ASPECTS OF HEAT AND MASS TRANSFER OF THE RECTIFICATION PROCESS IN LIMITED CONDITIONS

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Summary: The process of heat and mass transfer usually requires a high energy consumptiont for materials dehydration, separation of mixtures, the rectification of components with low boiling temperature and condensation with high boiling components. A particular interest consists in the separation of mixture (composition) in electric field, performing the mixture dispersion and transporting the unbalanced vapors.

Keywords: Heat transfer, mass transfer, electric field, electrodes, jet, temperature.

Introduction

The process of heat and mass transfer usually is quite intensive consumer of energy in case of material dehydration, separation of compositions in some sense, for rectification, combination and evaporation of components with low boiling and condensation of components with high boiling

To some extent, reducing the energy consumption and the rational organization of weight and heat transfer between unequal phases of liquid and vapors in a separated mixture, leads to unjustified increasing of dimensions of the mass transfer device and therefore, an increased consumption of energy.

A particular interest, represents the separation of a mixture in an electric field which occurs in the right direction and the separated mixture through dispersing of non-equilibrium transport vapors. As an example, we will study the jet movement between the electrodes.

It is studied the dispersion of a dielectric mixture and its transport through a narrow space, made electrodes plastids. The dispersed liquid is presented as jet, the distance between the plastids being much smaller than the size of the electrode.

The jet moves forward in the field of an electrode and transfers to the other through the non-equilibrium base vapors along the up aspirants plates, touching the opposite electrode due to the design characteristics, so it making a new movement on the opposite electrode. The normal functioning is ensured by the presence of the liquid phase of the film in both electrodes. The trial conduct in a gravitational field can provide the jet transfer over the gap. Taking into account the issue of a single stream and the degree of balance, it could be determined by temperature. The thermal coefficients are considered constant.

Process description

The process of heat and mass transfer can be written as an equation (1), with limit conditions (2) și (3).

$$\frac{\partial T}{\partial \tau} = a\frac{\partial^2 T}{\partial x^2} - \frac{a}{l^2}T + f(x_1\tau) \tag{1}$$

$$\frac{\partial T}{\partial x}(0,\tau) - \frac{\alpha}{\lambda}(T_n - T_0) = \Psi_1(\tau) \quad (2)$$

$$\frac{\partial T}{\partial x}(l,\tau) - \frac{\alpha}{\lambda}(T_n - T_0) = \Psi_2(\tau) \quad (3)$$

$$T(x,0) = \varphi(x)$$

We are considering position in space.
We will introduce a new function: (4)

$$\Psi(x,\tau) = (\alpha_1 x + \beta_1)\Psi_1(\tau) + (\alpha_2 x + \beta_2)\Psi_2(\tau) \quad (4)$$

From the equations and limit conditions are defined the value of coefficients (5):

$$\alpha_1 = \frac{1}{\alpha + \frac{\alpha}{\lambda}l};\ \beta_1 = \frac{1 + \frac{\alpha}{\lambda}l}{(\alpha + \frac{\alpha}{\lambda}l)\frac{\alpha}{\lambda}};\ \alpha_2 = \frac{1}{\alpha + \frac{\alpha}{\lambda}l};\ \beta_2 = \frac{1}{(\alpha + \frac{\alpha}{\lambda}l)\frac{\alpha}{\lambda}} \quad (5)$$

The equation solution will be sought in form of (6):

$$T(x,\tau) = V(x,\tau) + \Psi(x,\tau), 0 < x < l \quad (6)$$

We define function V(x, τ): (7)

$$\frac{\partial V}{\partial \tau} = a\frac{\partial^2 V}{\partial x^2} + f^{\circ}(x,\tau), 0 < x < l;\ 0 < \tau < \infty \quad (7)$$

Limit conditions are taken as: (8)

$$\frac{\partial V}{\partial x}(0,\tau) - \frac{\alpha}{\lambda}(0,\tau) = 0$$

$$\frac{\partial V}{\partial x}(l,\tau) + \frac{\alpha}{\lambda}V(l,\tau) = 0 \quad (8)$$

$$V(x,0) = \varphi^*(x), 0 < x < l \quad (9)$$

$$f^*(x,\tau) = f(x,\tau) - (\alpha_1 x + \beta_1)\Psi_1'(\tau) - (\alpha_2 x + \beta_2)\Psi_2'(\tau) \quad (10)$$

$$\varphi^*(x) = \varphi(x) - (\alpha_1 x + \beta_1)\Psi_1(0) - (\alpha_2 x + \beta_2)\Psi_2(0) \quad (11)$$

The solution will be requested as: (12)

$$V(x,\tau) = \sum_{n=1}^{\infty} V_n(\tau)X_n(x), \qquad 0 < x < l, 0 < \tau < \infty \quad (12)$$

Where Xn (x) - the functions of the limit value: (13)

$$X''(x) + \lambda^2 X(x) = 0, \qquad 0 < x < l \quad (13)$$

$$\left.\begin{aligned} X'(0) - \frac{\alpha}{\lambda}X(0) = 0 \\ X'(l) + \frac{\alpha}{\lambda}X(l) = 0 \end{aligned}\right\} \quad (14)$$

It defines the function $V_n(\tau)$. This must satisfy the initial conditions and the limit conditions, and the differential equation. To do this, we list a number of its functions Xn (x). (15)

$$f^*(x,\tau) = \sum_{n=1}^{\infty} \theta_n(\tau) X_n(x), \qquad 0 < x < l, \qquad 0 < \tau < \infty \tag{15}$$

$$\theta_n(\tau) = \frac{2\lambda_n^2}{(\lambda_n^2 + n^2)l + 2h} \int_0^l f^*(z,\tau) X_n(z) dz \tag{16}$$

$$\varphi^* = \sum_{n=1}^{\infty} a_n X_n(x), \qquad 0 < x < l \tag{17}$$

$$a_n = \frac{2\lambda_n^2}{(\lambda_n^2 + h^2)l + 2h} \int_0^l f^*(z) Z_n(z) dz, \qquad 0 < x < l, \qquad 0 < \tau < \infty \tag{18}$$

Solving equations (12), (15) and (7), assuming that the series (15) converges uniformly, then we get: (19)

$$\sum_{n=1}^{\infty} V'_n(\tau) + a^2 \lambda_n^2 V_n(\tau) = \theta_0(\tau)\, X_n(x) = 0, \qquad 0 < x < l, \qquad 0 < \tau < \infty \tag{19}$$

For equality (19) is required to comply with the equation: (20)

$$V''_n(\tau) + a^2 \lambda_n^2 V_n(\tau) = \theta_n(\tau), \qquad 0 < \tau < \infty \tag{20}$$

Supposing in (12) $\tau = 0$ and equaling (17) with (9) we get: (21)

$$\sum_{n=1}^{\infty} [V_n\,(0) - a_n] X_n(x) = 0, \qquad 0 < x < l \tag{21}$$

For equality (2) is sufficient: (22)

$$V_n(0) = a_n \tag{22}$$

$$\mathscr{b}_n(\tau) = \int_0^{\tau} l^{-a^2 \lambda_n (\tau - \tau_0)} \theta_n(\tau) d\tau + a_n l^{-a^2 \lambda_n \cdot \tau}$$

Solving the differential equation (20) with initial conditions (22) we get: (23)

$$V(x,\tau) = \int_0^{\tau} d\tau \int_0^l f^*(z,\tau) \mathscr{b}(x,z,\tau - \tau_0) dz + \int_0^l \varphi^*(z) \mathscr{b}(x,z,\tau) dz \tag{23}$$

$$unde\ \mathscr{b}(x,z,\tau - \tau_0) = \sum_{n=1}^{\infty} l^{-(a^2 \lambda_n^2 + h)(\tau - \tau_0)} \cdot \frac{X_n(x) X_n(z)}{\|X_n\|^2}$$

$$\varphi^*(x) = \Psi(x,0)$$

$$\|X_n\|^2 = \int_0^l X_n^2(x)dx = \frac{(\lambda_n^2 + H^2)l + 2H}{2\lambda_n^2}$$

The solution of the problem is written as:

$$T(x,\tau) =$$
$$= \int_0^\tau d\tau \int_0^l f^*(z,\tau) \cdot \sum_{n=1}^{\infty} l^{-(a^2\lambda_n^2+h)(\tau-\tau_0)} \cdot \frac{X_n(x)X_n(z)}{\|X_n\|^2} +$$
$$+ \int_0^l \varphi^*(z) \sum_{n=1}^{\infty} l^{-(a^2\lambda_n^2+h)(\tau-\tau_0)} \cdot \frac{X_n(x)X_n(z)}{\|X_n\|^2} + \left(\frac{x}{2+\frac{\alpha}{\lambda}l} + \frac{1+\frac{\alpha}{\lambda}l}{\left(2+\frac{\alpha}{\lambda}l\right)\frac{\alpha}{\lambda}} \right) \Psi_1(\tau) +$$
$$+ \left(\frac{x}{2+\frac{\alpha}{\lambda}l} + \frac{1}{\frac{\alpha}{\lambda}\left(2+\frac{\alpha}{\lambda}l\right)} \right) \Psi_2(\tau)$$

Conclusion

The resulting report allows to determine the flow temperature between the electrodes (its distribution between the plastids distance (the gap). At a stable state, the fluid parameters on the opposite side must be close to equilibrium. Otherwise, it is necessary to increase the gap. The parameters of the jet which is separated from the condensate, depends on position from the electrode plaque (2 axis).

The solution obtained by the x-axis is influenced by the z component, and this effect is due to changes in the composition of the film that flows to the opposite electrode plaque. The compactness of this device depends on the density of the jet stream. A more detailed analysis of this issue is beyond the scope of our study.

Bibliography

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