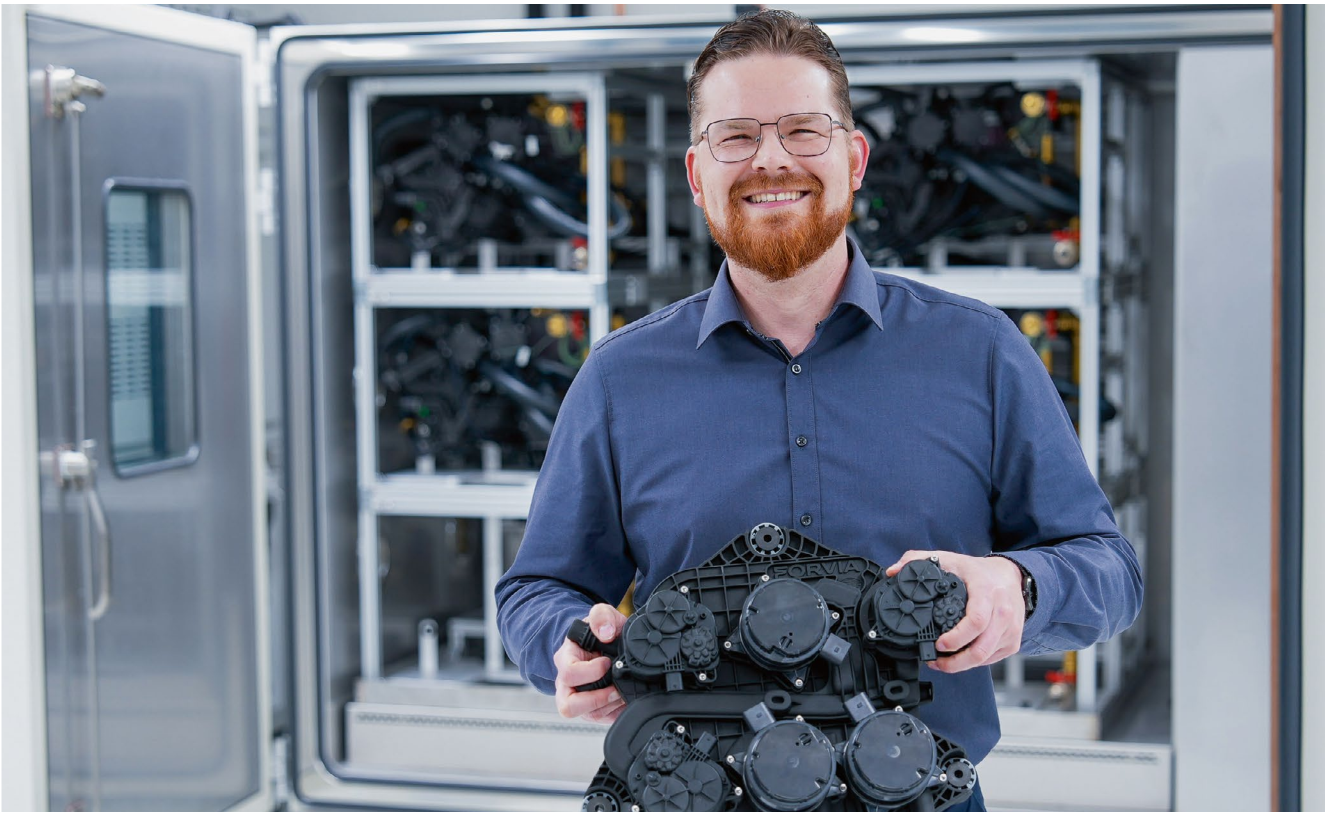

"The world of thermal management is fantastically interesting"

Thermal management plays a crucial role in electric automobiles. More efficient control of the drive battery temperature can increase the vehicle's driving range and reduce charging time. In our ATZ interview, Dr. Ingo Geue from Forvia Hella explains what the advantages of heat pumps and a zero-PFAS strategy are, why both CO_2 and propane are good alternatives, and how a system solution called the Coolant Control Hub max is able to reduce the number of refrigerant valves from eight to one.

ATZ _ Dr. Geue, for a long time, thermal management was only related to the water cooling system of a combustion engine. But today, the topic is becoming an significant aspect of an electric car. How do you notice this increase in importance in your everyday work?

GEUE _ We notice it every day in the many conversations that we have with various automotive manufacturers around the world. We are all driven by the question of how thermal management systems can be designed and developed. This is simply due to the fact that thermal management is a crucial lever for further raising the performance of electric cars while cutting costs at the same time. For that reason, we are increasingly focusing on issues such as temperature control for batteries or the efficiency of coolant pumps in order to extend driving ranges, shorten the charging times, maximize the life cycle of electric vehicles, and ultimately increase the user-friendliness and acceptance of electric mobility. However, I think it is important to emphasize that there is no right or wrong way, but that there are different philosophies and approaches depending on the vehicle architecture. But one thing is certain:

Dr.-Ing. Ingo Geue (born in 1983) has been Vice President for the global product segment Actuators/Fluidics at Hella GmbH & Co. KGaA (Forvia Hella) in Lippstadt (Germany) since the end of 2020. He studied mechanical engineering at TU Dortmund University (Germany) and completed his doctorate there in 2012 in the field of thermodynamics. He joined Forvia Hella in 2011 as a technical manager for a development project in the field of electrified vacuum pumps. In 2015, he was appointed Head of Department Mechanical Design Pumps and subsequently extended his responsibility to include the Design and Development Fluidics business unit. In 2018, he became Head of Design and Development Actuators/Fluidics. He has been in his current position as Vice President for the product segment Actuators/Fluidics for almost four years. He is responsible for just under 300 employees.

Due to the complexity of thermal management in electric vehicles, we have to consider it holistically, and in some cases, in a completely different way.

What do you mean when you say "there is no right or wrong way"? Which approaches are currently predominant in the market among car manufacturers, and which developments are emerging?

Various concepts currently exist in the market. The main difference is whether they focus on the coolant or the refrigerant system. For example, a major Asian OEM is currently using the refrigerant system to directly cool and heat both the vehicle interior and the battery. Other manufacturers, on the other hand, mostly use the coolant system to control the temperature of the battery. We are also seeing a trend towards thermal management systems that implement the majority of the required cooling and heating functions by using the coolant system, which means that the number of components required in the refrigerant system can be reduced. So a lot of things are changing when it comes to the architecture of thermal management systems in electric vehicles.

What about the next generation of development engineers and what is the situation as far as training is concerned? Are you currently looking for employees? Are there enough lectures in thermal management or even special courses in this subject at universities?

I may perhaps be a little biased, but the world of thermal management is fantastically interesting. It's exciting, but also complex, especially with regard to sustainability, fluidics, motors, electronics, and software. Ultimately, of course, there is also a growing demand for highly trained experts. At the moment, we are able to meet this demand quite well, especially through our international network. As a rule, thermodynamics is a fixed part of the curricula of courses such as physics, mechanical engineering, and mechatronics. That is a good academic basis. But if you ask me, it is the practical components such as internships or exam theses that are really the most interesting.

Heat pumps can sometimes have a negative image in the house building sector. What are their advantages in mobile applications? And under what environmental conditions do they no longer function?

In electric vehicles, heat pump systems are indispensable as we no longer have an internal combustion engine as a heat source. Extremely low temperatures can be a real challenge for electric vehicles depending on the technical solution. It is therefore all the more important to have a smart design for the heat pumps. Many of the current solutions are still quite complex and expensive. In order to make electric mobility affordable, the trend is increasingly towards highly integrated systems, often with a focus on the coolant system. This can not only reduce complexity, but also, for example, increase the energy efficiency and the range of electric cars.

"Concepts on the market differ according to whether they focus on the coolant or refrigerant system"

Used as a working medium and refrigerant, R744 – in other words carbon dioxide or CO_2 – was for a long time the favorite in terms of environmental compatibility. Why hasn't it become established in the high-volume market? And what is currently possible with propane or R290 as alternatives?

Basically, two alternatives are conceivable: propane or, as you mentioned, CO_2. The advantage of CO_2 is that, compared to other refrigerants, it has an extremely low global warming potential of 1 and would therefore be by far the most environmentally friendly solution. What is more, CO_2 is non-flammable and is well suited for use in heat pumps. But R744 needs to be operated at much higher pressures compared to traditional refrigerants, and this results in greater complexity. Propane would be another possible alternative to the R1234yf refrigerant currently used. Although propane is highly flammable, it has the advantage that it can be used at a lower pressure and it also has a very low global warming potential of 3.3. Both CO_2 and propane are therefore good alternatives. However, they both require a well-designed thermal management system that minimizes the need for refrigerants.

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"When it comes to controlling the temperature of batteries, there is no right or wrong way, but there are different philosophies and approaches depending on the vehicle architecture. Due to the complexity, we need to think holistically, and in some cases in a completely different way," Geue points out

There is a lot of discussion at the moment about per- and polyfluoroalkyl substances, or PFAS, which are used in vehicle air conditioning systems and in fluorinated refrigerants such as R1234yf. How do you intend to implement the fiercely debated EU ban in a technically appropriate manner?
The short answer would be: by rethinking the aspect of thermal management. Ultimately, it is about replacing R1234yf because it forms so-called forever chemicals in the environment. For that purpose, we are currently developing the Coolant Control Hub max, which uses the coolant system to control the temperature of the drive train, the battery, and the vehicle interior. This also means that the refrigerant system and the refrigerant components can be reduced to the absolute minimum required, with the result that the air conditioning system can completely do without PFAS and can instead be operated with CO_2 or propane as natural and environmentally friendly alternatives.

What benefits does your new Coolant Control Hub system solution offer for electric vehicles?
Our solution is a highly integrated, centralized thermal management system. In other words, it forms the main hub for thermal management in all important areas of the electric vehicle. The key benefit is that the Coolant Control Hub max uses all available heat sources for the operation of the heat pump. Therefore, the heat pump can be used for both the passenger compartment and the battery. This means that the vehicle driving range can be optimized, particularly at low ambient temperatures. In addition, efficient preconditioning of the battery for fast charging is possible.

What are the cost benefits of your system solution?
Thanks to the innovative concept and the high level of integration, we need significantly fewer components and materials. To give you some concrete examples: Conventional heat pump systems typically require six to eight refrigerant valves. But with our system approach, operation is possible with only one single valve. Our customers can also completely dispense with other components for the entire thermal management system.

Safe and reliable cooling performance in summer is one thing, but how do you provide heat for the vehicle interior in winter in a sustainable and technically efficient way? Is it still necessary to use an electric auxiliary heater?
Right from the start, we attached great importance to analyzing every conceivable use case down to the smallest detail. In this way, our development teams have identified more than 40 different operating states to ensure optimal thermal management in the vehicle, both in summer and in winter. For example, the Coolant Control Hub max has a self-heating function to heat the interior and the battery. This ensures that the vehicle's temperature is controlled at all ambient temperatures without the need for an electric auxiliary heater.

Can Forvia Hella supply all components of the system as a turnkey solution from a single source?
We have been active in the areas of fluidics, motors, electronics, and software for many years. As a result, we have gained a great deal of experience both at the component level and in the corresponding system expertise. Firstly, we can develop and manufacture all of the core components of the thermal management system ourselves, for example, the media pumps, the valves including the actuators, the temperature sensors, and the coolant distribution module. Secondly, our expertise enables us to bring these together to create a systems approach. We can therefore offer our customers tailor-made solutions that are adapted to their requirements and at the same time minimize the logistical effort involved.

How can a good overall system be created from all of the individual components? And what modularization and integration measures are there?
In principle, the individual components can be combined by mechanical integration to form a coolant distribution module. This in itself will significantly reduce the number of lines and interfaces required. We consistently pursue a strategy of modularized components that are based on a high standard of maturity and validation. But what is really exciting is a holistic integration approach, because this enables us to combine the components efficiently by intelligently interconnecting various sub-circuits. This reduces not only the number of lines and interfaces required in the system, but also the quantity of the individual components that are needed, such as valves, for example. In the end, that means a simplified system structure, an optimized use of installation space, lower weight, and therefore a greater range for the electric vehicle.

"What is really exciting is a holistic integration approach"

Dr. Geue, thank you very much for this interesting interview.

INTERVIEW: Michael Reichenbach

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