FROM METAL TO PLASTICS: SUSTAINABILITY, LIGHTER WEIGHT AT LOWER COSTS

Altair solutions enable X-Plast to improve a structural part for Knorr-Bremse Rail Systems. Owing to its low environmental impact, rail is one of the most sustainable means of transportation. To ensure a safe and reliable operation of railway components for more than 30 years these parts have to be strong and durable to meet the many requirements. They must withstand extreme temperature and climate conditions, as well as vibrations and high mechanical loads, even impact from stones.

For decades, developers of railway parts preferred metal as the materials of choice to ensure long-lasting, optimal performance. Owing to light-weighting trends and the increased performance of engineering plastics, this paradigm has been changing. Also, the pace of change has quickened as new development enablers for the industry, such as advanced simulation software, can be utilized to ensure mastering the industry challenges of today and tomorrow.

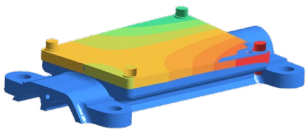
Excellence In Plastics for a Railway Giant: X-Plast and Knorr-Bremse Rail Systems

X-Plast is a young and agile design and engineering company located in Hungary, specializing in plastic injection-molded product development and manufacturing. As a development partner of many international organizations ranging from start-ups to large enterprises, X-Plast provides comprehensive solutions from the first conceptual design to the final assembly of high-quality products. Solving the majority of development challenges in-house, X-Plast offers its customers the huge benefit of a one-stop service.

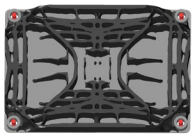
X-Plast, which has won several international awards for its innovative plastic products, aims to offer its customers plastic solutions that are as sustainable as possible. To achieve this goal, the company is using state-of-the-art software, ensuring advanced design and meeting development requirements – building up a product-specific development strategy. This comprises the full range of highly complex function-driven design methods, covering nonlinearity, process simulation, and anisostropy, which all enable a fully coupled analysis workflow. In many cases it is vital to perform physical component testing in addition to the digital validation before moving into serial production. X-Plast has also invested heavily in their in-house 3D printing lab to build functional prototypes and small series production.

Since 2019, X-Plast has been using Altair solutions for structural simulations to meet the increasing customer demands and trends. One of its longstanding customers is Knorr-Bremse, a leading supplier of safety-critical systems for rail and other applications. To reduce costs and weight of the railway components, they started a multi-year collaboration to replace metal parts with plastic ones. As of today, X-Plast has been involved in the development of more than 25 different structural components for Knorr-Bremse, substituting metal with a lightweight plastic solution.

Metal pneumatic system cover.
Image courtesy of Knorr-Bremse

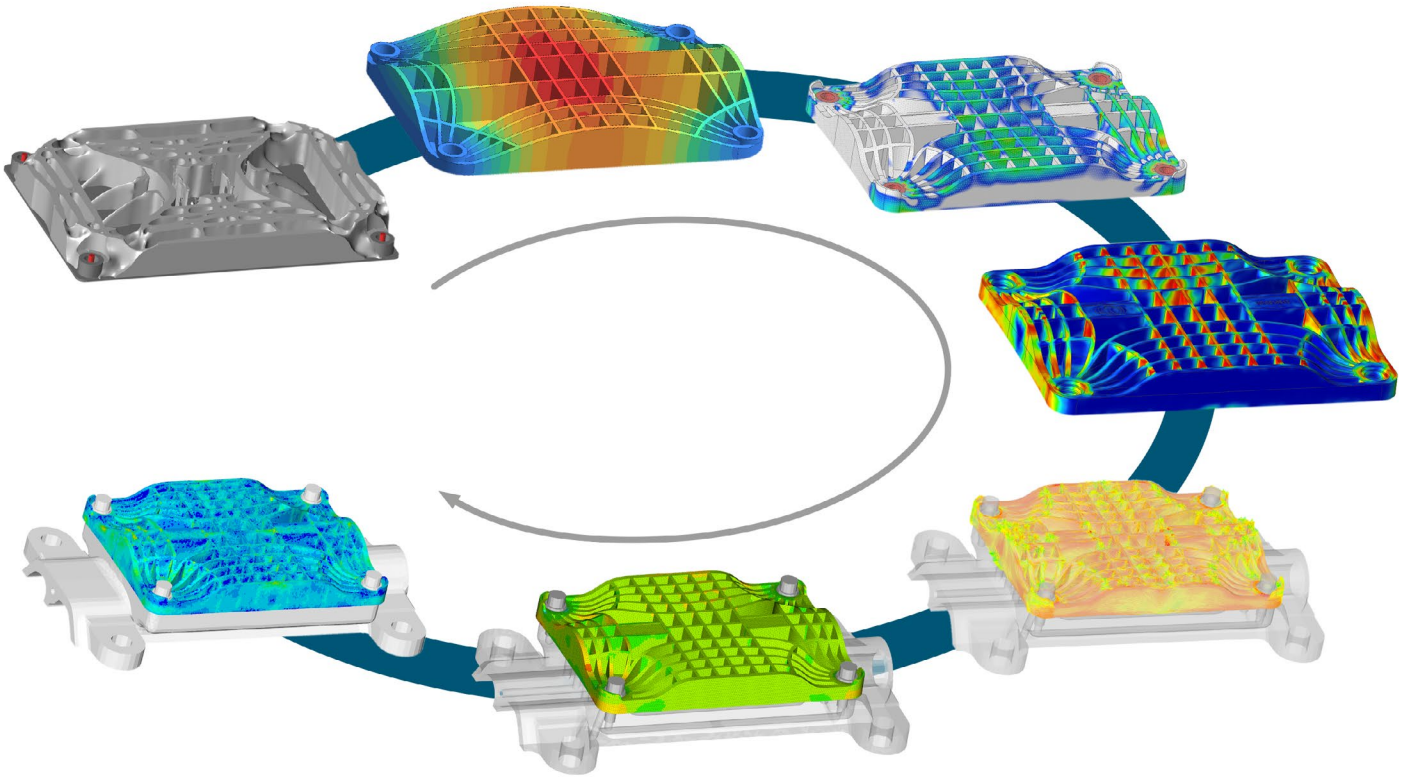


FEA assessment of metal pneumatic system cover.
Image courtesy of Knorr-Bremse



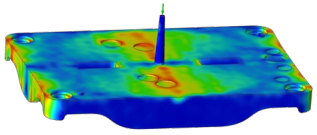
Material substitution concept from a topology optimization.
Image courtesy of X-Plast

Metal to plastic replacement – pneumatic system cover.
Image courtesy of X-Plast

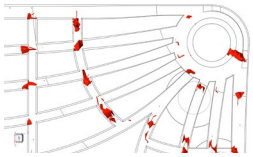


Metal to Plastics: Facing the Challenge

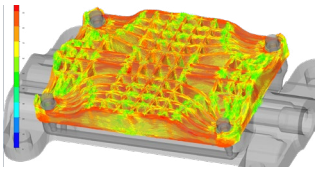
In a recent project, Knorr-Bremse tasked X-Plast with the redesign of a metal part to make it lighter while still meeting the original part's performance and stiffness targets. Based on the inhouse experience and knowledge in finite element methods and simulation, X-Plast developed a simulation-driven integrated development process, which enables them to find the optimal structure. The engineers used the geometry of the original metal part as a starting point for the topology optimization in Altair® Inspire™. In the intuitive Inspire interface manufacturing guides, design constraints and restrictions are easily applied to the model that led to the preliminary rib structure. To evaluate design variants in a very short time X-Plast leveraged Altair® SimSolid®, a powerful next generation simulation tool. Owing to short communication channels within the company, the mold designer and simulation engineer were quickly able to find a feasible and manufacturable solution, while further improving the final part's stiffness. The simulation department also performed a traditional finite element analysis to fine-tune the structure, insert geometry and to validate the mechanical strength of the assembly. Altair® SimLab® and Altair® OptiStruct® enabled the team to consider real-life conditions and nonlinearities, such as closing and sliding contacts, the effects of bolt tightening, and different operating temperatures. Furthermore, these tools allowed analysis of small details like stress concentration in the metal inserts. The final step of the isotropic phase of the integrated design process, the stress-based lifetime assessment was carried out.



Injection molding simulation



Identification of weld lines

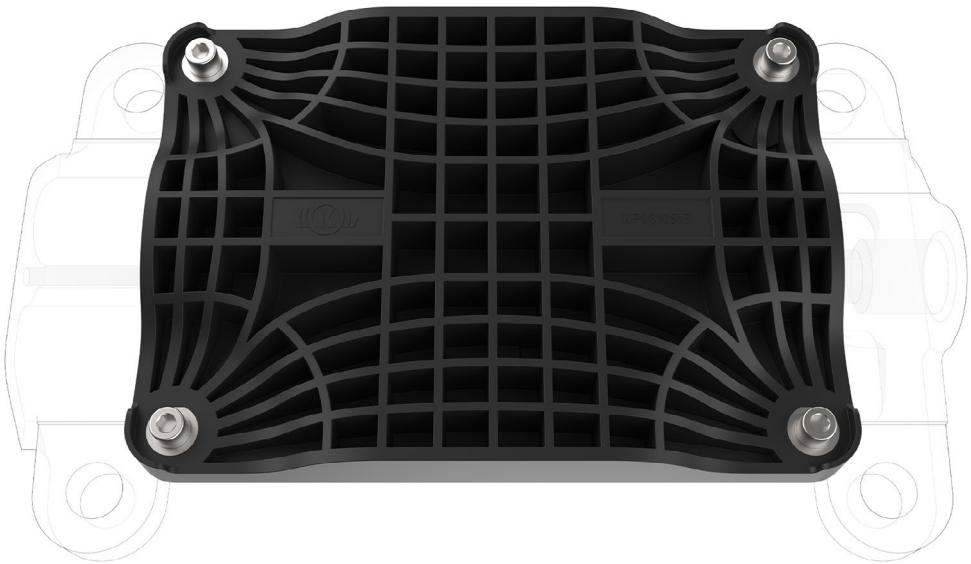


Fiber orientation tensor from injection molding simulation mapped with PART Converse

Integrative Simulation: Represent the True Nature of the Material

To address the anisotropic properties of the part, X-Plast turned to Part Engineering for expertise in structural mechanics, developer of the software solutions Converse and S-Life Plastics, and who is also a member of the Altair Partner Alliance (APA). By integrating the capabilities of Converse into X-Plast's development process, it was possible to bridge the gap between the injection molding software and the finite element simulation model. S-Life Plastics enables the engineers to perform a material data-based strength assessment to reach a high level of simulation accuracy and more reliable lifetime predictions of parts.

Injection molding simulation is an essential input for the part- and the tool designer because shrinkage and warpage effects can be identified and corrected. There are many process-related factors, which affect the part's physical and mechanical behavior. Several injection molding simulation tools, such as Altair® Inspire™ Mold, can also be used to obtain the fiber orientations for the complex anisotropic analysis.



Inspire offers a good compromise between simulation time and accuracy with the default values and hence paves the way to an anisotropic material model. Converse, on the other hand, through mapping and exporting the fiber orientation and other selected injection molding results, helps to convert the homogeneous isotropic finite element model into a standalone and ready-to-use anisotropic one. In addition to an element-related orientation also an orientation-dependent material model is required. Using the Converse MatEditor, an anisotropic material model can be generated within minutes.

After mapping, the anisotropic analysis can be performed. S-Life Plastics also offers a fully-automated strength assessment, accounting for all influencing factors, allowing for a fiber orientation-based lifetime prediction and closing the loop of the integrated design process.

25% ▼
LESS WEIGHT

35% ▼
LESS COST

30 YEARS
GUARANTEED LIFETIME

More Sustainable and Cost-Effective than Before

Using their engineering expertise and state-of-the-art Altair software solutions, X-Plast set-up an integrated development process to create highly-engineered, durable, and sustainable plastic products that also meet operation and manufacturing constraints, as well as high quality standards. The comprehensive offering of Altair together with its partners deliver holistic integrated product design that enables sustainability and impacts the bottom line. X-Plast was able to verify the part's mechanical behavior under different temperature conditions and ensure the desired lifetime requirement. X-Plast reached the serial production within eight months, saved 35% of product costs, and reduced the weight by 25%, while ensuring 30 years of lifetime.

Best Results – And More to Come

Digitization has become an important driver of innovation in the rail sector, offering great opportunities to improve component reliability and reduce sustainability burdens at one go. Using the Altair solutions X-Plast reached both the weight goals of the Knorr-Bremse plastic component and met all other performance targets. While sustainability usually entails greater expense to meet all requirements, X-Plast's highly engineered plastics design is even more cost-effective than the traditional metal part. Following this successful example, companies striving for sustainability no longer have to think twice before undertaking the challenge to replace metal parts with plastic ones. Using the right tools and the know-how of experts such as X-Plast means increase in ROI while achieve their sustainability goals is attainable at the same time.

To learn more about sustainable plastic part development visit: altair.com/plastics