

# The impact of artificial intelligence on valve sealing technology

Artificial intelligence is transforming valve sealing by optimising material design, manufacturing quality and predictive maintenance, helping industries improve safety, reliability, regulatory compliance and emissions control across demanding industrial applications.

By Ralf Vogel,  
European Sealing Association

**A**rtificial intelligence (AI) is becoming a powerful tool in industries that rely on safe, reliable, and efficient fluid control. While AI is often associated with autonomous vehicles or generative chatbots, its impact on packings, elastomeric seals and gaskets for valve sealing is rapidly increasing. These components are essential for preventing leaks, ensuring process safety and maintaining regulatory compliance in sectors ranging from chemical processing and energy to pharmaceuticals and water management. With the rise of digitalisation, ESA members are utilising AI to reshape how sealing materials are designed, manufactured, monitored and maintained.

## 1. Smarter material selection and design

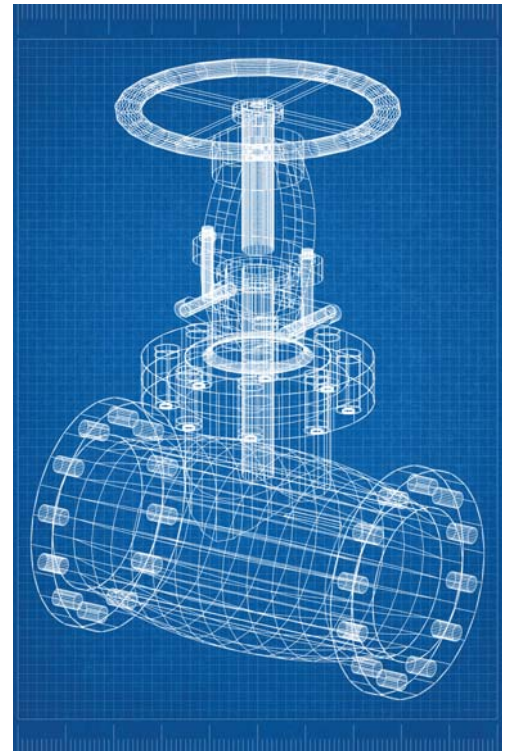
Traditionally, seal design has depended on a combination of engineering experience, material testing and industry standards. Today, AI-driven simulation tools are accelerating this process. Machine learning models can analyse thousands of combinations of materials, temperatures, pressures and chemical exposures to predict performance before physical prototypes are made. These models help engineers identify which filler materials, fibres, elastomers or graphite blends will deliver the best sealing efficiency and durability for a specific application.

AI-based finite element analysis (FEA) tools also allow manufacturing engineers to simulate deformation, creep, relaxation and stress distribution more precisely. This leads to better-engineered gasket geometries, improved packing sets and sealing solutions that can tolerate increasingly demanding conditions such as high cycling, aggressive media and higher pressures.

## 2. Quality control and manufacturing optimisation

AI-enhanced production monitoring is revolutionising the quality assurance of sealing materials. Optical inspection systems equipped with machine vision can detect microscopic defects, inclusions or irregularities that may compromise sealing performance.

Traditional SPC is reactive. AI enhanced SPC predicts deviations before product quality drifts out of tolerance. This reduces scrap,



minimises rework and ensures more stable production lines. It improves consistency and reduces the risk of product failures in the field.

Predictive algorithms also optimise curing times, compression cycles and machining processes. For example, AI can adjust production parameters in real time based on temperature or humidity changes to maintain consistent elastomer properties. As a result, manufacturers reduce scrap rates, enhance repeatability and produce gaskets and packings with more tightly controlled tolerances.

## 3. Predictive maintenance and leak prevention

One of the most significant advances comes from AI combined with smart sensors installed in valves or the sealing element. They can be part of new valves but also retrofitted. These sensors monitor vibration, torque, pressure changes and temperature trends. AI systems analyse this data to predict whether a seal is beginning to degrade long before a leak occurs. For operators, this means maintenance can be performed based on actual condition rather than fixed intervals, reducing downtime and improving safety. In critical applications - such as cryogenic service, hydrogen or high-temperature steam - early



detection of sealing degradation is particularly valuable. Still some engineering challenges like data quality and sensor calibration requirements, integration with legacy valve systems, cybersecurity considerations as well as sensor accuracy and lifespan in harsh environments have to be overcome. Tightening global emission regulations, AI-driven monitoring can help operators maintain compliance with standards such as LDAR (Leak Detection and Repair), ISO 15848 and API standards

for fugitive emissions. By learning from historical leak data, AI can suggest optimal packing materials, stem surface finishes or gland load adjustments, significantly reducing fugitive emissions. AI cannot replace sealing technology but it is enhancing it. Through improved design, material optimisation, smarter manufacturing and predictive maintenance, AI is enabling sealing solutions that are safer, longer lasting and more reliable. As industrial digitalisation expands, AI-supported sealing technology will play an increasingly crucial role in

process efficiency and environmental protection. ■

### ***About the author***

Ralf Vogel is a mechanical engineer and has been working in the sealing industry for 30 years. Currently, he is the Technical Director of the European Sealing Association.

