Project ID: **55179**

Project Title: **Acoustic Probe for Solid-Gas-Liquid Suspensions**

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1999 EMSP Annual Report

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Research objective:

The proposed research will develop an acoustic probe for monitoring particle size and volume fraction in slurries in the absence and presence of gas. The goals are to commission and verify the probe components and system operation, develop theory for the forward and inverse problems for acoustic wave propagation through a three phase medium, and experimentally verify the theoretical analysis. The acoustic probe will permit measurement of solid content in gas-solid-liquid waste slurries in tanks across the DOE complex.

Research progress:

As of June 30, 1999 we have completed two investigations concerning attenuation of sound in slurries. In Spelt et al. (1999a) we examined in detail the problem of predicting the attenuation of sound as a function of frequency for a suspension of spherical particles when the volume fraction of the particles is small. The theory, which accounted for the attenuation due to viscous, thermal, and scattering effects, was compared with the experiments for polystyrene particles in water and an excellent agreement was found. The same study also examined a more important problem of determining the size distribution of particles in a dilute slurry from the attenuation-frequency data for the slurry. A technique for solving this inverse problem was devised and the conditions under which it will be possible to determine the particle size distribution were determined.

In Spelt et al (199b) we developed a theory for predicting the attenuation in nondilute slurries. This theory was tested against several known analytical results in various asymptotic limits and against experimental data on concentrated slurries obtained both in our laboratory and by previous investigators. The agreement between the theory and experiments, which covered wide range of particle sizes --- from 0.1 micron to 200 microns, was very good.

We have also carried out attenuation measurements on gas-liquid and solid-gas-liquid systems. A theory was developed for predicting the attenuation for these systems. The experimental data showed the predicted trend that the noise due to bubbles must decrease as the frequency is increased when the frequency of sound waves is greater than the resonance frequency of the bubbles. Since the size distribution of the bubbles is not known a priori detailed comparison has not been made yet.

Planned activities:

It was shown in Spelt et al (1999b) that the data on phase speed of suspensions can be quite useful in determining the volume fraction of the particles. This is because the attenuation as a function of volume fraction of the particles can go through a maximum and the same attenuation can be obtained at two different volume fractions for a given frequency. The phase speed on the other hand changes monotonically with the volume fraction. Our present efforts are therefore directed at modifying the probe to also determine the phase speed of sound waves. In addition, we also plan to use a high speed imaging technique to determine the size distribution of the bubbles so that a more thorough comparison can be made between the attenuation data for the solid-gas-liquid systems and the theory. We also plan to develop a technique for the inverse problem for the three-phase slurries which would allow one to determine the volume fraction of the solids even when the size distribution of the bubbles is not known.

References:

Spelt P. D. M., Norato M. A., Sangani A. S. and Tavlarides L. L. 1999a Determination of particle size distributions from acoustic wave propagation measurements. Phys. Fluids, vol. 11, 1065-1080.

Spelt P. D. M., Norato M. A., Sangani A. S., Greenwood M. A. and Tavlarides L. L. 1999b Attenuation of sound in concentrated suspensions: theory and experiments. J. Fluid Mech. (submitted).