THE NUMERICAL MODELING AND THE INFRARED THERMOGRAPHY APPLIED TO THE DETECTION OF FLUIDS NATURE IN PIPES

Authors:

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INTRODUCTION
PLAN

Introduction

Description of the adopted model

Simulation Results

Conclusion
We considered two pipes commonly used in industrial networks. A metal pipe represented by a steel pipe, and another in plastic in PVC.

**The geometrical characteristics of the two pipes used in this study**

<table>
<thead>
<tr>
<th>characteristics</th>
<th>Pipe 1 (Steel)</th>
<th>Pipe 2 (PVC)</th>
</tr>
</thead>
<tbody>
<tr>
<td>tube length</td>
<td>1000 mm</td>
<td>1000 mm</td>
</tr>
<tr>
<td>inside diameter</td>
<td>80 mm</td>
<td>100 mm</td>
</tr>
<tr>
<td>thickness</td>
<td>3 mm</td>
<td>7 mm</td>
</tr>
</tbody>
</table>
In the model we studied two modes of heat exchange: Exchange of heat by conduction in the metal part of the pipe and heat exchange by convection between the inner surface of the pipe and the considered fluid that completely filled pipe.

The thermal response of the inspected pipe is raised in the form of the surface temperature.

The determination of the spatial distribution of this surface temperature of pipe is obtained by solving the following equation of heat:

\[
\frac{\lambda}{\rho c} (\Delta T) = \frac{\partial T}{\partial t}
\]

- \( \lambda \): the thermal conductivity (W/(mK))
- \( \rho \): the density (kg/m^3)
- \( c \): the specific heat (J/(kg.K))
- \( T \): surface temperature (°K)
- \( \Delta T \): the temperature of the pipe surface (°K)
The external faces of the pipes are exposed to a constant density $Q = 50 \text{ W/m}^2$.

- The initial temperature of the pipe is assumed: $T_0 = 293 \degree \text{ K}$.
- The internal are convective heat exchange with fluids.
- Velocity=0.013 [m / s].
- The initial temperature of fluids is assumed: $T_0 = 293 \degree \text{ K}$.
- The outlet pressure is zero.

Schematic of the mesh of the studied structure
### Effect of the liquid nature flowing in a steel pipe

<table>
<thead>
<tr>
<th>thermophysical characteristics</th>
<th>Steel pipe</th>
<th>PVC pipe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermal conductivity (k) (W/m.K)</td>
<td>44.5</td>
<td>0.589</td>
</tr>
<tr>
<td>Density (\rho) (kg/m(^3))</td>
<td>7850</td>
<td>999.054</td>
</tr>
<tr>
<td>Specific heat (C) (J/kg.K)</td>
<td>475</td>
<td>4180</td>
</tr>
</tbody>
</table>

### Effect of the liquid nature flowing in a PVC pipe

<table>
<thead>
<tr>
<th>thermophysical characteristics</th>
<th>Water</th>
<th>thermal oil</th>
<th>Ethanol</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermal conductivity (k) (W/m.K)</td>
<td>0.6</td>
<td>0.1891</td>
<td>0.169</td>
</tr>
<tr>
<td>Density (\rho) (kg/m(^3))</td>
<td>1000</td>
<td>886.2</td>
<td>798</td>
</tr>
<tr>
<td>Specific heat (C) (J/kg.K)</td>
<td>4200</td>
<td>1907</td>
<td>2460</td>
</tr>
<tr>
<td>Dynamic viscosity (Pa.S)</td>
<td>0.001</td>
<td>0.0105</td>
<td>0.00120</td>
</tr>
</tbody>
</table>
The surface temperature distribution obtained from the three fluids (water, ethanol and thermal oil) flowing in a steel pipe.

The spatial surface temperature variations according to oy axis of the considered pipe (in the direction of flow).
the distribution of the surface temperature of the three considered above liquid flowing through a PVC pipe.

- the spatial surface temperature variations according to oy axis of the considered pipe (in the direction of flow).

Spatial surface temperature variations of a PVC pipe containing (a) water, (b) the thermal oil and (c) ethanol
The temperature variation along steel pipe containing water, ethanol and oil heat. 

The temperature variation along PVC pipe containing water, ethanol and oil heat.

- We note that for each considered pipe the thermal response varies according to the liquid flowing therethrough; and accordingly the response of a pipe that contains water is different from that which contains the thermal oil or ethanol.

- The precedent results are observed independent of the pipe nature, steel or PVC.
PLAN

Motivation et objectif

Modélisation par éléments finis

Résultats et discussion

Conclusion
MERCI POUR VOTRE ATTENTION
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