“On-line accurate system to determine the void fraction of a two-phase fluid system”

Ghent University is seeking industrial partners interested in licensing in technology related to “an on-line system and method to accurately determine the void fraction of a two-phase fluid system in cooling or heating processes using e.g. refrigerants.”

Introduction

This technology offer relates to an algorithm to determine the void fraction of a two-phase fluid system based upon the signals received from e.g. a capacitive sensor. In contrast to e.g. a temperature measurement a measurement of the void fraction provides a direct measure of the “state of condensation or evaporation” in heating or cooling systems. The void fraction directly indicates the amount of fluid still to be evaporated or the amount of gas still to be condensed. Advanced control of the heating/cooling system not only requires a qualitative indication of the void fraction but also an accurate quantitative level of the void fraction. Currently, no such low cost, not-intrusive on-line sensor or technique for tubes with small diameters exists.

Technology

Researchers at Ghent University have found a way to accurately determine the void fraction of a two-phase fluid system. The technique is based on a three step approach

1. Obtaining the output signals from e.g. a capacitive sensor (or any other sensor sensitive to the void fraction)
2. Determining from these output signals the flow regime of the 2-phase fluid system as well as retrieving for that specific flow regime the corresponding relationships between the void fraction and the sensor output signals
3. Interpreting the output signals using the obtained relationship to obtain the void fraction

The differentiating aspect in this is the fact that the sensor output signals are translated into a void fraction whereby this translation depends on the flow regime determined in step 2. The flow regime itself can yet again be determined based upon a statistical analysis of the output signals in the amplitude and time domain.

Applications

The sensor with the built in algorithm can be used in the following applications:

- Applications looking for advanced e.g. linear control strategies of the heating or cooling process. Compared to the currently used on/off control strategies, this will yield more stable and accurate control of the process.
- Applications wherein the distribution of the fluid over the different tubes of a distributor is being controlled by intelligent control of valves steered by the determined void fraction in order to optimize the process.

- During the design phase, the sensor can be used to evaluate the working conditions of the system and to optimize the heat exchanger in terms of its shape, length, …

Advantages

The technique offers a number of key-advantages:

- The resulting void fraction is much more accurate due to the fact the actual occurring flow regime is taken into account.
- The void fraction can be measured for all kind of geometries, i.e. even inclined and bended tubes.
- The void fraction is measured directly based upon a parameter that depends directly on the void fraction and not-indirectly
- It is a non-intrusive, on-line technique
- The void fraction can be measured even of tubes with a small diameter

Status of development

A prototype of the sensor hardware exists based on a capacitive method. This sensor produces the output signals from which we were able to derive the void fraction. Currently this is done off-line in a separate calculation unit, but the techniques can easily be implemented in on-board software/calculation units of the sensor.

Partnership

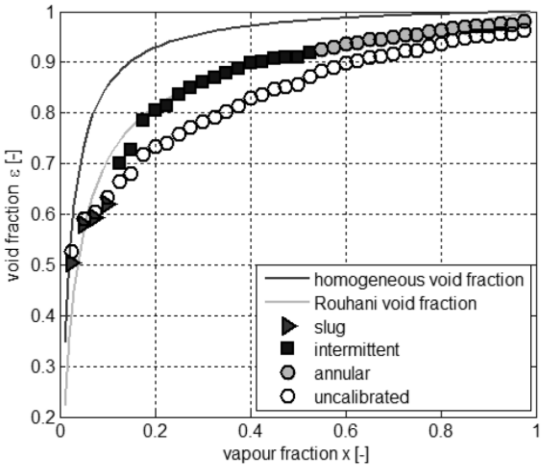
We are looking for an industrial partner to use the technology in their heating and cooling applications.

Intellectual property

The technology has been described in a patent application (PCT/EP2013/061323 – Methods and systems for characterizing void fractions), priority date 31 May 2012.

Figures

The figure below shows the accuracy of the proposed system and method compared to several other techniques based upon the relationship between the vapour fraction and the void fraction as can be calculated accurately by the Rouhani-Axelsson model (best practice and accurate model).



The dark line shows that assuming a homogeneous distribution of the void fraction results in too high void fraction estimates. Using an uncalibrated sensor (i.e. assuming a linear relationship between sensor output signal and void fraction) results in a too low void fraction estimate. The proposed method on the other hand yields very good estimates of the void fraction taking into account the different flow regimes, as can be seen by the fit between the triangular, rectangular and circular icons and the Rouhani-Axelsson curve.

The Inventor(s)

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References

Caniere H, Bauwens B, T'Joen C, De Paepe M, Mapping of horizontal refrigerant two-phase flow patterns based on clustering of capacitive sensor signals. International Journal of Heat and Mass Transfer 53 (23-24) (2010) 5298-5307

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