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On the ultrasonic atomization of liquids

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Abstract

This paper deals with an experimental study of liquid atomization phenomena. For this study an experimental set-up was designed and constructed. A special criterion to start the recording of the process with a high speed digital camera was developed. The frequency dependence of atomization threshold is considered. The theoretical predictions for atomization threshold are also checked. The agreement between the predictions and the experimental results fit qualitatively with the data well until a frequency of 22 kHz. For frequencies beyond this value the tendencies are the opposite.

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1. Introduction

The atomization of liquids is always an object of interest from both scientific and technical aspects. The first reported use of ultrasound to produce a fog from a liquid was published by Wood and Loomis, in 1927. In this remarkable paper Wood et al showed a complete experiment at high frequency producing atomization of liquids at 300 kHz. From the Wood paper a great number of papers devoted to study the ultrasonic atomization phenomena

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have been published (Söllner, 1936; Harmon, 1955; Crawford, 1955; Sorokin, 1957; Rozenberg and Eknadiosyants, 1960; Lang, 1962). More recent researches are addressed to find correlations between ultrasonic generated droplets and some of the problem variables (Rajan and Pandit, 2001). Also researches have been done of more complex liquids such as melted metals, for instance (Lagutkin et al., 2004). Even research has been done in atomization of multiphase liquids (Avvaru et al., 2006). In summary even being an old problem and very old phenomena several aspects of ultrasonic atomization remain open until today, showing the need for research in both aspects experimental and theoretical. In this paper an experimental research about ultrasonic atomization of liquids is presented. Then research covers a wide range of frequencies making the results more complete and with valuable data for uses in laboratory and in the industry. The range of frequencies covered is from 6 kHz to 40 kHz, that is to say, is the more used frequency range in the industrial uses of ultrasound. The variables considered are the vibration amplitude of atomizing device, the threshold of atomization and the droplet size.

2. Material and methods

For this research a complete experimental set-up was developed. To build the experimental set-up, nine high-power ultrasonic transducers were designed and constructed. Also the power ultrasonic transducers were fully characterized. A study to determinate the control variables of the problem was done, the control variables must allow the determination of ultrasonic excitation of atomizing transducer in the instant that atomization starts; this furnishes the atomization threshold at the working frequency. A special criterion to produce the start of data acquisition was developed; it solves the problem of detection the onset of atomization.

2.1 The transducer design

The transducers used in this experiment are piston-like sources. To obtain high displacement amplitudes in the tip of transducer, a stepped horn type transducer was designed and constructed. The active part of the transducer is a pre-stressed sandwich transducer (Neppiras, 1973). The design was optimized modeling the final device using finite element software. For instance, in the figure 1a the simulation results for a transducer of 22 kHz of resonance frequency it is presented. In the figure 1b a picture with the transducers set used in this research it is shown.

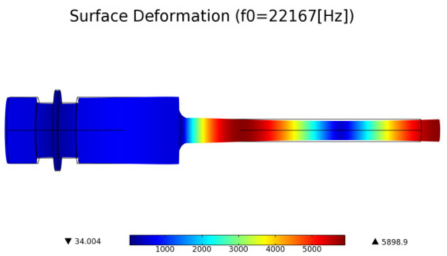

Figure 1a.- Example of power ultrasonic simulation. The transducer tip presents the greater displacement.

Figure 1b.- Ensemble of transducer for atomization experiments.

For the experimentation a set of nine of these transducers was designed and contructed, the ensemble of the transducers can be appreciated in the figure 1b.

2.2 Experiments

For the experimentation it is necessary to know the vibration amplitude just in the tip of the transducer. To know the vibration amplitude in all experimentation time, a curve between the feeding current and the vibration amplitude was done.