Experimental Study on the Effect of Potassium Chloride’s content on the Ice Melting Rate

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Abstract. The phenomenon of winter snow, the collapse of deep soft rock roadway, the tumble of plateau permafrost and the erosion of chocolate cheese are closely related to our daily life, and all involve the transformation between solid and fluid, which makes the study on the theory of solid-liquid conversion of materials full of importance and value of the application. In this paper, taking the content of potassium chloride as an independent variable, through the ice melting experiments to study the effect of content of potassium chloride on ice melting rate, the results show that with the increase of potassium chloride content, ice melting rate gradually accelerated. Through data analysis, the empirical formula of potassium chloride content and ice melting rate was obtained, and the numerical simulation was carried out by ANSYS software, and the relevant conclusions were drawn.

1. Introduction
The solid-liquid conversion of material is the transformation of material from solid to fluid under the action of external environmental factors.

The research methods have been transferred from the fields of solid mechanics to fluid mechanics, involving many disciplines. The scope of the solid-fluid conversion covers a wide range. The most simple solid-liquid conversion of materials is ice-water solid-liquid conversion. In everyday life, winter road snow is the most common solid-liquid conversion phenomenon. Road snow has a serious impact on transport and people's travel safety. People in order to solve this problem, there are a variety of methods. One of the most widely used in the world is to think of pavement chemicals to reduce the freezing point of ice or snow, and promote the melting of ice or snow in order to achieve the purpose of clearing. When using chemicals, the most commonly used is chloride. Guo Tiantong of Qingdao University of Science and Technology made a theoretical study on solidification of ice and water, and Liang Chang of Qingdao University of Science and Technology did the experiment on the effect of sodium chloride on freezing point and melting rate of ice, and fitted out the melting formula of salt ice, Quantify. At present, the research on the theory of ice-water solid-liquid conversion is still limited to a single component and does not involve the influence of different impurities on the solid-liquid ice-water conversion.

In this paper, we mainly study the influence of potassium chloride content on the ice-water melting rate. Different levels of potassium chloride were mixed with distilled water, and the samples were melted to obtain effective data for processing. The relationship between the content of potassium chloride and ice melting rate. The empirical formula and ANSYS numerical simulation software.
2. Ice melting model
The mathematical models for solving the problem of phase transition heat transfer can be divided into two main categories: Category 1: single-area model (unified model), because the model is applied to both the solid-phase zone, the liquid-phase zone and the two-So they can be solved only by applying a fixed set of grids and a set of boundary conditions, so the unified model is widely adopted. Heat enthalpy, sensible heat capacity and immobile interface method (coordinate transformation method) Is a good unified model in numerical calculation and is suitable for numerical solution of multi-dimensional problems. Category 2: Multi-region model, that is, to establish control equations for each phase, and by establishing appropriate boundary conditions on the phase interface Describe the coupling relationship between the solid phase region, the liquid phase region and the two phase region. Firstly, the phase transition heat conduction problems are generally divided into two parts by an infinite thin phase change interface, that is, the solid phase region and the liquid phase region have two parts The respective temperature field and physical parameters, such as temperature, density, thermal conductivity temperature, density, thermal conductivity and so on, respectively satisfy the non-steady-state heat conduction equation and their respective boundary and initial conditions. When the thermal conduction temperature field When the phase transition interval, the substance will absorb or release a large amount of latent heat. Moreover, in order to simplify the problem, the effect of natural convection or forced convection is omitted in the liquid phase region.

3. Experimental content
Experiment equipment: RPH-80-type constant temperature and humidity chamber, refrigerator, TES1310 with probe contact thermometer, abrasive, vernier caliper, beaker, electronic balance, knife, paper cup, cylindrical plastic mold.
This experiment is a constant temperature and humidity chamber for melting experiments with ice cream containing potassium chloride, the contents of the study are as follows: a certain amount of distilled water into a cylindrical plastic mold, then add a certain amount of potassium chloride, the mixing solution with a stirring rod Stir, flat on the refrigerator, curing two days. Two days later, the specimen of ice was taken out of the refrigerator and stripped. The cylindrical specimen were trimmed to the specified size, and then the specimen was placed in the refrigerator for curing. Open the chamber, set the specified temperature and humidity, The potassium chloride ice specimen removed from the refrigerator, quickly placed in a constant temperature and humidity chamber, and start timing until all the pieces of the specimen to stop after the thawing time, record the time spent.

4. Experimental data
Cylindrical ice samples with specific size were prepared by using the above aqueous solutions containing 0%, 5% and 10% potassium chloride respectively, and the surface temperature was recorded when it began to melt. The experimental data is shown in Table 1:

| Potassium chloride content (/%) | Melting time (t/s) | Specimen volume (V/m³) | Melting rate (m³·s⁻¹) |
|-------------------------------|-------------------|------------------------|------------------------|
| 0                             | 986.475           | 0.000107115            | 1.08584E-07            |
| 5                             | 983.5714286       | 0.000107115            | 1.08905E-07            |
| 10                            | 825.76            | 0.000107115            | 1.29717E-07            |

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5. Analysis of experimental data
Experimental data use Excel software for processing. Enter the test data that needs to be fit into the Excel spreadsheet and draw the graph as shown below.

![Simulation curve](image1)

**Figure 1. Simulation curve**

The curve is simulated in the form of a polynomial function and the fitting curve is obtained. \( y = -6E - 05x^3 + 1E - 05x^2 - 5E - 07x + 1E - 07 \), Goodness of fit: \( R^2 = 1 \).

6. Numerical simulation analysis
Select the 5% solids ice specimen 1/8 part, select the temperature profile of the 983s cloud as follows:

![Temperature nephogram](image2)

**Figure 2. Temperature nephogram**

It can be seen from the above temperature distribution map of ice cubes that the melting process is basically completed with the melting time of 983, and the minimum temperature is 0.002356. The simulation melting time of ice cubes with potassium chloride content of 5% can be determined to be 983. The melting time of the experiment was 983.5714. The experimental data are basically consistent with the simulation results.
7. Conclusion

(1). In this paper, under the condition of constant temperature and constant humidity, the melting experiment of ice cubes formed by different KCl solution shows that the melting rate of ice is faster when the content of potassium chloride is bigger. When the temperature and humidity are constant, changing the content of potassium chloride, the relationship between the melting rate of ice cubes and the content of potassium chloride is fitted by \[ y = -6E - 05x^3 +1E - 05x^2 - 5E - 07x +1E - 07 \] and the goodness of fit is 1. The law showed a polynomial function change, including potassium chloride ice melting time decreases with the increase of potassium chloride solids content, the melting rate increases with the increase of solid content.

(2). Before the content of potassium chloride is 5\%, the effect of solidification of ice water on solids conversion is little. After 5\%, the influence of solid content of potassium chloride on the solid content of ice water shows a significant increase.

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