Characterization of the Process of Ultrasound Driven Dispersion of Nanoparticles in High Viscosity Liquids

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Abstract

When a liquid is subjected to high intensity Ultrasound energy, many peculiar effects can be observed. Namely, Acoustic Cavitation & acoustic streaming. Both these phenomena have extensive applications in various fields ranging from Sonochemistry to material science. In material science, they are also used to disperse nanoparticle fillers to produce metal matrix nanocomposites [1]. Nanoparticles tend to agglomerate due to the strong van der waal's forces present. Under the presence of an acoustic field however, cavitation is manifested after breaching a threshold pressure. The cavities produced expand and contract under the compression and rarefaction portions respectively, finally imploding, resulting in massive pressures and temperatures [2]. These violent conditions effectively counter the inter-molecular forces that help form nano-particle clusters and there by affecting the material properties. So, for an efficient dispersion process, the spread of cavitation zones in a reactor should be of maximum. Even though sonoreactors have been studied widely for decades, there is limited data on their characterization when the volume of the sample is fixed. Also, due to the excessive directional sensitivity of the Ultrasound field, it is extremely difficult to optimize the geometry of a reactor. COMSOL Multiphysics® software is used to simulate the Ultrasonic field in a cylindrical reactor. The developed model will be validated experimentally. The geometry of the central plane of a cylindrical reactor is modeled (Figure 1). The Acoustics Module is used to resolve the pressure field and the streaming flow field is resolved using a Fluid Flow interface in COMSOL. The validated numerical model will be used to compare different configurations; changing the geometrical parameters of the reactor. To compare the results (Figure 2), the area where conditions are favorable for transient cavitation is measured for every configuration. The ideal configuration is then used to characterize the other parameters like frequency, input power, probe diameter, probe, and immersion depth.

Reference

1.Eskin, G.I.,” Ultrasonic Treatment of light metal alloys”, CRC Press, Chap.2, 1998.

2.C.E Brennen," Cavitation and Bubble Dynamics ", Oxford University Press, Chap.2, 2005.

Figures used in the abstract

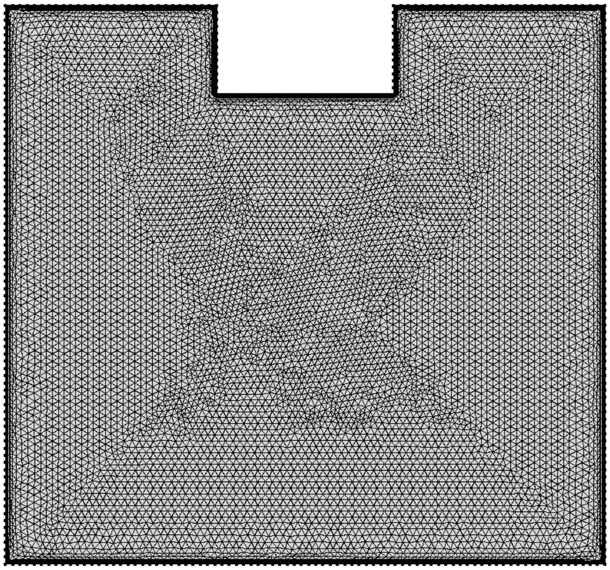

Figure 1: Modeled geometry of the reactor.

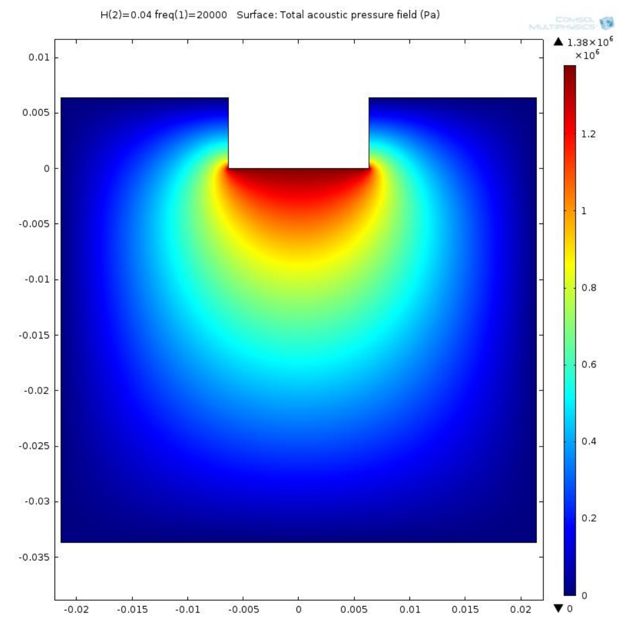

Figure 2: Acoustic pressure field.