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Importance of Scale Analysis Method in Porous Media under the Action Mechanical Vibrations

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Here in this short note, we explain the hypotheses leading to the time averaged system of equations. In time averaged equations we can distinguish two different time scales: one is "Slow" time scales. The other is "Rapid or Fast" time scales. These time scales will be explained here. We use the scales of oscillating momentum equation in porous media:

$$\left[\frac{\rho_0 v' \omega}{\varepsilon}\right]\left[\nabla P'\right], \left[\rho_0 \beta_T \Delta T b \omega^2\right], \left[\beta_T \rho_0\ \delta T' g\right], \left[\rho_0\ \beta_T \delta T' b \omega^2\right], \left[\frac{\mu v'}{K}\right] \qquad (1)$$

Assuming $\delta T' \ll \Delta T$, *we find* the scale of the oscillating velocity as:

$$v' = \varepsilon \beta_T \Delta T b \omega \qquad (2)$$

Also, by assuming that $\frac{\varepsilon v}{K\omega} \ll 1$, which allows us to neglect the frictional (diffusive) term in the oscillatory momentum equation.

Following the same procedure in the oscillator energy equation, we obtain the scale of oscillating temperature as:

$$\delta T' = \frac{1}{\sigma} \varepsilon \beta_T \Delta T^2 \frac{b}{H} \quad \left(\sigma = \frac{(\rho c)_*}{(\rho c)_f}\right) \qquad (3)$$

Also, In Energy equation, we may neglect the diffusion(conductive) terms under the condition:

$$\tau_{vib} \ll \tau_{con} = \frac{\sigma H^2}{a^*}, \left(a^* = \frac{*}{(\rho c)_f}\right) \qquad (4)$$

We emphasize that ω→∞. The convective oscillation terms can be neglected by the following assumptions:

$$b \ll \frac{H}{\frac{\varepsilon}{\sigma} \beta_T \Delta T} \qquad (5)$$

The above relation is the necessary condition for small amplitude vibrations.

By replacing the oscillatory temperature (δT') in the convective terms, we can neglect them:

$$\omega^2 \gg \frac{g}{H} \times \frac{\varepsilon \beta_T \Delta T}{\sigma} \qquad (6)$$

The above relation gives the frequency range for obtaining high-frequency vibrations. The conditions of achieving high frequency vibrations in porous media are compared with those of fluid media:

Fluid Media	***Porous Media***
$\tau_{vib} \ll min(\frac{H^2}{\nu}, \frac{H^2}{a})$	$\tau_{vib} \ll min(\frac{K}{\nu\varepsilon}, \frac{H^2}{a^*})$
$b \ll \frac{H}{\beta_T \Delta T}$	$b \ll \frac{H}{\frac{\varepsilon}{\sigma}\beta_T \Delta T}$
$\omega^2 \gg \frac{g}{H}\beta_T\ \Delta T$	$\omega^2 \gg \frac{g}{H}\frac{\varepsilon}{\sigma}\beta_T\ \Delta T$

Table 1: Comparison of scale analysis results in Fluid Media with those Porous Media.

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