S2.6.3 A Modified Ergun Equation for Yield Stress Fluid Flow through the Porous Media

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Filter cakes are widely used throughout many engineering processes. Fluid flow through a filter cake is driven by a pressure difference to overcome the flow resistance due to friction forces. Prediction of the pressure drop is essential for design of filter equipment to ensure sufficient pump power is available. The Ergun equation is a common correlation used to calculate the pressure drop of Newtonian flows through beds and filter cakes of granular materials. Ergun's equation is based on a model that simulates the porous medium as a bundle of capillary tubes. Many of the liquids we encounter in the different industries do not obey the Newtonian relationship between the shear stress and shear rate. Liquids such as high molecular weight polymer melts and polymer solutions as well as slurries of fine suspended particles (drilling muds, cements, mortars, foams, and toothpaste) require the applied stress to exceed a yield stress for the fluid to flow. When these yield stress fluids flow through a packed bed or filter cake they the flow dynamics are significantly different than for flows of Newtonian fluids. This means the Ergun Equation is not applicable to yield stress fluid flow in packed beds and filter cakes.

In this work, a modified Ergun Equation is derived for yield stress fluids. The correlation is fitted to experimental data to fit one parameter that accounts for the deviation of the pore geometry from the capillary tubes used to derive the model. Comparison of models between a Newtonian and a yield stress fluid flowing through a packed bed shows the yield stress fluid performs similar to the Newtonian fluid at large Reynolds numbers. At low Reynolds numbers the yield stress effect becomes dominant and the flow rate significantly decreases compared to the Newtonian fluid for similar operating conditions.