VIRTUAL PRODUCT DESIGN OF A MEDICAL AUTOINJECTOR

Sweden-based Nolato, a global provider of injection molded parts for numerous industrial and medical applications has developed Nolava as a collaborative project with companies including Altair and Avalon Innovation. Nolava is Nolato's medical self-injector, a complex electro-mechanical device housed in an injection molded fiber-reinforced plastic body. Applying Altair's state-of-the-art integrated simulation-driven design solution showed that virtual prototyping early in the design stage of development saves time and money by resolving problems before making a physical prototype or the associated manufacturing tooling.

Overview of Product Requirements

Every day autoinjectors are used around the world by thousands of people needing life-saving medication that can be administered in the home by non-medically trained staff (e.g. insulin for diabetic patients). The overall design comprises an injection molded, short fiber reinforced plastic body which houses the electro-mechanical assembly and battery. It operates by pressing on the plunger of the hypodermic syringe loaded into the device in a controlled, reliable manner. Consequently, the device must reliably dispense a single dose of medicine in a consistent, safe manner and also be robust enough for repeated use and resist being dropped or misused.

Testing products before manufacturing ensures everything is done correctly

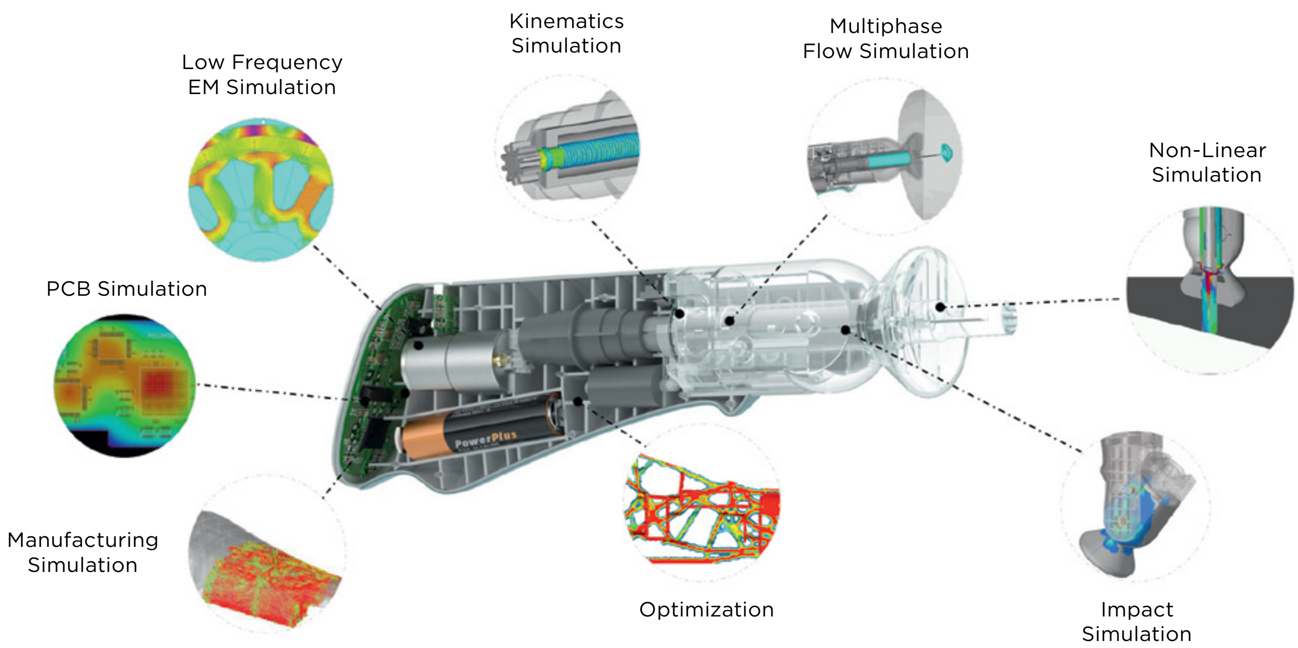
Virtual Product Development Simulation Cycle

Functionality of the drug delivery system: Computational fluid dynamic (CFD) analysis coupled with multibody dynamics examines the pressure on the plunger from the hypodermic needle bore size and fluid viscosity, loads where the components are fixed to the case, and the effects of temperature on function or leak.

Validation – Use and Misuse: Simulation reveals how the device performs regarding the defined use performance envelope, whereas virtual drop testing or overloading highlight any areas needing improvement, such as a better material choice, stronger clips, or adhesive to hold parts of the case together.

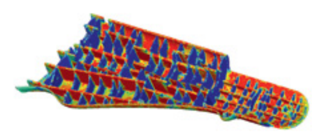
Optimization: From the defined load cases, identifying where material is needed leads to the most efficient structural performance, saves weight, and also reduces the amounts of material used. For Nolava, the ability to examine alternative rib structures at the part level design coupled with quickly comparing design iterations and verifying designs provided results at the assembly level.

Manufacture: Injection molding is the ideal candidate process for mass-production of the thermoplastic parts, providing the part has been "designed for manufacture." The performance can be accurately predicted by applying Altair's composites solutions to develop an accurate material model for use in the structural analyses.



Design for Manufacture

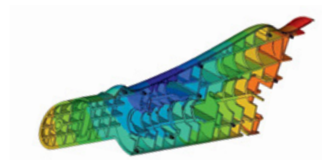
Today, injection molding can benefit from modern technological advancements that simulation offers to gain a deep understanding of the entire process all before taking the first step towards the factory floor. The first question is: "Will the as-designed component fill with polymer properly?" Altair's simulation tools help designers and process engineers work together to both test and resolve filling and cooling cycles and predict the occurrence of any defects resulting from the molding process. These can appear as air pockets, surface imperfections, or sink marks in thicker ribs. Regarding the part performance, causes of costly rejects include local weakness defects at weld lines, areas where material flows together around cut-out features or from different gates, and warpage.



Fiber orientation mapping from Altair flow simulation

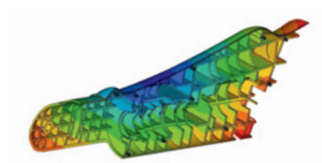
Altair Composites Solutions

With Nolava case being produced from a composite made of short fiber-reinforced thermoplastic, the fiber orientation throughout the part not only defines the material properties but is affected by variations throughout a molded component part. Here, the multiscale approach in Altair Multiscale Designer™ was used to create a material model[2] for structural stress analyses. Optimization technology can also be utilized to improve any underperforming part.



Effect of warpage without fiber mapping

Step 1: The injection molding simulation is run to obtain fiber orientation data to map into the structural mesh. A higher mesh density in needed in the molding simulation compared with a structural mesh to accurately calculate fiber orientations. A fill simulation provides the fill time, temperature, defect predictions (sink and weld marks), and fiber orientation. Fiber orientation is then mapped onto the structural mesh to determine Multiscale Designer's material model, which is used in the structural solver.



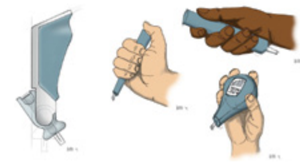
Effect of warpage with fiber mapping

Step 2: Take results from material characterization and map it onto the structural analysis mesh to apply displacements, stress, and warpage results. The effect of fiber reinforcement is clearly evident in the warpage and displacement results.

Step 3: To ensure correctly assembly, the gate positions for both halves of the case were optimized to give similar warpage and shrinkage. In parts with unmatched gates the pins fail to connect properly and are crushed, unless tolerances are increased.

Conclusion

Producing quality and durable injection molded parts that meet their intended roles relies on good part design anchored in best practices for design for manufacturing, along with a thorough understanding of the material properties, process parameters, and how they interact. For Nolato's virtual design-development project, Nolava, the ability to have a single workflow that goes from a sketch to a different concept designs, to understanding the injection molding process, to material mapping of reinforced engineering polymers, and to the structural performance of parts, led to confidence that the first prototype would function as expected. Altair's suite of integrated multi-disciplinary tools provides timely, robust, and accurate answers, allowing designers and engineers to easily explore options, deliver improved products, and reduce scrap and tooling rework costs.



Early Design Drafts

Integrating a multiscale approach to material modeling has effectively debunked the complexities of engineering with composites. It enables the proven benefits of composite materials, previously found only in high-value limited production runs, to be successfully exploited in everyday products regardless of industry. While the example here is for short-fiber reinforcements, the principles of multiscale modeling apply equally to continuous fiber composites and any multiphase inhomogeneous material, anywhere from concrete to innovative lattice structures, produced by additive manufacturing.

Today, having a single fully-integrated workflow shows that simulation-driven design delivers robust products from the start. Virtual product design is now a reliable, available, and affordable reality to all.

Learn more at:
altair.com/composites

"Altair's modern integrated approach for streamlining design for manufacture of injection molded components covers initial design of the part, understanding the injection molding process,...

...material mapping of reinforced engineering polymers, to efficient analysis and optimization of the structural and fatigue performance all within a single, integrated environment."

Patrik Ingvarsson, Manager TDC EU, Nolato Medical Solution

References

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