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APPLICATIONS OF DISPERSED PHASE ACOUSTICS

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The problem of the influence of the acoustic field on dispersed phase in the fluid has been studied in connection with application of acoustic coagulation for precipitation of gases. This subject contains important aspects of the natural environment protection. This paper gives an overview of the applications of dispersed phase acoustics, with particular emphasis on recent developments, e.g. acoustic method of airport fog precipitation. This innovative technology is based on the fact that water can be collected from fogs under the influence of acoustic waves. This work presents the new results of the analysis of the action of the acoustic field on the fogs.

Key words: acoustical field, dispersions (suspensions, aerosols), fog dispersal, acoustic coagulation and precipitation gases, the natural environment protection.

1. Introduction

The paper [1] summaries the basic theory of dispersed phase acoustics. The interaction of acoustic waves with dispersions can be used for separating the dispersed particles from the fluid. Under the influence of the acoustic wave, the particles existing in the fluid experience a certain characteristic displacement, referred to as the drift. The drift force depends on the particle size, on the parameters of the acoustic field, and on the fluid. The dispersed phase acoustics has reached only limited commercial application. The main reasons are high capital costs and high power requirements. It seems that the range of applicability of the dispersed phase acoustics is important in special cases.

An acoustic field, depending on the intensity and frequency of the wave, as well as the physical condition of the medium, may cause coagulation, i.e. the joining of small particles into larger aggregates or fragmentation of large particles into small ones [9].

The current research programmes concerned with the application of acoustic fields to the processes of gathering and sorting the particles dispersed in liquid media are being conducted in three main directions: search for highly efficient sources of acoustic energy, search for the acoustic field configuration which may increase the acoustic coagulation effect, determination and adjustment of acoustic field parameters to a suspension in order to intensify the phenomena which are advantageous due to their practical application.

2. Main fields of dispersed phase acoustics application

Dispersed phase acoustics may be useful in solving the problems of:

- natural environment protection: air de-dusting,
- de-gassing liquids,
- studying properties of cellulose,
- separation of blood cells from a liquid,
- fogs precipitation.

The acoustic coagulation process is based mainly on the orthokinetic interaction of particles vibrating with different amplitudes and phases [1]. The presence of drift forces plays auxiliary role by maximizing the orthokinetic process. The transport of the particles under the effect of the drift forces determines the rate of the cleaning process [4, 5].

As regards the practical applications, of particular importance are the estimations of particle acceleration caused by various type of drifts [1].

2.1. Natural environment protection: air de-dusting

Estimation of the amplitude A_D of the acceleration of the solid particle suspended in air effected by the drift forces as a function of particle radius has been presented in the paper [1]. In the process of acoustic coagulation the mean particle size increases, decreasing the toxicity of the aerosol and facilitating its further cleaning by traditional methods [10].

2.2. De-gassing liquids

The experimental and theoretical studies of acoustic agglomeration of gas bubbles in the liquid have become a new focus in ultrasonic fundamental research. The ultrasonic waves can be used for separating the gas from the liquid, under the threshold of the cavitation [1]. These mechanisms are very complex processes and their descriptions are not completely established.

2.3. Studying properties of cellulose

The papers [1] and [3] tended to develop the acoustic method of an examination of the paper-pulp. These works were engaged in problem concerning the changes of concentration of water suspension of cellulose fibres in ultrasonic field.

2.4. Separation of blood cells from a liquid

The ultrasonic waves can be used for separating the blood cells from the liquid (*in vitro*). The parameters of the cells and the medium they are placed in must be given (i.e. medium density and viscosity, wave propagation velocity in a given medium, etc.). The acoustic field parameters may be adjusted so that they are being separated from the liquid [6, 7].

2.5. Fogs precipitation

There is ample evidence that industrial activities modify local and sometimes regional weather conditions [8]. Fog is particularly hazardous at airports. Fog reduces visibility.

In meteorology, visibility is a measure of the distance at which an object or light can be seen. It is important to all forms of traffic: roads, sailing and aviation. A few airports different techniques are being used to precipitate fogs [2]. In the process of acoustic precipitate the mean particle size increases (rain) [5]. We present the new results of the analysis of the action of the acoustic field on the fog. We estimate the particles acceleration caused by various type of drifts in a stationary wave field.

3. Results of calculations

The main reasons for the movement of particles (fog) in an acoustic field (known as drift) are: the pressure of wave radiation on a particle (R-type drift); periodical changes in the viscosity of a vibrating medium (L-type drift); deformation of the acoustic wave shape (Z-type drift); asymmetry of the vibrating medium movement in a stationary wave (A-type drift) [1]. To compare the effectiveness of the action of various types of drift

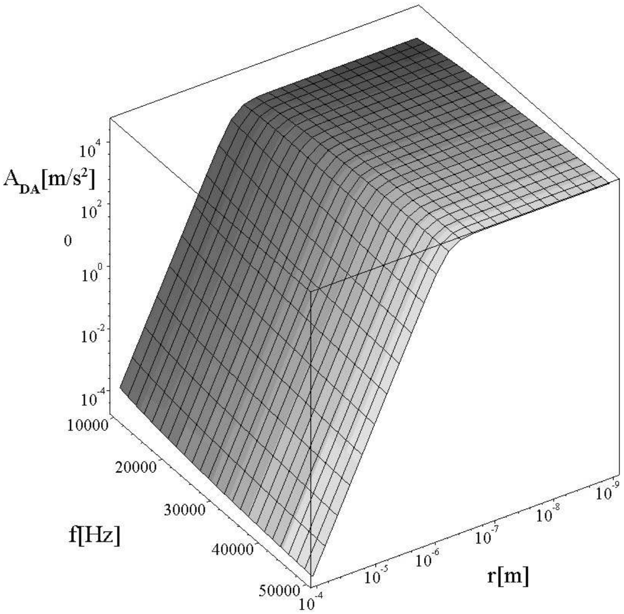

Fig. 1. Amplitude A_{DA} of the acceleration of the particle of water suspended in air, (fog) effected by the drift forces of types A, as a function of particle radius and frequency.

forces in an acoustic field on the water particles, the acceleration amplitude (it denotes $\mathrm{A_D}$) has been calculated. The results of calculations are given in Figs. 1–5. The plots made on logarithmic scale.

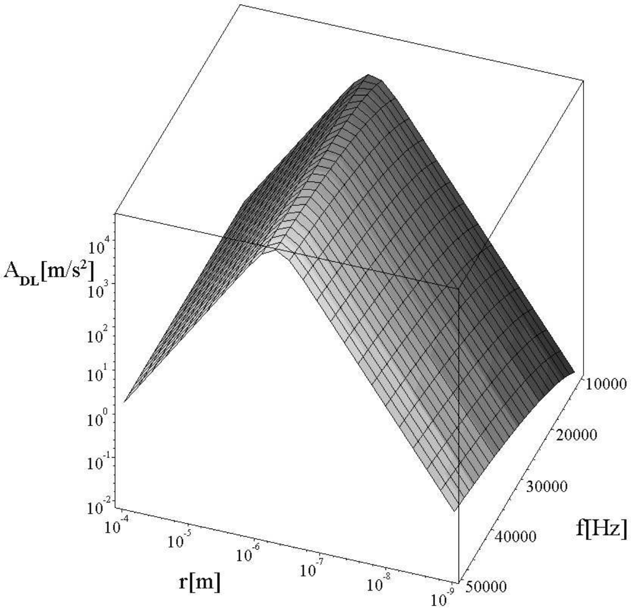

Fig. 2. Amplitude $\mathrm{A_{DL}}$ of the acceleration of the particle of water suspended in air, (fog) effected by the drift forces of types L, as a function of particle radius and frequency.

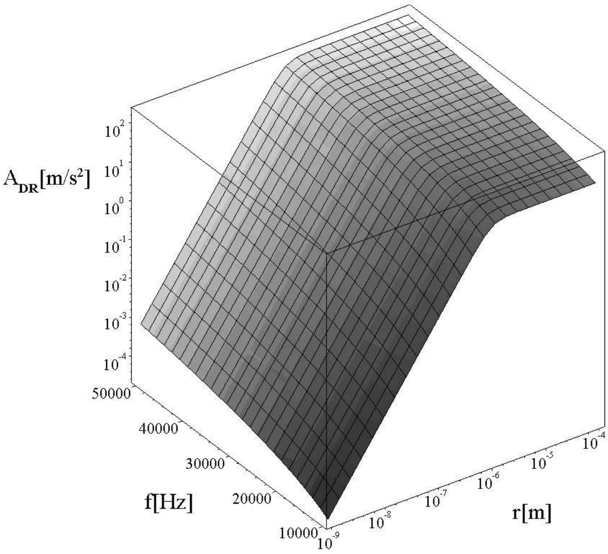

Fig. 3. Amplitude $\mathrm{A_{DR}}$ of the acceleration of the particle of water suspended in air, (fog) effected by the drift forces of types R, as a function of particle radius and frequency.

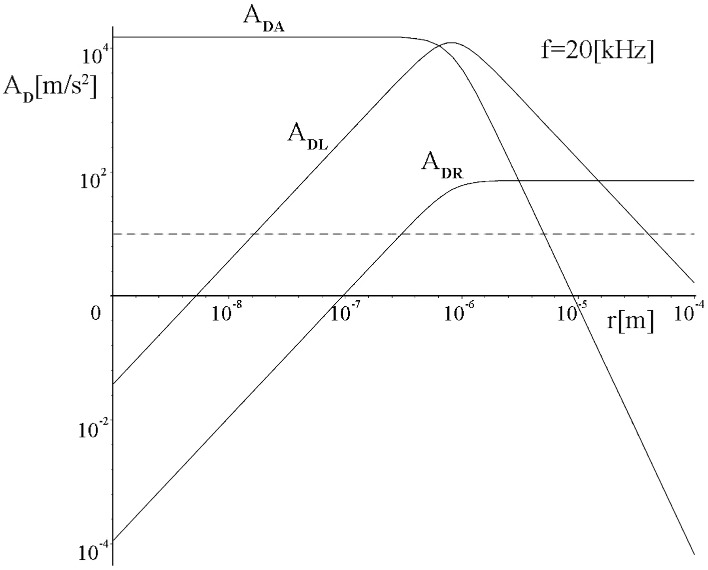

Fig. 4. A comparison of the amplitude A_D of the acceleration of the particle of water suspended in air, (fog) effected by the drift forces of types R, L, A as a function of particle radius at 20 kHz. The horizontal dashed line represents the acceleration of gravity.

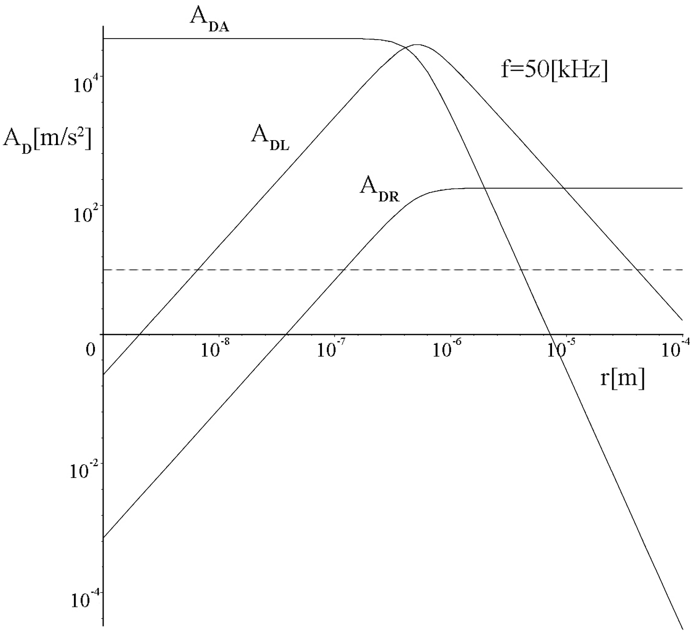

Fig. 5. A comparison of the amplitude A_D of the acceleration of the particle of water suspended in air, (fog) effected by the drift forces of types R, L, A as a function of particle radius at 50 kHz. The horizontal dashed line represents the acceleration of gravity.

For the quantitative analysis of described effects it is being assumed following numerals parameters values which characterize acoustic field, dispersed phase and the medium: particle density (water): 1.000 kg/m^3, medium density (air): 1.249 kg/m^3, acoustic sound speed in air: 340 m/s, density of wave energy: 1000 J/m^3, rang of particles size: 10^{-8}–10^{-4} m, frequency: 10 kHz – 50 kHz.

Comparative studies in different drift types conducted for fogs prove that the aforesaid types of drift are not mutually competitive, as they dominate within different, mutually complementary variability ranges of the parameters of the water particles and the acoustic field. For the largest particles, with radii of the order of 10^{-4} m, the radiation drift acceleration is the strongest, for smallest particles, with radii of the order of 10^{-8} m, the A-type drift acceleration dominates. In the intermediate interval, the L-type drift acceleration dominates.

4. Conclusions

In summing up the considerations, it can be stated moreover, that particular kinds of drift dominate various intervals of variation of the water particle radius. The phenomena causing transportation of the particles dispersed in liquids result in local changes in particle concentration and thus, under particular circumstances, in coagulation and acoustic precipitation of suspended particles. The water particles can be collected from fogs under the influence of acoustic waves. Dispersed phase acoustics takes up new applications in various fields of industry and medicine.

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