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Corrosion of Low Carbon Steel in Gasoline – Water (Brine) Mixture

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Abstract

The application of two - phase flow are found in chemical & petroleum industry such as: production tubing, casing tubing, horizontal pipe lines, chemical reactors & refineries.

The aim of the investigation is to measure the corrosion rate of low carbon steel in gasoline water mixture at different temperature (303K, 313K & 323K) & different rotary speed (30r.p.m, 60r.p.m & 90r.p.m). The gasoline concentration in mixture is ranging from (10 to 30% v/v). The corrosion rate measurement has been performed by the following techniques:

1-weight loss
2-polarization

The weight loss result showed that the corrosion rate decrease as the gasoline percent increased & the corrosion rate increase with temperature & rotary speed increasing .In cathodic polarization the limiting current density decrease as the gasoline percent increased. It is important to mention here the polarization experiments carried out in stationary condition at the temperature (303K+_ 273K).

الخلاصة

ان تطبيقات الجريان ثنائي الطور واسعة اتلانتشار في الصناعات الكيمياوية والصناعة النفطية مثل انابيب الانتاج وانابيب البطانة الانابيب الافقية الناقلة للنفط الخام والمفاعلات الكيمياوية والمصافي

الهدف من هذه الدراسة هو قياس معدلات تآكل الصلب الواطيء الكاربون في خليط من (الكازولين – ماء). معدل التآكل في خلبط (كازولين-ماء) تحت ظروف تشغيلية مختلفة من درجات حرارة (323K,313K,303K) وسرع دوران مختلفة (90r.p.m , 60r.p.m , 30r.p.m وتراكيز مختلفة للكازولين في الماء تتراوح(10-30%) نسبة حجمية . معدل التآكل تم قياسة بطريقتين هما :

1-طريقة فقدان الوزن .
2-طريقة الاستقطاب .

ان نتائج طريقة فقدان الوزن اوضحة بأ ن معدل التآكل يقل مع زيادة نسبة تركيز الكازولين في الخليط وان معدل التاكل يزداد بازدياد درجة الحرارة وسرعة الدوران .

ان نتائج طريقة الاستقطاب الكاثودي اوضحت ان كثافة التيار المحدد تقل مع زيادة تركيز الكازولين في الخليط. ومن الجدير بالذكر ان تجارب الاستقطاب اجريت في وسط ساكن ودرجة حرارة (303K+_273K).

Introduction

Corrosion is the interaction of the metal with its surrounding Steigerwald [1968], or it's the degradation of metal by an electrochemical reaction with its environment Henry [1999]. The importance of corrosion studies is threefold: the first area of the significance is economic including the objective of reducing material losses resulting from the corrosion of pipe lines, tanks, ships, metal components of machines and so on. The second area is improved safety of operating equipment which through corrosion may fail with catastrophic consequences. The third is conservation applied primarily to metal recourses Uligh [1977].The majority of corrosion reaction in different environments occurs by an electrochemical reaction, so, many factors affected the distribution, rate and type of corrosion that selection of an appropriate material for particular application

requires a sound understanding for the fundamental process which occur during chemical attack Stern [1957].
In oil field water is often produced in large quantities with crude oil; that leads to increase the corrosion effected in the pipe lines. Water acts as an oxidizing agent and its Bulk concentration as well as its diffusion rate is considered to be one of the important factors for corrosion of metals Anna [1985]. Corrosion casts the petroleum industry hundred of millions of dollars each year Tuttle [1987].

Experimental

1- Materials and Test solutions

The steel used in this study was low carbon steel (C , 0.06 ; Si , 0.09 ; Mn, 0.25 ; P , 0.011 ; S , 0.01 ; Fe , remains). Water produced with oil in Brega oil field from well no. 18-Depth 2080 ft has the following composition ($CaHCO_3$, 6100ppm; $CaSO_4$, 3615ppm; $CaCl_2$, 612ppm; $MgCl_2$, 4125ppm; NaCl, 14548ppm). Gasoline as a second phase was obtained from Trepoli refinery.

2- Procedure

2-1 weight loss measurement

For weight loss measurements , the metal samples (3×1×0.1cm) were completely immersed in 200ml of test solution (10% , 20% and 80% gasoline v/v) at different temperature (303 K^o , 313 K^o , 323 K^o) in a flask in such a manner that only 3cm of specimen was exposed and different rotary speed (30r.p.m , 60r.p.m, 90r.p.m) to the test solution . Prior to use the specimen were abraded in a sequence of emery papers grades 220, 320, 400, and 600 washed by tap water. Then the specimens were dipped in a detergent which specified the particulate material sticking to the surfer and edges. The specimens were rinsed in flowing water and was degreased in acetone, after washing with distilled water and pressed gently between two warm clean filter papers to absorb the moisture present on the surface. Then they kept in a desiccator over silica gel until time for using them. The specimens were exposed for a period of 24 hours at different gasoline concentration, different rotary speed and different temperatures. After that they were cleaned, washed with running tap water, removing the corrosion product, followed by deionizer water, dried degreased with acetone, dried for hours then weight loss was determined. Each experiment was carried out twice and the average was taken, then the corrosion rate calculated by;

$C.R = \Delta w/ (S.A) \times t$

Where:

C.R=corrosion rate (mg/day. square dcm)
S.A=surface area (square dcm)
t=time (day)

2-2 Polarization measurement

The schematic diagram of the electrochemical cell under static conditions is presented in figure (1). The four holes were distributed on the cover of container for thermometer to adjust the required temperature, working electrode reference electrode (saturated calomel Electrode, SCE) and counter electrode (graphite). The lugging capillary of electrode was placed (1mm) of working electrode with saturated KCl 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 mad of low carbon steel with exposed Area of a bout $3cm^2$. graphite was 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 capillary. The test solution was mixture of water – gasoline at different concentration of gasoline (10%, 20%, and 30%) and different temp. (303, 313, 323 K^o). the potential and current were recorded via a multi – range ammeter type AVO840B with range of 200 µA TO 200MA, respectively, through an alternative electric circuit involving also a DC power supply type 6236B Hewett Packard and multi – meter resister (resister box) type Cambridge with a range of 0 ± 0.1 MΩ and accuracy of±0.1Ω .

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, connected the power supply, resister, ammeter and voltmeter as showing in figure (1).

In the first step the potential of the specimen low (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).

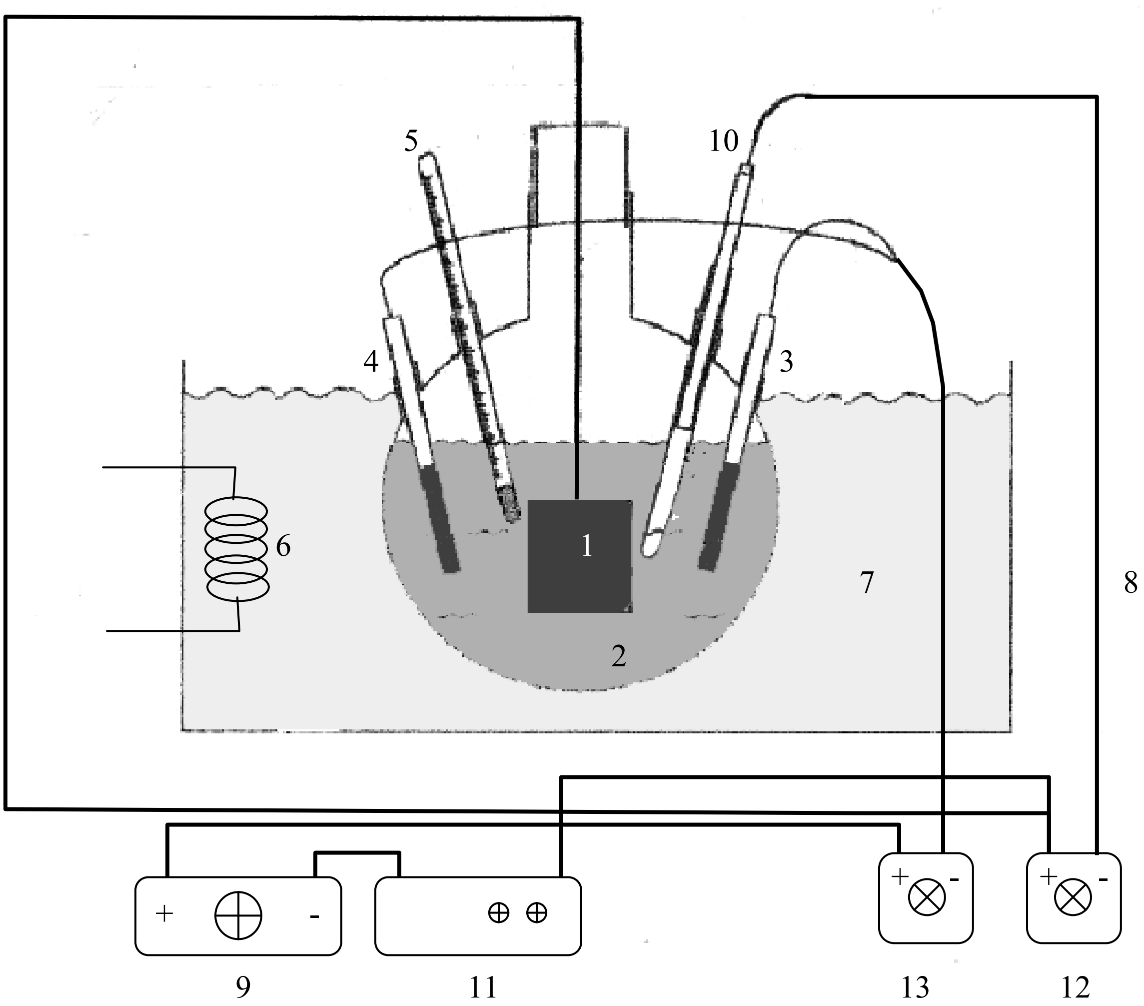

Fig (1) Schematic diagram for Polarization cell

1. plate specimen **2.water gasoline mixture** **3. Anode**
4.Luggin **5.Thermometre** **6.Heat exchanger**
7.Water path **8. Wires** **9. Power supply**
10.SCE **11. Resistance** **12.Volmetre**
13.Ametere

Results and Discussion

1-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 rotary speed, temperature and gasoline concentration was investigated in water- gasoline mixture. The results are listed in tables (1, 2, 3, 4, 5, 6, 7, 8 and 9) .The relationship between corrosion rate vs. rotary speed, temperature and water contain are plotted in figs (2, 3, 4, 5, 6, 7 and 8).

From the relationship between corrosion rate and rotary speed at different temperature and different gasoline concentration as shown in figs (2, 3 and 4). It can be seen that corrosion rate increase with increasing of the rotary speed in agreement with results of Atiya [1996]. The increase of rotary speed remove the oxide film that cover metal surface therefore the specimen surface remains with contact to the corrosive media.

From the relationship between corrosion rate and temperature at different rotary speed and different gasoline concentration as shown in figs (5, 6 and 7). It can be seen that corrosion rate increase with increasing of temperature because the temperature accelerated the chemical and electrochemical reactions (corrosion). These finding were in agreement with Kadhim[1996], Kang [2002].

From the relationship between corrosion rate and water percent in mixture as shown in fig.(8), the corrosion rate appeared to increased as water percent increased for a given of rotor speed and temperature, these finding confirm with the observation of Atwan [1987], Tang[2007] and Rozenfeld [1981].

2-Polerization method:

The corrosion behavior in water-gasoline mixture at different gasoline concentration at static condition and temperature (303 ±1 K) were investigated.

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 increasing water concentration as shown in figs (9, 10 and 12).

Conclusions

The following items were concluded:

1. The corrosion rate increase with temperature increasing.
2. The corrosion rate increase with rotating speed increasing.
3. The corrosion rate decrease with gasoline percent increasing.

Table (1): The corrosion rate at Temp=303k^o, water=90% v\v, gasoline=10% v\v

U(r.p.m)	S.A(cm^2)	Δw(gm)	C.R(mdd)
0	3	0.00167	55.71
30	3	0.00179	59.81
60	3	0.00186	62.06
90	3	0.00191	63.80

Table (2): The corrosion rate at Temp=313k^o, water=90% v\v, gasoline=10% v\v

U(r.p.m)	S.A(cm^2)	Δw(gm)	C.R(mdd)
0	3	0.00171	57.62
30	3	0.00183	61.2
60	3	0.00188	62.95

90	3	0.00192	64.2

Table (3): The corrosion rate at Temp=323k^o, water=90% v\v, gasoline=10% v\v

U(r.p.m)	S.A(cm^2)	Δw(gm)	C.R(mdd)
0	3	0.00176	58.76
30	3	0.00186	62.6
60	3	0.00194	64.70
90	3	0.00198	66.1

Table (4): The corrosion rate at Temp=303k^o, water=80% v\v, gasoline=20% v\v

U(r.p.m)	S.A(cm^2)	Δw(gm)	C.R(mdd)
0	3	0.00159	53.2
30	3	0.00174	58.1
60	3	0.00185	61.7
90	3	0.00187	62.6

Table (5): The corrosion rate at Temp=313k^o, water=80% v\v, gasoline=20% v\v

U(r.p.m)	S.A(cm^2)	Δw(gm)	C.R(mdd)
0	3	0.00164	54.9
30	3	0.00178	59.3
60	3	0.00186	62.2
90	3	0.0019	63.5

Table (6): The corrosion rate at Temp=323k^o, water=80% v\v, gasoline=20% v\v

U(r.p.m)	S.A(cm^2)	Δw(gm)	C.R(mdd)
0	3	0.00173	57.8
30	3	0.00184	61.3
60	3	0.00189	63.2
90	3	0.00195	65.2

Table (7): The corrosion rate at Temp=303k^o, water=70% v\v, gasoline=30% v\v

U(r.p.m)	S.A(cm^2)	Δw(gm)	C.R(mdd)
0	3	0.00152	50.7
30	3	0.00176	55.81
60	3	0.00171	57.06
90	3	0.00176	58.8

Table (8): The corrosion rate at Temp=313k^o, water=70% v\v, gasoline=30% v\v

U(r.p.m)	S.A(cm^2)	Δw(gm)	C.R(mdd)
0	3	0.00158	52.7
30	3	0.00170	56.7
60	3	0.00175	58.3
90	3	0.0078	59.3

Table (9): The corrosion rate at Temp=323k^o, water=70% v\v, gasoline=30% v\v

U(r.p.m)	S.A(cm^2)	Δw(gm)	C.R(mdd)
0	3	0.00167	55.8
30	3	0.00174	58.1
60	3	0.00179	59.7
90	3	0.0087	62.3

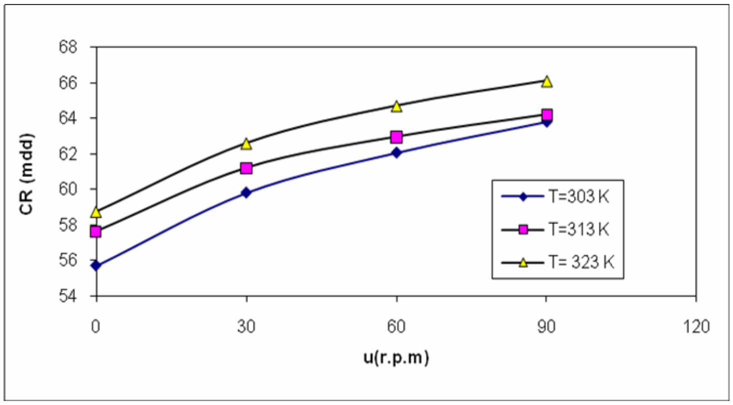

Fig. (2) Corrosion rate Vs. rotary speed at diffirent temprature when water 90% and gasoline 10%

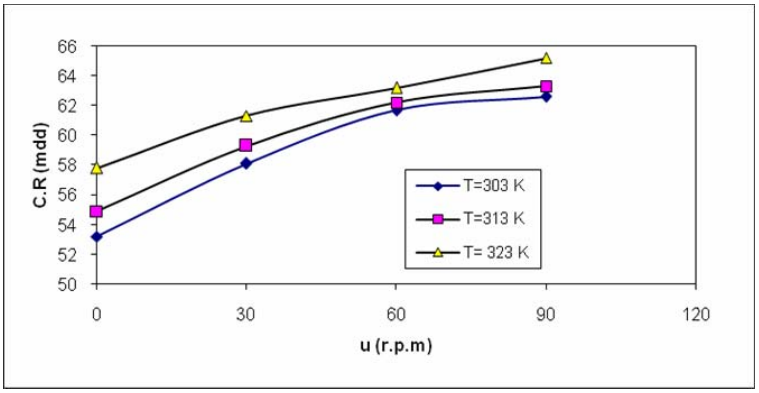

Fig. (3) Corrosion rate Vs. rotary speed at diffirent temprature when water 80% and gasoline 20%

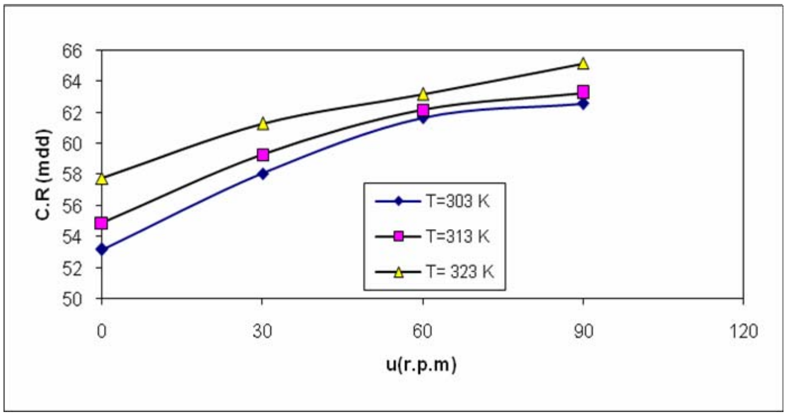

Fig. (4) Corrosion rate Vs. rotary speed at diffirent temprature when water 70% and gasoline 30%

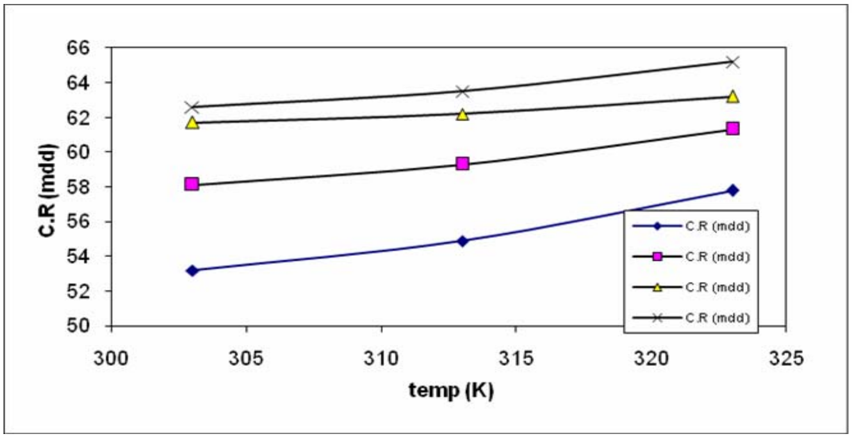

Fig. (5) Corrosion rate Vs. temperature at diffirent rotary speed when water 90% and gasoline 10%

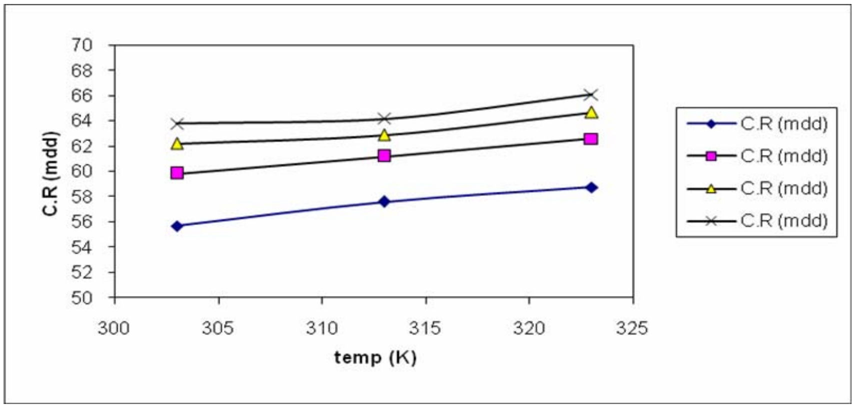

Fig. (6) Corrosion rate Vs. temperature at diffirent rotary speed when water 80% and gasoline 20%

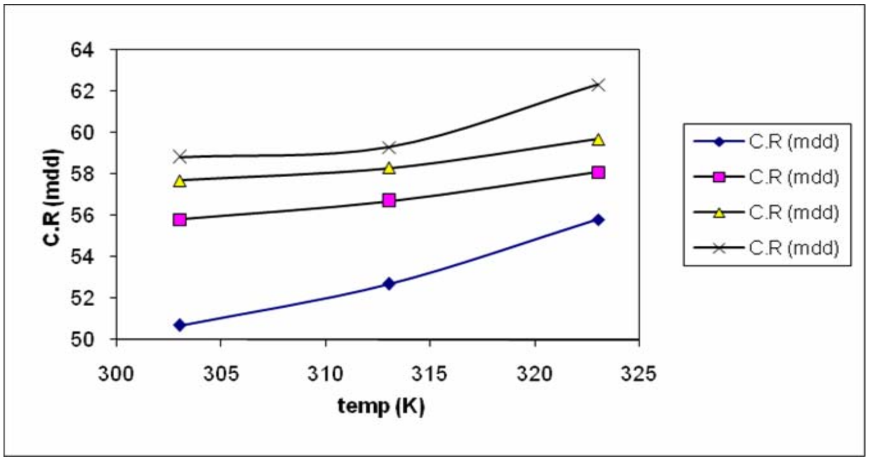

Fig. (7) Corrosion rate Vs. temperature at diffirent rotary speed when water 70% and gasoline 30%

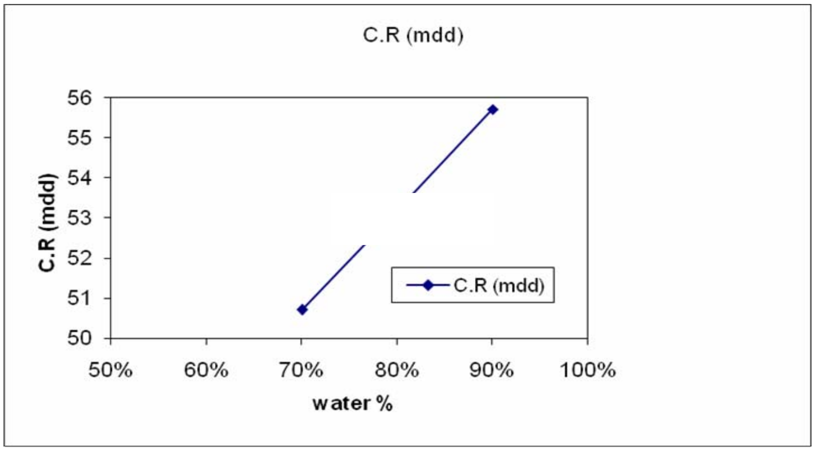

Fig. (8) Corrosion rate Vs. water percent in mixture when u=0, temp=303 K

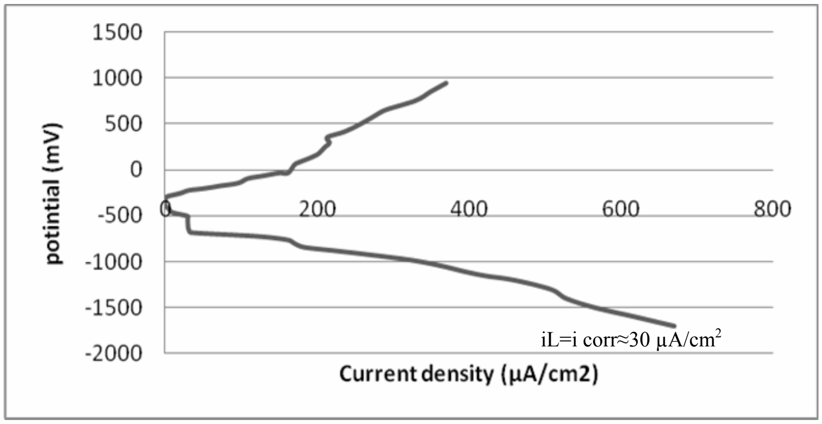

fig (9) Current density Vs. potential when water=90% v/v and gasoline =10% v/v

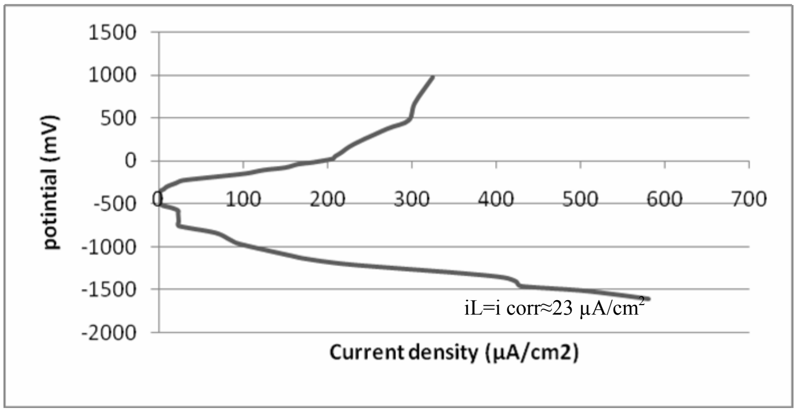

fig (10) Current density Vs. potential when water=80% v/v and gasoline =20% v/v

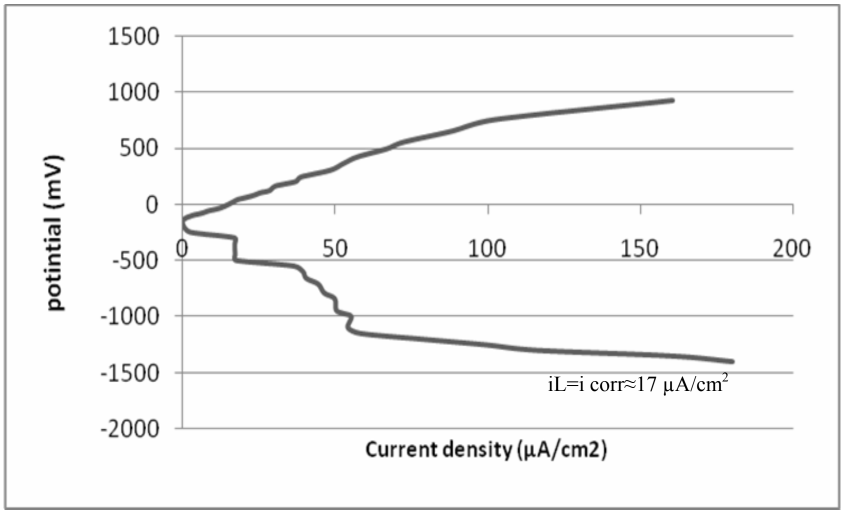

fig (11) Current density Vs. potential when water=70% v/v and gasoline =30% v/v

Symbols:
C.R= Corrosion rate
S.A= surface area
t= time
Ω=Ohm
K^o= Kelvin
i_L= limiting current
Icorr =corrosion current density

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