FLOWNEX®
SIMULATION ENVIRONMENT

NATURAL CONVECTION

This case study demonstrates the capability of Flownex to simulate natural convection (buoyancy driven flow). This is done by demonstrating the simulation of natural convection of air through a U-tube due to heat addition to one of the U-tube walls.

GENERAL INDUSTRY

CHALLENGE:

Natural convection & Buoyancy driven flow is common phenomenon in fluid networks, its effects can have both positive and negative influence on systems in industry.

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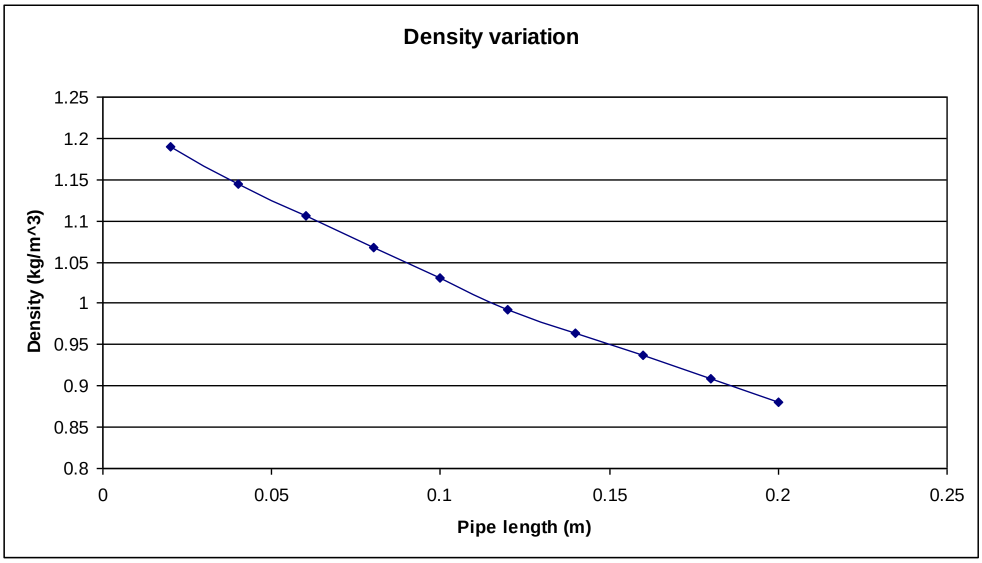
OBJECTIVES:

The objective of the simulation is to determine the mass flow of the air through the U-tube

SOLUTION:

The capability of Flownex to simulate natural convection is demonstrated in this case study. Flownex is used to calculate the mass flow of air through a U-tube due to natural convection resulting from heat addition to one of the U-tube legs.



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NATURAL CONVECTION THROUGH A U-TUBE

SYSTEM DESCRIPTION

The configuration considered in this example is shown in

Figure 1. It consists of a U-tube in which air is flowing due to natural convection. The inlet and outlet pressures are similar (atmospheric) and the driving force is due to the buoyancy effect resulting from the heat addition to one of the U-tube walls.

Fluid: air	U-tube properties:
Ambient temperature: T_a = 15 ° C	Roughness: ε = 30 µm
Ambient pressure: P_a = 100 kPa	Sum of secondary losses: K_s = 0.5

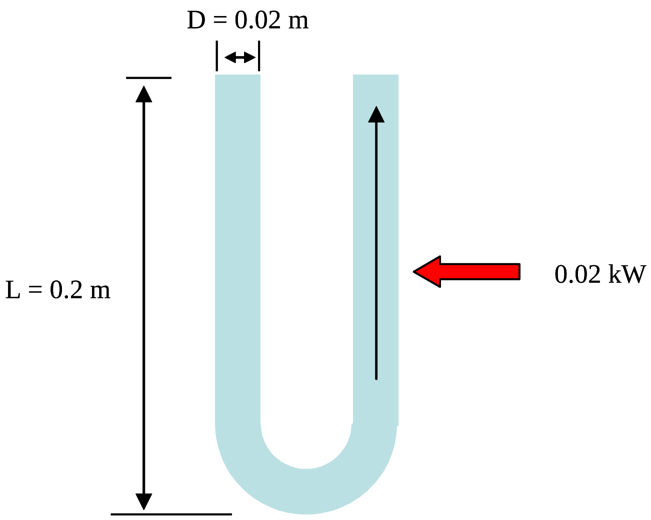

Figure 1: Schematic layout of a U-tube in which air is flowing due to natural convection.

OBJECTIVE OF SIMULATION

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FLOWNEX MODEL

The Flownex model of the system is shown in Figure 2.

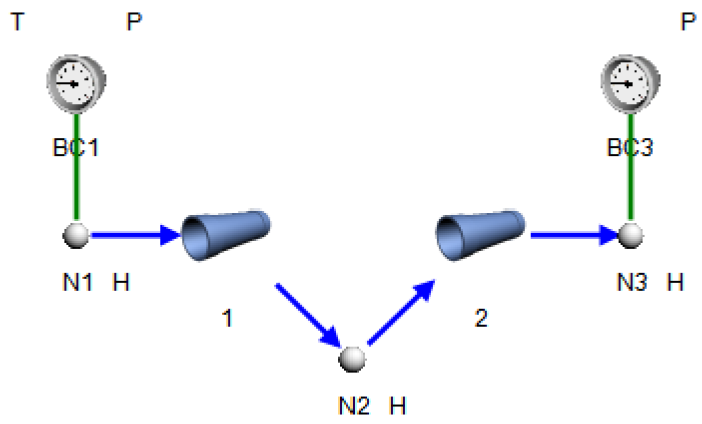

Figure 2: Flownex network.

The network consists of three nodes and two Pipe elements. Pipe element 1 models the left leg of the U-tube to the lowest point and element 2 models the right leg from the lowest point to the outlet. The height differences are specified on the nodes. A fixed heat transfer of 0.02kW is specified for Pipe element 2. Pipe element 2 is divided into 10 increments. This means that the pipe is divided into 10 shorter pipes of equal lengths (0.02m) and therefore gives a more accurate solution since the average element density is used in the calculations.

DESCRIPTION OF SIMULATION

An initial boundary condition for Node 3 is specified. This initial value will be used for the enthalpy interpolation before the first iteration of the solver in Flownex. This produces the desired temperature and density gradient throughout the U-tube to initiate natural convection.

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RESULTS

From the results it is seen that the mass flow is 0.00017kg/s. The density variation through the right leg of the U-tube is shown in Figure 3.

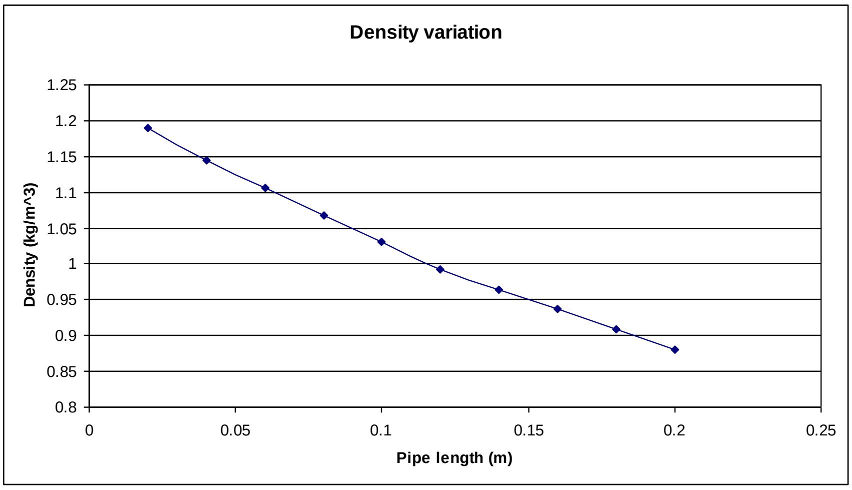

Figure 3: Temperature variation through right leg of U-tube.

CONCLUSION

The capability of Flownex to simulate natural convection was demonstrated in this case study. Flownex was used to calculate the mass flow of air through a U-tube due to natural convection resulting from heat addition to one of the U-tube legs.

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