CFD MODELLING OF THE HEAT AND ACOUSTIC STREAMING INDUCED BY A HIGH POWER ULTRASONIC HORN REACTOR

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ABSTRACT

In the last years, the use of high power ultrasonic horn reactors has gained a lot of interest in the food industry given the effects that can arise from cavitation events and streaming. This has led to the development of new ultrasonic food processing operations such as homogenization, extraction, viscosity modification, enzyme activation and inactivation and material infusion among others. Most of this development, however, was based on expensive and time-consuming trial-and-error experimentation. Hence, these systems still show a great potential for optimization. Furthermore, scaling up those processes has been difficult due to the lack of mathematical techniques that allow better understanding the complex interaction between the acoustic and the subsequently induced hydrodynamic field exhibited in sonoreactors. The lack of those models is explained by the high complexity of the interaction between sound, cavitation, induced flow and heat generation. When high power ultrasound passes through a liquid, it generates heat and acoustic streaming, which is the tendency of the fluid to form a steady bulk fluid. Both phenomena are caused by the transfer of energy from the sound wave to the liquid; the liquid absorbs energy from the wave producing heat and streaming while the wave losses energy attenuating the amplitude of the sound pressure. At high acoustic power, horn reactors produce jet like turbulent streaming.

In this paper, a CFD method to describe the acoustic streaming and heat generation induced by a high power ultrasonic horn reactor is presented. The method is based on solving the Navier-Stokes equation coupled with the energy transport equation. Streaming is modeled via the "Stuart steaming" theory developed by Lighthill, which describes acoustic streaming at higher Reynolds numbers, resulting from the application of a concentrated high power acoustic beam. The force that induces streaming is obtained via the spatial variation of Reynolds stress caused by the absorption of acoustic energy by the medium. The temperature profile inside the reactor is modeled by solving the energy transport equation estimating the heat generation term from the absorption of acoustic energy. The model predicts the velocity and turbulent distribution as well as temperature profiles inside the reactor. The information can be used to determine recirculation and mixing patterns, and to optimize the geometry of the reactor.

References

[1] Lighthill, J., *Acoustic streaming.* Journal of Sound and Vibration. **61**(3), p. 391-418 (1978)

[2] Trujillo, F.J. and K. Knoerzer. *CFD modelling of the acoustic streaming induced by an ultrasonic horn reactor*. in *Seventh International Conference on CFD in the Minerals and Process Industries*. Melbourne, Australia. (2009).