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SIMULATION MODULE OF PHYSICS EFFECT OF HYDROGEN ISOTOPIC MIXING IN CRYOGENIC DISTILLATION COLUMN

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Abstract
In the paper it is described the mathematical model of physics effect of hydrogen isotopic mixing in cryogenic distillation column, the algorithm to the numerical solving and the module of the computer code dedicated to this.
Keywords: hydrogen, isotope, cryogenic, distillation, simulation, mixer.

1. Introduction

The efficiently increase of tritium isotopic separation plants by cryogenic distillation require more distillation column than one - a *cascade*. In this structure of separation plants, two or more distillation columns are interconnected by multiple devices (catalytic equilibrators, control devices etc.). Figure 1 show usual structure of a cascade with for cryogenic distillation columns.

As the first effect in the computer simulated is the mixing problem: many liquid or vapor streams with the different isotopic concentrations and thermodynamic properties converge to the same points.

2. Method and samples

The mathematic model consists in four balance equations (of material) in principal:

$$\begin{aligned} D &= D_1 + D_2; \\ x_H &= \frac{D_1 x_H^1 + D_2 x_H^2}{D}; \\ x_D &= \frac{D_1 x_D^1 + D_2 x_D^2}{D}; \\ x_H &= \frac{D_1 x_T^1 + D_2 x_T^2}{D}; \end{aligned} \tag{1}$$

where:

D_1 - flow rate of top stream of column 1;

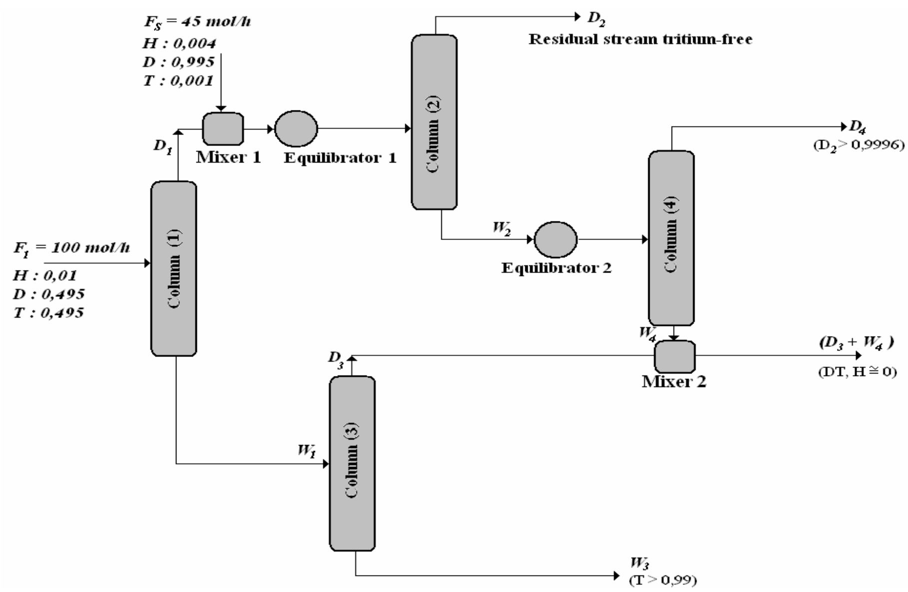

Fig. 1. Ordinary structure of cryogenic distillation plant

x_H^1, x_D^1, x_T^1 - atomic fractions of components *H, D, T* in D_1;

D_2 - flow rate of injected stream;

x_H^2, x_D^2, x_T^2 - atomic fractions of components *H, D, T* in D_2;

D - flow rate of total stream;

x_H, x_D, x_T - atomic fractions of components *H, D, T* in *D*.

Atomic fractions x_H^1, x_D^1, x_T^1 are obtained from material balance equations of top stream components (column 1):

$$
\begin{aligned}
x_H^1 &= x_{H_2}^1 + \frac{1}{2}\left(x_{HD}^1 + x_{HT}^1\right);\\
x_D^1 &= x_{D_2}^1 + \frac{1}{2}\left(x_{HD}^1 + x_{DT}^1\right);\\
x_T^1 &= x_{T_2}^1 + \frac{1}{2}\left(x_{HT}^1 + x_{DT}^1\right);
\end{aligned}
\tag{2}
$$

The calculation algorithm is simply and it is showed in figure 2:

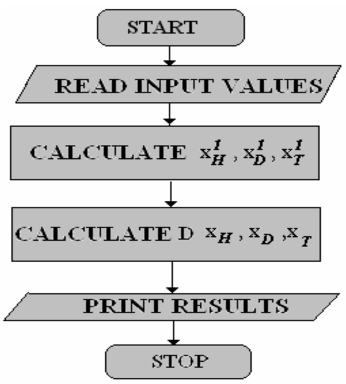

Fig. 2. Calculation algorithm for mixing

3. Results and Discussions

The experimental input values and the results of mixing simulation are the follows:

DEBITUL SI COMPOZITIA FLUXULUI 1
D1 = 25.00000 moli/h
XH1 = 3.999906000E-0002
XD1 = 9.399644500E-0001
XT1 = 2.003473723E-0002

DEBITUL SI COMPOZITIA FLUXULUI 2
D2 = 4.500000000E+0001 moli/h
XH2 = 4.000000000E-0003
XD2 = 9.399644500E-0001
XT2 = 1.000000000E-0003

DEBITUL SI COMPOZITIA FLUXULUI FINAL
D = 7.000000000E+0001 moli/h
XH = 1.685680714E-0002
XD = 9.753444464E-0001
XT = 7.798120439E-0003

The final results were in according with the experimental data.

4. Conclusions

The module dedicated of mixing problem is valid and may be considered a routine (external) for the simulated code of hydrogen isotopes cryogenic distillation.

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