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Demonstration of creep during filtration

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Deformation of particles and particle structure is not an instant process as is assumed in current filtration models – if it takes time. This time dependent stress relation is called CREEP. As the specific filter-cake resistance (α) is a function of the compressibility α will be time dependent if the system exhibit creep.

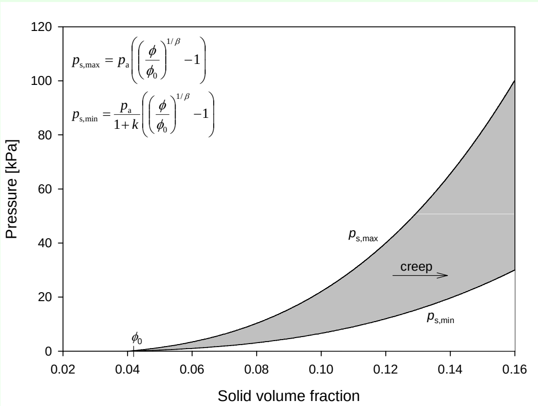

Figure 1: Development of solid pressure.
$p_{s,max}$ denotes the solid pressure of uncompressed particles whereas $p_{s,min}$ denotes the solid pressure of instantly compressed particles. Creep may be understood as the time dependent transition from $p_{s,max}$ to $p_{s,min}$.
Input data ϕ_0 = 0.04, p_a = 400 Pa, β = 0.32 and k = 2.336

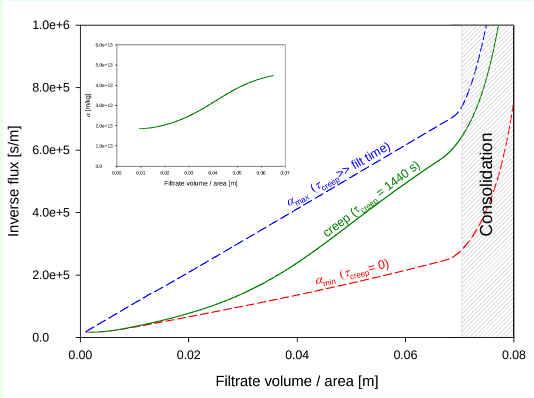

Figure 2: Ruths plot of a) uncompressed particels (in red), b) compressed particles, and c) a system which exhibits creep i.e. with a relaxation time comparable to the filtration time. The inserts shows
Numerical simulation of cake filtration at 1 bar.
Input data ϕ_s = 0.006, α = 2.56·10^{12} m/kg, n = *1.6, and data from Fig. 1.*

Creep has been adopted in conventional filtration model by introducing a excess pressure defined in Eq. (1) as well as a time constant (τ_{creep}) and creep constant (k). Further existing constitutive equation has been slightly modified Eq. (2).

Eq. (1) $$\frac{dp_{excess}}{dt} = k\frac{dp_s}{dt} - \frac{p_{excess}}{\tau}$$

Eq. (2) $$\left(\frac{1-\varepsilon}{1-\varepsilon_0}\right)^{1/\beta} = \left(\frac{\alpha}{\alpha_0}\right)^{1/n} = 1 + \frac{p_s - p_{excess}}{p_a}$$

The creep phenomena is primarily expected when deformable organic slurries are filtered As the creep phenomena is time dependent, the manifestation of creep will depend on the filtration time, subsequently the mass load of the filter.

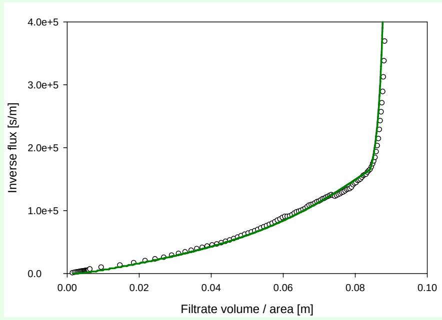

Figure 3:. Filtration data of 6 g/L activated sludge (circles) at 1 bar along with the fitted line, based on a numerical model in which creep is accounted for (green line).

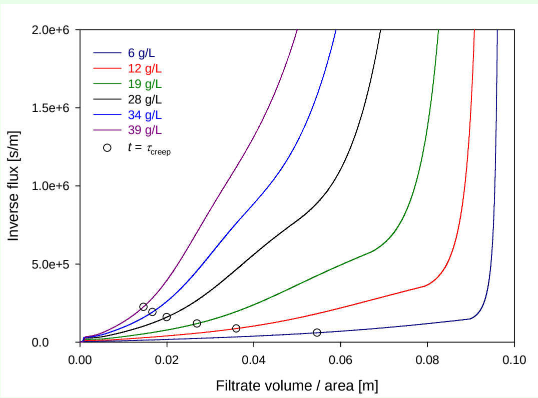

Figure 4: Ruths of model filtration with varying solid concentrations (Data corresponding to the creep relaxation, τ_{creep}. As the solid concentration increase, less filtrate is produced in a given time and, hence the transition from a lower resistance to a higher resistance occurred at lower filtrate volumes.

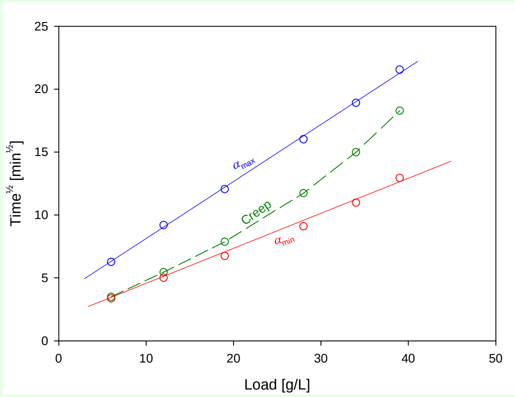

Figure 5: Crucial to the scaling of the filtration process is the relation between the time it takes to produce a given filtrate volume (t_v) and the mass load of the filtrate (m_L) i.e. $t_v \propto m_L^2$ or $t_v^{½} \propto m_L$. In the figure is shown t_v (at 0.04 m^3 of filtrate per area, m^2), m_L relationship for uncompressed particles (red line) and compressed particles (blue line). Both of these exhibits the expected $t_v^{½} = m_L$ relationship. For the system that exhibits creep is seen that the tv, m_L – relationship does not hold.