"Enhanced Wellbore Stabilization and Reservoir Productivity with Aphron Drilling Fluid Technology"

Topical Report:

Task 2.1: "Aphron Visualization"

by

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Objective

Evaluate the Acoustic Bubble Spectrometer for measurements of bubble size distribution (BSD) in aphron drilling fluids at elevated pressure.

Project Description

The BSD of a Transparent APHRON ICS™ drilling fluid at elevated pressure was determined via Acoustic Bubble Spectrometry (ABS) under static and dynamic conditions and compared with the BSD determined via optical imaging.

Conclusions

Acoustic Bubble Spectrometry (ABS) measurements, under static conditions, of the Bubble Size Distribution (BSD) of a Transparent APHRON ICS™ mud at pressures ranging from ambient up to 2000 psig yielded average bubble sizes two to six times lower than those measured optically. Under dynamic conditions, ABS measurements yielded nearly identical BSD's at 2000 psig and when the system was returned to 0 psig and held at that pressure for 15 min. However, optical imaging revealed a marked difference in the BSD at the two pressures.

Thus, ABS is not considered a suitable method for monitoring the BSD in aphron drilling fluids. On the other hand, this project led to the development of an HTHP flow loop and an optical imaging procedure which will be useful for monitoring the BSD of aphrons at elevated pressure and temperature.

Introduction

The Acoustic Bubble Spectrometer has been identified as a potential method for monitoring the size distribution of aphrons *in situ*, such as in an oil well drilling fluid flowline.[1] Research was continued from Task 1.1 of this Project, Aphron Visualization,[2] in which ABS was tested against laser light scattering (Coulter Counter) and optical (visual) imaging to determine the bubble size distribution (BSD) of the aphrons at ambient temperature and pressure.

Task 2.1 continued this investigation by measuring the bubble size distribution via ABS and optical imaging at elevated pressures up to 2000 psig.

Experimental Approach

ABS measurements were recorded using a custom-made high-temperature high-pressure (HTHP) re-circulating system. To improve sensitivity and stability, the 1 in. x 1 in. hydrophones used at ambient pressure were discarded in favor of 3 in. x 3 in. hydrophones, which are mounted in the custom-made high pressure vessel, the ABS Cell, as shown in Figure 1. The ABS Cell is connected to a re-circulating reciprocating pump. Attached in parallel is a module consisting of a sight flow glass through which the aphrons can be monitored visually by means of a digital fire wire, high-picture-quality, camera. Pressure is applied to the re-circulating system using a syringe pump with an accumulator, i.e. a high-pressure cell with a piston to separate the APHRON ICS™ mud from the pump water.

The Transparent APHRON ICS™ mud used in this series of tests has the same primary viscosifier, aphron generator and stabilizer package (at the same concentrations) as the standard Aphron ICS fluid, but does not contain any of the opaque components, making it easier to obtain the visual measurements.[2]

The mud formulation was loaded into the re-circulating system, and ABS and visual (digital camera) measurements were recorded at various pressures ranging from 0 psig to 2000 psig and back to 0 psig. Also, with the re-circulating pump running, ABS measurements were taken at 2000 psig and later at 2nd 0 psig (return to atmospheric pressure following pressurization) + 15 min.

Results

The BSD's (Bubble Size Distribution) was measured for the Aphron Sample at 1000 psig using ABS and photomicrography. The BSD major ranges for the two techniques shown in Figure 2 are as follows:

- ABS 30 - 70 µm
- Photomicrography 70 - 430 µm

Figure 3 shows the major BSD ranges for the 2nd 0 psig (return to atmospheric pressure from 2000 psig):

- ABS 130 - 290 µm
- Photomicrography 370 - 690 µm

The photographs that yielded the Photomicrography BSD's in Figures 2 and 3 are shown in Figures 4 and 5, respectively.

The Dynamic (re-circulating pump running) ABS results obtained at 2000 psig and 2nd 0 psig + 15 min were almost indistinguishable (see Figures 6 & 7), but the photographs from Run Series #2 of Figure 7 of the mud taken at almost the same time shows a distinct difference in the number and size of the aphrons at these two pressures (Figures 8 & 9). Clearly, the dynamic ABS results are not accurate, and the BSD's generated under these conditions may simply be artifacts.

Future Work

In order to validate the Acoustic Bubble Spectrometer results, a method was required to be developed by which the aphrons could be observed and enumerated directly in a visual procedure at higher pressures. This optical imaging technique has been so successful, it is now the standard method by which BSD measurements are made and even individual aphrons are monitored.

Using this visual method, work will continue on the effects of temperature on the aphrons in a high pressure environment similar to conditions down hole.

References

1. Chahine, G. L. and Kalumuck, K. N., "Development of Near Real-Time Instrument for Nuclei Measurement: The ABS Acoustic Bubble Spectrometer," Proc. FEDSM'03, International Symposium on Cavitation Inception, 4^{th} ASME_JSME Joint Fluids Engineering Conf., Honolulu, Hawaii, July 6-10, 2003.

2. O'Connor, B. and Growcock, F., "Enhanced Wellbore Stabilization and Reservoir Productivity with Aphron Drilling Fluid Technology - Topical Report: '*Task 1.1: "Aphron Visualization'," * DOE Award Number DE-FC26-03NT42000, Houston, Texas.

Figure 1: HTHP Re-Circulating System with Acoustic Bubble Spectrometer, 3 in. x 3 in. Hydrophones & Visual Monitoring Equipment

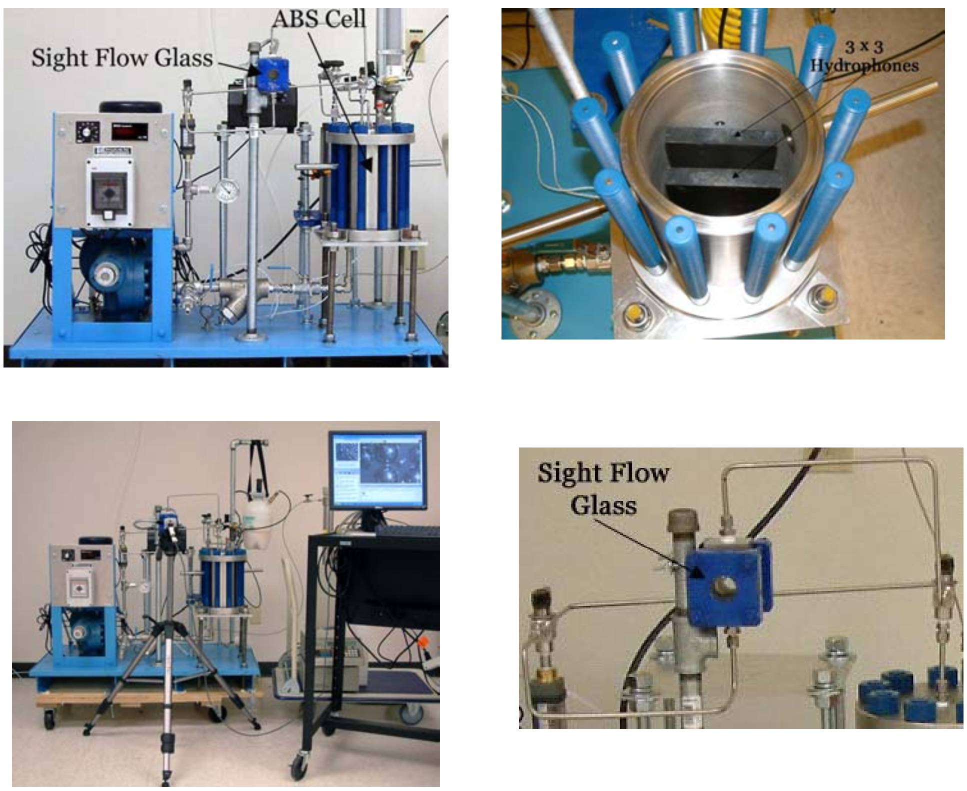

Figure 2: Bubble Size Distribution at 1000 psig – Photograph in Figure 4

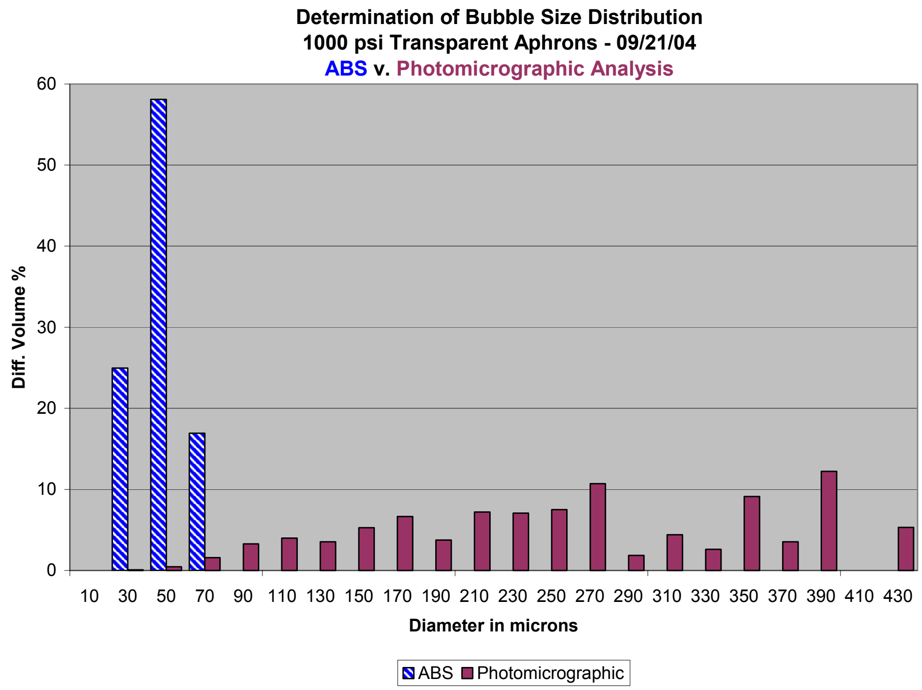

Figure 3: Bubble Size Distribution for 2nd 0 psig – Photograph in Figure 5

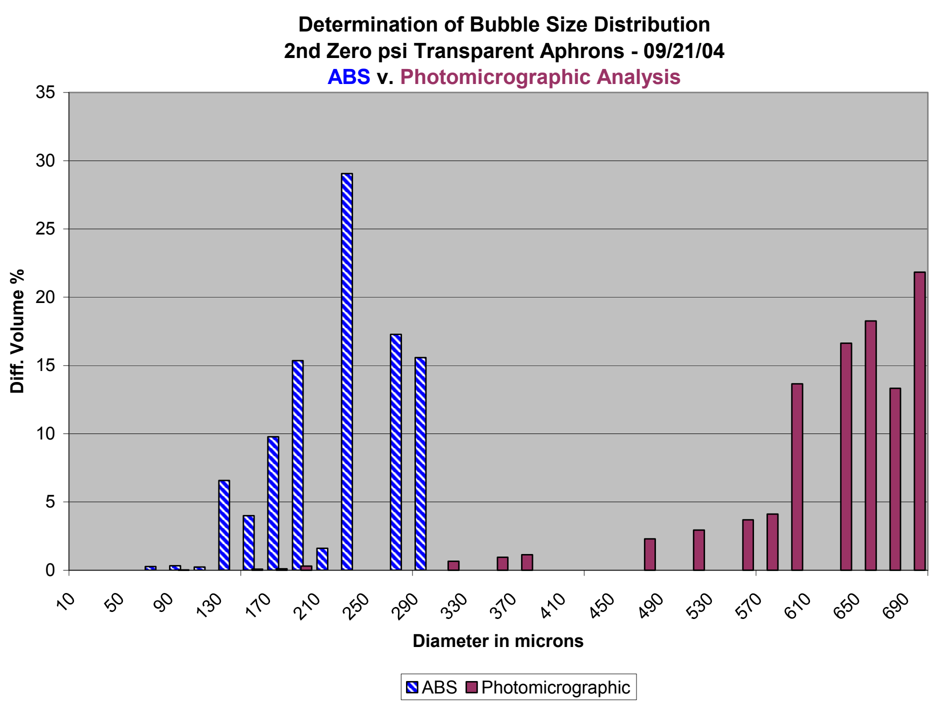

Figure 4: Photograph of Transparent APHRON ICS^{TM} at 1000 psig

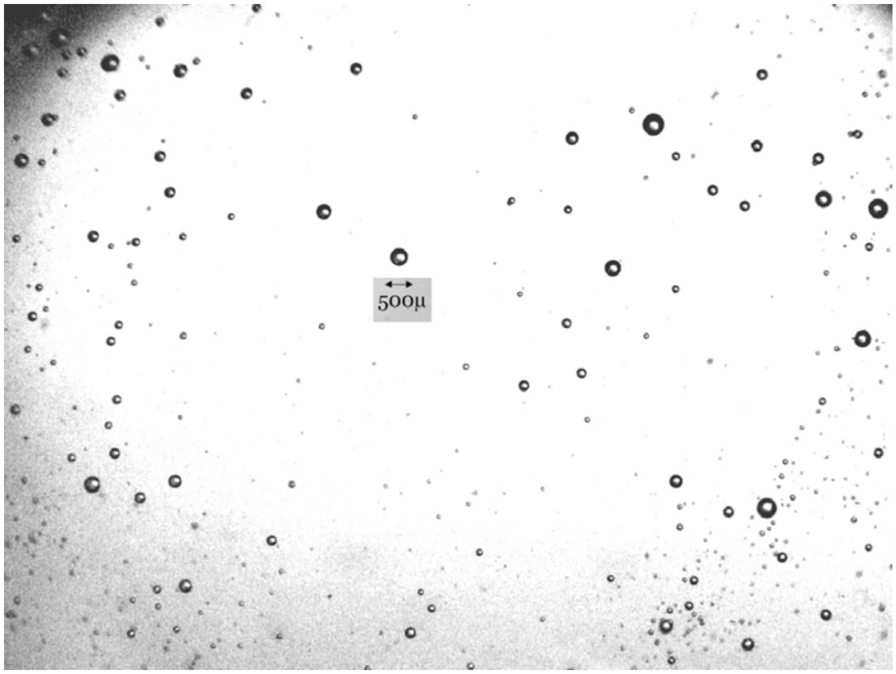

Figure 5: Photograph of Transparent APHRON ICS^{TM} at 2nd 0 psig Following Depressurization from 2000 psig

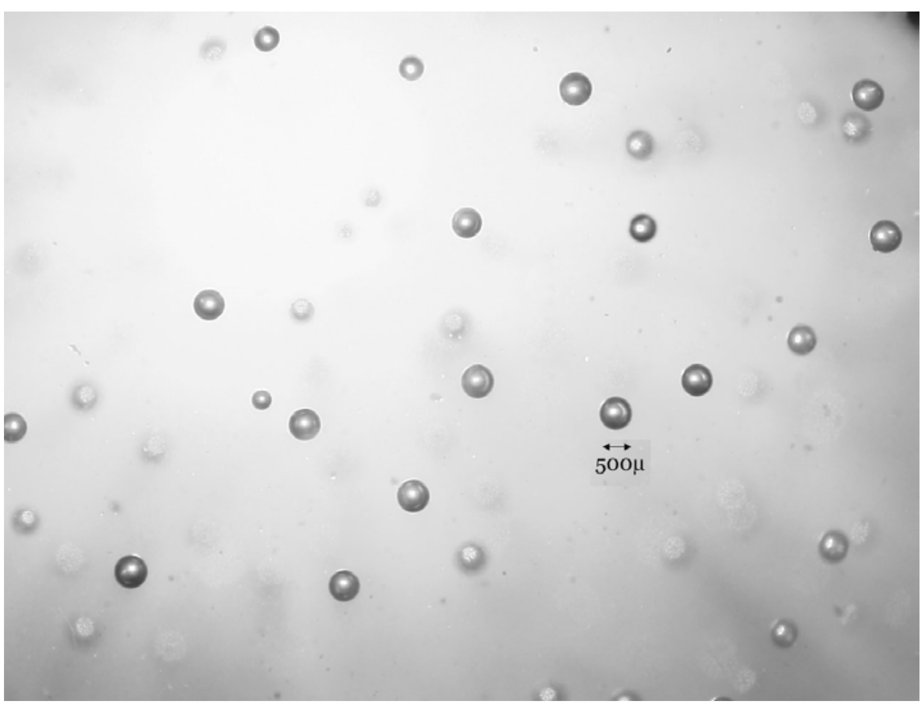

Figure 6: ABS Dynamic Run Series #1 at 2000 psig and 2nd 0 psig + 15 min

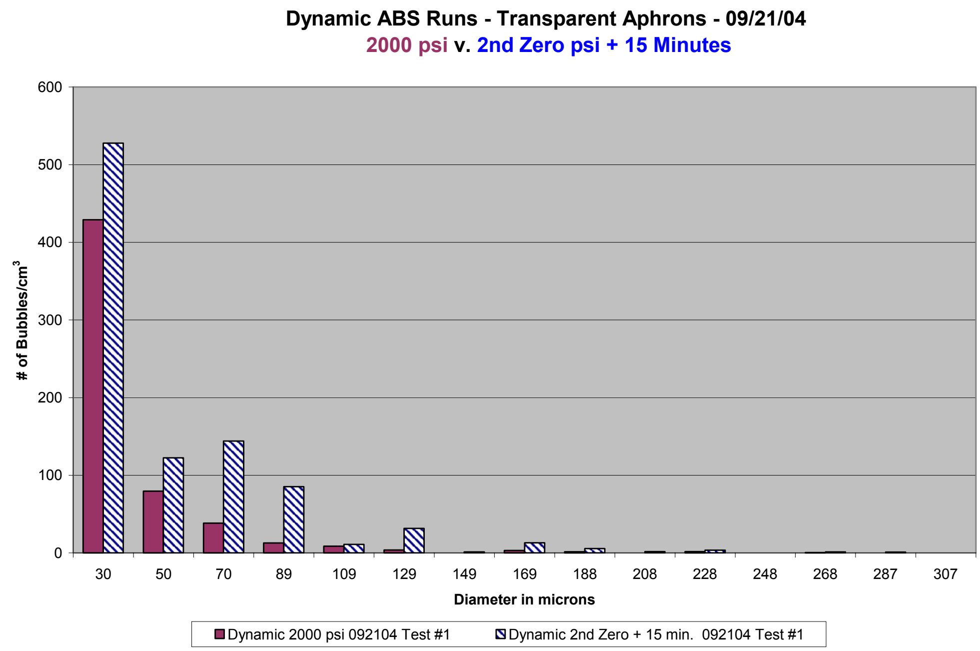

Figure 7: ABS Dynamic Run Series #2 at 2000 psig and 2nd 0 psig + 15 min (Photographs in Figures 8 & 9)

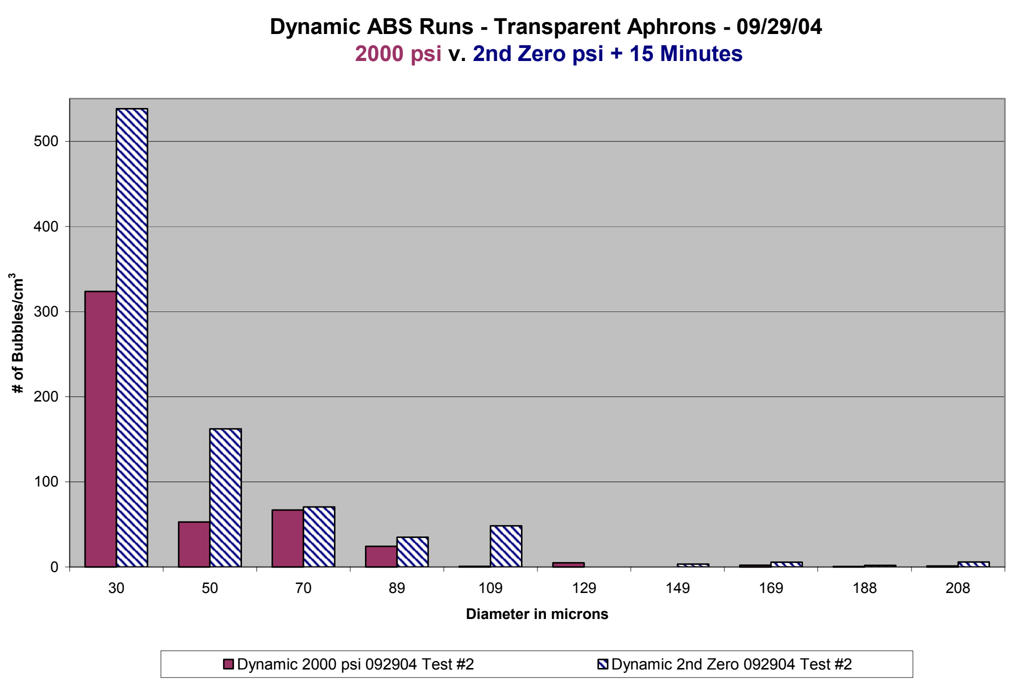

Figure 8: Photograph of Transparent APHRON ICS™ at 2000 psig

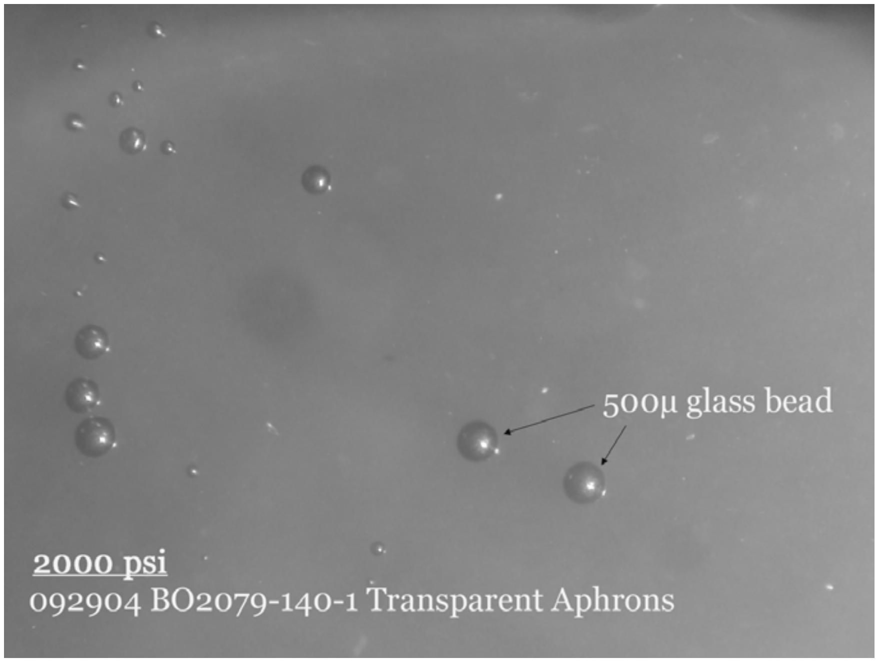

Figure 9: Photograph of Transparent APHRON ICS™ at 2nd 0 psig + 15 min