Two-Phase Flow and Heat Transfer

Ecoulement Biphasiques et Transfert de Chaleur

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Topics to Be Covered in Course:

- Two-phase flow patterns.
- Two-phase flow pattern transition maps.
- Void fraction methods and measurements.
- Two-phase pressure drop theory.
- Condensation on external surfaces.
- Condensation inside horizontal tubes.
- Nucleate pool boiling and bundle boiling.
- Evaporation inside tubes.
- Thermal design methods.
Course Format:

• Course is based on new book that has just been published by J.R. Thome on the web: *Engineering Databook III*, available since September 13, 2004 at [http://www.wlv.com/products](http://www.wlv.com/products) then clicking on Wolverine Databook III on that page.
• Chapters from book are available on website (for free) so print yourself.
• Other new chapters and publications may be added as needed and copies will be provided.
• Exercises will be assigned and solutions covered the following week.
Tentative Course Schedule:

<table>
<thead>
<tr>
<th>Dates</th>
<th>Topic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sept. 15-23</td>
<td>Introduction, flow patterns and maps.</td>
</tr>
<tr>
<td>Oct. 20-28</td>
<td>External condensation</td>
</tr>
<tr>
<td>Nov. 3-11</td>
<td>Internal condensation</td>
</tr>
<tr>
<td>Nov. 17-Dec.2</td>
<td>Pool and internal boiling.</td>
</tr>
<tr>
<td>Dec. 8-9</td>
<td>External boiling.</td>
</tr>
<tr>
<td>Dec. 15-16</td>
<td>Power point presentation by students</td>
</tr>
</tbody>
</table>

Above schedule is approximate.

Course project will be the implementation of a two-phase flow and/or two-phase heat transfer model into a **Matlab** program, simulations and power point presentation to the class (responding to questions) as the final exam.
Introduction to Two-Phase Heat Exchangers:

- A background in single-phase heat transfer, fluid mechanics and heat exchanger design is assumed.
- Two-phase heat exchangers refers primarily to condensers and evaporators in their numerous forms.
- Two-phase heat exchangers are widely used in the power industry, petrochemical processing industry, air-conditioning and refrigeration industries, automotive climatization, food processing industries, high heat flux cooling applications, etc.
- Some examples of such exchangers and their applications are shown on the next slides.
- Electronics cooling is a new important application.
Petrochemical Heat Exchanger:

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X-Shell Condenser:

X-Shell:

- Coolant out
- Vapour inlets
- Perforated distributor plate
- Vapour distribution space
- Condensate drain
- Coolant in
- Tube bundle
- Tube support plates (baffles)
E-Shell Condenser:

- Vapour inlet
- Shell
- Vertically cut segmental baffles
- Condensate outlet
- Coolant outlet
- Vent gas outlet
- Coolant inlet
J1-2 Shell Condenser:

Note: J-shell is like to E-shells side-by-side.
J2-1 Shell Condenser:

J2-1 SHELL:

Top View

"J21"

In

In
Coal Fired Power Boiler:
Horizontal Thermosyphon Reboiler:
Horizontal Thermosyphon Reboiler:

\[ \rho_1, \text{ Liquid density in downcomer} \]
\[ \rho_2, \text{ Liquid-vapor mixture density in riser} \]
\[ \rho_3 = (\rho_1 + \rho_2)/2, \text{ Average density in vertical reboiler} \]
Vertical Thermosyphon Reboiler:

- Minimum liquid level
- \( H_1 \)
- \( \rho_1 \)
- \( \rho_2 \)
- \( H_2 \)
- Top tube sheet
- \( \rho_3 \)
- \( H_3 \)
- Reference line
- Bottom tube sheet
Horizontal Kettle Reboiler with Weir:

Horizontal shell-side evaporator with hairpin tubes. Separation of droplets by baffle.
This course primarily focuses on the methods used for designing two-phase heat exchangers:

- Heat transfer methods for evaporation.
- Heat transfer methods for condensation.
- Two-phase pressure drop design methods.
- Flow pattern types and maps.
- Void fraction prediction methods.