SHW
A member of the Pankl Group

Future mobility and challenges of modern E-Drive

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Abbreviations

TMM	**Termal Management Modul**
EOP	**Electrical Oil Pump**

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Executive Summary Whitepaper

Innovations have always been the key drivers of the automotive industry. Thus, innovative ability is a key indicator of how successfully automotive manufacturers and suppliers can meet the challenges of electrification.

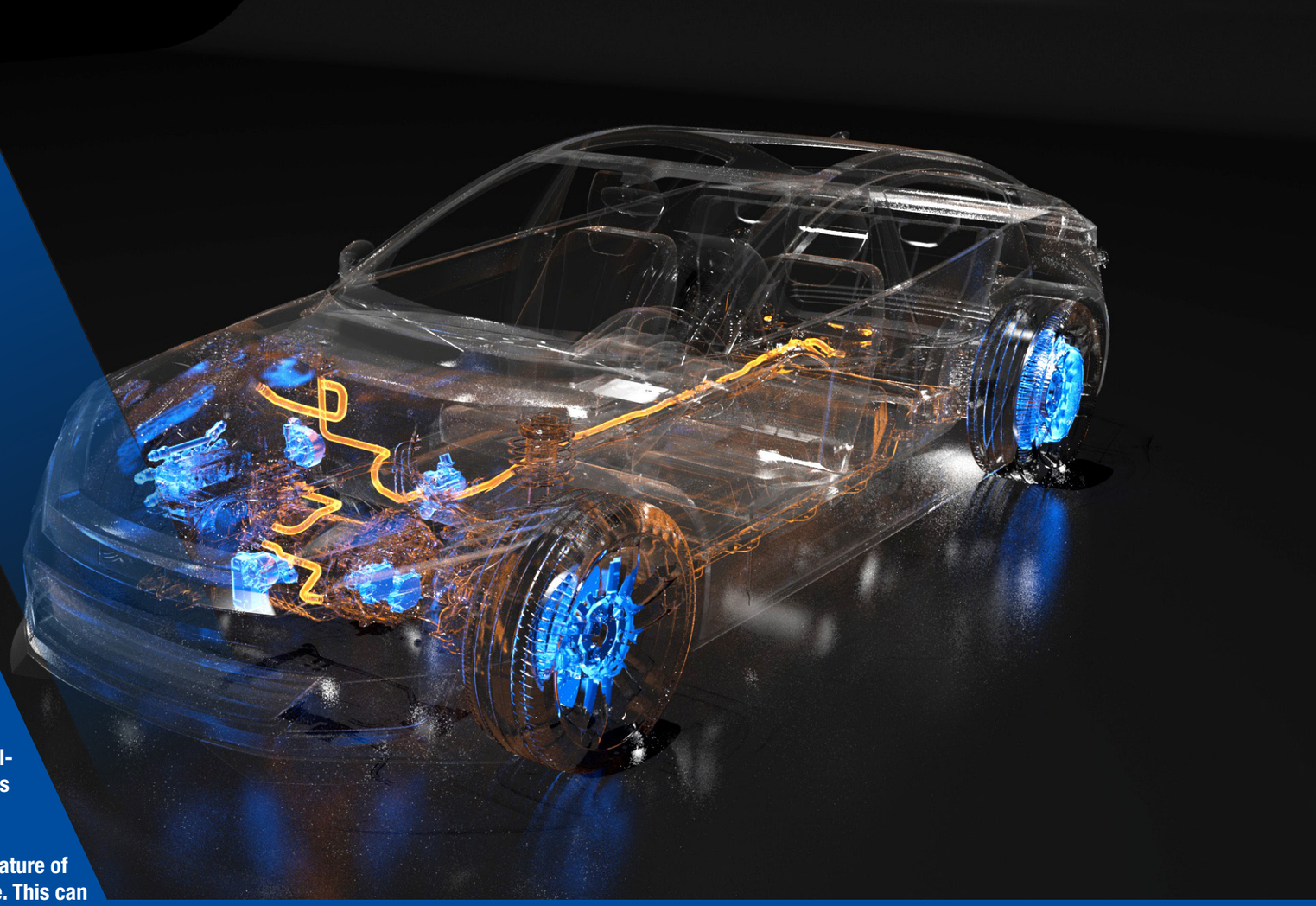
The main challenge is to respond to customer needs, regulatory requirements, and technological developments by creating innovative product solutions.

Compared to 2020, the sales of new electric vehicles more than doubled in 2021, with a growth rate of 51.8%. This meant that sales of electric vehicles accounted for around 5% of global passenger car sales.[3] Such growth resulted from attractive subsidies as well as increasingly powerful technical components.

In addition to factors such as affordability and climate neutrality, a long driving range and battery charging time play a particularly significant role. Many potential buyers still have doubts and fears that the performance will not meet their expectations. However, the fact is that Germans do not travel more than 40 kilometers by car per day, and thanks to improved battery capacities, driving ranges of between 200 and 600 kilometers are now possible, depending on the vehicle.

In this context SHW is analyzing the requirements on the component level that particularly challenge automotive manufacturers in the development of EVs and is presenting possible solutions that will contribute to a higher range, battery life and shorter battery charging time.

In order to operate an electric vehicle with a high efficiency, it is necessary to keep the temperature of the electric motor, the power electronics and the battery within an optimum temperature range. This can be achieved - depending on the component - with integrated oil and cooling management. Thus, SHW is taking part in rapidly creating the necessary technical conditions to drive mobility forward on a nationwide and sustainable level.



3 Statista (2022): Electric Vehicles - Market Data Analysis & Forecast

Preamble

The market segment is changing significantly, not least as a result of the elimination of vehicles with internal combustion engines in the EU from 2035 onwards, and therefore also the requirements and perspectives of the customers.

And that means new challenges for the supplier landscape. The suppliers evaluate their current strategic positioning and set the course for the future with an appropriate transformation strategy.

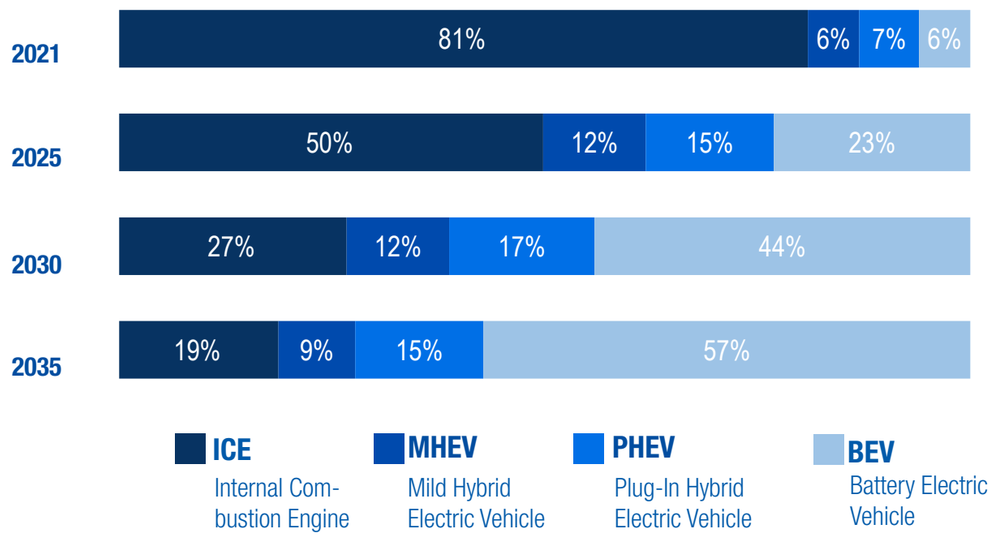
Environmental protection, sustainability and renewable energies have been placed in the media for years. CO_2-neutral production and compliance with new environmental requirements are just a few of the new challenges for the automotive industry.

As a result of political pressure and government support programs, the market share of battery-electric (BEV) and plug-in hybrid (PHEV) vehicles has increased significantly and is expected to change the automotive market in the long term.

This is forcing automotive manufacturers and suppliers to develop and finally implement transformation strategies. Some of the important requirements for electrified vehicles are the cooling and lubrication of components such as the e-axle and the battery.

By 2034 EVs and Hybrids will account more than 80 % of all global light vehicles that will be produced.

Abb.: Global Light Vehicle Production Forecast, Propulsion System Design (Source: IHS Markit, October 2022)



Challenges & requirements for BEV‘s

The customers are expecting from modern **battery electric vehicles** long driving range, fast battery charging, fabulous acceleration, big in-cabin room and high reliability. For the driving range of BEV’s is not only the capacity of the battery pack responsible. In fact the efficiency of all components and systems has an huge impact on the possible milage. Due to a better overall **system efficiency** the battery pack, as the main cost and weight driver, can be reduced in size without compromising the driving range.

As well the weight is an important factor for efficiency. Any additional kg is increasing the necessary power for acceleration and has a bad influence on the friction losses. Even if some energy can be saved by recuperation, you loose efficiency due to exceeding weight.

To give the designer enough freedom to combine dynamic styling, comfortable in-cabin space and plenty available space in frunk and trunk space, battery pack and e-axles need to be very compact. **High functional integration levels** and **rightsizing of the subsystems** help to get very compact solutions.

The battery charging time is for the customer an important argument for or against the decision to buy an BEV. To shorten the charging time, there is a clear trend for high voltage and high current charging stations. To enable a battery pack for high current loading over the complete loading cycle, a pre-conditioning of the battery temperature is necessary in advance, and effective battery cooling is required during the loading process to keep the cell temperature within the allowed safety limits.

Many customer have the expectation on BEV’s, especially in the mid and higher class product range, to impress them with very fast acceleration and high power and torque. For e-axles and transmissions a proper cooling and lubrication system is required to ensure the system reliability even at peak power demands.

In case of sportive BEV’s, in addition the g-forces during race-track driving needs to be considered in the layout of the lubrication circuits.

To avoid fast power degradation caused by critical battery temperatures, the battery pack must be effectively cooled down.

Challenges for the future powertrain

Friction reduction & lubrication
Any friction is causing losses in efficiency, potential wear on mechanical components and generates heat. To ensure low friction values, the trend is going to oil types with very low viscosity. This leads to higher demands on the oil pumps, but as well on the oil as under no situation the oil film in bearings and between drive-gears should get lost.

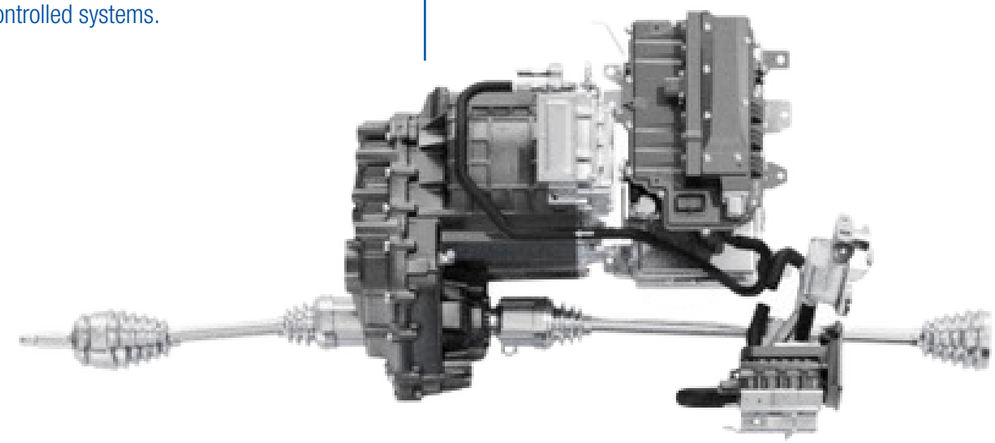
Lubrication & oil management
E-axles in the lower power range have only less requirements for cooling and lubrication. In some cases it could be sufficient only to let the drive-gears splash into the oil and spread the oil around inside the transmission.
For e-axles in the mid and high power range active lubrication and cooling is essential.
Electric oil pumps are necessary to supply the right amount of oil for cooling and oil pressure to ensure under all conditions the oil film in all bearings and gear contacts. high-power e-axles for sportscars should have a low center of gravity and need oil circuits which are able to withstand high g-forces. Both requirements leads to the need for dry sump lubrication system with 1 or more additional scavenge oil pumps.

Software and functional safety
The e-axle system components and the e-axle system as a whole has high demands on the software and the functional safety. This requires a tightly interlocked development of all electric controlled systems.

Cooling
Even with the high efficiency grade of today's e-motors, many heat energy is conducted into the e-drive system at high load demand. In addition, all bearings, transmission gears and differentials heat up as well due to the unavoidable friction when the power is transferred to the wheels. All that thermal energy must be dissipated over oil and/or water jackets to heat-exchangers or coolers.

Thermal management
With a clever thermal management solution, motor, transmission, cabin and battery system will be kept in a proper temperature range without consuming much electric energy.
Over electric controlled coolant valves several coolant circuits can be regulated.
The parasitic heat losses from e-motor and the drive-train friction can be partly recovered with heat-exchangers and used i.e. for cabin heating to save battery capacity.

Low weight & packaging
High functional integration level of subsystems and the combination in multifunctional modules allows to reduce weight and packaging space compared to standalone subsystems.The usage of plastic compound materials gives further potential for weight optimisation of the e-axle.



Thermal management of BEV battery systems

Thermal challenges
Battery lifetime and performance is strongly depending on the operating temperature of the battery cells. Battery quick charging requires high current. To enable the battery pack for high current loading from begin of the loading cycle, a pre-conditioning of the battery temperature is necessary. If the battery temperature is to low, the capacity is reduced and loading speed is limited until the temperature is increased by the internal resistance. But this resistance can rise the temperature at fast loading to much, therefore an effective battery cooling is required to keep the cell temperature within the allowed safety limits.

Even during driving cycle a temperature management of the battery pack is required to enable even peak power demands without power degradation caused by critical battery temperatures and to avoid lifetime reduction of the battery cells.

Thermal battery cooling solutions
Battery packs for low power BEV's are using passive cooling technology like heat dissipation to the air or liquid cooling.

For the mid- and high power range battery's, a liquid based cooling system with an electric pump must be used.

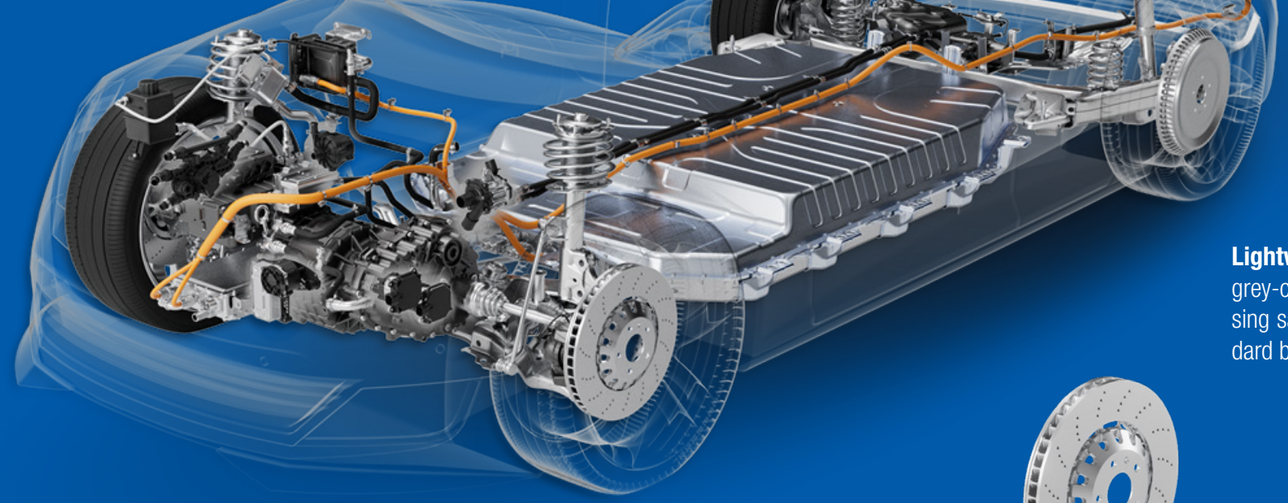
Standard solution is a indirect cell cooling with water-glycol pumped through water jackets as near as possible to the cells. The water-glycol coolant can be controlled by thermal management modules and heat exchangers.

Immersive battery cell cooling with die-electric oil is an more effective solution compared to indirect cooling with water glycol cooling systems. The cells are directly in contact with the coolant and oil has as higher heat capacity. This immersive cooling in combination with battery cooling modules allows to keep the temperature under control even when in near future higher voltages and current will be used for fast charging.

Solutions to increase efficiency and weight reduction for BEV platforms

There are plenty of systems and components in the BEV's, which have significant influence on the overall efficiency and weight.

Electrical main water pumps in combination with thermal management modules are able to replace multiple smaller auxilliary electrical water pumps and save weight and costs. Less pumps, means less pipes, less interfaces and less cables. High content of plastic compound components is increasing the weight saving.

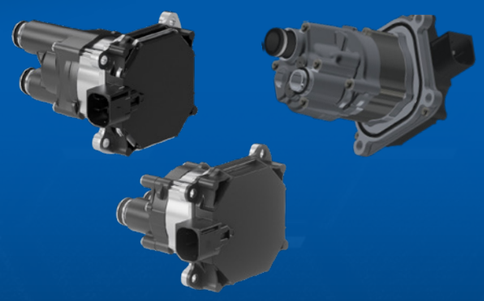


Electrical controlled cooling manifolds and **thermal management modules** are made mainly from lightweight plastic compounds and combine flexible coolant flow regulation of several cooling circuits integrated in a compact design. Due to the flow optimized design and the on demand flow regulation, parasitic losses are reduced to a minimum.

Lightweight hybrid brake drum consisting of grey-cast-iron friction ring and aluminum housing saves up to 40% weight compared to standard brake drums.

Lightweight composite brake discs with aluminum bell reduce the unsprung mass up to 3,5 kg per wheel compared to standard brake discs, what gives a significant CO_2 reduction.

Oil management modules integrate multiple components and system functions in a very compact environment. Beside the electrical oil pumps further components can be integrated such as heat exchangers, filters, check valves, sensors, and oil pan. Due to the deletion of many unnecessary pipes, interfaces, brackets and the usage of plastic compound materials oil management modules can enable significant weight reduction.
The integrated heat-exchanger transfers the heat from the drive system to the water-glycol cooling system where the heat can be used for the cabin heating.



Electrical oil pumps deliver on demand the oil for lubrication and cooling of the e-axle systems. The usage of electrical tandem oil pumps can reduce the number of necessary oil pumps and can supply oil to different circuits at various pressure levels with only one pump.
The usage of plastic compound material is increasing the weight reduction potential.

Solutions to increase reliability for high power BEV platforms

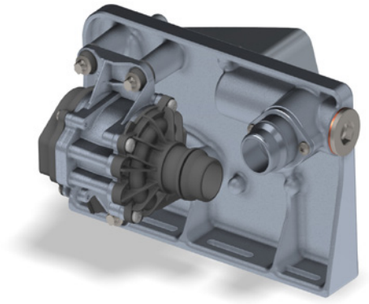
BEV's in the higher classes are showing the trend to more and more torque and power. This is causing an increased amount of heat dissipation due to the high electrical power and the mechanical friction which requires specific cooling devices. The high torques on the other side, which need to be transferred in the drive system, require a reliable lubrication of all involved mechanical components. This lubrication must be ensured under all driving conditions, even with high g-forces during race-track driving.

Electrical main water pumps are able to supply on demand high coolant flowrates or if required higher coolant pressure to ensure stabile cooling of the system even under permanent high load conditions.

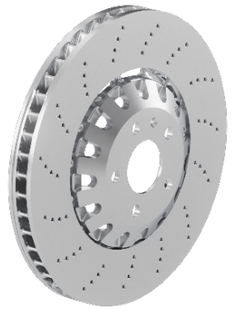
Electrical controlled cooling manifolds can divide the coolant flow flexible to the different cooling circuits, depending on the current driving situation and comfort requirements.

Oil management modules supply the necessary amount of oil for cooling and lubrication into the system, the integrated heat-exchanger keeps the oil temperature even under hard driving conditions in a healthy range. The integrated oil filter avoids any critical contamination.
For sportcars, the oil management module can integrate as well the oil sumps and a scavenge pump, preferable integrated to the electrical tandem oil pump. This will enable the lubrication system for engaged driving on the race tracks.

Battery modules with **immersive battery cell cooling** by dielectric oil is more effective cooled compared to indirect cooling with water-glycol coolant. This immersive cooling in combination with battery cooling modules allows to keep the cell temperature under control even when in near future higher voltages and current will be used for fast charging.



Lightweight composite brake discs with aluminum bell improve brake performance, the response characteristic due to the weight reduction up to 3,5 kg per wheel. Excellent cooling avoids brake fading under hard driving condition. In combination with an optional hard coating, the composite disc shows a extreme long llifetime, rust resistance and very low particle emission.



About us

SHW is a member of the Pankl Group and a global player specialized in developing and manufacturing single components or complete systems like **lightweight pin-dics, pumps** as well as **integrated modules** for cooling and lubrication of components in different markets: passenger cars, high performance cars and truck & off-highway.

We **place our customers at the center** of all our thoughts and actions.

For us, **quality means meeting all customer expectations** and an intention to establish long-term **relationships** to our business partners.

We **promote innovation** in order to increase the added value of our products.

We are **the fastest in all aspects of our business.** We are movers and are willing to constantly improve ourselves and our environment.

We strive for operational excellence in order to **protect the environment** using efficient processes and production methods that conserve resources and reduce our carbon footprint.

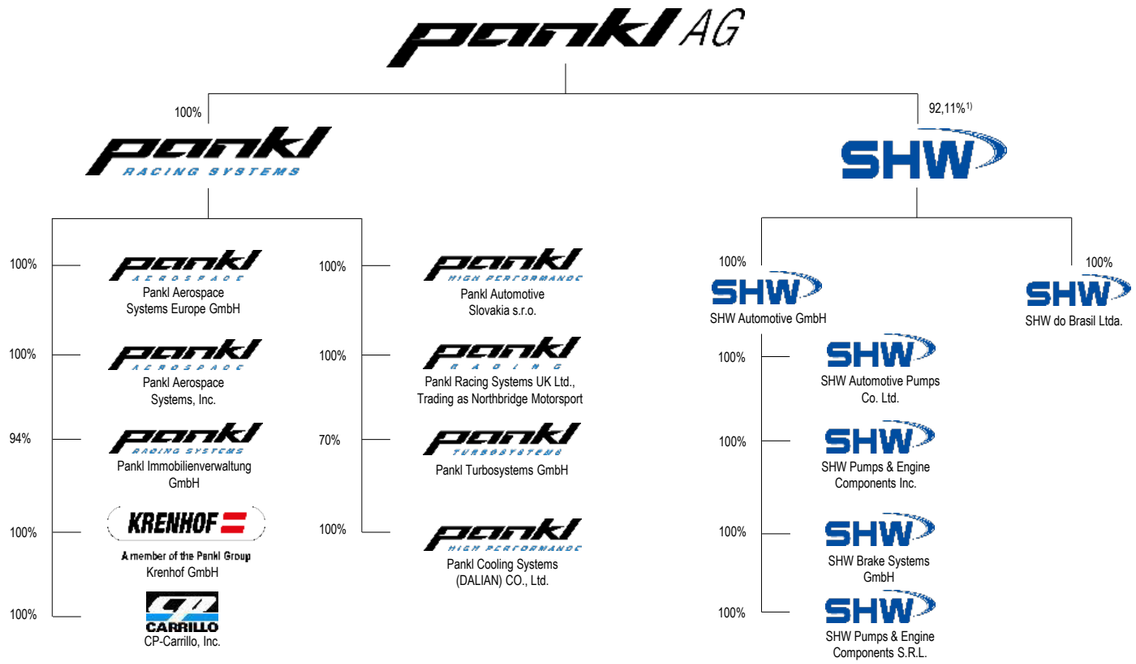
We **constantly improve our own performance** and that of our products in order to defend our market position in our core businesses and to build on this.

We develope all **software and PCBA's inhouse in our R&D centre** according to customer and functional saftey requirements.

We **serve our products globally** from our plants in europe, north america, south america, china.

We **offer all kinds of** mechanical and electrical oil pumps, oil modules, electrical main waterpumps, thermal management modules, battery cooling pumps and modules.

We **develope, test and validate** our e-pumps and modules completely inhouse.



1,685 employees

Sales 2021 **427** Mio. Euro

Global Footprint **8** Locations

Passenger cars

High performance cars

Commercial vehicles

Location

Aalen | Bad Schussenried | Neuhausen ob Eck | Tuttlingen | Timisoara | Toronto | Sao Paulo | Kunshan | Haimen

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