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THE CATHODIC PROTECTION OF THE VALVES FROM THE CONFIGURATION OF MANEUVER KEYBOARD OF A CRUDE OIL DECANTATION PARK

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***Abstract**: A general problem that faces those who carried out the operation, maintenance or corrective predictive of parks valves decanting the oil, is a lock so that the valves remain open or be closed. For modern parks are provided with ball valves and gaskets made of composite materials can be wrong just to avoid a deadlock situation subset of such equipment due to corrosion cell caused by salt water reservoir that is part of crude oil. This paper proposed a method for valves considered classics, to eliminate this unwanted effect of these valves corrosion. The cathodic protection of these valves is a simple and effective that explained in a few steps to implement such a system and some experimental features.*
***Key words:** keyboards, valves, corrosion, cathodic protection, reactive anode, corrosion potential.*

1. GENERAL ISSUES

The corrosion of the metals represent the reaction between a metallic structure and the environment through which it is in contact, the effect of this type of reaction depend by the time and leads to measurable physical-chemical characteristics and from here to damages. The corrosion can be electrochemical, chemical or physical-chemical, the electrochemical being specific to the pipelines posed to the underground and over ground.

For all two components of the galvanic cell, located in short-circuit, the potential difference between the anode and cathode it is that which generate the corrosion process. And also, the difference toward the equilibrium potential can increase a lot if in the pipelines networks are dispersion currents.

A mode to control the corrosion is the cathodic protection which is applies to the transporting pipeline networks for hydrocarbons with isolation posed outside. Through the cathodic protection is assuring electrons injection, to maintain the metallic structure of pipelines in the range of a pipeline-ground potential $E_{pr} = (-1.2 \div -0.85)\ \text{V}$ in the purpose to neutralize the corrosive agents from the ground.

The need of the electrons is provided, even by the reactive or galvanic anodes or by a DC generator (continuous current injection station), in the case of the most frequent single-phase charger.

The most common protection with galvanic anodes it is that with anodes from Al-Zn, Zn, Mg, anodes which are posed near the pipeline in serial and connected by a by-pass, to the pipeline.

Because of the potential difference between the pipeline steel and the galvanic anodes it is creating an electrons current having as affect the increase of the pipeline potential EP (mV). The process is that one electro-chemical: the metals posted into a moisture environment, become active and pass through into solution in the form of ions as a fact of transferring of electrical loads generated by the potential difference created by the free electrons.

From an experimental perspective the potential $EP(\text{mV})$, pipeline-ground should be finding between the values: (-850 ÷ 1200) mV in order that the cathodic protection to function in a qualitative way. If the measured potential pipeline-ground exceed the value of -1.2 V occur the danger of separation of hydrogen from the water which can produce an cracking corrosion in the molecular structure of the pipeline steel, this effect of hydrogen atom entrance is called also as wedge effect. The protection current cannot be injected into a single point of the pipeline and its length is higher, because each current injection is effective only over a certain distance.

In this case the designer shall refer to use an algorithm, depended by the physical parameters of the pipelines respectively of the ground, to determine the required number of the reactive anodes groups or by the cathodic protection stations with current injection necessary on the pipeline length.

A special situation, which will describe in this paper, is that regarding by a cathodic protection variant which we proposed as for the maneuver valves posted on the route of transporting pipelines and also as for the valves from the configuration of a keyboard afferent to the decantation park of crude oil by salted water.

Fig. 1.1 Maneuver technological equipment into a hydrocarbons delivery point (photo)

Regarding the potential differences from the assembly of a valve, the fact that: the maneuver rode being made from steel, the valve body is made from grey cast iron and the sealing inner from the cable gland from bronze or brass is enough to be an moisture environment because those potential differences to put it in connection, becomes electrical loads which practically create through the corrosion phenomena an "welding" of the faucet in open or closed position.

2. THE ANALYSIS OF THE CORROSION PROCESS IN THE CASE OF A FAUCET VALVE

The environment into which is positioned a valve, valves groups, it is extremely important for generation of corrosion process. At the apparition of keyboard damage, in this case into a crude oil decantation park, a major risk it is the pollution of the environment case in that is passing through the valves disassembling, from the configuration of a technological equipment, to be replaced or repaired. Thus, starting from the inconvenient described above, in the paper, we present a variant of cathodic protection, with reactive anodes, in the purpose to stop the damages of those valves appeared because the phenomena mentioned above. In this sense was analyzed the variant application of magnesium anodes on the body of a faucet valve by following of the potential $E_{pr}\left(\mathrm{mV}\right)$ valve/ground using an voltmeter with internal resistance by 105 Ω/VCC and Cu/$CuSO_4$ reference electrode.

The current amount which can be generated by an anode it is proportional with its mass and with electro-chemical equivalent of the metal from which it is manufactured. The required mass of the anode it is establish according with expression, [2]:

$$m = \frac{M}{n \cdot F} I \cdot t \cdot \eta \qquad (2.1)$$

where:

$I(A)$ – is the current which should be assured to the construction

$t(s)$ – the planned time for protection

$\eta = 60\text{-}95\,\%$ – protection capability, dependent by the anode's material

M_a – atomic mass of the anode's material (MAl = 26,981(uam); MZn = 65,38(uam); MMg = 24,305(uam)

N – oxidation main group (nAl = 3; nZn = 2; nMg = 2)
$F = 96500$ (C ·mol-1) – Faraday's constant

The application with reactive anodes on the surface of the valve body and monitoring of the potential represent a simple and efficient technological solution. Practically, in this case the cathodic protection is made by keeping the potential of the valve in the range values of potential E_{pr} (-850 ÷ 1200) mV . To control and to maintain this potential is necessary to be mounted isolation flange between the tubular material, from the configuration of technological equipment, and the valves posted in this configuration. It was opt for this solution considerate that through the pipelines and through those valves, passing through the crude oil accompanied by the formation water, is forming a condensation which creates a moisture environment to perform for an electrical cell formed: zinc anode – faucet body.

3. THE MODEL OF THE BODY VALVE. THE POTENTIAL OF METALLIC STRUCTURE

To realize an simulation where through visualize and then to analysis the variation of potential E_{pr}, in the range of cathodic protection, for the facet body, presented in figure 3.1 was chose the method of finite element, using Solidworks software, variant 2007, MEF[1]. The valve for which was perform the simulation of the potential variation in the purpose to optimize of potential $E_p\left(\text{mV}\right)$ have the following physical characteristics:

L – the length of the valve, 600 mm;
M – mass, 45 kg;
D – the diameter of the flange, 340 mm;
DN – the diameter of the valve, 200 mm
Number of the holes per flange, 10 pcs.

In the simulation performed by MFE with the aid of SolidWorks (Cosmos) software was considered that the valve is loaded with crude oil and salted water and immersed in the water; the resistivity of the formation water it is of 25 Ω•cm and the conductivity approximately of 7 S/m. In the analysis was considered more areas from the configuration of the valve body, and namely: 1. main area of the body; 2. the flanges; 3. seat valve (fig. 5.3).

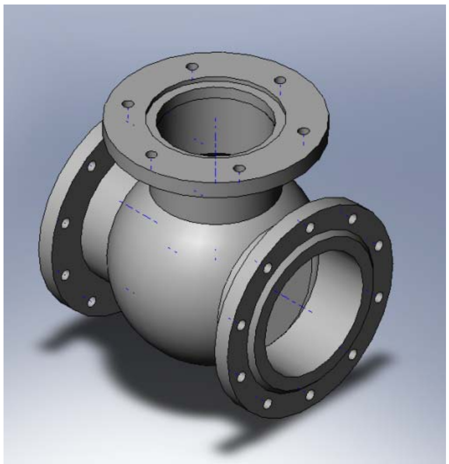

Fig. 3.1. Body valve with diameter of the flange of 200 mm

Through this simulation we apply an algorithm from Cosmoswork starting from: the choosing of the type of simulation, choosing of the material of valve body: grey cast iron; a thermal flux $\phi(W)$, some tests – numerical values, directed to the anodes mounted on the valve body; the quantity of the heat $Q(J)$ send to the valve body by conduction. The temperature of the interior, exterior surface (C° or K); is set the size of the network of valve body, is processed by iterations, are achieved values, looked by colors and tones of colors, numerical expressed on value scale – numerical values (fig. 5.3 and 5.4).

4. THE ANALOGY BETWEEN THE ELECTRICAL AND THERMAL FIELD

Because the software package, for design and simulation, SolidWorks, CosmosWorks 2007 doesn't have in the structure a software to simulate the modification of the electrical potential of a certain metallic structure was recourse at the anthology between the electrical

[1] The method of finite element, using the SolidWorks software.

and thermal fields, analogy on which the technical literature, the physics, respectively heat engineering has explained it. Thus, in the table 4.1 we present the main parameters of those two fields and their analogy. Using this analogy we precede experimental by thermal simulation: thermal flux ≡ electrical current; thermal conductivity ≡ inverse of electrical resistivity; quantity of the heat ≡ electrical voltage; temperature ≡ electrical potential etc.

From the technical literature [6] was shown that there is an analogy between the Fourier's law and Ohm's law, in this sense the Fourier's law:

$$Q = \lambda \frac{S \cdot \left(T_{si} - T_{se}\right)}{d} \cdot \tau \text{ [J]} \qquad (4.1)$$

$$\phi = \lambda \frac{S \cdot \left(T_{si} - T_{se}\right)}{d} \text{ [W]} \qquad (4.2)$$

where:

Q – the quantity of the heat transmitted by conduction (J or Wh);
ϕ – the thermal flux;
λ – the coefficient of thermal conductivity (W/m˚C), for grey cast iron is 58;
S – surface area of the element through which is made the thermal transfer, perpendicular on propagation direction of the heat (m^2);
T, T_{se} – temperatures of the internal surfaces, respectively exterior of the element (˚C and K)
τ – time (h);
d – thickness of the element (m).

Ohm's law can be put in the form:

$$I = \frac{U}{R} = \frac{E_1 - E_2}{\rho^1 / s} = \frac{1}{\rho} \cdot \frac{S\left(E_1 - E_2\right)}{1} \text{ [A]} \qquad (4.3)$$

where:

I – the intensity of electrical current (A);
U – the voltage (V);
R_e – the electrical resistance (Ω);
E_1, E_2 – the electrical potential at the ends of the conductor (V);
ρ – the electrical resistivity (Ω·m);
S – the area of the conductor section (m2);
l – the length of the conductor (m).

From the expressions (4.1) and (4.2) results the physical measures analogous

Table 4.1 Analogy between the thermal and electrical parameters

No.	***Thermal field***	
1	Thickness of the element	d
2	Temperature	T
3	Temperature difference	ΔT
4	Thermal conductivity	λ
5	Thermal flux	Φ
6	Unitary thermal flux	q
7	Thermal resistance	R
Electrical field		
1	The length of conductor	L
2	Electrical potential	E
3	Potential difference	ΔE
4	Inverse of electrical resistivity	1/ρ
5	Intensity of electrical current	I
6	Current density	J
7	Electrical resistance	R_e

5. MODIFICATION OF THE POTENTIAL, IN CATHODIC PROTECTION DOMAIN, BY MOUNTING OF REACTIVE ANODES ON VALVE BODY

These experimental tests, thermal simulation, which we used by MFE, exploiting by the mentioned parameters of thermal field, and by a range values of the unitary thermal flux analogue with current density J (A/m2) determined, as energy source, location of two magnesium anodes, Φ100/30 mm on the valve body.

Following the performed analysis, analogue speaking, was result values of injection current leads to the intuited results and namely at the potential values more negative at the valve seat, considered as the most vulnerable zone. The value of current densities we considered experimental depended by the considered environment, salt water formation, was in a value range of 100÷220 μA/cm^2.

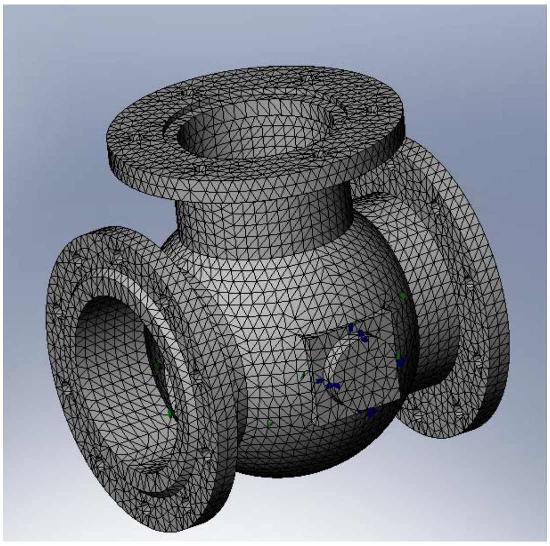

Fig. 5.1. The method of finite element, the network of valve body analyzed by thermal load

Considering that the choose position of the anodes and the montage conditions on the external surface of the valve body, respectively the volume of those magnesium anodes was achieve, by simulation at a anodic current of 1150÷1435 μA (thermal flux W) in analysis) an potential E_{pr} mV (temperature 20÷40 C°) in the domain where in a stability at the corrosion reaction.

Fig. 5.2. Un-polarisable electrode Cu/$CuSO_4$

After iterations, using of MEF was result the areas with potentials marked in colors and numerical values between the two values considered as inferior and superior limits of electrical potential, (-0,85 ÷ -1,2) VCC from the domain of a good cathodic protection for a metallic structure (fig. 5.3, 5.4).

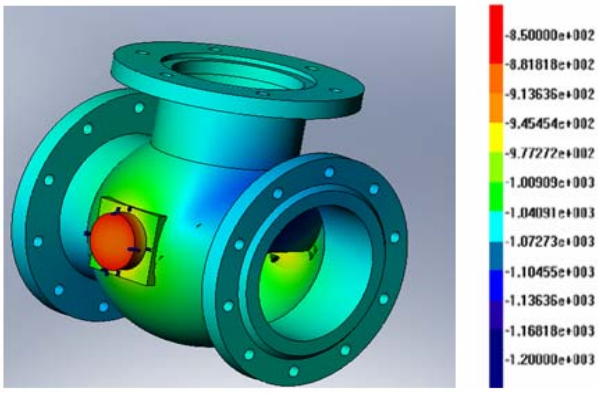

Fig. 5.3. The potential distributed by the two anodes on the structure of the valve body

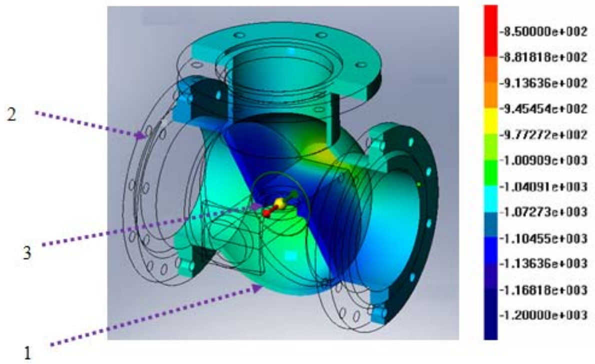

Fig. 5.4. Th The area of seat valve cathodic protected (section):
1 – Body valve, 2 – Flange, 3 – Seat valve

6. CONCLUSIONS

Using the method of finite element can perform experimental the optimization of cathodic protection with reactive anodes, for a metallic structure of an equipment, by determination of number of reactive anodes needed, dependent by the geometrical dates of the metallic equipment and its mass. In this sense it can be determined experimentally, by tests, with the aid of this software the type of the reactive anode and also their location on the external surface of an equipment, tank, and tubular material.

From the simulation which performs for the valve characterized by the geometric dates shows in chapter 3 result location of the two cylindrical magnesium anodes ϕ100/30 mm, positioned from one side to another of the valve body.

The protection with active anodes (galvanic) represents a cathodic protection temporary system and which must be update by a corrective maintenance. From the economical point of view, this cathodic protection method can constitute an immediate practical application for metallic valves from existent installations in the case of decantation-park of crude oil than salt water, where the oxidation reaction is very fast.

It is a cathodic protection method which can be applied in the areas where are not electrical energy sources; the installation of anodes is relative simple, the current provided being weak, do not determine the apparition of sparkles, which make it applicable in the areas characterized by the a potential explosive environment.

For the protection with galvanic anodes to be limited as action, only on the body of a valve is necessary to apply at the connecting flanges of the valve, electrical-isolating flanges and the isolating of the contact with the ground or other metallic structures with the aid of which shall avoid the dispersion of the potential in the tubular material of the keyboard.

In this paper it is shown the practical aspect given by the cathodic protection of industrial valves with faucet, this simulation by a method which is MFE it is important for designing of the cathodic protection system and for other valves and from the networks of: water, natural gases, liquids hydrocarbons etc.

7. SELECTIVE REFERENCES

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Protectia catodica a robinetelor din configuratia claviaturilor de manevra a unui parc de decantare a titeiului

O problemă generala pe care o intampină cei ce efectueaza exploatarea, mentenanta predictiva sau corectiva a claviaturilor din parcurile de decantare a țițeiului, consta in blocajul robinetelor in asa fel incat acestea raman fie deschise fie inchise. Pentru parcurile moderne acestea sunt prevazute robinete cu sfera cu garnituri din materiale compozite si cu posibilitatea de a fi gresate tocmai pentru a evita o situatie de blocaj a subansamblului mobil a acestor echipamente datorita coroziunii generate de apa sarata de zacamant ce este parte componenta a titeiului. Aceasta lucrare prezinta o metoda propusă pentru robinetele cu ventil sau pana etc., considerate clasice, pentru eliminarea efectului nedorit al coroziunii. Protectia catodica a acestor robinete presupune o metoda simpla si eficienta pentru implementarea unui astfel de sistem precum si cateva caracteristici experimentale.

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