**△ ALTAIR**

PRODUCTION OPTIMIZATION OF HIGH-PERFORMANCE ADHESIVES BASED ON ARTIFICIAL INTELLIGENCE

Introduction

In automotive manufacturing, polyurethane adhesives are essential for ensuring vehicle performance and quality – but harnessing their full potential remains challenging. Bonding methods, strength, and environmental resilience must be validated across various components, requiring significant research and development (R&D). Like other polymers, polyurethanes vary structurally (linear, branched, etc.), with properties shaped by factors like molecular weight and temperature. Precise formulation is vital for seat stability, engine heat/vibration resistance, and weather durability. Artificial intelligence (AI) and machine learning now provide new opportunities to screen raw materials (using predictive models) and balance performance and cost (using prescriptive methods). This data-driven approach accelerates polyurethane development and drives innovation in materials research.
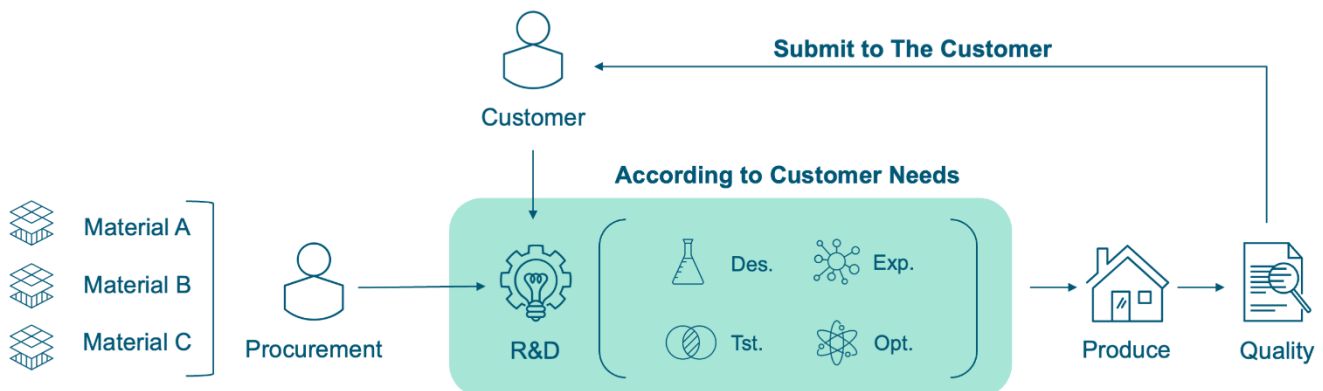
The Challenge

Slight variations in raw materials, mixing ratios, or processes can impact an adhesive's final performance. Whether it's tensile strength, thermal decomposition temperature, or stability under different conditions, it often takes repeated experiments to refine formulations. Laboratory and production environments also vary, making reproducibility a challenge. Trial and error consume substantial time and cost; and once performance inconsistencies or other hurdles arise, earlier efforts may be nullified. As quality and innovation demands continue to increase, reducing risks and accelerating R&D have become paramount.

Long cycle

High cost

**There is no guarantee that you will find the closest match every time**

The Solution

Altair's integrated approach brings together solutions from its extensive portfolio into cohesive, powerful workflows designed to address organizations' most complex challenges. A key component of this ecosystem is the integration of the Altair® RapidMiner® data analytics and AI platform with Altair® Material Data Center™. This synergy consolidates materials intelligence into a single source of truth, leveraging advanced machine learning models to drive innovation, bridge data gaps, and optimize material selection—providing a critical competitive edge in achieving sustainable product innovation.

To address their materials development challenges, enterprises now leverage AI and machine learning to optimize polyurethane adhesive formulations. Using solutions like Altair® AI Studio, teams can build machine learning workflows in a no-code environment, enabling both data scientists and materials engineers to collaborate in a dynamic shared environment. By gathering historical data and applying predictive analytics, researchers can rapidly pinpoint promising raw materials and formulations. Then, prescriptive analysis and evolutionary algorithms help balance key performance indicators (e.g., tensile strength, thermal decomposition temperature) to generate optimal candidates. With only small-scale tests needed for validation, trial-and-error drops significantly, accelerating R&D and boosting competitiveness.

The Methodology

The following diagram shows how Altair RapidMiner can help optimize the ratio of polyurethane adhesives.
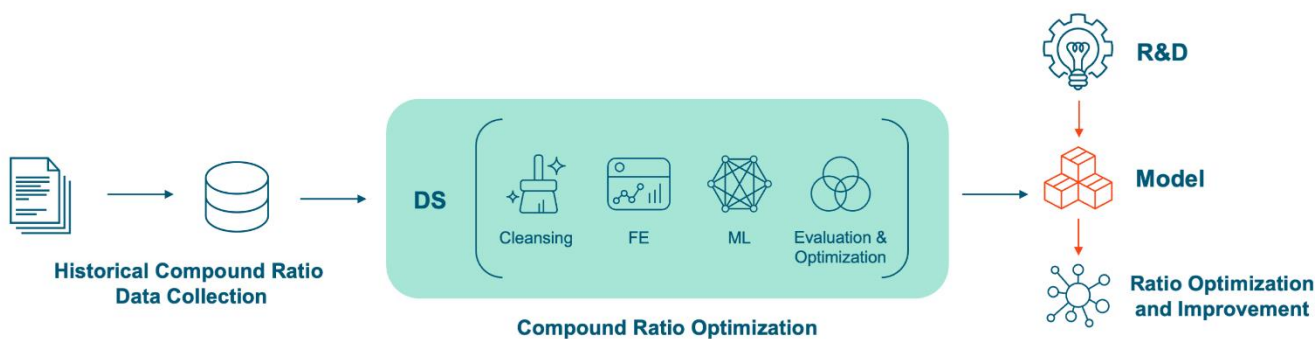

To get the most from Altair RapidMiner, first gather extensive historical experimental data on polyurethane adhesives (including experimental records and database information). Variables can include raw materials, process data, and KPIs (such as thermal decomposition temperature, mass loss, tensile strength, etc.). To predict multiple KPIs simultaneously, there are two strategies: merge them into one model, or build separate models and consolidate the results. In this example, we adopt the first approach. Below is a list of relevant variables:

Category	Raw Material Data	Process Data	Performance
Characteristic Variables	**Raw Material Composition:** Precise chemical composition of additives such as resins, hardeners, fillers, etc. **Raw Material Quality:** Purity, particle size, density, and impurity content of raw materials.	**Mixing Parameters:** Mixing speed, time, and temperature. **Degassing efficiency:** Vacuum, time, and temperature during degassing. **Heating & Curing Time:** Heating rate, curing temperature, and curing time. **Environmental Parameters:** Production humidity, temperature and cleanliness. **Device Status:** Operating parameters of mixers, degassing equipment, furnaces and other production equipment.	**Performance Parameters:** • Thermal Decomposition temperature (ºC) • Loss of quality (%) • Tensile Strength (MPA)

Next, build machine learning models using Altair AI Studio.
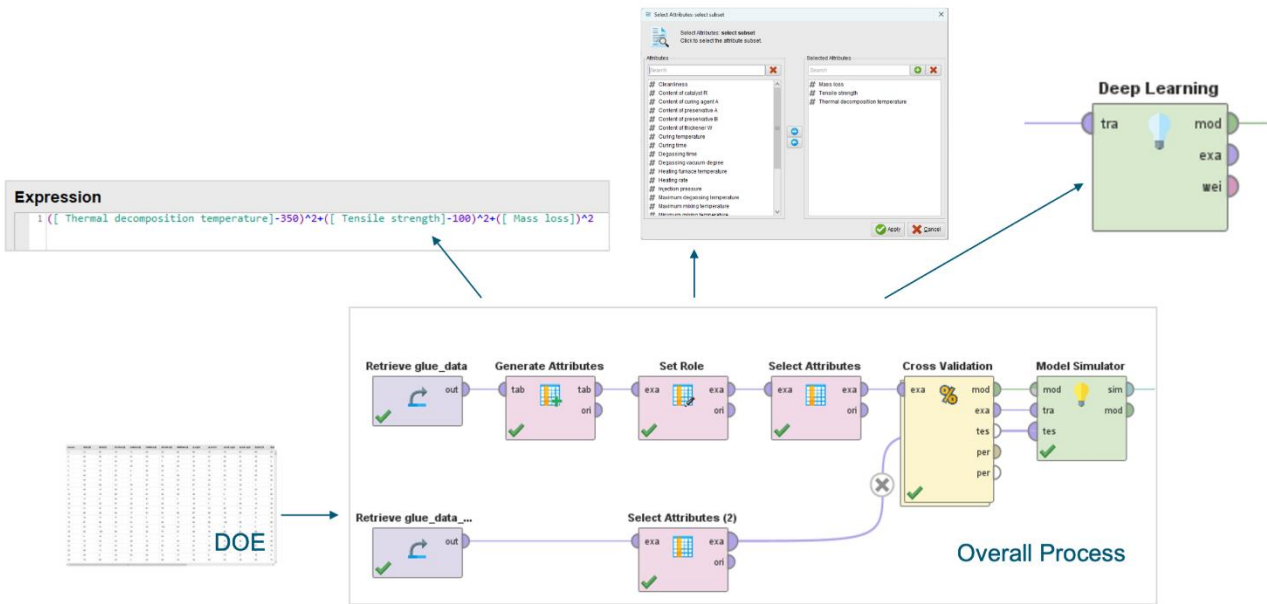
In Altair AI Studio, the optimization function is used to set certain proportions of data to conduct a reverse search for the optimal ratio of polyurethane adhesives and adjustable process parameters.

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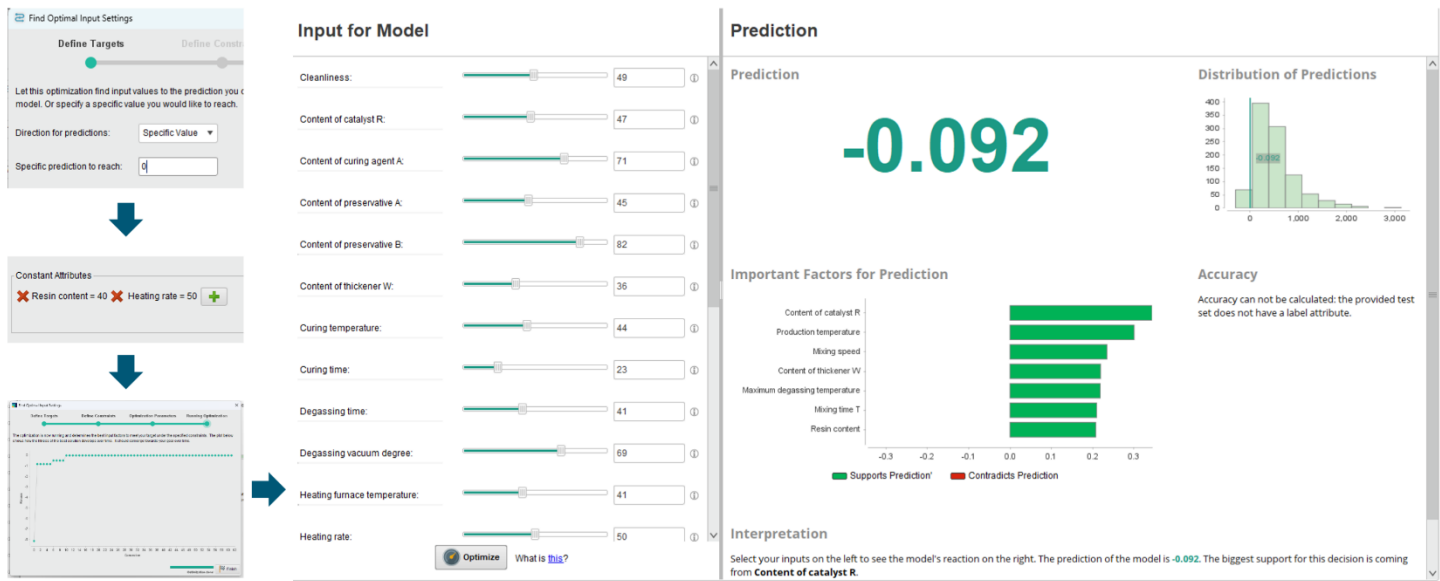
Conclusion

In adhesive formulation development, moving beyond trial-and-error toward efficient, precise material innovation hinges on synthesizing data science, materials science, and engineering expertise. Rather than relying solely on machine learning tools, the goal is to seamlessly merge advanced AI algorithms with R&D professionals' domain knowledge and existing data. By using Altair AI Studio's no-code environment, materials engineers, data scientists, and production experts can collaborate in a single workflow – maximizing the value of historical formulations, performance test results, and industrial process data. Predictive and prescriptive analysis models then help teams rapidly generate reliable formulation recommendations, close performance data gaps, and optimize cost-performance trade-offs.

Moreover, this integrated approach can serve as a model for broader materials science innovations. By combining AI, materials science, and engineering, organizations can slash product launch timelines, boost quality and reliability, and maintain a competitive advantage in fast-evolving markets. Best of all, what's shown here is only a glimpse of Altair technology's capabilities. For more information on Altair technology and to discover how they can help you redefine material intelligence, visit altair.com/altair-rapidminer and altair.com/materials.