INTRODUCTION

The effective protection of the surface of articles made from metals and alloys operating under conditions of wear or an intense corrosion effect can be performed via the deposition of protective coatings on the surface, which is preliminarily prepared; i.e., oxides, organic films, and different impurities are removed from it. The high adhesion of deposited coatings with metal surfaces can be provided by its preliminary cleaning with an ion beam or glow-discharge plasma. These methods are sufficiently efficient in regards to their sufficiently expensive and comparatively small details. The duration of the cleaning process and the cost of treating 1 m² of the surface prevent their widespread application in high-tonnage production, for example, sheet rolling, pipes, or large-scale details of machines and installations [1].

An alternative method for cleaning and preparing the surface of steel rolling is the treatment of the surface with arc discharge [2–5]. The erosion of the cathode at large (larger than several millimeters) distances between the electrodes, which is caused by chaotically moving cathode spots, allows us to use the arc to vary the properties of the surface. Upon applying the magnetic field tangential to the cathode in the discharge gap, the motion of spots becomes directed and allows us to control their location and motion velocity over the cathode surface. In the low-pressure arc, the value of \( \nu_S \) is a complex function of parameters of the fields and properties of the gas medium. This spot can move either in the direction of the action of Ampere forces or opposite of it, while the critical gas pressure, which corresponds to the inversion of the motion, depends on the arc current, magnetic field strength, and kind of gas [6]. The spot velocity \( \nu_S \) depends on the roughness and degree of oxidation of the metal surface.

Cathode spots of a long low-pressure arc with a closed discharge gap are able to remove the scale, oxide films, and fat contaminations from the surface of metal rolling in the delivery state. Due to their thermal effect, the structural-phase state of the near-surface layer of steel also changes. Therefore, vacuum-arc treatment can form the optimal conditions for the high adhesion of coatings with the matrix surface.

DESIGN AND OPERATING PRINCIPLE OF A VDO-I INSTALLATION

To investigate the process of the effect of low-pressure arc discharge on the state of the surface of construction materials, we designed a VDO-I pilot installation of the physical modeling of electroarc cleaning, the appearance and functional diagram of which are presented in Fig. 1.
The installation consists of a working chamber; a vacuum system; a control rack; and an arc evaporator, which is presented in Fig. 2.

A working chamber 1.5 m in length and 1.25 m in diameter is pumped by two NVM-18G forevacuum pumps to a residual pressure of $10^{-2}$ torr. It is controlled from a panel of the control rack of the vacuum system with the help of electromagnetic valves. The working gas is nitrogen, which enters the chamber from a cylinder with a reducer with the use of a hand-operated inlet valve. The pressure is monitored using vacuum manometers—standard 13VT3-003 with a PMT-6 sensor and precision VD-1 Membrovak—and is held constant during the treatment cycle.

A ground for the motion of the arc evaporator along the steel sheet is mounted in the upper part of the chamber. Electromotor $\delta$, which moves the electrode (arc initiator 9) over the sheet surface, is attached on the left to a large cylindrical pole of external magnetic system 1. A table mounted in the lower part of the chamber provides the motion of the steel sheet and the fixation of a necessary distance ($d$) between anode 5 and cathode (sheet) 6. The possibility of moving the arc evaporator along the axis of the cylindrical chamber makes it possible to obtain a strip with removed oxides on the steel sheet.

The arc evaporator, which in reality is an anode block with two magnetic systems, contains internal graphite anode 5 and external 1 and internal 4 magnetic systems for the induction of steady-state and alternate magnetic fields, respectively [7]. The process of cleaning the surface is based on the interaction of cathode spots with a contaminated cathode (steel sheet) surface. The steady-state arc magnetic field in the discharge gap between anode 5 and cathode 6 is induced using solenoid 2 and a cylindrical coaxial...