**Evaluation of Transfer Coefficients: Engineering Correlations**

**Heat Transfer Correlations**

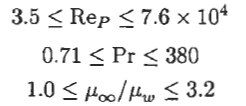
If a spherical object is immersed in an infinite stagnant fluid, the analytical solution for the steady-state conduction can be expressed in the following form:

Nu=2

If there is a fluid flow, contribution of the convective mechanism needs to be included in the total heat transfer. Correlation, which includies the convective heat transfer, is as followings:



Physical properties except the viscosity at the wall should be evaluated at the bulk temperature. The given expression is valid for the following conditions:



After the average heat transfer coefficient is calculated, the rate of heat transfer can be calculated as followings:



**Mass Transfer Correlations**

If a spherical object is immersed in an infinite stagnant fluid, the analytical solution for the steady-state diffusion can be expressed in the following form:

Sh=2

If there is a fluid flow, contribution of the convective mechanism needs to be included in the total mass transfer. Correlation, which includies the convective mass transfer, is as followings:



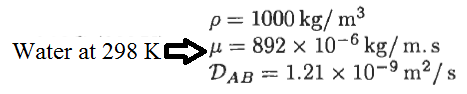
Steinberger and Treybal at 1960 proposed the given correlation, which includes a correction term for natural convection. The given expression is valid for the following conditions:



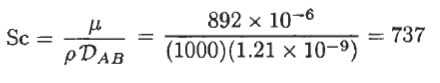
After the average mass transfer coefficient is calculated, the rate of mass transfer can be calculated as followings:



**Example**: A spherical object made of benzoic acid with a desity of 1267 kg/m3 and with a diameter of 12 mm is dropped in a long cylindrical vessel filled with pure water at 25°C. If the height of the vessel is 3 m, determine the amount of benzoic acid dissolved from the spherical object when it reaches the bottom of the vessel. The solubility value of benzoic acid in water is 3.412 kg/m3.



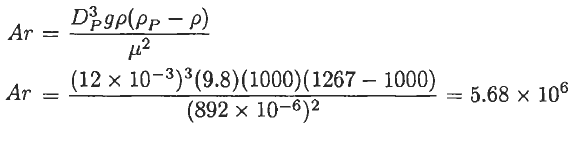
**Solution:**



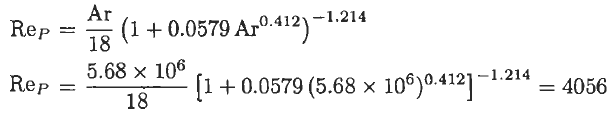
Assumptions:

1. The spherical object reaches its terminal velocity instantaneously.
2. The diameter of the spherical object does not change along the vessel, which means that the Reynolds number and the terminal velocity remain constant along the vessel.
3. Steady-state condition
4. The physical properties of fluid phase “water” do not change as a result of mass transfer

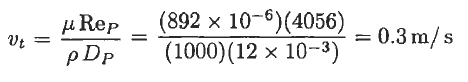
In order to determine the terminal velocity of the spherical object made of benzoic acid, the Archimedes number needs to be used:



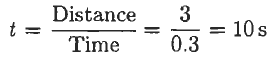
The Reynolds number is calculated from the given correlation below:



The terminal velocity can be can be calculated using the Reynolds number:



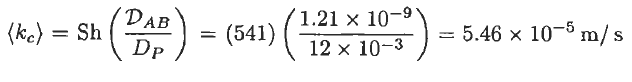
Since the spherical object made of benzoic acid falls the distance of 3 m with a velocity of 0.3 m/s then the falling time can be calculated as followings:



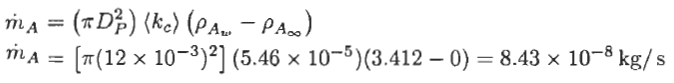
The Sherwood number can be calculated from the following correlation:



The average mass transfer coefficient can be calculated using the following correlation:



The rate of mass transfer of benzoic acid into the fluid phase “water” ca be calculated by using the following equation:



The amount of benzoic acid transferred from the spherical object made of benzoic acid ca be calculated as followings:



**References**:

İ. Tosun, “MODELLING IN TRANSPORT PHENOMENA A Conceptual Approach”, Elsevier, 2002.