

THE DEVELOPMENT OF A VIRTUAL MODEL OF LABORATORY INSTALLATION

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Abstract

One of the main tasks of higher education institutions is the introduction of information computer technologies (ICT) into the educational process. In this paper, it is proposed to use the possibilities of virtual reality in the educational process. In particular, the results of a developed virtual model of the laboratory installation, the device and the operating principle of its individual components and the installation as a whole are shown.

As the object of research, the installation for obtaining coatings on a material in a vacuum using an arc discharge was used. The installation is called vacuum-arc accelerator - VDU-1. The essence of the proposed method is to apply a functional coating on the substrate material to improve the performance characteristics of structural materials. The problem of extending the service life is relevant for solving various materials science tasks of an applied character. The coating is obtained due to an erosion of the cathode during pulsed plasma treatment.

In order to show the operation of the installation as a whole, its main elements and systems were presented in 3D format. To implement this task have been used computer programs as 3Ds Max and C #. These studies are part of the virtual laboratory work on obtaining coatings by the vacuum arc method. Based on this work in the future, it is also possible to show the physics of the sputtering process and the dependence of the result of plasma treatment on the parameters of the experiment. The results of the virtual experiment will allow to analyze the obtained data and to correct the experiment.

Thus, the virtual laboratory can become an integral part of the laboratory training in the students training of natural and technical specialties. The use of virtual opportunities will help to improve the perception and understanding of such complex laboratory settings as proposed by us. This will increase the efficiency of the work of university students in special courses, where they become acquainted with such laboratory work.

Keywords: Virtual model, Vacuum-arc accelerator, plasma treatment, coatings.

1 INTRODUCTION

Application of plasma streams for various technological purposes is associated with stabilization of work of a plasma source. In this work as the generator of plasma, the VDU-1 installation has been used [1]. The scope of application of VDU-1 is very wide: from the plasma diagnostics to obtaining coatings. Therefore, the development of virtual laboratory work for a study of VDU-1 is important and significant. This virtual development will help to increase the efficiency of experimental installation and will make it more economical. The virtual laboratory will help students to solve various unusual situations and problems related to the subjectivity of an experiment, offers many opportunities for carrying out research works and statement of experiments, and serves as the important addition for primary acquaintance with a specific experimental setup and technologies [2-4].

2 METHODOLOGY

2.1 Experimental setup

Virtualization was made of a real experimental setup – vacuum arc accelerator (VDU-1), developed in the special laboratory of pulsed plasma accelerator of Al-Farabi Kazakh National University [1,3]. Fig. 1 below shows the appearance of the installation.

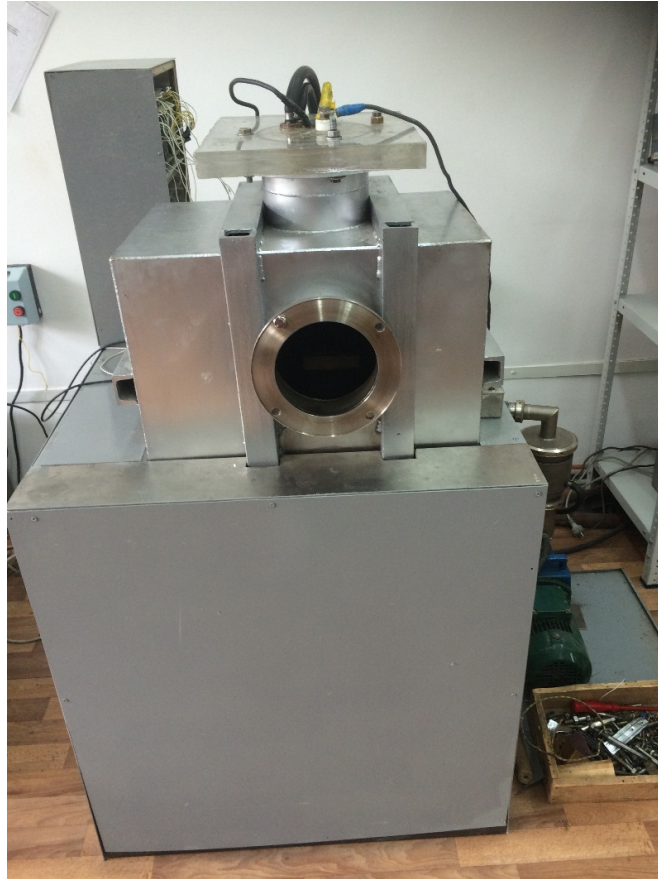


Figure 1. External view of the installation VDU-1.

VDU-1 is an installation that allows to obtaining coatings and powders by processing the material under investigation in a plasma arc discharge medium and operates on the principles of plasma accelerators [5-8]. The plasma accelerators are formed particle flows with velocities up to 10^5 m/s, with energies up to $10 \div 100$ eV, with the degree of ionization of the stream (ion fraction in the total flow) to 60-95% and the material utilization coefficient approaching 100%. The VDU-1 uses a "vacuum arc" - a high-current low-voltage discharge, formed in a deep vacuum and developing in a vapor of the electrode material subjected to erosion (Fig. 2). The plasma in the case of VDU-1 it contracted on the surface of the cathode and discharged into the interelectrode space due to its own magnetic field [6,7].

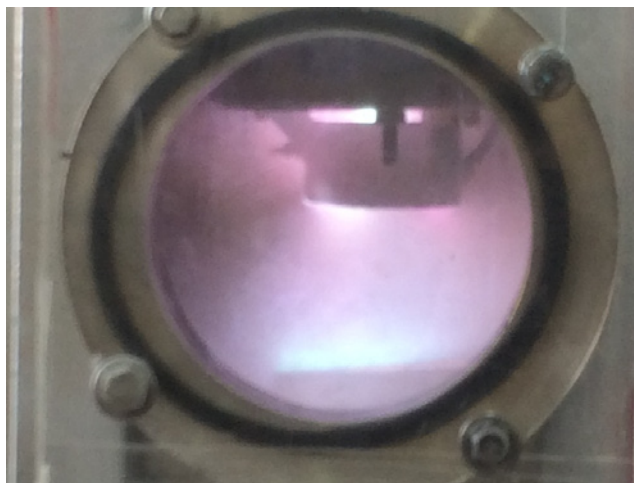


Figure 2. Formation of vacuum arc in a chamber of the installation VDU-1.

2.2 Software for virtualization of the experiment on VDU-1

To develop a virtual laboratory, in this case, it is proposed to use a comprehensive software package 3Ds Max, which includes everything necessary to create a virtual laboratory. For example, the 3Ds Max software package contains a graphics driver that uses the capabilities of DirectX and Open GL, a built-in 3D editor, separate programs for implementing sound, shadow, and other physical effects, as well as creating a landscape. 3Ds Max allows to create virtual laboratories of different levels and minimize the use of additional programs. 3Ds Max is a software system for creating and editing two - or three-dimensional graphics and animation, which works on the basis of operating systems such as Windows, OS X, Windows phone, Android, Apple iOS, Linux. The platform for 3Ds Max can be ordinary computers (Windows XP/Vista/7.OSX), mobile devices (Android. IOS. Blackberry), Internet browsers (Flash, Web Player), etc. A simple interface and graphics capabilities make the program 3Ds Max handy in the implementation of a virtual laboratory. Although there is a rich library of ready-made software solutions and powerful script drivers for fast compilation, some code has to be written in JavaScript or C#. Language features of C # are comparable to Java. C# is a programming language for .NET (dot-net) architecture developed by Microsoft. .NET is a new platform in the programming technology, that is created for computers included in the network. This technology is called Visual Studio.NET., this environment provides for the use of Visual Basic, C++, and C # programming languages, but it is not limited to this [9,10].

3 RESULTS

When getting acquainted with the installation, students need to know the device and the principle of operation of both the installation as a whole and its separate parts. In this regard, at this stage of the work, the aim was to visualize the installation in 3D-format, to show the operation of the installation and its separate systems, such as vacuum and electrode systems (Fig. 3-5). In addition, the possibility of a smooth transition from General to detail was taken into account in the development of the virtual model to improve the quality of perception. For example, at the beginning, the student is acquainted with the appearance of the installation from different positions, then his attention is focused on the separate details of the installation and the third stage the student has the opportunity to be acquainted with the structure of each system separately.

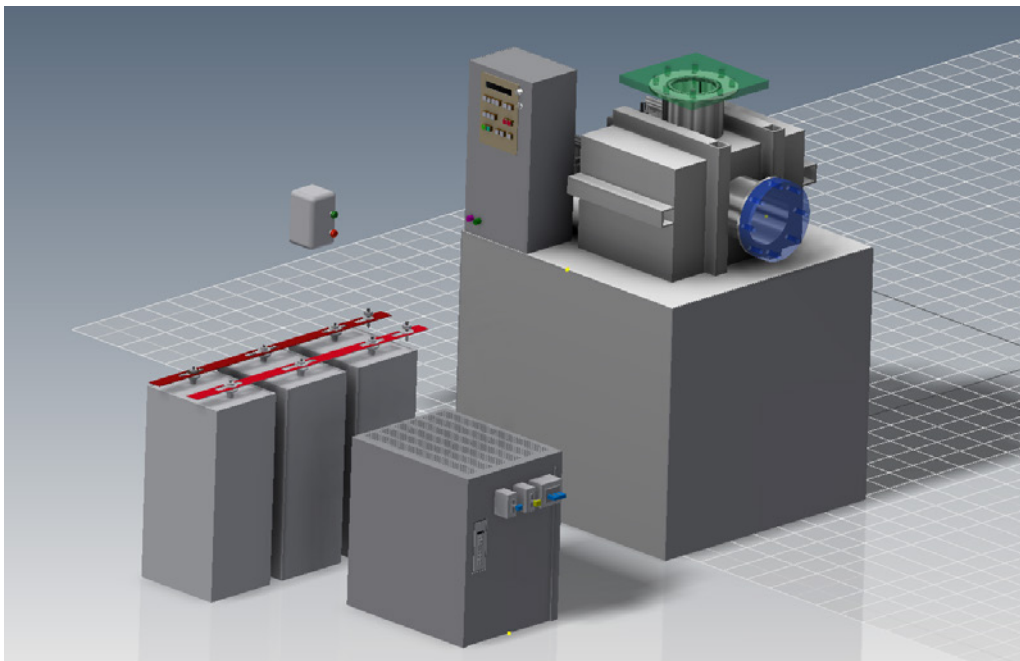


Figure 3. Side view of the virtual model of VDU-1.

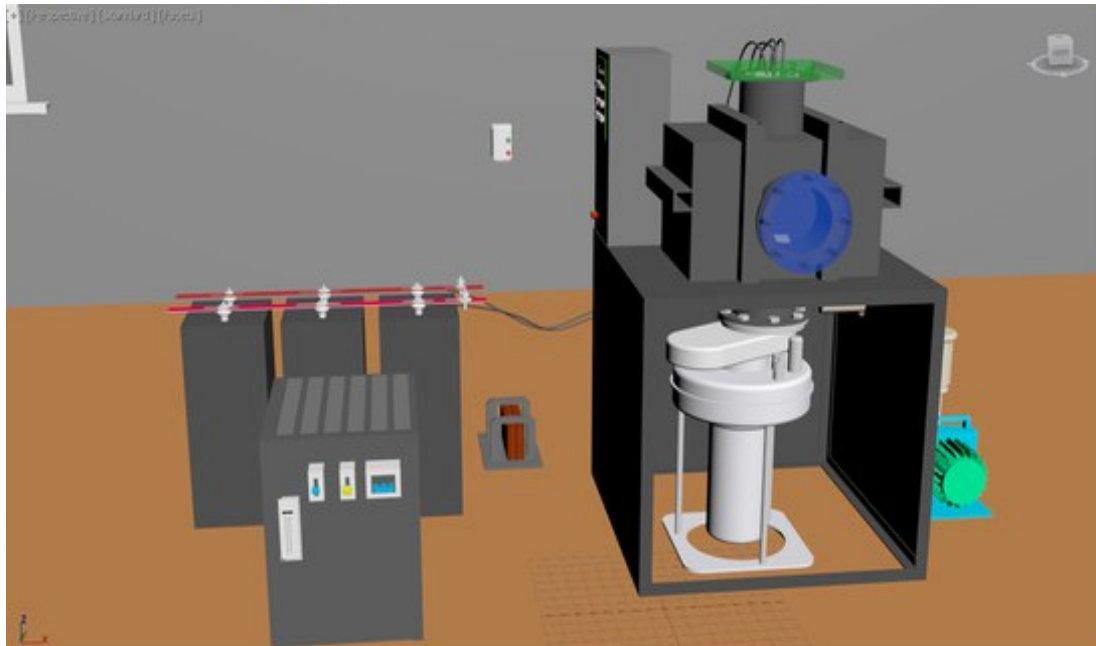


Figure 4. The vacuum system of the VDU-1, consisting of two pumpers and vacuum control device.

The deposition process is possible at a sufficiently high vacuum to 10^{-5} Torr, so the air is air pumping from the VDU-1 working chamber in two stages: up to 10^{-2} Torr by a mechanical fore-vacuum pump and then by a diffusion pump to the required value, as shown in Fig. 4. The vacuum control is carried out by the vacuum control unit.

To obtain a "vacuum arc," an electrode system consisting of an anode and a cathode and an igniting electrode located next to the cathode is used. Ignition of the arc discharge is provided by passing an igniting pulse with an amplitude ~ 10 kV. Under the influence of current, the film on the cathode evaporates and ionizes in the ignition zone. The operation of the accelerator is based on the erosive destruction of the surface layer of the cathode, which ensures a stable burning of the vacuum arc discharge in the gap between the cathode and the anode (Fig.5). On the water-cooled ("cold") cathode used in the installation, the arc is represented as a series of cathode spots with a diameter of up to units μm moving along its end surface with a velocity of the order of 10^2 m/s, which allows the cathode to remain generally cold despite the high energy density, concentrated in the spot.

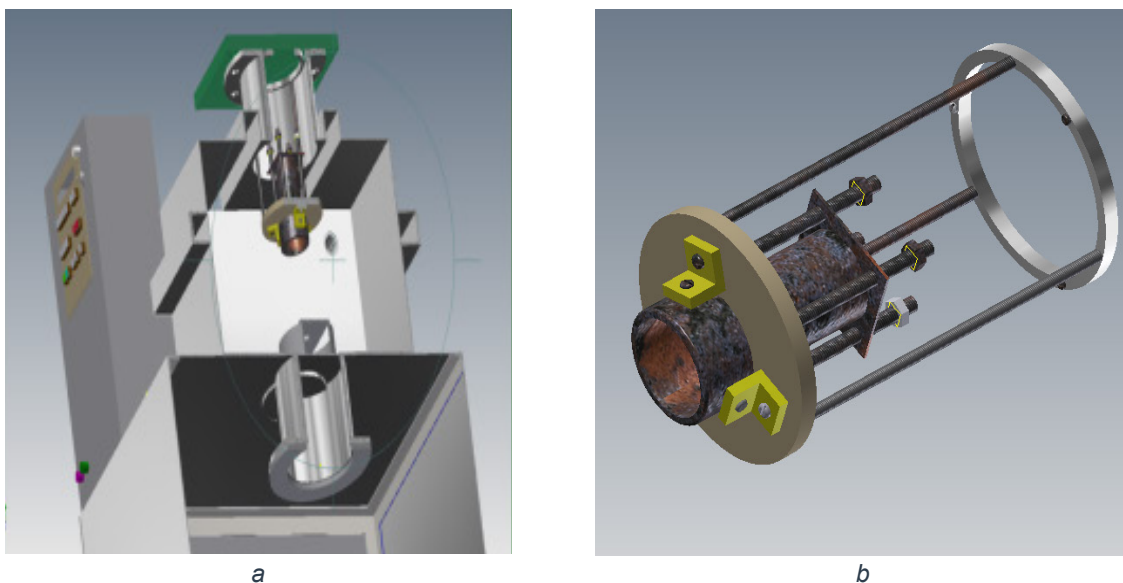


Figure 5. The electrode system of VDU-1: a) in the cross-sectional profile of installation; b) as separate installation item.

In addition, a virtual work was developed that demonstrates the operation of the installation itself, specifically, the arc ignition processes and the experiment on coating the substrate material (Fig. 6). This part of the work was necessary to adjust the operating modes of VDU-1 (Fig. 7).

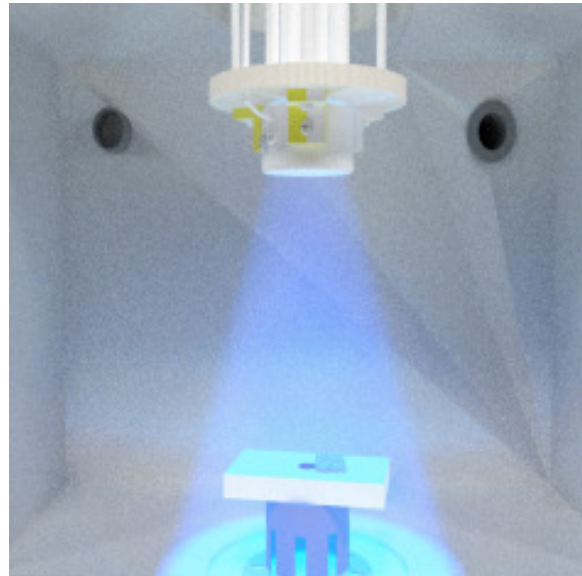


Figure 6. Visualization of the coating experiment.



Figure 7. A fragment of a video by adjusting the parameters of the experiment.

4 CONCLUSIONS

Virtual laboratories are an important component in learning, as it encourages users to be active in learning, observing and experimenting. This innovation expands and complements the possibility of mastering the educational material by the student.

In addition, many researchers of scientific education recognize that virtual laboratory studies increase the interest and competence of students to scientific research because the user of the program "Virtual laboratory" has the ability to observe the progress of the experiment at each stage of its implementation.

In this regard, we suppose that virtualization of such a complex experimental installation of the VDU-1 type will allow increasing both the efficiency of the installation itself and helping students in studying the details and operation principle of the installation.

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