§18. Improvement of Molten Salt's Thermal Properties by Mixing Nanoparticles

Ueki, Y., Fujita, N., Shibahara, M. (Osaka Univ.),
Yagi, J., Tanaka, T., Sagara, A.

Fluoride molten salt is a candidate for a coolant in FFHR blanket design[1]. Among fluoride molten salts, FLiNaK (46.5 LiF-11.5 NaF-42.0 mol% KF) is a good surrogate of FLiBe, since FLiNaK does not contain Be, which is harmful. FLiNaK is a high Prandtl-number fluid. In order to employ it as coolant in the blanket, enhancing the thermal conductivity of FLiNaK is favorable. Enhancement of the thermal conductivity by mixing nanoparticles is considered a feasible approach. Thermal conductivity of molten fluoride salt FLiNaK has been reported in literatures so far (e.g. refer to the reference[2]). However, their literature data differ in a wide range. Some of those data are even contradictory. This arises from difficulty in measurements at high temperature of more than 727K of the melting point, as well as a chemical reactivity of FLiNaK. Because of this, yet there has been no reliable database of FLiNaK thermal conductivity. To buid a reliable and consistent database of FLiNaK thermal conductivity is necessary. In the present study, thermal conductivity is experimentally evaluated at approximately 773K by a transient hot wire method. The value measured in the present study is compared with the literature values.

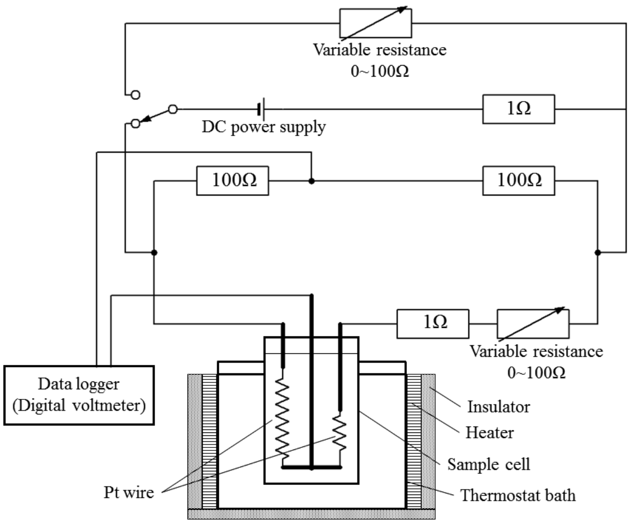

Fig. 1. Measurement setup: electric circuit, sample cell, and thermostat are illustrated.

Working principle of the transient hot wire method is to heat up a target fluid through flowing electric current in small-diameter Pt wires, and evaluate change in Pt-wire temperature from change in electrical resistivity so that the target fluid thermal conductivity is evaluated from heat flux from the Pt wires and the change in the electrical resistivity[3]. Figure 1 illustrates the experimental setup of the thermal conductivity measurement. The Wheatstone bridge circuit, which includes a long and a short Pt wires, is employed. The two Pt wires are immersed in molten FLiNaK contained in a sample cell. The sample cell is installed in a thermostat. The measurement temperature is 773K in the present study.

Figure 2 illustrates the present measurement result in comparison with the literature value. In the present study, the measurement result is 0.220 ± 0.009 W/m· K. The measurement is reproducible. However, the result is lower than the literature data. Allen[4] reported that the thermal conductivity has a positive correlation with temperature. On the contrary, Ishii et al. performed a molecular dynamics simulation of FLiNaK thermal conductivity, and reported that the thermal conductivity has a negative correlation with temperature. Other experimental investigations with the coaxial cylinder method[5], and the laser flush method[2] showed that the measured thermal conductivity had a positive correlation with temperature. Based on this, interatomic potentials employed for the molecular dynamics simulations might to be invalid. Nevertheless, the literature values are higher than the present result. One of its possible reasons is that natural convection might have influenced the previous measurement, which may induce overestimation of the thermal conductivity. The transient hot wire method is able to detect any natural convections, and eliminate their influences on measurement results. Another reason is electric leakage from the Pt wires into FLiNaK, which influences the measurement results. Currently, electrical insulation on Pt wires is being tested. Our future work is the thermal conductivity measurement by means of the transient hot wire method with electrically-insulated wires.

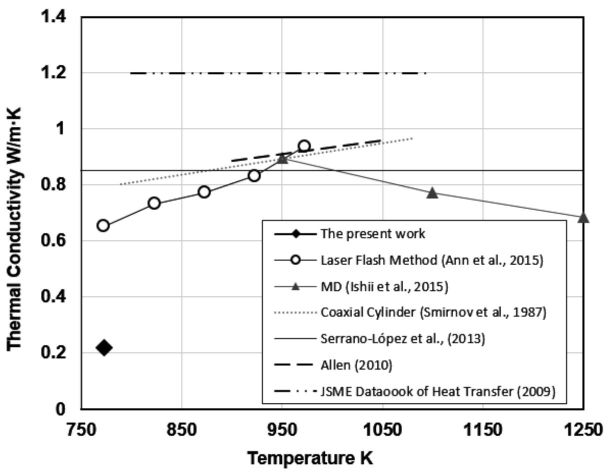

Fig. 2. Measurement result of FLiNaK thermal conductivity at 773K, and literature data.

1) Sagara, A. et al: Fusion Eng. Des. **89** (2014) 2114.
2) Ann, X.-H. et al.: Int. J. Heat Mass Transfer **90** (2015) 872.
3) Nagasaka, Y. et al.: Transactions of the JSME **47** (1981) 1323 (in Japanese).
4) Sohal, M.S. et al.: Idaho National Laboratory Report, INL/EXT-10-18297 (2010).
5) Smirnov, M.V. et al.: Electrochimica Acta, **32** (1987) 1019.