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THEORETICAL STUDY OF THE MOTION OF A DROP WITH A PARTICLE MASS

A large number of works is devoted to the study of the hydrodynamic interaction of a spherical particle at low Reynolds numbers, [1]. In doing so, both solid particles and droplets were considered. However, consideration of the influence of substance evaporation from the particle surface was carried out with a large number of approximations [2]. In this regard, the purpose of our work is to perform theoretical analysis of drop motion with simultaneous evaporation of substance from its surface.

The evaporation rate of water is described by the equation:

$$w = \beta_y \left(p_н - p \right) MF, (1)$$

where w-evaporation rate,

For the calculation of mass efficiency, we apply the Fresling equations:

$$\mathrm{Sh} = 2 + 0,6\,\mathrm{Re}^{0,5}\,\mathrm{Sc}^{0,333}.(2)$$

At the same time, Sherwood's number can be expressed as:

$$\mathrm{Sh} = \frac{\beta_y dRT}{D}.$$ **Ошибка! Закладка не определена.**

From equations (2) and (3) we can express the mass transfer coefficient:

$$\beta_y = \frac{D}{\delta RT}\left(2 + 0,6\,\mathrm{Re}^{0,5}\,\mathrm{Sc}^{0,333}\right). (3)$$

Then, taking into account equation (4), equation (1) takes the form:

$$w = \frac{\pi D p_н M d}{RT}\left(2 + 0,6\,\mathrm{Re}^{0,5}\,\mathrm{Sc}^{0,333}\right). (4)$$

The evaporation rate of a drop can also be described with the help of the equation:

$$w = -\frac{\mathrm{d}m}{\mathrm{d}t} = -\frac{\mathrm{d}}{\mathrm{d}t}\left(\frac{\pi d^3}{6}\rho_ж\right) = -\frac{\pi \rho_ж d^2}{6}\frac{\mathrm{d}d}{\mathrm{d}t}, (5)$$

By equating the right parts of equations (5) and (6), after appropriate transformations we can write down:

$$-\frac{\mathrm{d}d_\text{к}}{\mathrm{d}t}=\frac{4Dp_\text{н}M}{RT\rho_\text{ж}d_\text{к}}\left(1+0{,}1\mathrm{Sc}^{1/3}\left[\frac{(\rho_\text{ж}-\rho)\rho g}{2\mu^2}\right]^{1/2}d_\text{к}^{3/2}\right).(6)$$

We enter the following designations:

$$A=\frac{2Dp_\text{н}M}{RT\rho_\text{ж}};\ B=\left(0{,}1\mathrm{Sc}^{1/3}\left[\frac{(\rho_\text{ж}-\rho)\rho g}{2\mu^2}\right]^{1/2}\right)^{-\frac{1}{3}}.$$

Taking into account the accepted designations, by integrating equation (7) after the transformations we will finally obtain the time during which the particle will completely evaporate.

$$t=\frac{B^4}{A}\left(\frac{x_0}{B}-\frac{1}{6}\ln\frac{\left(1+\frac{x_0}{B}\right)^2}{\left|1-\frac{x_0}{B}+\left(\frac{x_0}{B}\right)^2\right|}-\frac{1}{\sqrt{3}}\left(\mathrm{arctg}\left(\frac{2\frac{x_0}{B}-1}{\sqrt{3}}\right)+\mathrm{arctg}\left(\frac{1}{\sqrt{3}}\right)\right)\right)(7)$$

Path h which passes a drop until it completely evaporates, we calculate by using the equation: or

$$\mathrm{d}h=\frac{(\rho_\text{ж}-\rho)gB^3d_\text{к}^3\mathrm{d}d_\text{к}}{36\mu A\left(B^3+d_\text{к}^{3/2}\right)}.(8)$$

By entering the designation $C=\frac{18\mu A}{(\rho_\text{ж}-\rho)g}$, we make a note of

$$\mathrm{d}h=\frac{B^3}{C}\left(x^4-B^3x+\frac{B^6x}{B^3+x^3}\right)\mathrm{d}x.(9)$$

By integrating, we get

$$h=\frac{B^8}{C}\left[\frac{1}{5}\left(\frac{x_0}{B}\right)^5-\frac{1}{2}\left(\frac{x_0}{B}\right)^2-\frac{1}{6}\ln\frac{\left(1+\frac{x_0}{B}\right)^2}{\left|1-\frac{x_0}{B}+\left(\frac{x_0}{B}\right)^2\right|}+\frac{1}{\sqrt{3}}\left(\mathrm{arctg}\frac{2\frac{x_0}{B}-1}{\sqrt{3}}+\mathrm{arctg}\frac{1}{\sqrt{3}}\right)\right].(10)$$

LITERATURE

1. Грин *Х.,* Лэйн В. Аэрозоли – пыли, дымы и туманы. Ленинград: Химия; 1972. 427 с.

2. Лыков А.В. Тепломассообмен в процессах испарения // Инженерно-физический журнал. –1962. Т. 5, № 11. – С. 12–24.