Chapter 1

Development and Research of Phase-Transition and Thermochemical Materials for Heat Accumulation

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ABSTRACT

The chapter discusses various phase-transition heat-accumulating materials. Their application in heat pumps and their use for heat supply are presented. Phase-transition heat-accumulating materials in heat pipes are also considered, various types of heat pipes are presented. The installation of heat storage with phase-transition materials is presented. Along with phase-transition heat-accumulating materials, the chapter considers thermochemical heat-accumulating material of photochemical reactions of energy storage. As an example of a thermochemical heat-accumulating material, a solar power plant for thermochemical energy storage is presented. A developed computer program for the description of thermochemical reactions allows examining chemical and thermochemical reactions in multicomponent reciprocal systems, which can be carried out in the course of the reciprocal multicomponent systems. The computer program allows identifying thermochemical reactions occurring in mutual multicomponent systems, regardless of component and dependent on temperature.

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INTRODUCTION

In recent years, work has been intensively carried out in many countries around the world to develop energy storage technology based on phase-transitions of materials, which is regarded as a promising direction for creating efficient heat storage systems (HSS) (Babaev Kharchenko, Panchenko & Vasant, 2019; Adadurov, 2005; Babaev, 2016a; Babaev, 2014; Duffy & Beckman 2013; Magomedov, 2000; Shishkin, 2005). Thermal accumulation using heat of phase-transitions of the first kind of inorganic compounds and eutectic compositions is currently one of the most promising ways to save energy.

Recently, more and more attention has been paid to thermochemical batteries, which ensure the storage of energy as a result of the passage of some reversible chemical reaction. Accumulation of heat in this case occurs when a chemical reaction proceeds to the side in which it goes with heat absorption, and the heat return to the consumer is due to the reverse reaction (Babaev, 2016b, Babaev & Danilin, 2002; Duffy & Beckmann, 2013; Popel & Fortov, 2015; Twidell & Weir, 1990).

BACKGROUND

The success of the creation and introduction of thermochemical heat accumulators, which can be considered as seasonal, depend on the solution of thermophysical problems related to the selection of the necessary working substances and the economic problems associated with their cost parameters.

Chemical reagents and reactions for a chemical heat accumulator must meet the following requirements:

- Cheapness and accessibility;
- High volumetric density of stored energy;
- If possible, reaction without catalyst;
- Be chemically inert with respect to the structural materials of the thermal battery;
- Ease in implementing control over the course of a chemical reaction by means of temperature or pressure;
- A large number of thermochemical cycles;
- Have a large and developed external surface to intensify the course of the chemical reaction.

Of great importance is the search for new energy-intensive thermochemical heat-accumulating materials. Literary analysis (Magomedov, 2000; Engelsht & Muratalieva, 2013) shows the wide possibilities of their application. In addition, the chemical reactions used to store energy can convert low-potential energy into a high-potential energy. A similar feature is not possessed either by batteries based on phase transitions, nor, especially, by heat capacity.

Chemical energy can be stored either directly in the form of the internal energy of the molecules (for example, obtaining under the action of light enriched energy conformers, in particular valence isomers), or in reaction products that can interact with each other, releasing energy in a useful form.

To accumulate solar energy, in particular, it is possible to use any endoenergetic reactions that under the action of solar radiation (SR), accompanied by a rearrangement of chemical bonds or molecular structure. At the same time, two groups of processes that convert solar energy into chemical energy-photochemical and thermochemical can be distinguished from the mechanism of action of SR.

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