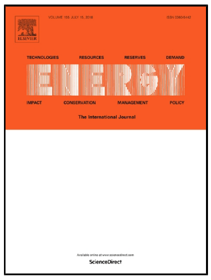
Accepted Manuscript



Improved thermal transient modeling with new 3-order numerical solution for a district heating network with consideration of the pipe wall's thermal inertia

Hai Wang, Hua Meng

PII: S0360-5442(18)31279-9

DOI: 10.1016/j.energy.2018.06.214

Reference: EGY 13256

To appear in: *Energy*

Received Date: 30 March 2018

Accepted Date: 28 June 2018

Improved thermal transient modeling with new 3-order numerical solution for a district heating network with consideration of the pipe wall's thermal inertia

Hai Wang, Hua Meng*

School of Mechanical Engineering, Tongji University, No. 1239, Siping Road, Shanghai 200092, China

Abstract: An improved thermal transient model was put forward to predict the thermal transient behavior of a long pipe. The model took particular consideration of the influences of the pipe wall's thermal inertia. Then a new 3-order numerical solution was presented to solve the proposed model. The new solution would not only preserve the sharp temperature front during the heat propagation, but also achieve fine computational accuracy even for the coarse grids. In addition, the proposed model and numerical solution could be easily coupled with enormous common hydraulic models to be available to a general DH network. The model and solution were validated in a real DH system. The simulation results had a good agreement with the measured data. Furthermore, in order to quantify the degree of the influence of pipe wall's thermal inertia, a practical indicator was developed based on ten types of often-used pipes in the DH projects. The research results showed that, for the large pipes with diameters over DN 200, the simulation errors caused by neglecting the pipe wall's thermal inertia were no more than 10%, which meant it was unnecessary to consider the thermal inertia for larger diameter pipes during the process of modeling.

Key words: District heating, Thermal transient model, 3-order numerical solution, Thermal inertia, Pipe network

Nomenclature			
d	diameter (m)	u	specific internal energy of water (J/kg)
e	water energy (J/kg)	v	velocity (m/s)
f	friction factor	$\dot{V}$	volume flow rate (m^3/s)
g	gravity acceleration (m/s^2)	*Subscripts*	
h_{i}	convective heat transfer coefficient between the inner pipe wall and water ($W/(m^2 \cdot K)$)	f	water flow
h_{o}	convective heat transfer coefficient between the casing and soil ($W/(m^2 \cdot K)$)	i	inner
k	thermal conductivity ($W/(m \cdot K)$)	o	outer
L	length of the pipe (m)	soil	ground soil
P	pressure (Pa)	w	pipe wall
Pr	Prandtl number	*Greek symbols*	
Q	heat flux (W)	ρ	density (kg/m^3)
q_{v}	specific heat loss in volume (W/m^3)	φ	indicator of thermal inertia
Re	Reynold number	*Abbreviations*	
r	radius (m)	4GDH	4th Generation District Heating
T	temperature (K)	CV	control volume