Crude oil demulsification assisted by ultrasonic energy using acoustic field distribution mapping

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Abstract

Evaluation of crude oil demulsification with ultrasonic bath after acoustic field mapping using hydrophone.

Introduction

The formation of water-in-oil (W/O) emulsions during crude oil production is a problem for petroleum industry. The presence of emulsified water increases the oil viscosity, which difficults its transport through pipelines resulting in increasing costs and corrosion damage.[1] In this way, some recent studies have been demonstrated the potential of ultrasound (US) as an alternative technology to those conventionally used in industry for promoting demulsification. Regarding to the industrial applications of US, it may be found in cleaning processes, chemical reactions (sonochemistry), and in the industrial preparation of emulsions.[2] When acoustic waves are propagated in a bath, their effectiveness is critically dependent of some parameters related to the solvent and sample, such as viscosity, surface tension, vapor pressure, and temperature. However, the intensity of US is one of the main parameters to improve sonochemical effects.[2] Furthermore, the intensity of the acoustic field is not equally distributed within the liquid.[3] For this reason, in the present study we developed an automated system to map the distribution of acoustic field in US bath by using a hydrophone in view of establish the appropriate positions for improving demulsification efficiency.

Results and Discussion

All experiments were performed with 50% (m/m) oil/water emulsions containing 50 ppm (v/v) of demulsifier. For the demulsification with a 35 kHz US bath (24x30 cm), sonication times of 0, 5, 10 and 15 min and amplitudes of 20, 60 and 100% were evaluated, at 50 °C. Considering the US mapping obtained with hydrophone, it was possible to observe a clear indication of higher intensity acoustic field located over each transducer. Considering the optimized conditions, the demulsification of a synthetic emulsion was performed in 9 different positions in the bath (Figure 1A). Demulsification efficiencies up to 95% were acieved on the positions of higher intensity acoustic field (1, 2, 3 and 4 in Figure 1B), with 100% of amplitude and 15 min of sonication. In another way, low efficiencies (< 50%) were obtained in positions with low intensity of acoustic field, which may be related to destructive interference of mechanical wave.

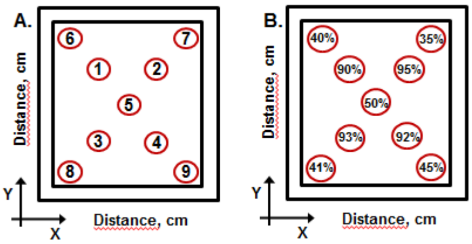

Figure 1. (A) Top view of US bath identifying the positions where tubes containing oil emulsion were placed. (B) Efficiency of water separation from petroleum emulsion at different positions in US bath.

Conclusions

Results obtained in this study showed that ultrasound may be considered a promising technology for crude oil treatment. In addition, the acoustic field mapping with the aid of a hydrophone allowed establishing the regions of highest intensity of energy, which contributes to a better efficiency of the US bath for demulsification processes. The efficiencies obtained for water removal were higher than 90% in positions of more intense acoustic field. In this way, the use of ultrasonic energy, associated with the use of demulsifying agent, may be a promising alternative for promoting crude oil emulsions demulsification with high efficiency, in a relatively short time of sonication. Additionally, by using the proposed approach it was possible to better understanding the process related to water separation from crude oil, which allowed intensification of this process.

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