JOURNAL OF ENGINEERING SCIENCES
ЖУРНАЛ ІНЖЕНЕРНИХ НАУК
ЖУРНАЛ ИНЖЕНЕРНЫХ НАУК
Web site: http://jes.sumdu.edu.ua
DOI: 10.21272/jes.2018.5(1).f1
Volume 5, Issue 1 (2018)

UDC652.1:586.24

Analysis of the Application of the Galvanic Circuits in Schemes of the Catodic Protection for Underground Papelines

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Article info:
Paper received: October 26, 2017
The final version of the paper received: January 4, 2018
Paper accepted online: February 24, 2018

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Abstract. The possibility of using anode earthing in an assembly with a container is considered. Ensuring the integrity of the pipeline is a topical issue in connection with the environmental and economic consequences. The process of pipeline protection is accompanied by the removal of metal particles, at the electronic level. When creating a potential difference, the current will shift from the anode to the cathode. In the process of this shift electrons from the anode earthing switch are moved to the pipeline under the influence of an electromagnetic field. It thereby destroying the anode and expanding the metal elements under protection. Description of galvanic capacitive solution for cathodic protection stations is executed. To exclude the effect of the electrochemical protection on the cathode and, thus, improve the protection of the pipeline.

Keywords: cathodic protection station, underground metal pipeline, electrochemical corrosion.

1 Introduction

Ensuring the integrity of the pipeline is a topical issue in connection with the environmental and economic consequences. Currently, one of the effective methods of protection is the use of cathodic protection stations (HVAC). The article considers the possibility of using anode earthing in the assembly with the container. It contains a titanium dioxide magnesium anode, mounted inside a galvanized tube and filled with coke oven.

The urgency of considering the use of the anode in the assembly, in increasing the term of its operation, as well as improving agro-ecological indicators.

Consider using anode earthing plug in a container assembly. It contains a titanium dioxide magnesium anode, mounted inside a galvanized tube and filled with coke oven, which will increase the life of the anode earthing, as well as improve the agro-ecological parameters. Perform a description of the electrical system anode-ground-object that is protected. Consider the process that generates protective capability.

2 Materials and Methods

The basis of the work of electrochemical protection is the process of suppressing the influence of anode currents cathode due to the work of an external source. When the current flowing on an object that is protected more than a drain, an anodizing process occurs.

Anodizing allows you to create a thin, oxide film on the surface of the metal that acts as a protective layer. The method is based on the physical properties of the current of the galvanic pair.

When a difference in potentials between the metals is created and the current from the tread flies to the protected object, in our case the pipeline. This process is also accompanied by the removal of metal particles, at the electronic level. When creating a potential difference, the current will shift from the anode to the cathode. In the process of this shift electrons from the anode earthing switch are moved to the pipeline under the influence of an electromagnetic field. It thereby destroying the anode and expanding the metal elements under protection.

Anodic earthing doped metal (conductor) provided with a large number of free carriers (electrons) to generate electric current (Figure 1). The flow of current occurs due to the motion of electrons from the anode, which is an anode earthing, under the influence of the electromagnetic field on the cathode, in the case considered pipeline [1].

The result of cathodic protection is the excessive formation of ions of hydroxide, that is, the oxidation of the environment occurs. As a result, a violation of the balance of salts in the soil, which leads to the formation of salt deposits on the surface of the pipeline.

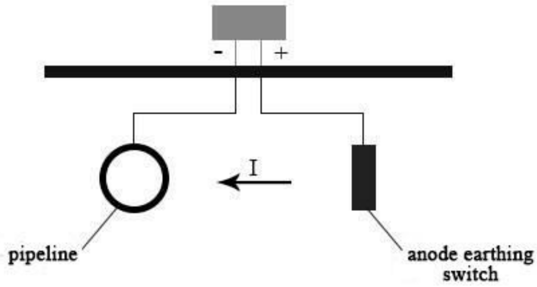


Figure 1 – The classical scheme of cathodic protection

3 Results and Discussion

These factors change the processes of electrochemical protection on the cathode. Complicating the cathode reaction in a double electric layer, due to diffusion problems with the transfer of oxygen. Similarly, a decrease in polarization current or an increase in polarization resistance, due to the growth of the layer of sediments near the protective pipeline [2].

At atomic level, metal is a crystalline lattice, with atoms. Which consist of electrons, negatively charged particles, and positively charged nuclei. Electrons that move freely and are not bound to the atom are valence electrons. Which and determine the behavior of the substance during the chemical process. The places where the electrons are absent are weak. If an ion with a missing electron will interact with the water molecule, the water molecule will be able to suppress this ion. Such a process will take place under the action of electrostatic force of gravity. In addition to the water molecule, which tries to suppress the ion of the ferrum, it acts on the free metal electrons that are attracted to the ion of the metal to free electrons. Free electrons return ions. When the process of dragging the ions comes to equilibrium on the boundary of the metal medium, an exchange current is formed and a double electric layer is formed. In this process, besides water, is still affected by oxygen, which attracts electrons, thus breaking the balance. Oxygen, taking electrons, creates a new negatively charged particle outside the metal. After removing the electron, oxygen contributes to the destruction of the metal [2]:

$$4Fe + 6H_2O + 3O_2 \rightarrow 4Fe(OH)_3. \quad (1)$$

In the case of cathode protection, we obtain an anode medium-cathode chain. Which is characterized by current, voltage and resistance. This can be expressed as follows:

$$I = (\varphi_{o\kappa} - \varphi_{oa}) / Z, \quad (2)$$

where I – current circuit anode-medium-cathode; Z – resistance of the circuit anode-medium-cathode; $\varphi_{ok} - \varphi_{oa}$ – potentials between the anode and the cathode.

$$Z = \sqrt{R^2 + \frac{1}{\omega^2 C^2}}. \quad (3)$$

The resistance in the circuit anode medium cathode will have both an active and a reactive component. The resistance depends on the environment, which means that it is variable and as a result the protection current will not be constant.

The deflection current on the pipeline oxidizes the medium, and leads to the formation of salts around the pipeline. Thus, changing the chemical composition of the soil. Which entails a change in the resistance of the medium and the currents of protection.

The result of cathodic protection is excessive formation of ions of hydroxide OH^-, that is, the oxidation of the environment occurs. As a result, a violation of the balance of salts in the soil, which leads to the formation of salt layer on the surface of the pipeline. These factors change the processes of electrochemical protection on the cathode. Complicating the cathode reaction in a double electric layer, due to diffusion problems with the transfer of oxygen. Similarly, a decrease in the polarization current or an increase in the polarization resistance, due to the growth of the precipitation layer near the protective pipeline [2].

The result of cathodic protection is the excessive formation of ions of hydroxide, that is, the oxidation of the environment occurs. Soil oxidation affects yields, as well as one of the factors influencing the occurrence of diseases in plants. Just an insignificant acidification of the environment, a decrease pH per unit, causing a decrease in the potential of the metal on 0.06 V.

The layer of precipitation near the protective pipeline is the salt. Which leads to deterioration of agro-ecological indicators.

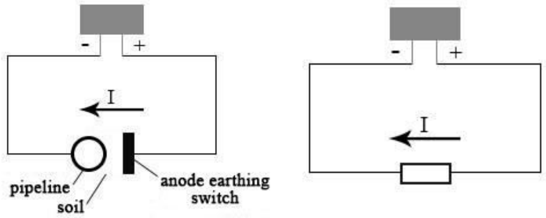
At the moment, a method has been developed that allows the galvanic solution to be maintained without destroying the anode earthing.

In this method, the object consists of a container. It contains a titanium-dioxide magnesium anode, mounted inside a galvanized tube and filled with coke oven.

Anode earthing is protected from the environment, removal of electrons in the soil from its surface does not occur. To anode earthing lead « + » power and an electric field is created around it. What attracts electrons from the environment, that is, the soil. Thus, creating a directed motion of electrons in the medium and the flow of electric current into the pipeline. In this way, the cathodic protection of the pipeline with galvanic decoupling is created. The scheme is shown in Figure 2.

Consider the work of a bipolar and field transistor. In Figure 3, an example of the field and in Figure 3 b, a bipolar transistor is shown.

In a field transistor, it is generally assumed that electrons move from source to drain, and controls the current voltage applied to the p-region, the gate [2].

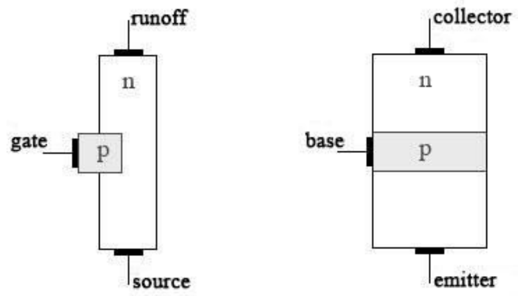


a b

Figure 2 – Cathodic protection of the pipeline with galvanic decoupling

The bipolar transistor of Figure 3b consists of two p-n transitions formed by a layer of semiconductors with impurities. The transition of the collector-base in the bipolar transistor with the common emitter is shifted in the opposite direction, resulting in a potential barrier preventing the main carriers from moving when the key is unlocked and power is not supplied to the base. From emitter to collector, which create current. When the power is fed to the base, the base-emitter transition becomes displaced in the forward direction.

As a result, the electrons from the emitter through diffusion pass through the base to the collector. Non-basic carriers from the base moving to the collector create a collector current in the transistor.

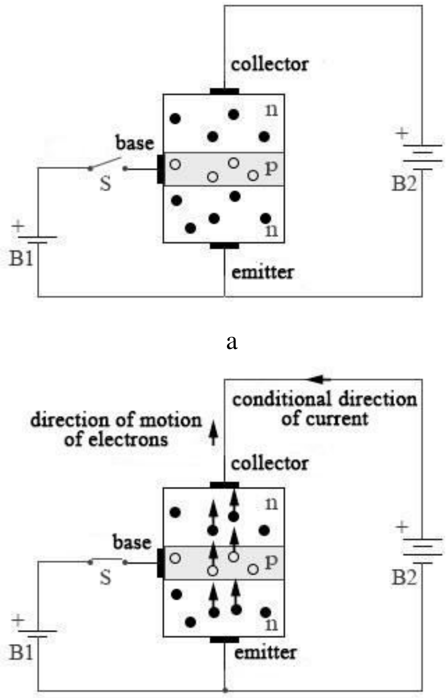


a b

Figure 3 – Field and bipolar transistor: a – schematic representation of the design of the field-type transistor with the n-type channel; b – a schematic representation of the construction of a bipolar p-n-p transistor

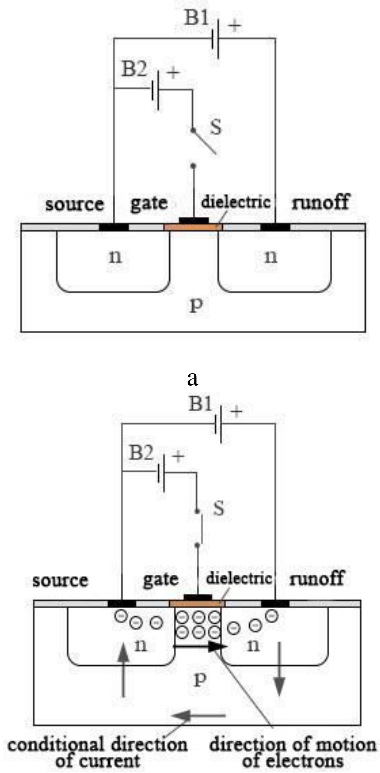
With the displaced forward direction of transition, the base-emitter flows through the circle emitter-collector [2]. In the field transistor Figure 4 with p-n transition, the current depends on the size of the depleted layer, near the gate. The shutter is doped to a large extent, compared to the n channel.

Typically, n-type areas are located on both sides of the p-type bar, Fig.5, in which case the conducting channel will be between the two depleted layers. By applying the voltage to the gate, a magnetic field will be formed around it. What kind of electrons will be attracted to the region under the dielectric, after which a channel is formed between the leak and the drain, which will move the electrons. As a result, there will be an electric current [2].



b

Fig.4 Schematic image of the operation of the bipolar transistor: a – without the base current; b – with the base current



b

Figure 5 – Schematic image of the field transistor operation: a – without the current; b – with the current

Similarly, one can consider the electrical system of the anode-ground-protected object. Consider the process in which the protective potential is formed.

Important for electrical engineering is the phenomenon in which, the flow of electric current through conductors leads to the emergence in the surrounding space of the magnetic field. Having two conductors with charges + *q* and – *q*, and driving them in motion with the help of EMF, we get the electric current in the conductor [3].

A magnetic field is formed around such a conductor. Which affects the moving charges, having magnetic moment and polarity, located in the environment between the pipeline and the anode. The magnetic field arranges the orientation of the molecules from the plus to the minus, thereby creating a directed motion.

The medium between the anode and the pipeline is a dielectric. Which when moving to an electric field is able to change its properties. The dielectric molecule consists of different charges of + *q* and – *q*. In what the -q rotates around + q and their rotation centers converge. When the molecule is affected by an external field, the orbit of the electron is deformed, their centers cease to coincide. The molecule begins to behave like an electric dipole [4].

To protect the pipeline from the steel without a protective coating from corrosion, a certain current density is required. In a sterile neutral state, the current density is in a range of 4.3–16.1 mA/m^2; well aerated neutral soil 21.5–32.5 mA/m^2; dry, well aerated soil 5.4–16.1 mA/m^2; wet soil 16.9–64.6 mA/m^2; sour soil 53.8–161.4 mA/m^2; a soil that supports the activity of sulfate-reducing bacteria 451.9 mA/m^2.

For a pipeline with a protective coating in the soil, the required current is un a range of 0.01–0.2 mA/m^2. As the coating is destroyed, the current density needs to be increased [5].

4 Conclusions

The description of galvanically capacitive solution for cathodic protection stations is executed. This method allows to prevent damage to the balance of salts in the soil. The considered method allows prolonging the life of the anode earthing switch. The creation of a protective current under the influence of the magnetic field, which is the EMF, affects the electrons in the soil. Electrons, which are the charge carriers under the action of EMF, form a directed motion, thereby creating a current of protection. This method also allows improving agro-ecological parameters.

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Аналіз застосування гальванічної розв'язки в схемах катодного захисту підземного трубопроводу

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Анотація. У статті розглянуті можливість використання анодного заземлювача в збірці з контейнером. Забезпечення цілісності трубопроводу, є актуальним питанням у зв'язку з екологічними і економічними наслідками. Процес захисту трубопроводу супроводжується виносом частинок металу, на електронному рівні. При створенні різниці потенціалів, струм буде зміщуватися від анода до катода. У процесі даного зсуву електрони з анодного заземлювача переміщаються до трубопроводу під впливом електромагнітного поля. Тим самим руйнуючи анод і виносячи елементи металу з, що знаходиться під захистом. Виконано опис гальванічної ємнісний розв'язки для станцій катодного захисту. Що б виключити результат впливу процесу електрохімічного захисту на катоді. Тим самим поліпшити захист трубопроводу.

Ключові слова: станція катодного захисту, підземний металевий трубопровід, електрохімічна корозія.