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鉛リチウム合金の熱的物性評価に関する研究
Study on thermophysical properties of lead lithium alloy

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1. Introduction

Liquid lead lithium alloy (Pb-Li) is one of the candidates of the tritium breeders of fusion reactors. The thermophysical properties of the alloy, such as thermal conductivity, specific heat, viscosity and density, are essential to design the fusion blanket system. Some of the thermophysical properties of the alloy are reported in the previous papers [1-2]. However, the available data for the thermal conductivity is quite limited. The thermal conductivity is obtained by the equation;

$$\lambda=\rho C_P\alpha \quad (1),$$

where ρ is the density, C_p is the specific heat and α is the thermal diffusivity of the alloy.

The purpose of the present study is to make clear the thermal conductivity of the Pb-Li alloys having the Li concentrations in the range between 0 and 30 atom% at various temperatures. In the present work, the density, the specific heat and the thermal diffusivity of the alloys are evaluated based on the previous studies and the experimental data newly obtained in the current work. Then, the thermal conductivity as functions of the Li concentration and the temperature is evaluated.

2. Evaluation of density of Pb-Li alloys.

The Pb-Li alloys having various Li concentration were fabricated in the previous study [3]. The density data of the alloys in a solid state was obtained by means of the Archimedean method with the samples fabricated. The equation of the densities at the room temperature as a function of Li concentration (0at% < χ_{Li} < 28at%) is obtained as

$$\rho_{(300K)}\,[kg/m^3]=-6.02\times10^{-2}\times\chi_{Li}+11.3 \quad (2).$$

The density of the alloy in a liquid state is evaluated based on the previous studies [4]. The density as the functions of the temperature (673K < T < 823K) and the Li concentration (0 at%< χ_{Li} <30at%) is described in the equation;

$$\rho[kg/m^3]=(-6.34\times10^{-2})\times\chi_{Li}+11.4-1.19\times10^{-3}T \quad (3).$$

3. Evaluation of thermal diffusivity of Pb-Li alloys

The thermal diffusivities of Pb-5Li, Pb-11Li and Pb-17Li were measured by means of laser flash method using ULVAC TC-9000 with the samples in ref. [3]. The temperature dependence of the thermal diffusivity is larger at higher Li concentration in the alloys. The dependence of Li concentration on the thermal diffusivity is larger at higher temperature. For example, the equation for the thermal diffusivity of Pb-17Li at the temperature between 573K and 773K is obtained as,

$$\alpha_{Pb\text{-}17Li}[cm^2/s]=3.46\times10^{-4}T-1.05\times10^{-1} \quad (4).$$

4. Evaluation of specific heat of Pb-Li alloys

The specific heats of Pb-10Li and Pb-25Li were already obtained in the previous study [4]. The specific heat is larger at the higher Li concentration. The approximation curves were obtained based on the data of the previous report [4]. For example, the specific heat at 873K is described in the equation;

$$C_{P(873K)}[kJ/kgK]=4.64\times10^{-5}\chi_{Li}^2+8.83\times10^{-4}\chi_{Li}+0.144 \quad (5).$$

5. Evaluation of thermal conductivity of Pb-Li alloys

The thermal conductivities of Pb-Li alloys at the temperature between 573K and 873K were evaluated based on the data in the previous studies and obtained in the current work. The thermal conductivities are shown in Fig. 1. The thermal conductivity of Pb-17Li at the temperature of 673K, 773K and 873K are higher than those of Pb, Pb-5Li and Pb-11Li. The thermal conductivity of Pb-17Li had larger temperature dependence than those of Pb, Pb-5Li and Pb-11Li.

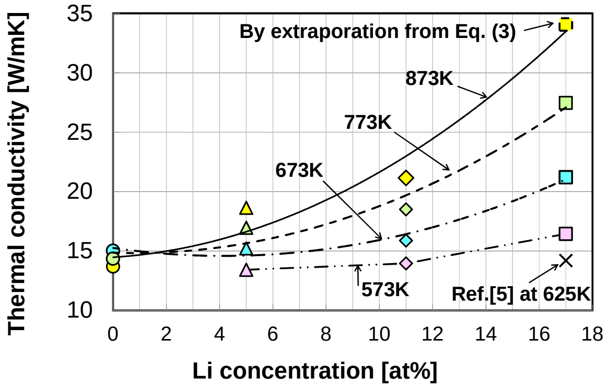

Fig. 1 Thermal conductivity of Pb-Li alloys as functions of Li concentration and temperature

Reference

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