Progress Report

Research Objectives

The principal objective of the project is to develop an acoustic probe for determining the volume fraction of particles in a flowing suspension. This will include testing the theory of acoustic wave propagation in suspensions and demonstrating the application of the probe by installing it on a flow loop through which a suspension is flowing and determining the particle volume fraction. The signal from the probe must be processed such that the noise arising from the presence of the gas bubbles, if present in the system, is removed to yield an accurate estimate of the particle volume fraction. Once the probe is developed and tested successfully at Syracuse University, it is to be installed and tested in the flow loop at Oak Ridge National Laboratories for surrogate slurries for the Hanford Nuclear site. Particular attention is to be given to testing suspensions with low particle volume fractions since slurries to be transported in nuclear waste processing will have low particle volume fractions.

Research Progress and Implications

At the end of the first year of this three year project, we have carried out experiments with several different suspensions systems (e.g. glass particles in water, polystyrene particles in water, clay in water, and a nuclear waste simulant consisting of precipitated salt in saturated supernate) for a wide range of particle volume fractions. Both the speed and the attenuation of the sound as functions of the acoustic wave frequency were measured. These measurements were found to agree very well with a theory for wave propagation by Spelt et al. (1999, 2001). Measurements for attenuation were made with particle volume fraction as low as 0.005 and it was shown that the acoustic probe can be used for such low volume fractions (Hedges 2001). The attenuation of sound occurs by three mechanisms: incoherent scattering, viscous damping, and non-adiabatic thermal changes inside the particles. The theory by Spelt et al (1999, 2001) accounted for all these mechanisms and various particle-liquid systems examined in the study were chosen such that the theory for all the three mechanisms can be tested. Experiments have also been carried out for suspensions in which small amount of gas bubbles are injected. A theory was developed for predicting the attenuation in suspensions containing gas bubbles. Once again, the predictions of the theory were in agreement with the experiments (Norato 1999).

Planned Activities

The experiments carried out to date were conducted for suspensions in a 35 ml acoustic sampling cell. We are in the process of designing a flow loop in which the suspension will be pumped through a pipe so that the acoustic probe can be tested for on-line monitoring. The activities in progress and planned for the current year are intended to prepare for testing at the Oak Ridge National Laboratories:

1. Design, build, commission, and test at Syracuse University a working prototype probe to include: compact electronic data generation, acquisition and analysis system; supernate phase separator; automated signal processing system; and capability for mounting probe on a 2 inch pipe.

2. Design, build, and commission a 2 inch diameter flow test loop for solid-liquid slurry transport at Syracuse University to test and modifiy, as needed, the acoustic monitor for signal acquisition, data processing, and phase separation capabilities.

Mr. Alexander Scherbakor of the Kiev Polytechnical University in Kiev, Ukraine has joined our team on April 1, 2001. He is an expert in acoustic signal analysis and is contributing to the effort described above.

References

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