Impurity effect on thermal property of the LiF-NaF-KF mixture

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1. Introduction

Molten salt reactors(MSRs) are characterized by the use of molten salt as coolant and show very different chracteristics from the light water. The primary advantage of MSRs is its inherent safety come from high boiling temperature and high volumetric heat capacity when undesired operation condition. Also molten salt remains liquid form without any pressurization unlike most PWRs which operate under 150 atmospheres to prevent boiling at operation temperature, 315℃. Therefore, molten salt as coolant can significantly increase thermal efficiency and operational safety at high operation temperature. FLINAK is considered as a promising candidate for the intermediate coolant, which is the ternary eutectic alkaline metal fluoride salt mixture LiF-NaF-KF (46.5-11.5-42.0 mol.%). It has a low melting point of 454℃, a high boiling point of 1570℃, high heat capacity, and chemical stability at high temperature.

Naturally, careful attention must be paid to prevent FLINAK freezing under operation because of a high melting temperature of 454℃. Also study of impurities effect on melting point of FLINAK is required for operational safety of nuclear reactor.

In this study, the reliability of instrument for measuring melting point was built by comparing measured value with reported literature value. And we will investigate the effect of impurity on melting point of FLINAK.

2. Experimental

2.1 Experimental Apparatus

The schematic diagram of the measuring apparatus is depicted in Fig. 1. The apparatus consists fundamentally of a test cell, electric furnace, temperature control system, atmospheric gas refining system and associated instrumentation. The sample was into the test cell both to be heated and cooled in the electric furnace. The temperature of the electric furnace (220V-7kW) was controlled by a programmable temperature-controlling unit (Program PID Controller UP-35A).

The sample crucible was installed in the quartz-glass tube (40 mm O.D., 36 mm I.D., 400 mm in length) which was cooled by flowing water through copper tube at the upper side. The Pyrex glass cap was set at the top of the tube in order to control the atmosphere in the tube. To prevent for the samples from suffering a change in quality, the tube was filled with argon gas (99.999%). K type thermocouple having a 3 mm diameter and sheathed in a protection tube is set into sample crucible. The thermocouples in the sample crucible was located at just center the sample, and that in the electric furnace are located at the middle point between the furnace wall and the test cell in the same horizontal level as the thermocouples in the sample crucible as shown in Fig. 1. The output of the thermocouple in sample was recorded hybrid-recorder.

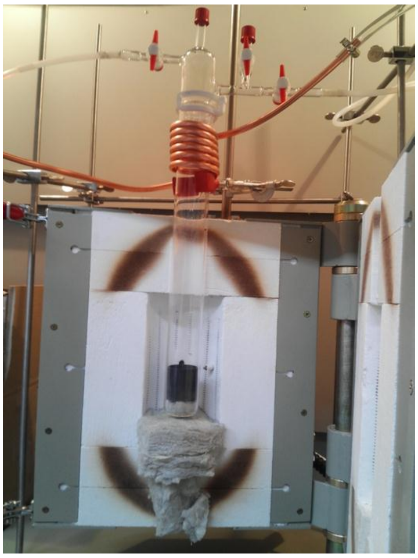

Fig. 1. Experimental apparatus

2.2 Experimental Process

In order to dehydrate the test samples, LiF(Aldrich inc., 99%) powder, NaF(Aldrich inc., 99.99%) powder and KF(Aldrich inc., 99.98%) powder, they are respectively dried at 200℃ for 24 hours under Ar gas(99.999%) atmosphere. And dried fluorides are weighed and mixed in glove-box. In the measurements, in order to protect the sample from pollution and chemical reaction, argon gas (99.999%) flow into the quartz-glass tube with 0.2 bar pressure. A fluoride-salt ternary mixture (46.5 mol % LiF, 11.5 mol % NaF, 42.0 mol % KF) is set into glassy crucible both to be heated and cooled in the electric furnace. The temperature is measured by quartz glass sealed K-type thermocouples which is immersed inside the 20.181g mixture sample of glassy crucible under Ar gas atmosphere. The rate of temperature change in the electric furnace is controlled with heating rate of 2℃/rnin. and cooling rate of 10℃/rnin.

Table Ⅰ: Measured value of melting point

	Melting point in heating curve	Melting point in cooling curve
1	466℃	454℃
2	462℃	454℃

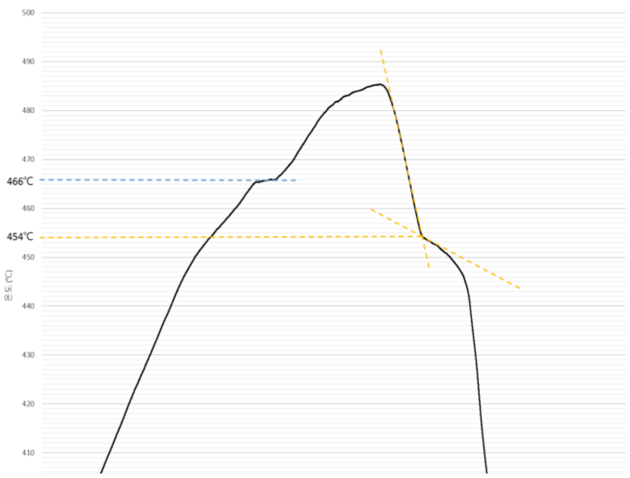

Fig. 2. Temperature change of thermocouple set in the ternary fluorides mixture

3. Results and Discussion

In Figure 2, the temperature changes of FLINAK is demonstrated as a heating-cooling curve. In the figure, curve denotes the temperature of the sample. Some periods can be observed where the temperature remains constant for both heating and cooling process. A constant value of temperature can be recognized as indicating the melting point of the salt. There were some cases where the cooling equilibrium temperature did not coincide with the heating one due to the difference of the condition of the sample. In the present measurement, the constant temperature obtained in the cooling process was adopted as the melting point because the liquid condition after the melting is more homogeneous than the powder condition before the melting. Measurement results of the melting points are summarized in Table. 1. The present measurement results almost agree with the reported literature value (454℃), which represents the reliability of instrument for measuring melting point

Generally, measurement data of melting points cannot be simply compared with each other because various factors such as purity of the sample, drying treatment, and sample mass will exert considerable effects on the melting point. In the present case it is considered that the suspension condition of the sample in the crucible, and heating or cooling process will cause the differences between the present data and the reference data. It appears that convection in the molten sample in the crucible may occur and affect the temperature distribution in the sample.

4. Conclusion and Future Work

We acquired the reliability of instrument by measuring the melting point of pure FLINAK. We will investigate the effect of metal impurities on the melting point of FLINAK. Anions of molten salts such as fluoride ions can lead to increased corrosion rates if they can form stable complex ions with metals such as Cr and Fe which are normally concluded in MSR structural material and induce the chemical reaction with FLINAK during operation time.

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