

Corona discharges around electrical conductors have been known since the early 18th century. It turns out that under specific conditions, e.g. when there is a potential difference between the electric conductors of a high-voltage line, corona discharges on the surface of these conductors generate wind. Air then travels from the higher voltage wire to the lower voltage wire. This flow of air is called the ionic wind. It is true that the observation of this phenomenon in transmission lines has been accepted as a side effect of the use of high voltage and considered unfavourable. However, the idea of using the ionic wind for other - useful - purposes has emerged. Scientists all over the world are trying to use the corona discharge phenomenon as a source of propulsion for light unmanned aerial vehicles. An example is the work of Prof. Adamiak of the University of Ontario who, while conducting research, created a lightweight triangular-shaped device and called it a "levitation unit". This small system consisting of virtually only a emitter and collector electrode was able to generate a large enough ion wind to lift the device. The latest development in this field is a lightweight unmanned aerial vehicle from MIT, which also used Coulomb forces to generate propulsive thrust. Although the flight was performed in a university gym and the plane flew at a distance of 15 metres, it was another step forward in the field of drives using electroaerodynamics. The object of our project is to develop a mechatronic system for generating airflow using high voltages of electric current to drive a toroidal propeller of e.g. a windmill. Unlike current research carried out in the world, where ion wind is a direct source of thrust generation, our project will use the mechanics of air ions to drive the toroidal propeller. We will build a special system to generate ion wind, which is the result of collisions of ions with electrically neutral air molecules in a dedicated electrode system operating at high voltage. The aim of the project will be to investigate the physics of airflow generation by means of Coulomb forces and their influence on the aerodynamics of the toroidal propeller. Based on our preliminary considerations, we have formulated a research hypothesis assuming that, compared to the existing flow of the aircraft toroidal propeller without the influence of the Coulomb force, the presence of flow induced by ion motion will increase the lifting force acting on the propeller. The research methodology covers two fields of science, which makes the project interdisciplinary. The physical model of phenomena occurring in the ion propulsion system includes both electrostatic phenomena and laws governing aerodynamics. The aim of the project is to develop an effective computational model to simulate various structural solutions of the Coulomb force-driven toroidal propeller and to produce a working real model. We plan to focus on setting up a test rig with an ion wind-driven propeller to collect the necessary experimental data. These will serve as input parameters for computer simulations. Advanced computer simulations will then be carried out to produce an effective computational model in a computer environment. The simulations will be used to make adjustments to the previously constructed test rig in order to optimise its performance. The validation of data from the research model and the computer model will provide an opportunity for a better understanding of the phenomena occurring in the system under study and for the acquisition of knowledge and skills in developing advanced electroaerodynamic simulations. The project will be carried out using COMSOL Multiphysics software, which is a powerful computational tool. Experimental tests will be carried out on a test stand using existing blades made in laminating technology. Aerodynamic parameters of the physical propeller model will be measured in a wind tunnel using a precision measuring balance. In addition, electrical quantities of the system will be measured using specialised measuring equipment. The specificity of electroaerodynamics consists in very complex and mutually occurring physical phenomena. The implementation of the research project, which is the subject of this application, will allow to obtain numerous results showing the relationship between electrostatic and aerodynamic phenomena occurring in the ion wind generation system. The research will allow to understand more precisely the mechanics of collisions between ions and air molecules, and to determine the threshold of effectiveness of such a propulsion system for unmanned aerial vehicles. There will also be a new scientific problem related to the effect of the ion wind generated by Coulomb forces on the aerodynamics of the toroidal propeller. No one has yet studied this aspect with respect to corona discharge systems. It is also planned to investigate the novel idea of the effect of electrode array rotation on the efficiency of air ion production.