Investigation of Carbon Steel Corrosion in Water Base Drilling Mud

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Abstract

Carbon steel, the most widely used engineering material, accounts for approximately 85%, of the annual steel production worldwide. Despite its relatively limited corrosion resistance, carbon steel is used in large tonnages in marine applications, nuclear power and fossil fuel power plants, transportation, chemical processing, petroleum production and refining, pipelines, mining, construction and metal-processing equipment. This paper Investigate Carbon steel corrosion in water. The corrosion rate in production and casing pipes in water base drilling mud (packer fluid), different salt concentration (100gm/L , 150 gm/L , 200gm/L) have been used and different temperature (30co , 50 co , 70 co) have been investigated. Weight loss and polarization methods were applied. The results indicate that the corrosion rates decrease with the increasing of salt concentration while the corrosion rates increase with increasing of temperature

Keywords: Carbon Steel, Corrosion, Drilling Mud

1. Introduction

Water base drilling fluids present corrosion problems primarily because they are subject to contamination from corrosion accelerators such as oxygen, carbon dioxide hydrogen sulfide or salts that are always present in varying quantities(B.W Bradley. 1970).

Saturated salt solutions are commonly used both as drilling and as packer fluids. Unsaturated salt solutions are believed to cause more server corrosion than saturated fluids. Increased solubility of acid gases and oxygen in the dilute solution is the basic cause. Inhibitors are commonly recommended for these solutions because corrosion is clearly problem in highly conductive salt environment(H.E BUSH. 1974). In high pressure oil or gas well, the produced fluids flow through a tubing string which is retrievable and positioned in a permanently installed casing .the annulus between the tubing and casing is frequently filled with a drilling fluid to provide weight and to help seal the packer at the bottom of the annulus. The packer fluid may consist of mud formation, emulsion, or a clear packer fluid is less expansive and has some advantages over other fluids.

The evaluation test requires a static system with proper surface - to -volume ratio. Since the required temperature is high and air must be eliminated, a pressurized bomb with a glass liner makes a suitable test vessel. Because a relatively large area is needed, coupons are the simplest and most logical detection technique, although others can be used .the deficiency of the test is that uniform corrosion is measured even though localized pitting is quite often the mode of failure in oil or gas tubing(E.Schasch. 1973). Johnston and Gowan(Jhonston and Cowan. 1964), Simpson(J.P Microbiology on. 1966), Barbee(Barbe, 1966), have contributed information on the cause and effect of contamination in packer fluids. These authors present both laboratory and field data and clearly show that the fluid placed in the annular space of the well requires careful selection if successful and economical completions are to be assured.

The authors (H.E bush, R.D.Barbee and J.P Simpson. 1966) interpretation of drill pipes records from west Texas also indicates that 75 percent of drill pipe loss is due to corrosion. A recent estimate by a large drilling contractor was the drill pipe less amounted to (120 $ a day per rig.). On 75 percent of this corrosion loss, the direct cost of corrosion is seen to be (90 $ a day per rig.).

Of approximately 700.000 producing wells in the United States, 96.000 require some of work over annually. Drilling fluid corrosion, of course dose not cause all of the work over but it is recognized as a significant contributing cause.

2. Experimental

A) Material And Test Solutions

One of the most widely used techniques in drilling fluid corrosion control employs drill string corrosion coupons, supplied by the chemical and petrochemical research center in the ministry of science and technology the coupons was about (3 cm)length and (1cm)width having the following chemical composition

C = 0.042% , P = 0.022% , Si = 0.215% , Mn = 0.797%   , S = 0.015% ,   Cr = 0.205% , Mo = 0.040% , Ni = 0.135% , Cu = 0.202% , Fe = remains

Water base drilling mud used as a corrosive solution , different salt concentration (100 gm/l ,150 gm/l,200 gm/l) been applied.

B) Procedure

1) Weight Loss Measurement

For weight loss measurement ,the metal samples (3*1cm) were immersed in 300 ml of water base drilling   mud at different salt concentration (100 gm/l ,150 gm/l,200 gm/l) , and different temperature (30c° ,50 c° and 70 c°) in a flask in such manner that only (3 cm²) of specimen was exposed in the test solution .

Prior to use the specimen were abraded in sequence tap water by using the   following emery paper grades ,220,320,420 and 600 as shown in figure(2) ,washed with tap water followed by distilled water ,dried with clean tissue paper , immersed in ethanol , dried with clean tissues paper ,immersed in ace tone ,and dried with clean tissue paper .

They were then left to dry for on hour over silica gel be for weighted and used the specimens where exposed for a period of 48 hours at different salt concentration and different temperature. After that they where cleaned, washed with running tap water, removing the corrosion product, followed by distilled water dried with clean tissue paper, degreased with acetone dried for on hour over silica get before weighted, then   weight loss was determined. Each experiment was cared out twice and the average was taken. Then the corrosion rate calculated by the following equation:

C.R= w/ (S.A)*t

Where ;

C.R=corrosion rate (mg/day.dcm²)

S.A=surface area (dcm²)

T=time (day)

2) Polarization measurement

The four holes were distributed on the cover of container for thermo meter to adjust the required temperature, working electrode reference electro de (saturated calomel Electrode, SCE) and counter electrode. The lugging capillary of electrode was placed (1mm) of working electrode with small amount of KCL (solid) was kept in the solution of SCE as long as the test. A three – electrode system was used in polarization experiment. The working electrode was made of low carbon steel with exposed Area of a bout 3cm². The counter electrode and a saturated calomel electrode (SCE) was the reference electrode, which was connected to the working compartment of the electrochemical cell through a lugging capillary. The test solution was water base drilling mud with different salt concentration(100 gm/l,150gm/l,200gm/l) and temp. (30c).

Before each test, the cell and electrodes were was heel with running tap water, followed by deionizer water, after the corrosion cell parts were joined together, as shown in fig.(3).In the first steep the potential of the specimen (carbon steel) were measured relative to reference electrode and recorded with time.

In the second step the polarization scan began from cathodic to anodic branches. The potential was increased from a value versus SCE below the open – circuit potential (OCP) to a value versus SCE above the (OCP).

3. Results and Discussion

A) Weight loss method

In this technique the average corrosion rate of two runs was equal to the arithmetical average of the two specimens. The effect of salt concentration and temperature was investigated in water-base drilling mud. The results are listed in tables (1,2,3) .The relationship between corrosion rate Vs. salt concentration at different temperature shown in fig.(4).From the relationship between corrosion rate and salt concentration at different temperature and different , it can be seen the corrosion rate decrease with increasing of salt concentration because the ratio of dissolved oxygen decrease with increasing of salt concentration therefore the corrosion rate decrease   in   agreement   with   results   of   Habeeb&Matlub(H.S.Habeeb   and   F.K.Matlub. 1988),Konsowa&El-Shazly(Konsowa, A.H. and A.A.,Elsevier, 2002)and Kuntiya(Kuntiya,A. and Necolella,C. 2005). From the relationship between corrosion rate and temperature at different salt concentration these finding were in agreement with Habeeb&Matlub(H.S.Habeeb and F.K.Matlub. 1988).

B) Polarization method

The corrosion behavior in water-base drilling mud at different salt concentration at static condition and temperature (30 ±1) were investigated, the results have been shown in fig. (5,6, and 7).

In this mode of measurement the run period was about 90 min. the limiting current being equal to corrosion current in this study, the corrosion current increase with decreasing salt concentration as shown in fig. (8).These finding were in agreement with Habeeb & Matloub (H.S.Habeeb and F.K.Matlub, 1988)&Al-Jendeel (H.A.Al-Jendeel, 2007)

4. Conclusions

The response of carbon steel to water corrosion depends primarily on

1)   The corrosion rate increase with increasing the temperature

2)   The corrosion rate decrease with increasing the salt concentration

   Symbols:

   C.R= Corrosion rate

   S.A= surface area

   t= time

   iL= limiting current

   i corr.=corrosion current density

References

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Table 1. temp 30 cº

Salt concentration	S.A (cm²)	W (gm)	C.R (mdd)
100.000	3	0.0031	123
150.000	3	0.00196	98
200.000	3	0.00184	92

Table 2. temp 50 cº

Salt concentration	S.A (cm²)	W (gm)	C.R (mdd)
100.000	3	0.00256	128
150.000	3	0.0024	120
200.000	3	0.00216	108

Table 3. temp 70 cº

Salt concentration	S.A (cm²)	W (gm)	C.R (mdd)
100.000	3	0.0256	140
150.000	3	0.0024	133
200.000	3	0.0025	125
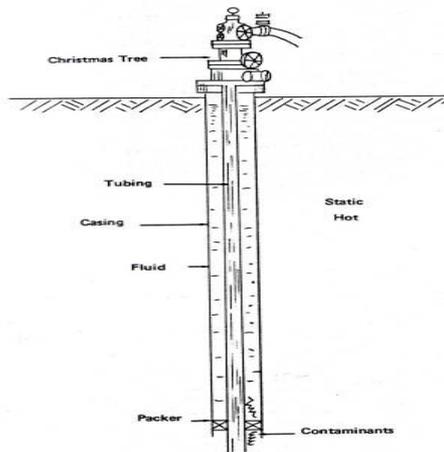
Figure 1. illustrates construction of a well using packer fluid

Figure 2. Experiment Setup
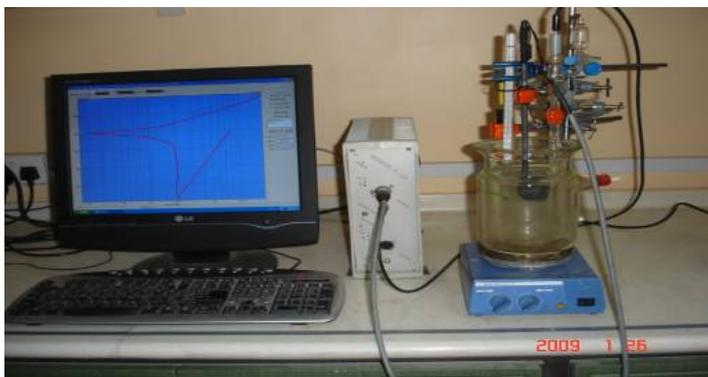
Figure 3. Polarization cell
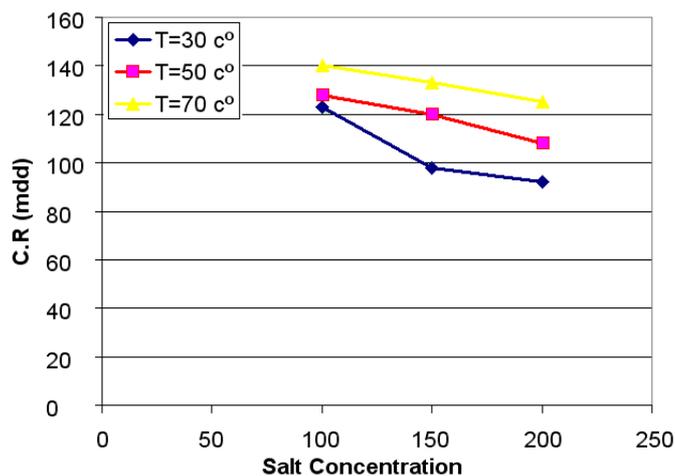
Figure 4. Relation between Corrosion Rate and Salt Con. at diff. temp.
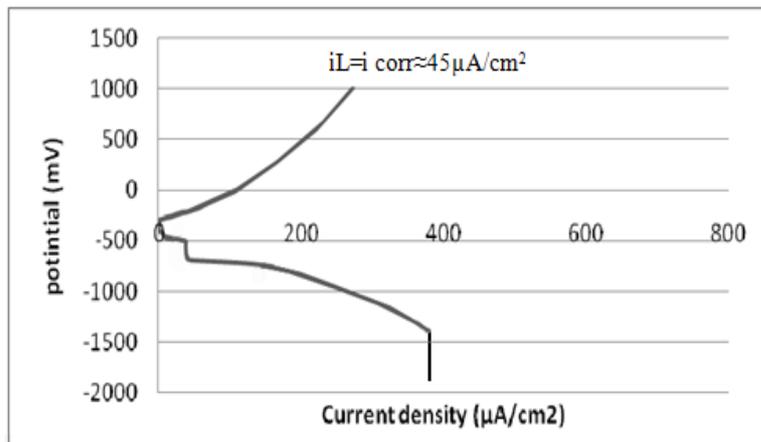
Figure 5. current density vs. potential at salt concentration(100gm/L)
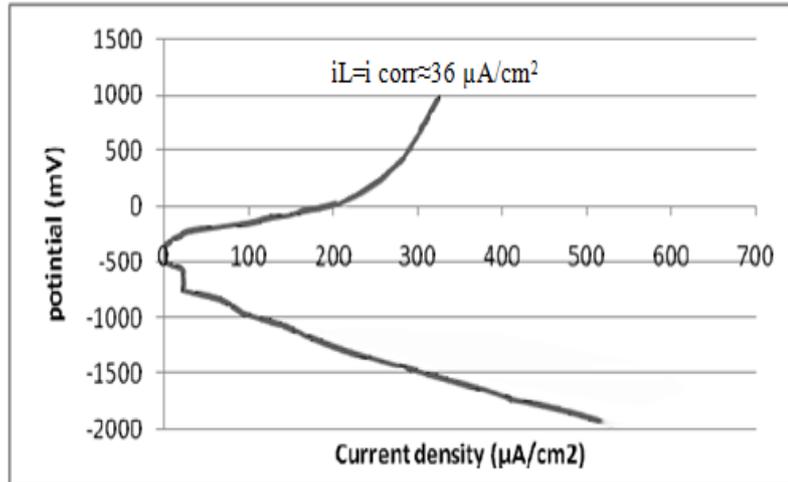
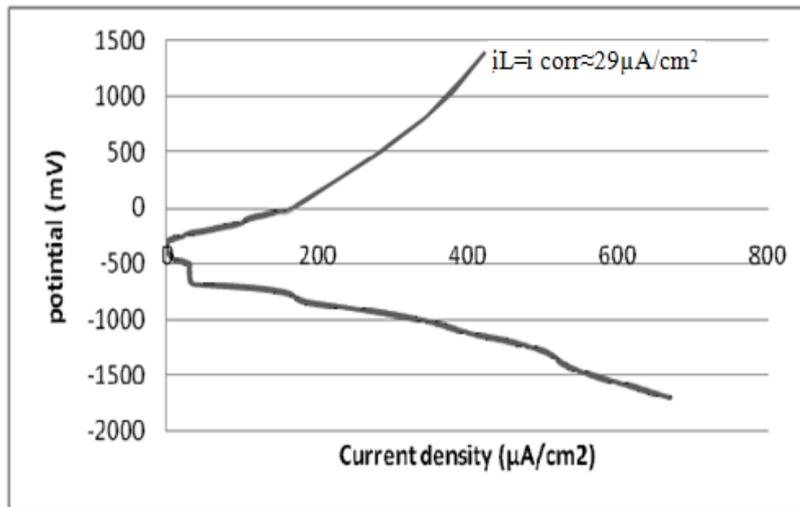Figure 6. current density vs. potential at salt concentration(150gm/L)

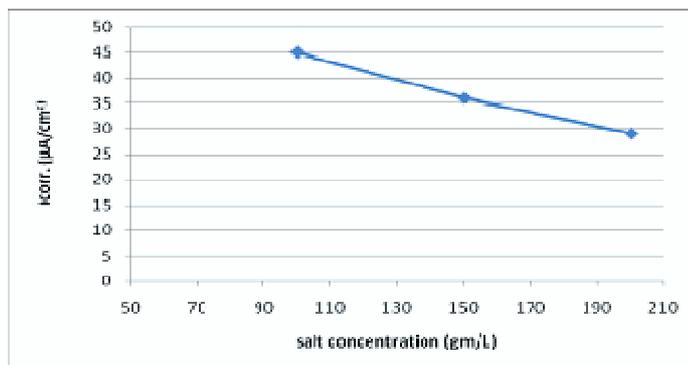Figure 7. current density vs. potential at salt concentration (200gm/L)

Figure 8. Salt concentration vs. i_{corr} at constant temperature