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A new way for improving efficiency of CECE-process based hydrogen isotope separation plant

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Development of nuclear energetics requires closure of nuclear fuel cycle (NFC). Since existing technologies cannot provide full extraction of tritium from irradiated nuclear fuel (INF) some aqueous media of INF reprocessing will be contaminated with tritium. Recycling this water will cause tritium accumulation in INF reprocessing system. Hence there is need to remove tritium from aqueous streams to avoid accumulation.
Different methods can be used for hydrogen isotope separation. One of the most effective methods is Combined Electrolysis and Catalytic Exchange process (CECE-process). The main advantages of this method are high separation factor and no need to use any additional reactants. The main disadvantages of this method are high energy consumption for electrolysis of water, hydrogen explosion hazard and lack of data on mass transfer in columns with diameter larger than 100 mm.
The main obstacle for using CECE-process is high operation costs. This paper describes one of ways to reduce operation costs through decreasing energy consumption per unit of detritiated water.
One of the basic parameters of separation process in counter-current column is Θ, the ratio of the extraction factor Γ to maximum achievable extraction factor Γm. Value of Γm is defined by thermodynamical properties of separation system and Γ is set by plant designer. Increasing Θ leads to enhancing of efficiency of column (in case of constant flow rate), but maximum value of Θ equal to unity can be achieved in column of infinite height.
The method proposed assumes increasing not Γ, but Γm by lowering temperature of column at single or multiple theoretical separation stages. Lowering temperature will cause increase of separation factor and hence Γm at this stages. Extraction factor following stages is lower than on the first one so there is no need to lower temperature at the rest of column height.
The main disadvantage of this method is increase of column height due to lowering mass transfer efficiency at low temperature. However, it should be mentioned that growth of capital cost of column could be compensated by lower operation costs (up to 10-15%) for phase reversal. In addition, there is some uncertainty in determination of separation process parameters in transition temperature zones.
In the paper estimation of effect of improving efficiency of separation column that could be achieved and results of some experiments showing realizability of this method are presented.

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