Temperature Profile in Homogenous Stationary Pipe Flow Analytical Ramey @model

Motivation

Analytical model of temperature step-response in a Homogenous Stationary Pipe Flow with account for the heat exchange with surroundings Unknown macro: 'single-cite'.

Model equally works for wellbore flow, ground, on-ground and bottom-water pipelines.

Outputs

$T(t,l)$	Along-hole Temperature Profile

where

t	Flowing duration
l	Length along pipe

Inputs

T_s	Intake temperature	$T_e(l)$	Background temperature of the surroundings
$\dot m$	Mass flowrate	U	Heat Transfer Coefficient (HTC) between pipe fluid and surroundings
a_e	Thermal Diffusivity of the surroundings	r_f	Flowing pipe radius
λ_e	Thermal Conductivity of the surroundings	r_w	Wellbore radius

Equations

(1) $T(t,l) = T_e(l) - R(t)\, G_e(l) + \Big[T_s - T_e(0) + R(t)\, G_e(l) \Big] \cdot e^{-l/R(t)}$	(2) $G_e = \frac{dT_e}{dl}$	(3) $t_D(t) = \frac{a_e\, t}{r_w^2}$
(4) $R(t) = \frac{\dot m\, c_p}{2\pi\, \lambda_e} \cdot \Big(T_D(t) + \frac{\lambda_e}{r_f\, U} \Big)$	(5) $T_D(t) = \ln \Big[e^{-0.2\, t_D} + (1.5 - 0.3719\, e^{-t_D})\, \sqrt{t_D} \Big]$	

Assumptions

Intake Flowrate is constant in time	Intake Temperature is constant in time

$q_s(t) = q_s = \text{const}$	$T_s(t) = T_s = \text{const}$
Thermal diffusivity of the surroundings is constant along-hole	**Thermal Conductivity of the surroundings is constant along-hole**
$a_e(l) = a_e = \text{const}$	$\lambda_e(l) = \lambda_e = \text{const}$
Flowing pipe radius is constant along-hole	**Wellbore radius is constant along-hole**
$r_f(l) = r_f = \text{const}$	$r_w(l) = r_w = \text{const}$
Heat Transfer Coefficient (HTC) between pipe fluid and surroundings is constant along-hole	
$U(l) = U = \text{const}$	

See Also

Physics / Fluid Dynamics / Pipe Flow Dynamics / Pipe Flow Simulation / Temperature Profile in Pipe Flow @model / Temperature Profile in Homogenous Pipe Flow @model

References

Unknown macro: 'cite-summary'