Thermal effects on bubble growth in discrete n-alkanes mixtures

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Hydraulic systems usually do not use water as working medium. For example, for direct injection into internal combustion engines the fuel may be approximated as a discrete mixture of n-alkanes. At cavitation conditions, the growth of the bubbles is influenced by the properties of the fluid that depend on the molar fraction of the individual species as well as the spatially and temporally varying mixture composition. The characteristics of bubble dynamics in the presence of thermal effects on a discrete multicomponent bubble is investigated. Brennen[1] defined a critical time in which the order of magnitude of the thermal term becomes equal to the remaining terms. The thermal term in the Rayleigh – Plesset Equation will gain in magnitude over the other terms in the equation when the critical time has passed. The growth behavior will change and the inertial, viscous, gaseous, and surface tension terms in the Rayleigh-Plesset equation rapidly decline in importance. While thermal growth has been observed by many researchers for singlecomponent fluids, e.g. water, we study it by simulation for n-alkane mixtures.

An in-house code based on the spherical bubble dynamic model by Kawashima, et al.[3] and Nigmatulin, et al.[4] is developed that includes mass and heat transport. The phase change as well the diffusive transport and de-/adsorption of non-condensable gases i.e. air is considered. The method is validated by the water measurements of Dergarabedian[2] and extended for discrete mixtures of n-alkanes. It is applied to study the thermally controlled growth of a multicomponent spherical single bubble. A strong local de-mixing of initial liquid mixture occurs during phase transfer, and an in-homogenous composition and species distribution within the bubble is found. It is shown that bubble dynamics in mixtures is strongly influenced by the presence of highly-volatile components. These species dominate the composition inside the bubble which contribute to reach the critical time at lower times than expected.

[1] C. E. Brennen, *Cavitation and bubble dynamics*. The Oxford engineering science series: 44, New York, Oxford Univ. Press, 1995.

[2] P. Dergarabedian, *The rate of growth of vapor bubbles in superheated water*. ASME J. Appl. Mech., 20, 537–545, 1953.

[3] H. Kawashima and M. Kameda, *Dynamics of a spherical vapor/gas bubble in varying pressure fields*, Journal of Fluid Science and Technology, vol. 3, no. 8, pp. 943–955, 2008.

[4] R.I. Nigmatulin, N.S. Khabeev and F.B. Nagiev, *Dynamics, Heat and Mass Transfer of Vapour-Gas Bubbles in a liquid*. Int. J. Heat Mass Transfer, vol. 24, no. 6, pp. 1033-1044, 1981.

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