Long-term Reliability Evaluation of Fluororesin Gasket for Electrode of Automotive Lithium-ion Battery Using Simulation

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ABSTRACT

In recent years, in order to prolong life of automotive lithium-ion batteries for electric vehicles and hybird vehicles, fluororesin such as PFA (Tetrafluoroethylene-perfluoroalkyl vinyl ether copolymer), which has excellent electrolyte resistance, electrical insulation properties, climate resistance and low moisture permeability, is being used as a material for gaskets around electrodes [1]. Since the reliability such as sealing performance and strength properties of amtomotive lithium-ion battery gaskets must be guaranteed for 10 years or more, the long-term reliability evaluation of fluororesin gaskets has become an important issue.

In this paper, we proposed a simulation method based on finite element method and a material model composed of a combination of an elasto-plastic model and a creep model to evaluate the changes in fluororesin material properties with time [2]. The elasto-plastic model is assumed to meet von Mises yield criterion and isotropic hardening rule and is approximated by multiple lines. The creep model is characterized by a modified time hardening type creep model. Specifically, the elasto-plastic model of PFA is prepared based on the tensile stress-strain diagrams at a normal temperature and a high temperature (65 degrees Celsius), and the creep model of PFA is created based on the compression creep test with different stresses at the normal temperature and the high temperature.

The validity of the proposed simulation method was verified by comparing the simulation results of the compression set of PFA over time with the experimental results. Compression set is an important characteristic for gasket materials. It is found that the simulation results of compression set changes over 5 years almost agree with the experimental results. This proved that the proposed simulation method is valid and effective for evaluating the long-term reliability of PFA.

Using the above simulation method and the material model of PFA, we evaluated the long-term reliability of PFA gaskets for the electrodes of automotive lithium-ion batteries. From the simulation results, we clarified the influence of protrusion of electrode and lid on the long-term reliability of the gaskets, and revealed the optimum protrusion shape that cae reduce the maximum principal strain while maintaining the maximum sealing pressure of the PFA gaskets. In addition, the simulation method can also be expected to optimize the gasket shape with less aging changes in sealing performance, and contribute to the reliability improvement of the automotive lithium-ion batteris.

In summary, we conclude that by using the proposed simulation method, it is possible to quickly evaluate the long-term reliability of gaskets for automotive lithium-ion batteries when shapes of the gaskets, electrode protrusions and lid protrusions change without relying on experiments, and realize optimum gasket designs in a short time.

REFERENCES

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[2] ANSYS Mechanical APDL 19.0 (2018).