

Density Measurement of Molten KHF_2

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An apparatus has been manufactured to measure the density of molten KHF_2 . A linear dependence of the density on temperature is found in the range of 280–450 °C.

Key words: Molten KHF_2 ; Density; Temperature.

Introduction

Problems of spent nuclear fuel could be solved by means of transmutation technologies. Long-lived actinides, generated during fuel fission, contain a large amount of exploitable energy. Therefore spent nuclear fuel should not be considered as a waste but as a valuable energy source. Molten fluorides are very perspective for application in transmutation systems as heat carriers in the primary and secondary circuits. KHF_2 can be considered for the secondary circuit as a heat carrier because of its very low melting temperature.

1. Some Characteristics of KHF_2

KHF_2 , a relatively stable fluoride applied in so-called high-temperature electrolyzers for the production of elementary fluorine [1], transforms from an alpha to a beta phase at 195 °C. It is very soluble in water (3.25 grams per 100 ml of water at 20 °C) [2]. Part of the phase diagram of the system (K, H)F is shown in Figure 1.

2. Density Determination Principle

An apparatus has been developed for density determinations of molten fluorides. The volume expansion of a defined salt mass “m” with the temperature is measured, and the density of the molten salt is computed by the equation

$$\rho = \frac{m}{V} = \frac{m}{V_0(1 + \beta \cdot \Delta t)} \text{ [kg/m}^3\text{]},$$

where

ρ = density [kg/m³]

m = sample mass [kg]

V = sample volume [m³]

V_0 = sample volume at the temperature t_0 [m³]

Δt = temperature difference ($t - t_0$) [K]

β = temperature volume expansion coefficient [1/K].

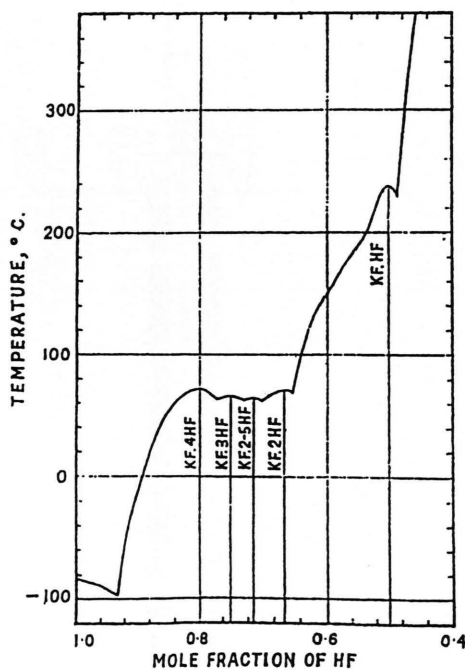


Fig. 1. Phase diagram of the (K, H)F System [3].

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Table 1. Average content of impurities in the initial charge of KHF_2 .

Element, compound	Pb	Cd	Ni	Cr	Al	Cu	Zn	Mn	Fe	Na	chlorides	sulphates	nitrates	H_2O
Content [ppm]	0.4	0.02	9.8	10.7	31	3	1.8	1.8	23	182	< 1000	1400	1500	400

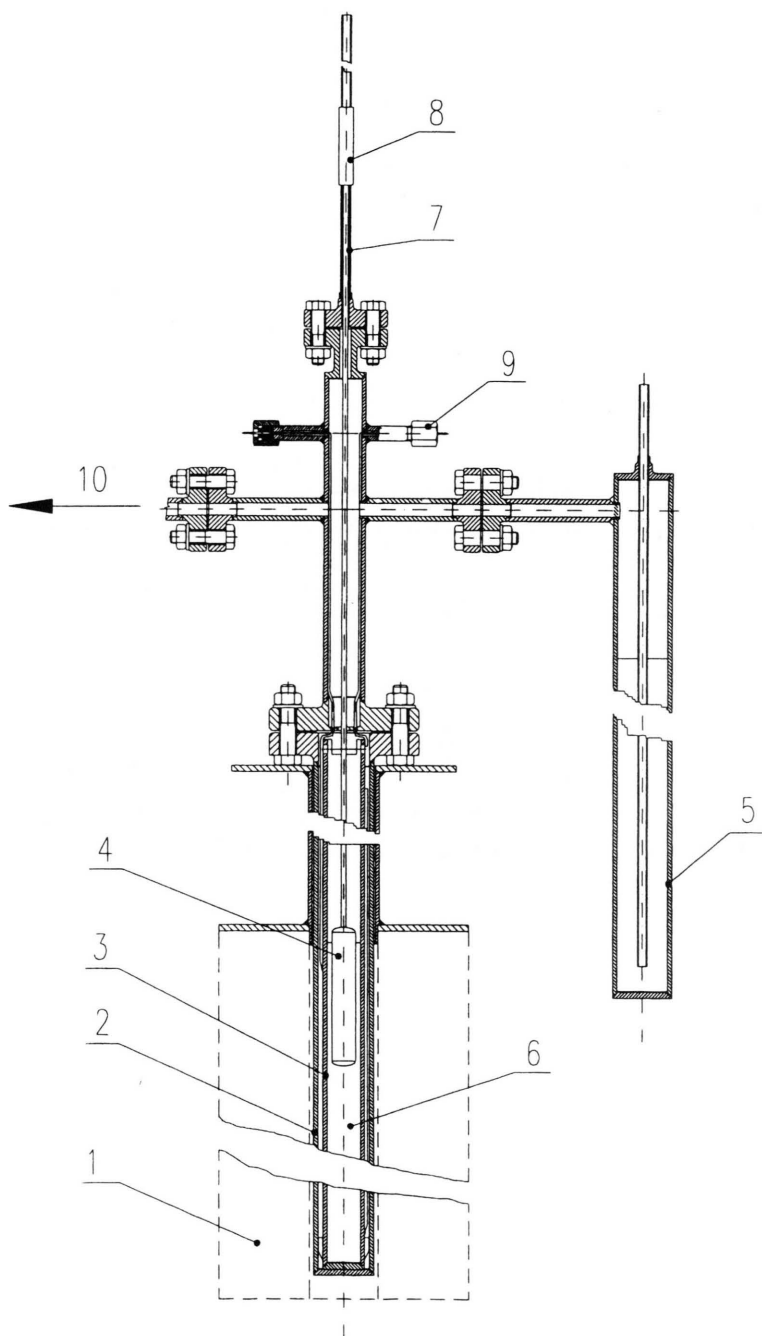


Fig. 2. Densitymeter
 1: Furnace and heating system,
 2: Outside tube,
 3: Salt sample chamber,
 4: Salt volumetric changes monitoring,
 5: Generator of HF ,
 6: Salt sample,
 7: Salt volumetric changes monitoring,
 8: Salt volumetric changes monitoring,
 9: Connections to the temperature monitoring system,
 10: to the vacuum and cover gas system.

3. Apparatus and Measurement-Procedure

The densimeter for molten fluoride salts is shown in Fig. 2 [4, 5].

Vacuum leak tests and overpressure leak tests of the apparatus have been carried out, dry nitrogen having been used as cover gas.

Averaged contents of impurities in the initial charge of KHF_2 are given in Table 1.

Before melting, the KHF_2 charge of mass “*m*”, located in the sample chamber, was heated to approximately 140 °C and dewatered by the vacuum system. Volumet-

ric changes of KHF_2 with temperature were monitored by a specific system, (Pos. 4, 7, 8), Figure 2. Temperatures were measured by thermocouples.

4. Evaluation of Measured Data

Measured data were recalculated into KHF_2 density values and plotted in Figure 3.

The density versus temperature data in the range of 280 to 450 °C were approximated by the linear dependence [6]

$$\rho = 2086 - 0.5685 \cdot t,$$

where *t* is the temperature in °C and ρ is the density in kg/m^3 .

The influence of the chemical purity of KHF_2 on the density and melting point as well as the influence of the cover gas type will be studied in the near future.

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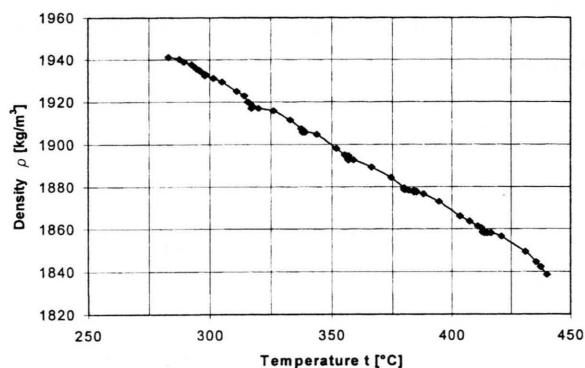


Fig. 3. Density of molten KHF_2 vs. temperature.

- [1] J. Regner, Technical Electrochemistry, Academia Praha, 1967.
- [2] F. Petrů, Inorganic Chemistry – Non-Metal, SNTL Praha, 1967.
- [3] G. H. Cady, Jour. Amer. Chem. Soc. 1431 (1934).
- [4] F. Dubšek, Design of Experimental Facilities for Determination of Thermophysical Properties of Molten Fluoride

- Salts, Report Nr. QR-EM-052-98, Energovýzkum Ltd, November 1998.
- [5] P. Slavíček and O. Matal, Report Nr. QR-EM-065-00, Energovýzkum Ltd, Brno, December 2000.
- [6] T. Šímo and O. Matal, Report Nr. QR-EM-054-00, Energovýzkum Ltd, Brno, December 2000.