LABORATORY PLANNING GUIDE

L32 v3 Heat Transfer Laboratory

Content
Covered subjects according to the curriculum ................................................................. 2
Main concept .................................................................................................................. 3
Initial training provided for laboratory personnel ......................................................... 3
Requirements / Utilities ............................................................................................. 4
Schedule of requirements ........................................................................................... 4
Covered subjects according to the curriculum

Major topics of learning content:

- determining the mean heat transfer coefficient
- comparing different heat exchanger types
- function and behaviour during operation of a
  - tubular heat exchanger
  - plate heat exchanger
  - shell and tube heat exchanger
  - jacketed heat exchanger
- plotting temperature curves
  - in parallel flow operation
  - in counterflow operation
- relationships between Nusselt, Reynolds and heat flux
- relationships between Nusselt, Reynolds and Prandtl
- measurement of the pressure distribution and development of the speed gradient
- development of families of characteristic curves for pipe bundles
- pressure loss at pipe bundles
- calculation of the air velocity
- heat transfer at different surfaces: flat plate, pipe bundle and fins
- temperature distribution in the heat exchanger
- calculation of heat transfer coefficient for free and forced convection
- Lambert’s cosine law
- inverse-square distance law (Lambert)
- Stefan-Boltzmann constant
- Kirchhoff’s laws: absorptivity, reflectivity and emissivity
- radial and linear heat conduction (flat wall)
- determination of temperature profiles with different materials
- determination of thermal conductivity $k$
- steady-state heat conduction in gases and liquids
- determination of thermal conductivities $k$ of various fluids at different temperatures
- determination of the thermal conductivity $k$ of various specimens
- temperature curves as a function of length
- heat transfer through different specimens connected in series
- thermal energy balance of heat source and heat sink
- determination of the thermal resistance
- determination of the radiation coefficient
- pressure curve within a fluidised bed
- pressure losses depending on flow velocity and particle size of the bulk solid
- determination of the fluidisation velocity
- separation of mixtures with different particle sizes by sedimentation
- heat transfer in the fluidised bed
  - influence of the air flow rate on the heat transfer
  - influence of the heater position
  - influence of the particle size
  - determination of the heat transfer coefficient
- geothermal probe with heatpipe principle
- investigation of radial and vertical temperature profiles
variation of the thermal load
variation of the quantity of working medium contained
determination of the quantity of heat that can be discharged
pumping behaviour of an open circuit

Main concept
The laboratory is designed for accommodation of 24 students + 2 laboratory staff:
- 2 - 4 students form a team and work together at a workstation / training system
- 15 workstations of 13 different types
- Each experiment unit either floor standing or on its own table to allow short prepare times
- 10 workstations are equipped with a PC
- Each workstation is equipped with a manual containing technical information, basic theory, experiment instructions, evaluation help and safety advice.
- Student teams are scheduled to change workstations from lab session to lab session in order to perform the entire range of experiments within the course duration.
- Average time per experiment: 90 to 120 minutes.

2 workstations for laboratory staff (with PC and internet access)
1 printer for common use
1 cupboard for small parts, consumables, tools, paper etc.

Initial training provided for laboratory personnel
To be conducted immediately after installation and commissioning of the equipment.
General topics to be covered for any of the educational systems:
- Basic familiarization with the system.
- Functions and components.
- Overall system configuration aspects.
- Start-up and operational aspects.
- Conduction experiments, including evaluation and calculation.
- Using the system with and without the software (where applicable).
- Trouble shooting and maintenance aspects.
- Hands-on, practical familiarization aspects.
- Seminar participants with the delivered system.
- Details of the manuals.
- Safe operation and preventive maintenance.
Requirements / Utilities

Power supply:
- 230 V / 50 Hz / 1 phase – at least 30 power sockets distributed according to lab lay-out

Water:
- Cold water
- Drain

Others:
- Compressed air

Laboratory computer network:
- 2 internet connections for staff
- 10 internet connections for students

Location:
- Laboratory space min 72 m²
- This laboratory could be installed on any floor (e.g. ground floor or 1st floor)

Schedule of requirements

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Description</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Item 1</td>
<td>Heat exchanger supply unit</td>
<td>2 pcs.</td>
</tr>
<tr>
<td>Item 1.1</td>
<td>Tubular heat exchanger</td>
<td>1 pcs.</td>
</tr>
<tr>
<td>Item 1.2</td>
<td>Plate heat exchanger</td>
<td>1 pcs.</td>
</tr>
<tr>
<td>Item 1.3</td>
<td>Shell &amp; tube heat exchanger</td>
<td>1 pcs.</td>
</tr>
<tr>
<td>Item 1.4</td>
<td>Jacketed vessel with stirrer &amp; coil</td>
<td>1 pcs.</td>
</tr>
<tr>
<td>Item 1.5</td>
<td>Water chiller</td>
<td>2 pcs.</td>
</tr>
<tr>
<td>Item 2</td>
<td>Heat transfer bench</td>
<td>2 pcs.</td>
</tr>
<tr>
<td>Item 2.1</td>
<td>Parallel flow module</td>
<td>1 pcs.</td>
</tr>
<tr>
<td>Item 2.2</td>
<td>Mixed flow module</td>
<td>1 pcs.</td>
</tr>
<tr>
<td>Item 2.3</td>
<td>Tubular forced convection heat exchanger</td>
<td>1 pcs.</td>
</tr>
<tr>
<td>Item 3</td>
<td>Heat conduction in metals</td>
<td>1 pcs.</td>
</tr>
<tr>
<td>Item 4</td>
<td>Heat conduction in fluids</td>
<td>1 pcs.</td>
</tr>
<tr>
<td>Item 5</td>
<td>Heat conduction and convection</td>
<td>1 pcs.</td>
</tr>
<tr>
<td>Item 6</td>
<td>Free and forced convection</td>
<td>1 pcs.</td>
</tr>
<tr>
<td>Item 7</td>
<td>Heat transfer by radiation</td>
<td>1 pcs.</td>
</tr>
<tr>
<td>Item 8</td>
<td>Thermal conductivity of building materials</td>
<td>1 pcs.</td>
</tr>
<tr>
<td>Item 9</td>
<td>Convection and radiation</td>
<td>1 pcs.</td>
</tr>
<tr>
<td>Item 10</td>
<td>Heat transfer in the fluidised bed</td>
<td>1 pcs.</td>
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<tr>
<td>Item 11</td>
<td>Geothermal probe with heat pipe principle</td>
<td>1 pcs.</td>
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<tr>
<td>Item 12</td>
<td>Geothermal energy with two-well system</td>
<td>1 pcs.</td>
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</tbody>
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