

Review  
of the Ph. D. thesis of Vladimir Chirkov  
entitled "Influence of Charge Formation Mechanism on the Structure of  
Electrohydrodynamic Flow in Highly Non-Uniform Electric Field"  
submitted for the degree of Doctor of Philosophy in Physics  
at the St. Petersburg State University

Electrohydrodynamic (EHD) flows emerge in liquid dielectrics under the effect of strong electric field, playing an important role in high-voltage conductivity of low-conducting liquids and influencing the processes of mass transport and breakdown strength of the latter. At present, heightened interest to charge transport processes in dielectric liquids is explained by that the latter are widespread as electroinsulating and cooling medium in high-voltage plants where EHD flow emergence can whether worsen or improve characteristics of the devices. However, employing EHD flows in an efficient way demands detailed understanding their structure and availability of advanced methods for computer simulation of the corresponding processes. Undoubtedly, the issue is of great importance and is investigated by a number of scientific groups all over the world. Taking into account the state-of-the-art of the question, I may claim that the subject of the dissertation is topical, and its studying at the time being is promising owing to the development of computing power and software for computer simulation.

The significance of the work is directly linked with its complexity. In the literature, the phenomenon under investigation is described by a complicated set of several nonlinear interrelated equations, which disables conducting the detailed theoretical analysis of EHD processes and, thereby, retards progress of EHD technologies. However, the new method for simulation of EHD flows, which was developed by the author, is an effective one and it lets one considerably succeed in the development of applied EHD devices and improve characteristics of the latter. Moreover, Vladimir Chirkov pays a lot of attention to the issue that is of great importance for conducting numerical calculations of EHD flows, namely to investigation of charge formation mechanisms that underlie any physical model of the phenomena. However, it is worth noting that only the influence of a charge formation mechanism on the structure of electroconvective flows is considered, but not the physical basic of charge formation processes, which, in my opinion, was studied insufficiently.

The results are original, of high quality and presented in a sufficient extent. To obtain them, the author both made a number of numerical calculations and provided self-contained experimental research, and both types of data are presented in the papers written by Vladimir Chirkov. However, though the combination of experimental investigation and computer simulation is an advantage of the work, from the other hand, it underlies the fact that proposed method for numerical calculation is not a self-contained one and demands specific experimental data.

I am not an expert in the field of experimental methods for investigation of EHD processes; however, I can confirm that the choice of numerical method for calculation of the set of unsteady non-linear differential equations was quite justified. Described approaches to verification and analysis of accuracy of the solutions allow me count that the results are trustworthy. Besides, it is also proved by a satisfactory agreement between computer simulation and experimental results obtained under similar conditions.

The dissertation possesses quite logical structure. The introduction allows one to understand the point of the issue and main complications that are to be resolved. The review of general and related studies shows Vladimir Chirkov's awareness about both fundamental researches and the latest works in the field. The main part of the thesis is well-structured as opposed to the included articles that have implicit interrelation when considering them apart from the thesis. Nevertheless, the dissertation as a whole produces a good impression, and main part of the thesis matches well with the investigations presented in the articles.

Comparing the results of the thesis with ones obtained by the other authors, it can be concluded that the present work substantially contributes to the research of EHD processes. The results and especially the part, concerning EHD flows in liquids with non-zero conductivity, possess a novelty. The field-enhanced dissociation is directly shown to lead to the emergence of EHD flows, which has to be taken into account, when developing and designing EHD devices. Besides, the method for calculating the integral current characteristics presents a special interest and lets one take into account both different cases of charge formation and the effect of EHD flows on the electric current in the system.

According to the presented list of Vladimir Chirkov's papers and reports, all parts of the dissertation were approved at a number of conferences, including major symposia in the field. At the same time, one half of reports was made in Russian and the other one — in English, which let one believe that the results were presented to wide range of specialists both in Russia and abroad.

There are a few flaws in the dissertation. First of all, when one proposes a new method for numerical calculation of some phenomenon, it is highly recommended to conduct a comparison of the method with existed ones by both the time cost and quality of the results obtained under the similar statement of a problem. Then, I want to mention again that the simulation technique is not self-contained, since its realization demands using some phenomenological coefficients. However, the latter is justified by the general state of research in the field, and it is not a shortcoming of the present work. Besides, in spite of obvious practical value of the results, there are no examples of application of developed method for design of EHD devices; though, according to the list of Vladimir Chirkov's publications, such results were partially presented at conferences.

The dissertation of Vladimir Chirkov consist of 86 pages, including 4 original papers, the introduction, discussion of the results, conclusions and acknowledgements.

On the basis of the analysis of the presented work, I come to a conclusion that the dissertation of Vladimir Chirkov fully complies with the international standards for PhD dissertation in the corresponding field.

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