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Thermal management

Implementation of custom solenoid valves in thermal management systems to accurately control flow rate can enable greater vehicle reliability and efficiency

Next-generation vehicles require improved thermal management control. Keeping components and systems within the optimal temperature range can offer increased reliability, efficiency, durability and safety. Developing custom solutions incorporating solenoid valves is emerging as an attractive and cost-effective choice.

These solutions can be obtained using a solenoid valve, a subset of similar solenoid valves, or an array of different solenoid valve types. There are three electromechanical solenoid valve types used in most liquid-cooled systems – binary, proportional and latching. The performance requirements of the valve will determine what type needs to be used. Both binary and latching valves allow two flow control positions – either fully open or fully closed. A proportional valve allows the controller to vary the position of the flow restricting component, changing fluid output.

With magnetic and fluid modeling software, the performance of any type of solenoid valve can be designed with confidence before producing physical samples. Figure 1 displays a latching and a binary magnetic circuit. Magnetic flux is generated from either a permanent magnet or by applying power to a copper coil. As the magnetic flux increases through the ferritic materials, the parts become saturated, and therefore create a greater magnetic force.

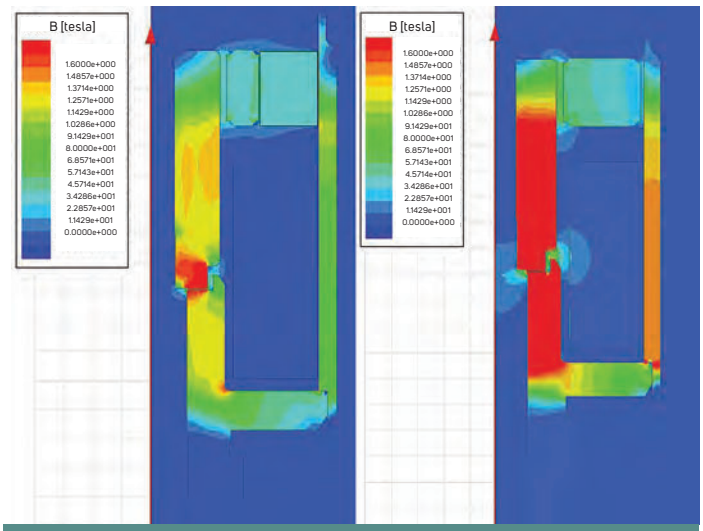

Figure 1: Latching magnetic circuit (left) and binary magnetic circuit (right) valve types

The latching circuit incorporates permanent magnets and requires zero power to stay in the retracted position (Figure 1). Conversely, the binary magnetic circuit requires constant power to stay retracted. Magnetic modeling enables the magnetic performance, weight and the material selection to be tailored to specific requirements. Variables such as pressure drop, flow rate and fluid dynamic forces can be optimized based on results obtained from fluid modeling. Figure 2 shows a 3D fluid pressure model. At each positional change, output flow rate can be recorded to create a flow-rate curve. Using these baseline platforms, future development will have fewer design changes, resulting in improved project timelines and cost savings.

Each custom solenoid valve is designed for a specific application, so its performance is neither over- nor under-engineered. Attributes that can be tailored include: the response time, solenoid actuation life, temperature rating and outlet flow accuracy. With proper material selection, it is possible to increase durability and therefore valve compatibility can be assured for almost any automotive fluid. Proper material selection means valves can operate at temperatures from -50°C to +200°C (-58°F to +392°F).

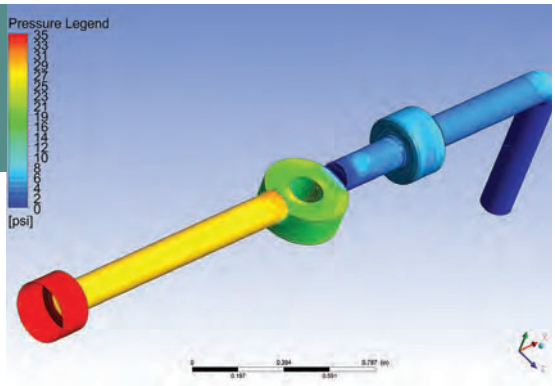

Figure 2: 3D CFD modeling can show any changes in pressure, flow rate and fluid dynamic force

Solenoids offer short response times while enabling flow control accuracy up to 2%. Solenoids also provide the additional benefit of a failsafe position. A typical solenoid has a hard stop with a mechanical return. This is beneficial in safety applications where the device must return to its initial position in a state of zero power. With the correct attributes, all requirements can be met for many applications.

Many vehicles can benefit from this technology. Solenoid valves can be used in the engine compartment, thermal management of batteries, electrical components and systems, or the entire cooling system. Since valves do not require proximity to the main pump supply, they can be placed strategically throughout the vehicle. As more electronics are added with vehicle advances, electrical component temperature-sensitivity must be considered. This sensitivity requires temperature to be maintained in a tighter operating range. Thanks to the inclusion of a thermal management system, a 1-2% performance improvement in these electrical systems or batteries can correlate to significantly greater vehicle efficiency.

Implementing a custom solenoid valve for thermal management can provide an efficient, cost-effective solution. Having the ability to control flow with different solenoid types enables the correct solution to be adapted to specific needs. This solution is resistant to extreme temperatures, can ensure accurate flow, provides a failsafe option, and improves reliability and efficiency.