-RP then called the integrated module of Moldex3D mold simulation software behind the scenes to simulate the injection molding process, predict the fiber location and orientation and map them onto the structural resin model. “The integration of Moldex3D within the Digimat-RP user interface eliminates the need to involve people from other departments to get the necessary molding filling simulation, saving time during the design,” Pulina said.

3. Anisotropic Simulation Achieved by Coupling Digimat-RP and Abaqus FEA Software

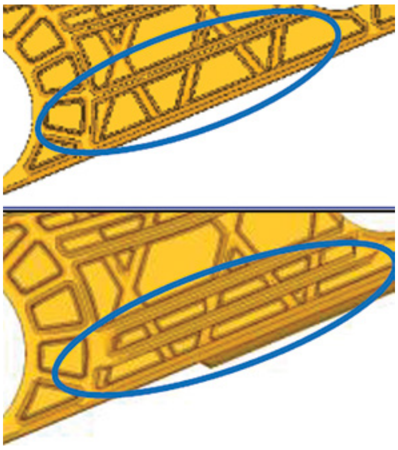
Pulina then launched a coupled transient analysis between Abaqus and Digimat. At each time step, Abaqus provided the deformed material geometry to Digimat which recalculated the material properties for each element in the simulation function of the local fiber orientation and other relevant properties such as the residual stresses calculated in the mold filling simulation onto the Abaqus finite element model. Beside Abaqus, Digimat-RP also provides similar integration with other leading finite element analysis software including MSC Marc, MSC Nastran (SOL 400&700), ANSYS Mechanical, Samcef, LS-Dyna Implicit & Explicit, Permas and PAM-Crash.



Workflow for coupled simulation



Anisotropic coupled simulation accurately predicts failure point



Design geometry optimized based on simulation results

Results and Correlation

The failure locations predicted by anisotropic coupled simulation Digimat to Abaqus for dry plastic with bushings, conditioned plastic material with bushings, and conditioned plastic without bushings, all matched the physical testing results. The force at failure predicted by anisotropic coupled simulation matched the testing results within 10% for dry plastic with bushings, 5% for conditioned plastic with bushings and 5% for conditioned plastic without bushings.

After validating the accuracy of the simulation, Pulina went on to use it to optimize the design of the control arm and the injection molding process. He evaluated different mass fractions and looked at various injection molding parameters to determine their effect on fiber location and orientation. He found that part material properties were most sensitive to the location of the injection gate. He positioned the injection gate so that the fibers were oriented to best resist the loads applied to the control arm. The result was a part that fulfills the static collapse load target. Yet, while the original steel part weighed 6.4 pounds, the new fiber reinforced plastic part weighs only 3.8 pounds, a 40 percent reduction. “The ability to manage the entire prototype design process from within a single software package saved 20 to 30 percent of the time that would have normally been required to design the new control arm,” Pulina concluded.

About Magneti Marelli

Part of Fiat Chrysler Automobiles N.V. (FCA), Magneti Marelli is a leading tier one automotive supplier that produces a wide range of systems and components including instrument clusters, lighting systems, engine control systems, suspension systems, exhaust systems, and many others. Magneti Marelli supplies all the leading automobile original equipment manufacturers and has 43,000 employees, 86 manufacturing facilities and 14 research and development centers.