Wellbore Temperature Profile @model

Motivation

One of the key tasks of in Pipe Flow Dynamics is to predict the along-hole temperature distribution during the stationary fluid transport.

In many practical cases the temperature distribution for the stationary fluid flow can be approximated by homogenous fluid flow model.

Pipeline Flow Temperature Model is addressing this problem with account of the varying pipeline trajectory, pipeline schematic and heat transfer with surroundings around pipeline.

Outputs

$T(t,l)$	along-pipe temperature distribution and evolution in time

Inputs

$\mathbf{r}(l)$	pipeline trajectory, $\mathbf{r} = \mathbf{r}(l) = \{x(l),\ y(l),\ z(l)\}$	$\rho(T,p)$	fluid density
$A(l)$	pipeline cross-section area	$\mu(T,p)$	fluid viscosity
$T_0(t)$	inflow temperature	$T_{e0}(l)$	initial temperature of the surroundings around the pipeline
p_0	inflow pressure	$c_p(l)$	specific heat capacity of the surroundings around pipeline
q_0	inflow rate	$\lambda_e(l)$	thermal conductivity of the surroundings around pipeline
$U(l)$	heat transfer coefficient based on pipeline schematic		

Physical Model

Stationary flow	Homogenous flow	Axial symmetry around the pipe

Mathematical Model

Heat transfer in wellbore due to convection and conduction along the wellbore flow	Heat transfer in rocks around the wellbore due to conduction
(1) $\rho \, c \, \frac{\partial T}{\partial t} = \frac{d}{dl} \left(\lambda \, \frac{dT}{dl} \right) - \rho \, c \, v \, \frac{dT}{dl} + \frac{2 \lambda}{\lambda_e} \cdot \frac{r_f}{r_w^2} \cdot U \cdot [T_e(t, l, r_w) - T]$	(2) $\rho_e \, c_e \, \frac{\partial T_e}{\partial t} = \nabla (\lambda_e \nabla T_e)$
(3) $T(t=0, l) = T_{e0}(l)$	(4) $T_e(t=0, l, r) = T_{e0}(l)$
(5) $T(t, l=0) = T_0(t)$	(6) $T_e(t, l, r \rightarrow \infty) = T_{e0}(l)$
(7) $T(t, l = l_{max}) = T_{e0}(l_{max})$	(8) $T_e(t, 0, r) = T_s(t)$
	(9) $T_e(t, l_{max}, r) = T_{e0}(l_{max})$
Heat exchange between wellbore fluid and rocks around the wellbore	
(10) $2\pi \, \lambda_e \, r_w \, \frac{\partial T_e}{\partial r} \bigg|_{r=r_w} = 2\pi \, r_f \, U \cdot \left(T_e \bigg|_{r=r_w} - T \right)$	

(see Derivation of Stationary Isothermal Homogenous Pipe Flow Pressure Profile @model)

Proxy Models

Linear superposition of Homogenous Pipe Flow Temperature Profile @model and Linear Semiplane Temperature Profile @model

See also

Physics / Fluid Dynamics / Pipe Flow Dynamics / Pipe Flow Simulation

[Heat Transfer][Heat Transfer Coefficient (HTC)] [Heat Transfer Coefficient @model]

[Wellbore Injection Homogeneous Flow @model] [Temperature Profile in Wellbore Injection Homogeneous Flow Analytical @model]

[Wellbore Homogeneous Flow Production @model] [Temperature Profile in Wellbore Production Homogeneous Flow Analytical @model]

References

https://en.wikipedia.org/wiki/Darcy_friction_factor_formulae

https://neutrium.net/fluid_flow/pressure-loss-in-pipe/