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Research Article

Mathematical Model for Definition of Thermal Conditions in Desublimation Process of Volatile Metal Fluorides

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Abstract

Towards optimization of process parameters and creating of automatic control system for desublimation process a mathematical model for the process of desublimation of volatile metal fluorides in surface devices has been created (by the example of uranium hexafluoride). Optimal modes for the process of desublimation calculated with the developed model have been estimated in experimental tests and they showed reasonable convergence with the experimental data.

Keywords: *Mathematical Model, De-sublimation Process*

Introduction

From proper organization of desublimation process of thermal conditions of volatiles in surface desublimators often not only stability and efficiency of desublimation equipment depend, but also environmental safety of production. Thus, with production of uranium hexafluoride by fluorination process of uranium oxides, uranium hexafluoride during desublimation process is able to accumulate in certain areas of device's surface, where the most efficient conditions for this process are formed (Lazarchuk V.V et al,2006), which often leads to clogging of the device or the case when a non-condensed phase passing through the device, therefore maximum filling of industrial desublimators by based product (G_{max}) rarely exceeds 80% and for devices of complex geometry, such as annular desublimators, this value is only 30-50%.

As a solid layer is formed, free cross section of desublimation device is reduced, and accordingly, gas velocity increases, surface temperature of desublimation and conditions of heat transfer from the product to the surface of desublimation device change (Gromov B.V, 1978). This leads to changing of surface temperature of desublimation which may lead to breakthrough of gaseous uranium hexafluoride through device, so gases which contain uranium hexafluoride, oxygen and surplus of fluorine pass through two or more serially connected desublimators after the fluorination step. In each subsequent device along the gas flow, the surface of desublimation increases. So the vital task is definition of optimal desublimation conditions of uranium hexafluoride from gas mixture for the purpose of control the front of desublimation in the device and increment of filling of desublimator by solid product due to its equal distribution in the device avoiding losses of the product associated with inefficiencies on the desublimation surface and prevention of sudden clogging of the device by solid uranium hexafluoride.

These problems can be solved assisted by the mathematical model for the process of desublimation, which has been developed by us, describing mass, thermal and hydrodynamic flows inside the device. This model allows to determine:

- mass flow of gas-vapor mixture and solid uranium hexafluoride in the device (material flows);
- coefficients of heat and mass transfer from gas-vapor mixture to solid surface;
- cooling time of gas-vapor mixture from initial temperature to the temperature of desublimation of uranium hexafluoride;
- velocity and mass of uranium hexafluoride producing from gas flow to solid phase per unit surface of desublimator;
- alteration of thermal and hydrodynamic flows within the device occurring due to increasing of thickness of product layer on the walls during desublimation process.

Calculation of annular-shape devices or flat plates is very complicated, so consider the mathematical model for determining of optimum thermal conditions for annular desublimation devices.

Material calculation for the process of desublimation of uranium hexafluoride

Material calculations were based on configuration of the flows in annular desublimator which enter and go out,

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