An-Najah National University
Effluent Treatment Processes for Energy Industry (10626584)
Tutorial 05 - Granular Depth Filtration - Spring 2019
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1. Using the equation developed by Rose, determine the headloss through a 750-mm sand bed for a filtration rate of 240 L/m^2.min. Assume that the sand bed is composed of spherical unitized sand with a diameter 0.5 mm and a porosity of 0.40. The kinematic viscosity is equal to 1.306 x 10^{-6} m^2/s.
   If a 0.3-m layer of uniform anthracite is placed on top of the sand bed, determine the ratio of the headloss through the anthracite to that of the sand. Assume that the grain size diameter of the anthracite is 2.0 mm and porosity is 0.5. Will intermixing occur? Assume ϕ for anthracite = 0.73, ρ anthracite = 1.7 g/cm^3, and ρ sand = 2.65 g/cm^3

2. A wastewater containing 1.3 mg/L particulate matter is to be treated in depth anthracite filtration processes at temperature of 15 °C. A pilot study showed that σ_B and k_{HL} can be described by the following equations:

$$\sigma_B = \frac{\left[2.85\times10^3\left(\frac{mg}{m^{1.5}h^{0.5}}\right)\right]}{v^{0.5}d}$$

$$k_{HL} = \left[1.37\times10^{-6}\left(\frac{m.L}{mg}\right)\right]\frac{L}{d}$$

   The proposed design for the full-sale filters is given as
   $v = 12\frac{m}{h}$, $ES = 1.0\ mm$ and $H_T = 2.5\ m$
   Assume the clean headloss can be estimated using Ergun's equation with anthracite porosity, $\epsilon = 0.5$ and sphericity, $\emptyset = 1.0$. The expected effluent particle concentration is 0.01 mg/L. Based on the above given information determine:

   a. The optimal filter bed depth
   b. The optimal time for breakthrough corresponding to the bed depth found in (a)

Hint: plot the time to breakthrough and the time to the limiting head as a function of bed depth from 1.0 to 2.5 m.

3. A filter is backwashed at 40 m/h at 15 °C. Determine whether a 0.1 mm particle of sand will be washed from the filter?

4. Using the Yao filtration model, $\frac{C}{C_o} = exp\left(\frac{-3(1-\varepsilon)\eta\alpha L}{2d_c}\right)$, examine the effect of filtration rate on filter performance for particles with diameters of 0.1, 1.0 and 10 μm. Assume a mono-dispersed media of d_c =0.5 mm diameter, porosity 0.42, particle density 1020 kg/m^3, filtration rate 10 m/h, filter depth 1 m, temperature 20°C, and attachment efficiency, α=1.0. Plot your results as C/C$_o$ against filtration rate over a range from 1 to 25 m/h. Comment on the effect of filtration rate and particle size on the filter performance.