THE EFFECT OF CATHODIC PROTECTION UPON EROSION-CORROSION WEAR

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INTRODUCTION

From pumped liquids in oil wells, formation waters are very aggressive one containing important quantities of dissolved salts and in many cases sand fine particles. Crude oil also contains an important quantity of highly mineralized water, rich gases with a great percent of CO_2, grains of sand from petroliferous bed.

Gaseous or liquid hydrocarbons are not corrosive in the water absence. In the case of formation waters, corrosion process are intensified by the presence of some active substances, especially dissolved salts, CO_2, H_2S, bacterial activity and in some cases even by the oxygen. In the water extracted from a formation in which were made acidifying operations contains also HCl. In many times in formation waters are present naphthenic acids. In production fields formation water represents an average of 60…70% of total quantity of extracted fluid, [1]. Corrosion rise with the water percent quantity. Dissolved salts way of action is complex, but the salts mainly raise the water conductibility due to the ionizing effect intensifying the electrochemical corrosion processes. Formation waters contain mainly chlorides of sodium, potassium, calcium, magnesium etc. but also iodides and sulphates.

Because sodium chloride is in the greatest quantity and has the main effect above corrosion rate is used to be indicated only contains in this salt, in salt kilograms contains in a water wagon or in g NaCl/*l* water.

The rest of chlorides as $CaCl_2$ and $MgCl_2$ presented in formation waters action in different ways depending of the nature, concentration, temperature and pH of the solutions. Magnesium chloride, $MgCl_2$ is extremely dangerous of corrosion point of view if remains in crude oil for refinery, because in distilling processes at high temperatures in the water vapours presence appear HCl.

In formation waters are also small quantities of sulphates. Sulphates presence could lead at a specific H_2S corrosion in the micro-organisms presence.

Oxygen is the common agent which intensifies corrosion in neutral mediums. The effect is greater in mineralised waters than in soft waters. Formation waters at drill surface are without oxygen, but in the separation, stoking, transport dissolve the oxygen from atmosphere.

Dissolved oxygen quantities by the water depends of salt contains and temperatures and is around 4 mg O_2/l water (4 ppm), [1].

H_2S represents the most corrosive component of formation waters. The aggressively of H_2S rises in the presence of CO_2, O_2 and water.

CO_2 produce an important corrosion above iron alloys. Pressure and temperature intensify the CO_2 aggressivity, [3].

Pressure and temperature are factors which separately or together sensible modify metallic equipments degradation process. High pressures raise CO_2 and H_2S dissolving quantities in formation waters making the character more acid, [3].

Temperature raise sensible corrosion rate. For formation waters the raise is continuous. One effect, is the easier oxygen diffusion to the metallic surfaces were intensify corrosion. In the mean time, with temperature raise the reaction rate between metal and medium, due to hydrogen depolarization and the raise of salt waters conductibility and ions mobility. Ions mobility became easier with reducing electrolytic medium viscosity.

Taking account of these considerations, formation waters are electrolytic mediums and degradation of metallic equipments has an important corrosive component. A way to reduce wear is to reduce the corrosive part of wear. Because medium has a explosive potential, the method with impressed current could not be applied. In this case, at centrifugal pumps, the corrosive wear could be reduced by using chatodic protection with active anode.

Paper presents erosion tests at different impingement angles, with and without active anode, in formation water medium, made on materials from rotor and body centrifugal pumps.

EXPERIMENTS

To circulate crude oil containing above 60…70% formation water are used centrifugal pumps. Because sand particles and corrosive character of crude oil the wear mechanism is an erosive-corrosive one. The important quantities of formation water from crude oil make the aggressively of crude oil to depend of formation water aggressively.

Formation water used as working medium has the composition presented in Table 1, [2].

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[2] PETROLEUM-GAS University of Ploiesti, Dept. of Drilling, ROMANIA

Tab.1 Formation water analyze

Characteristic	Value
pH	6,54
Density, g/l	1.064
Impurities, mg/l: - suspension	16,60
- oil	1,40
Dissolved gases, mg/l:- Oxygen	0,22
- Carbon dioxide	free = 74,80
-Hydrogen sulphide	no
Chemical composition, mg/l: Na^+ (K^+)	27.716
Ca^{2+}	3.809
Mg^{2+}	939
Cl^-	51.830
SO_4^{2-}	138
HCO_3^-	482
Fe_2O_3	14
Al_2O_3	13
Minerals	84.941
Probable composition, g/l: $Ca(HCO_3)_2$	0,640
$CaSO_4$	0,195
$CaCl_2$	9,952
$MgCl_2$	3,676
NaCl	70,438

Samples were made of carbon steel type OT450, of gray cast type GJL HB 215 and GJL HB 115.

In Figure 1 it is shown the erosion device schema and in Figure 2 are presented the superior and inferior disks for fixing samples at different impingement angles.

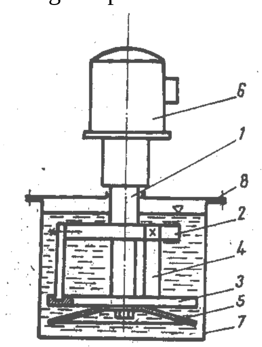

Fig. 1: Erosion device

1- ax; 2- superior disk; 3- inferior disk; 4- sample; 5- stirrer; 6- engine; 7-tank; 8- cover

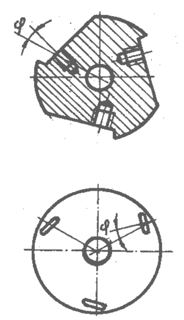

Fig. 2: Sample fixing disks

Tests were made at 15^0, $30^0$and 45^0 impingement angles at 1450r.p.m. with and without active anode attached at samples.

Was establish wear for tested material samples and also was measured roughness on impact samples face.

In Figure 3 it is shown the wear results obtained for samples of material GJL215 at 15^0 impingement angles.

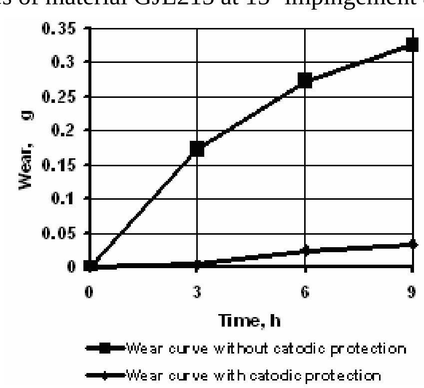

Fig. 3: Wear curve for material GJL HB 215 at 15^0

In Figure 4 it is shown the wear results obtained for samples of material GJL HB 155 at 15^0 impingement angles.

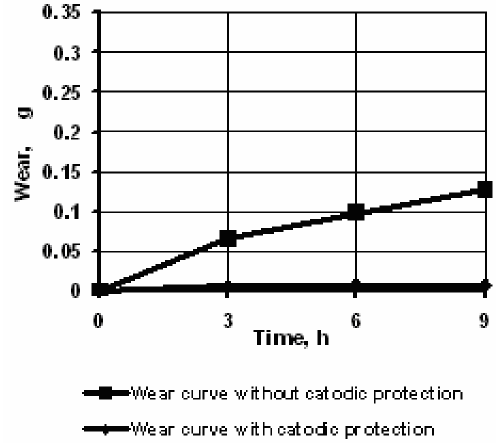

Fig. 4: Wear curve for material GJL HB 155 at 15^0

In Figure 5 it is shown the wear results obtained for samples of material OT 450 at 15^0 impingement angles.

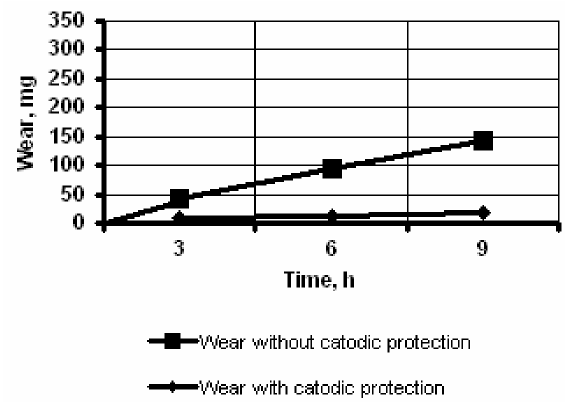

Fig. 5: Wear curve for material OT 450 at 15^0

At 30^0 and 45^0 were obtained similar curves as presented in figures 3, 4 and 5.

Roughness was measured on impact samples face at initial time and after 3, 6 and 9 hours of working in the device.

In the Figure 6 is presented roughness modification curve for material GJL HB 215 at 15^0 impingement angles.

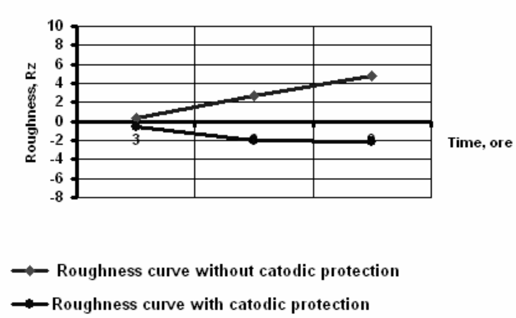

Fig. 6: Roughness modification curve for material GJL HB 215 at 15^0

In the Figure 7 is presented roughness modification curve for material GJL HB 155 at 15^0 impingement angles.

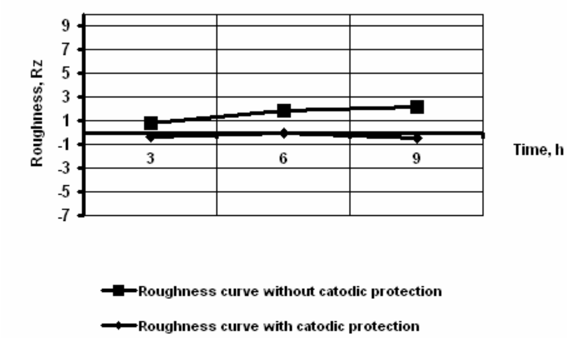

Fig. 7: Roughness modification curve for material GJL HB 155 at 15^0

In the Figure 8 is presented roughness modification curve for material OT 450 at 15^0 impingement angles.

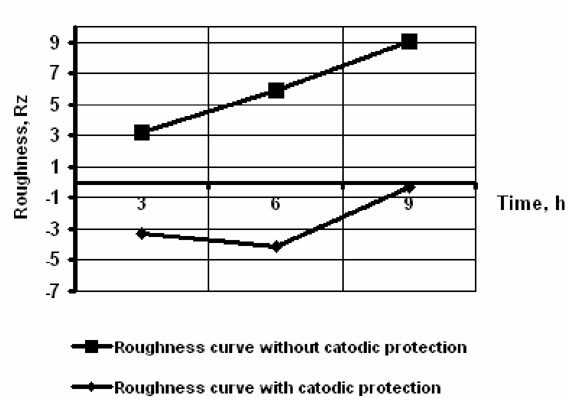

Fig. 8: Roughness modification curve for material OT 450 at 15^0

At 30^0 and 45^0 were obtained similar curves as presented in figures 6, 7 and 8.

CONCLUSION

Cathodic protections with active anodes reduce erosion wear at all tested materials and impingements angles. Also cathodic protection improves surfaces roughness.
For roughness the critical impingements angles for sample materials GJL HB 155 and OT 450 is 15^0 and for material GJL HB 215 without cathodic protection 15^0 and 30^0 and 15^0 with cathodic protection.
For erosion wear the critical impingement angle is 15^0 for all tested materials with and without cathodic protection.

Active anode in all cases improves surface roughness and reduces erosive-corrosive wear.

The obtained results presented permit the paper authors to formulate a patent to protect centrifugal pumps with active anodes.

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