Analytical Study on Multi-stream Heat Exchanger Include Longitudinal Heat Conduction and Parasitic heat Loads

Weiping Zhu, Xujuan Xie, Huitui Yang, Laifeng Li, Linghui Gong

1. State Key Laboratory of Technologies in Space Cryogenic Propellants, Technical Institute of Physics and Chemistry, Chinese Academy of Sciences, Beijing 100190, China
2. Graduate University of Chinese Academy of Sciences, Beijing 100049, China

Background

High performance heat exchanger is a critical component in many cryogenic systems and its performance is typically very sensitive to longitudinal heat conduction, parasitic heat loads and property variations. This paper gives an analytical study on 1-D model for multi-stream parallel-plate fin heat exchanger by using the method of decoupling transformations. The results obtained in the present paper are valuable for the reference on optimization for heat exchanger design.

Objectives

- Cryogenic multi-stream parallel-plate fin heat exchanger
- Analytical Study on Multi-stream Heat Exchanger Include Longitudinal Heat Conduction and Parasitic heat Loads

Inlet parameters

Each stream's mass flow, inlet temperature and inlet pressure are as shown in the following Table 2.

<table>
<thead>
<tr>
<th>Stream</th>
<th>( T_r (K) )</th>
<th>( P_r (bar) )</th>
<th>( \rho_r (g/cm^3) )</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>40</td>
<td>15</td>
<td>18</td>
</tr>
<tr>
<td>B</td>
<td>50</td>
<td>12</td>
<td>20</td>
</tr>
<tr>
<td>C</td>
<td>60</td>
<td>6</td>
<td>10</td>
</tr>
</tbody>
</table>

Analytical solutions

The governing equations can be solved by the method of decoupling transformations. The solution is:

\[
\begin{align*}
\frac{d\rho_1}{d\rho_2} & = 0 \\
\frac{d\rho_1}{d\rho_2} & = 0 \\
\end{align*}
\]

Temperature distribution

Using the method and the analytical solutions in the present paper, we can get that the temperature distribution in this example heat exchanger is as shown in the Fig.5.

Conclusion

- This paper presents a mathematical model for a multi-stream heat exchanger. In this model, both longitudinal heat conduction and parasitic heat loads are concerned. By using the method of decoupling transformations, the analytical solutions of the model is obtained.
- In this paper, heat exchanger is in steady-state. When some stream's mass flow or inlet temperature is changed, heat exchanger is in dynamic state. This will be investigated in the near future.