Electromobility
Mechanical Tolerance Compensation Systems for High-Voltage Batteries
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Intelligent Fastening Solutions for the Automotive World of tomorrow

WITOL is your experienced development partner for Tolerance Compensation and Adjustment Systems. From the initial concept to serial production - WITOL offers best practice solutions with standardized parts as well as 100% individual solutions both adapted to your interface and given environment.

WITOL stands for highest precision, quality and robust design - while optimizing total costs.

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MECHANICAL TOLERANCE COMPENSATION ELEMENTS IN BODY ASSEMBLY

Tolerance compensation systems have been used in the automotive industry for decades and are now standard equipment for all OEMs. The main focus is on mechanical joining - typically a component is mounted on the body. In the case of installation situations with play or in the case of high positional accuracy, the WITOL tolerance compensation system takes over the automatic compensation so that both components are connected tension-free in their respective positions without stress. The WITOL is pre-assembled either on the body or on the add-on part. When the screwing process is started, the tolerance compensation system is activated and guarantees a constant quality of the connection, thus reducing assembly time and rework.

It was shown relatively early, that the proven advantages of a mechanical tolerance compensation element also comes into play in different areas of high-voltage batteries. The large number of individual cell modules that have to be fixed to the battery housing results in tolerance chains that have to be compensated.

Assembly of high-voltage batteries using mechanical tolerance compensation systems

The future of the automotive industry is electrified and high-performance high-voltage batteries are moving into focus. The use of tolerance compensation systems brings significant advantages in the battery fixation to the body and the assembly of the individual cell modules.
for in addition to the unevenness of the battery housing. The use of largely standardized compensation systems also results in a reduction in eHPV (Engineered Hours Per Vehicle).

The safety requirements for the protection of the battery interior require high expenditures for the crash management of the battery frame, which thereby becomes very rigid. The comparatively large components, some of which take up the entire underbody of the vehicle, must now be married to the body tension-free and without deformation.

**FIXATION OF THE HIGH-VOLTAGE BATTERY**

In order to achieve the desired performance and range, the high-voltage batteries are designed for maximum size, and should blend in with the bodywork as much as possible in the overall concept. The HV battery is a rigid component, while the body is a relatively torsion-prone component. When the HV battery is bolted to the car body, considerable bending forces can occur even with only a small distance between the individual contact surfaces of the joints on the battery housing.

With the connection to the car body, undesirable deformations can thus occur, since the tolerances of large individual components increase over the length - both the high-voltage battery itself and the entire car body can be affected. The effects on the car body can be very diverse. Among other things, the gap dimensions and joint patterns may be impaired. Attachments do not remain in the correct position to each other, which inevitably leads to time-consuming reworking. In addition to deformation of the car body, the high-voltage battery can also be affected, which in turn can impair battery performance and would limit the overall performance of the vehicle (**FIGURE 1**).

In order to effectively eliminate the tolerance problem in the area of the external battery connection, WITOL has developed particularly robust tolerance compensation systems. For this purpose, the WITOLs are pre-assembled at the external connection points of the battery housing or the body. Afterwards the known screw connection can be carried out in the assembly process. To do so, the screw is inserted into the WITOL, turning the screw activates the compensating element, the gap between the high-voltage battery and the body is automatically compensated. The use of WITOLs result in a tension-free screw connection of the two components. In addition, the WITOLs not only compensate for the tolerance in the axial direction. By means of suitable long or squared holes and sufficiently large screw heads, tolerances radial to the screw axis can also be compensated.

**INTERNAL CONNECTION - ASSEMBLY OF THE INDIVIDUAL CELL MODULES**

Similar to the external connection, there are also tolerance cases in the internal life of the high-voltage battery. When the individual cell modules are mounted to the battery housing, this has

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**FIGURE 1**: Hard screwing of the high-voltage battery to the car body can cause deformation of the HV battery and the car body. Using WITOL tolerance compensation elements guarantees a tension-free screw connection of the components to each other. (© WITOL)
a direct effect on the performance and service life of the battery. Both the modules themselves as well as the housing are subject to tolerances. With a conventional screw connection, the following two problems in particular can occur: Either the gap between the cell module and the battery housing is too large, resulting in a significantly reduced cooling capacity, or the contact between the module and the liquid gap filler cannot be ensured over a large area. In both cases, the gap must then be compensated with additional cost-intensive liquid gap filler. High compressive stresses can occur if the screw connection is made without compensating the tolerance. However, if the tension is too high, this can lead to deformation of both components and insufficient thermal management of the HV battery. Especially the sensitive cell modules, that are significantly weaker in performance and limited in their lifetime in the case of inefficient cooling.

Using the same principle of operation as for the connection of the HV battery to the car body described above, the use of WITOLs can also eliminate the negative effects when connecting the cell modules internally. To dissipate the waste heat during charging and discharging of the battery, cooling systems are mainly used in the bottom of the battery housing. An appropriate heat conducting medium is used for heat transfer between the components. The layer thickness of such is considered to be as thin as possible to ensure the best possible thermal conductivity (FIGURE 2).

When the module is brought to the housing and into the desired end position, this is frozen by the WITOL. In the screwing process, the tolerance compensation element WITOL compensates for the gap between the cell module and the housing flange (FIGURE 3). In addition, the use of WITOLs offers a further advantage. If individual cell modules or the entire battery housing has to be replaced during the course of its service life, smooth removal and installation is possible without any problems thanks to the universal screw connection.

COOLANT AS NEURALGIC POINT WITHIN THE HV BATTERY

The coolant as a liquid gap filler or thermal conduction pad is an elementary
component of the entire HV battery and is decisive for the maximum energy density and thus the performance of the whole electric vehicle.

For optimum thermal conductivity, each individual cell module must have full-surface contact with the coolant. The coolant must also compensate for the tolerances of the modules and the unevenness of the housing base and ensure full-surface contact.

When using WITOLs, the cell module is pressed into the end position and the gap filler is displaced at the same time - this ensures full-surface contact of the cell module even with the smallest amounts of coolant (FIGURE 4). At the same time, WITOL compensates for the tolerance to the housing flange, so that the unevenness no longer needs to be filled with any additional gap filler.

The tolerance compensation by means of WITOLs can thus generate several essential advantages: Due to the significantly reduced amount of gap filler and thinner thermal pads, the thermal conductivity is significantly improved, resulting in an increase in performance and longer service life of the entire battery. Massive cost savings can be achieved in this way by using less material of the coolant. Another important advantage is the positive effect on total weight, which is relevant to the overall performance of electric vehicles. It is not only the savings in coolant and the reduction in weight that contribute significantly to the sustainability of the electric vehicle, but also the extended service life and ease of maintenance are decisive factors.

REQUIREMENTS HIGHLY AUTOMATED PRODUCTION

The automotive industry in general is an industry with a high degree of automation in assembly. In addition, the degree of digitalization in the automotive industry is already very high. In the course of Industry 4.0, highly automated assembly processes will continue to increase in the future in order to create the basis for connected production. Customers are also increasingly requesting fully automatic feeding and screwing of tolerance compensation elements. This not only ensures trouble-free feeding, but also optimizes cycle times by reducing assembly times and thus saving on personnel costs.

When installing HV batteries, risk prevention is an additional factor in favour of automating the assembly process. Some work must be carried out by a robot in order to eliminate the risk of injury to the workers. In addition, fully automated assembly also minimizes the degree of contamination, which poses additional quality risks for sensitive components.

WITOLs are suitable for any type of removal and installation and thus meet the individual requirements of the customer’s feeding and setting technology. By means of an automatic feeding and screw connection, parameters such as pushing forces and torques can be predefined and continuously monitored. An automatic query as to whether the WITOL has been set provides additional safety for the final assembly of the batteries.

In addition to a process-reliable improvement in assembly times, the issue of reworking also plays a significant role in vehicle construction. The use of tolerance compensation systems has a positive effect on the overall quality of fully assembled vehicles. By using WITOLs, the final assembly result is independent of the skills of the individual workers, or can even be carried out fully automatically as described.