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A facility that follows the standards of a clean room environment is ideal

Braking systems:

technological advances that bring us to a standstill

Daniel Triolo, Andreas Minatti, Dr. Rudolf Randler and Dr. Jakub Kadlcak, look at the future of braking systems and how small components such as sealing solutions play an instrumental role in terms of safety, integrity and performance.

Some might be tempted to argue that braking systems have changed relatively little in the last 25 years. A combination of vacuum booster, callipers and brake fluids in place has been the standard, and therefore the requirements in terms of components have also remained consistent. Engineers were clear in the design parameters and geometries required and, although small changes have been implemented, the principles remained the same.

Today, however, the technology has evolved and will continue to do so without a doubt. The development of the electrohydraulic booster (EHB) means that not all partners along the supply chain have experience in handling the new, advanced sealing solutions that are now required. Of course, this evolution into EHB technology has largely been driven by the move towards the electrification of vehicles and the increasing amount of advanced driver assistance systems. Electric Vehicles (EVs) are projected to account for 19% of the market by 2030 – with Full and Plug-in Hybrids accounting for 11% and Internal Combustion Engine (ICE) only and Mild Hybrid Vehicles the remaining 70% - and the EHB is a natural fit, particularly given there is no internal vacuum creation in EVs that is required for the vacuum booster.

The technology is a complete departure from the traditional vacuum booster, and therefore it is essential that manufacturers and sealing solutions experts work closely together in order to bring products to market as soon as possible in terms of serial production to benefit from the advantages of the new system.

How EHB systems contribute to designing the car of the future

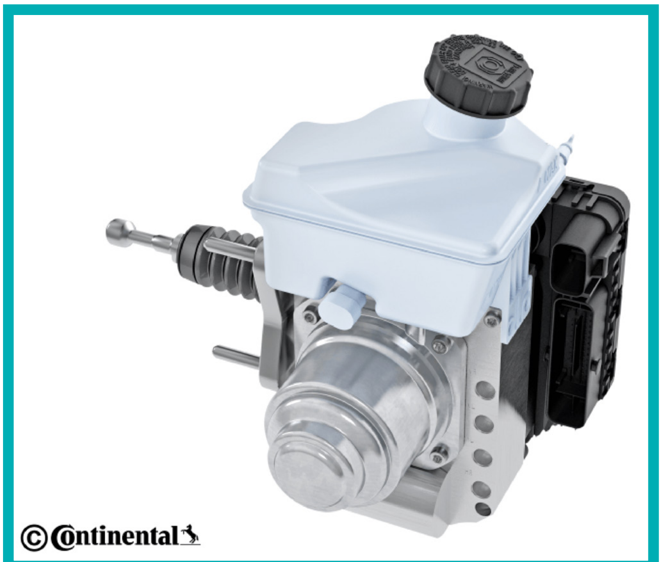
While the vacuum booster has done a stellar job of making global road users safer for decades past, there are several advantages to the move into electrohydraulic alternatives. One is that electrohydraulic boosters are smaller and lighter, which means there is more space free within the engine compartment, while in EVs there are significant advantages where recuperation is concerned – bringing energy from the braking system back into the battery. There are also advantages in operating advanced driver assistance systems, as everything is electrically controlled.

Braking power in an emergency is also much higher and generated much faster than with a standard vacuum booster system. Normally, in a vacuum booster, the brake is applied with the foot and there is a physical relationship between the brake pressure transmitted through the hydraulic system and the size of the vacuum booster. However, the calculation of the transmission force is difficult because it depends very much on the individual that applies the brake and is perceived very differently from person to person. With an electrohydraulic booster, electric actuation of the brake is achieved which in turn reacts much faster and generates much more friction power than was possible in the past with the vacuum booster. This provides a far more consistent performance and potentially shortens response times in terms of reacting to an emergency situation on the road, enhancing driver and passenger safety.

Advancements in sealing applications enabled the use of sensors for streamlined production and tracking. The traceability of parts via smart sealings - for example with embedded sensor technology – could expedite a product recall if required, minimizing the safety impact and potential reputational damage a brand could suffer. Sensors could also be used for predictive maintenance purposes in the future, along with providing solutions relating to authenticity that could combat counterfeiting and ensure parts are from the original manufacturer. Not least, sealing solutions designed and co-engineered specifically for purpose in these new applications will provide the highest levels of quality and integrity, ensuring the safe operation of the braking system throughout its lifetime.

Co-engineering helps to deliver the safest possible braking systems

Given the critical importance of reliable, effective braking systems and the fundamental impact any fault could have

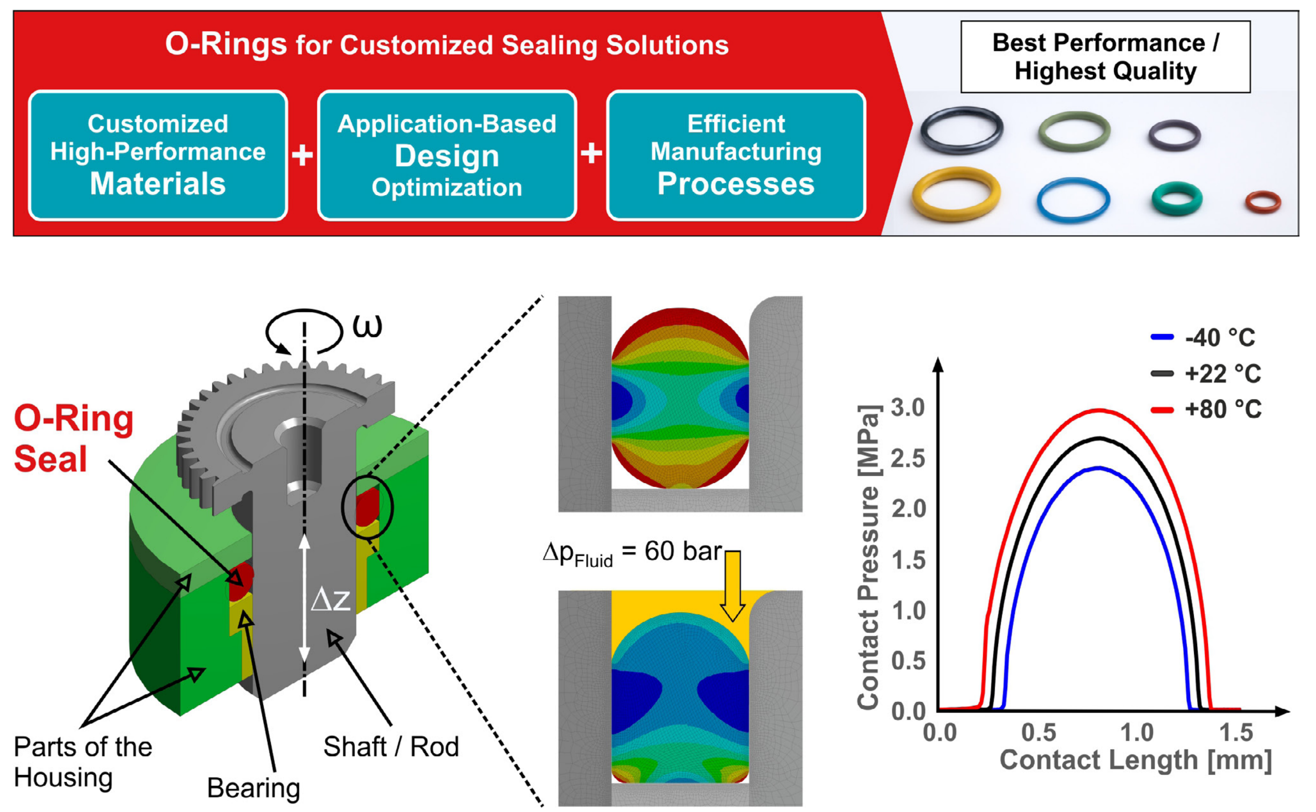


Continental's EHB MK C1, where Datwyler assists its partner with high-performance polymer components, is one of the most important electrohydraulic brake systems.

in terms of safety, a wide range of factors must be carefully considered when developing system-critical components such as seals. With the EHB, a number of special requirements are imposed, such as abrasion resistance, cleanliness categories, and the precision of sealing solutions in production. Among other things, the elastomer components in modern brake control systems must also be able to resist high-frequency, dynamic-mechanical loads under high pressure, and simultaneously guarantee safety over the lifetime of a vehicle.

To ensure these requirements are met to the highest possible standards, many companies looking to enter into advanced braking solutions are choosing to work in partnership with component suppliers at a very early stage in the development process. This partnership approach in co-engineering projects can make the difference between a good product design and a perfect one. Where system-critical sealing systems are concerned it is key to take into account all functional needs and the requirements of materials, tooling designs, and manufacturing processes.

As seen in the graph on next page, elements such as geometric design and functional performance optimization can be supported by structural mechanics simulations, while virtual molding simulations ensure best tool design, efficient production processes and top product quality. Sealing systems only achieve their optimum functionality if the designs of the sealing element and mounting space are a perfect match. Therefore successful co-engineering projects require cooperation very early in the development process, when there is still sufficient design freedom for the overall system to optimize both the sealing element and the installation space.



As an example for components specifically designed according to customer requirements, the illustration shows a customer-specific O-ring seal for use in brake systems - a design perfectly matched to the installation space and operating conditions in combination with a tailor-made material makes the difference.

Meeting new project requirements with material and design expertise

Evolving technology often requires a new approach to material development and the designs associated with the finished solution. Here it is a distinct advantage for producers of braking systems to engage with a component supplier with a demonstrable track record in this area. Often, a design or compound may only need a slight adjustment to deliver optimal performance, but if a supplier lacks the knowledge to make the necessary modifications, severe delays could be encountered.

In terms of safety, only an optimal solution will meet the required standards. Therefore, understanding the compound and the process required in its manufacture is essential – particularly when dealing with system critical parts. Primary and secondary seals, for example, fall into this category, as failure during operation compromises the entire braking system. Even if a vehicle is still able to stop, any decrease in the efficiency of that system is of severe concern and a potential hazard.

Today, with advanced simulation capabilities available, product development time can be shortened and therefore time-to-market and cost can be reduced. Through working closely with system suppliers from the outset, designs can be optimized in terms of the sealing elements to ensure there are no unforeseen issues when a product goes into full production.

This can even include the simulation of the flow behaviour of the compound - how it will behave when injected into a mold cavity, for example - and how the gating system can be designed to optimize the required tooling to ensure the most efficient production processes for manufacturing the highest quality products. Every design and processing detail can be simulated and checked ahead of time – meaning manufacturers can enter into production with the full confidence required of their sealing solutions.

As an example of a potential issue that could occur in material development, here we will look at a compound that has become sticky – rendering it ineffective. A slight adjustment is all that is needed, but the expertise required to identify and overcome this quickly has been earned over many years.

Cleanliness is key when optimising the production process

Because of the potential for particles and residual dirt to jeopardize the functionality and lifetime of the sealing system, an optimized production environment, capable of producing several million units per year, is required to ensure the highest levels of cleanliness where sealing component production is concerned. A facility that follows the standards of a clean room environment is ideal, especially when combined with lean concepts which optimize process flows and meet cleanliness standards. The ultimate aim is to maintain the highest possible quality standards with zero defects.

The monitoring of cleanliness levels accomplished by this environment should ideally be undertaken by an in-house laboratory, while highly automated production processes minimize the need for human contact wherever possible to further mitigate the risk of contamination.

A recognized method for measuring particle precipitation in the automotive industry is the so-called "Illig-value": For its calculation, all detected particles are classified according to their size and then the number of particles of each size class is weighted with graded factors and summed up. The right sealing solutions supplier will aim at optimising this value by implementing a tailored production line concept.

In addition, as the compound development process can be optimized from the outset, standards such as those set by REACH can also be factored in, allowing manufacturers to meet current requirements and to mitigate the risk of non-compliance with any pending or future requirements that may be in the pipeline.

Future-proofing braking systems through strong partnerships

As technological advances in braking systems continue to forge ahead, manufacturers must be prepared to adapt to remain competitive. Of course speed to market is a vital element when looking to offer a new technology and to achieve this while maintaining the highest levels of quality and safety required in the mobility sector can be a challenge if not approached correctly.

Things move fast, and already the industry is seeing the emergence of brake-by-wire technology. This is considered to be the next level after EHB, and the main component differences are that there are no brake fluids within the system, meaning it will be smaller still when compared to EHB. The parts and their associated components will be even more sophisticated, therefore there will be a very high focus on precision molding and a move towards automated processes.

Engaging with expert suppliers helps to expedite the development process exponentially, whichever technology is the focus, and where a co-engineering approach can be adopted, the benefits continue to mount. As braking systems continue to advance, building partnerships now can ensure suppliers to the industry will be ready for the future, ensuring the safety of road users as their highest priority.

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Preventing braking system failure before its fate is sealed

In EHB systems, failure of primary and secondary seals can cause leakage, leading to failure of the entire brake fluid cycle and a system that is, for all intents and purposes, out of control. To combat this situation, the processes involved in the manufacture of the sealing compound and its housing must be controlled and optimized.

Defining the appropriate parameters for the production of these parts is critical and should be as a result of trials to refine the process. This is undertaken for every part produced. On the supply side, a dedicated prototyping team should ideally be entirely focused on this element. As a result, every part that goes into serial production will have its own optimal production parameters. This will make the transition to serial production a smoother one, helping reduce time spent and costs associated with going from prototyping to production.

From the first stages of prototyping to serial production, production parameters such as vulcanisation time and temperature are critical to get right, particularly when producing elastomer parts. OEMs and suppliers are often unaware of some of the seemingly minor issues that can make massive differences at a later point. As an example, in the vulcanisation process a complex 3D structure is created where the polymer macromolecules are chemically linked to each other. These links, when you vulcanise for too long, can break due to the temperature. This can weaken the physical properties before the part even leaves the facility.

It is crucial to keep in mind that every single compound has its production optimum, whether it is a mixing programme or vulcanisation conditions for parts, which has to be aimed for and determined via a series of testing in the lab and in the process development department. Elements such as the molecular structure of the compound are monitored indirectly to determine this optimum, leading to a solution of the highest possible quality.

[1] Source - FEV