Corrosion study of steel pipe in soil environment by polarization technique

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Abstract- *This study presents an overview of the corrosion threat to liquid pipelines focusing on the detection of external corrosion. For this steel coupon were buried in three different soil containers for 7 month.*

Corrosion by soil is a complex phenomenon due to the number of variables involved. In principle, steels should be in the passive state in soils but the presence of water and aggressive chemical species such as chloride ions, sulphates as well as different types of bacteria and stray current can cause localised corrosion. Soils constitute the most complex environment known to metallic corrosion. Corrosion of metals in soil can vary from relatively rapid material loss to negligible effects, depending on soil environment. Soil engineering properties and soil contents are important parameters that influence soil corrosivity and level of corrosion dynamic. The corrosion potential and corrosion rate of buried coupons were studied by potentiodynamic polarization.

Keywords**-** Soil corrosion Soil properites Corrosion relationship potentiodynamic polarization

I. INTRODUCTION

Underground metal structures are usually expected to have a long working life, Structures such as natural gas, crude oil pipelines and water mains are only some of the many structures reported to have been affected by soil corrosion around the World. Corrosion is the disintegration of metal through an unintentional chemical or electrochemical action, starting at its surface.

The fundamental cause of the deterioration of buried pipeline is soil corrosion. All metals exhibit a tendency to be oxidized, some more easily than others. The corrosion process is usually electrochemical in nature. When metal atoms are exposed to an environment containing water molecules they can give up electrons, become themselves positively charged ions. This effect can be concentrated locally to form a pit, a crack or it can extend across a wide area to produce general deterioration.

Corrosion of buried steel pipe in soil mainly depends on soil properties such as soil resistivity, soil redox potential, soil pH, soil organic content, temperature and chemical composition also by microbial activity. [1] With increase of temperature the driving

forces of anodic and cathodic reaction were strengthened in solution. Hence dissolution of sample was aggravated and average corrosion current density was gradually increased. [4]

When pH was strongly acidic, the driving forces for the reaction was fast and corrosion products could not adhere to metal surface resulting increased corrosion of metal. However strongly alkaline soil contains high amount of OH- ions and which is beneficial for formation of passive film layer on metallic substrate which acts as corrosion protection layer. [4] Corrosion of metals is always associated with development of negative voltage caused by the release of electrons.[16]

II. EXPERIMENTAL

1. Materials and Methods

It has been aimed to investigate corrosion performance of buried pipeline. Therefore material selected for this study is commercially used Mild Steel pipe having chemical composition as shown in table 1.

Table 1. Chemical composition of MS pipe used for corrosion study

Elements	C	Mn	Si	S	P	Fe
Wt. %	0.040	0.12	0.032	0.007	0.012	Balance

Soil samples for the study collected from three different locations covering approximately 20 km distance. At each of selected locations the soil samples were collected by digging a hole of 0.5 m deep. Soil sample will be collected from each sites and kept in polyethylene bags before sent to the laboratory for further soil analysis. The collected soil samples were tested for soil corrosivity properties such as soil resistivity, soil redox potential, soil pH, soil moisture contents in a laboratory as per IS 2720 Standard and soil chemical composition in which chloride contents (Cl-) as per APHA 4500-Cl-B, soluble bicarbonate (HCO3-) as per APHA 2320 B, Sulphate contents (SO4--)as per IS 3035 (Part 24) and Nitrite contents as per IS 3035 (Part 34).

2. Material preparation

Total 63 pipe specimens were cut from original pipe each having 25.4 mm outer diameter 2 mm thickness and 20 mm length. Out of 63 specimens, 21 pipe specimens were kept in each soil sample in order to check their corrosion behavior in soil environment. Triplicate specimens were removed after every month from collected soil samples for corrosion test and their characterization.

3. Cleaning

Two cleaning methods were used to remove the impurities of the coupons, namely mechanical and chemical cleaning. The mechanical cleaning was carried out to remove the soil particles on the surface of samples using a soft brush. It was then followed by ultrasonic cleaning whereby the samples were immersed in distilled water for the period of 15 min

4. Corrosion Studies

A conventional three electrode cell was used with Stainless steel plate as counter electrode, Saturated Calomel Electrode SCE is used as reference electrode, steel pipe specimens as a working electrode and electrolyte in 3.5% NaCl solution. Tafel polarization test were performed on steel pipe specimens, which are immersed in three different soil medium, after each month of immersion (0 to 7 months) on Gamry potentiostat instrument (Reference 600). Frequency range was 100 KHz to 10 mHz.

Specimens for electrochemical tests were made from steel pipe whose chemical composition was shown in table. The corroded steel pipe samples were cut into tests specimen with dimensions of 17 mm × 20 mm and then covered with epoxy resin except test surface with the working area of 3.4 cm2.

III. RESULTS AND DISCUSSION

1. Potentiodynamic polarization studies

Potentiodynamic polarization behavior of as receives MS pipe specimen in 3.5 wt % NaCl solution is depicted in the figure 1. Corrosion current densities and corrosion rates value of as received pipe specimen before immersion in soils obtained from polarization experiment was 67.90 µA /cm2 and 9.15 mpy respectively. The corrosion rate of steel pipe specimen which are immersed in three different soils are shown in the table 3 and Fig.2 shows comparison of steel pipe corrosivity in soil based on corrosion rate analysis.

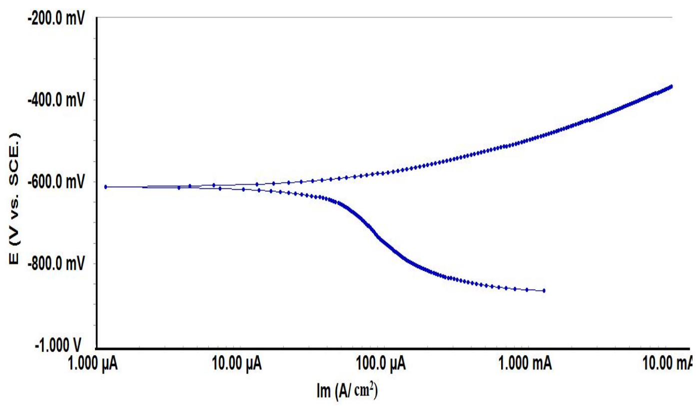

Figure 1. Polarization curve for as received MS pipe specimen in 3.5 wt% NaCl

For the pipe specimen which is immersed in soil 1 has corrosion rate 9.15 mpy before immersion in soil and it become decreases to 2.685 mpy after one month immersion. It can be seen that with increasing the immersion period, potentiodynamic curve were changed.

As per analysis when immersion period increased from 1 to 2 and 3 month, corrosion rate was increased from 2.685 mpy, 8.492 mpy and 9.835 mpy respectively. But after 3 month corrosion rate was increased gradually and reaches value of 64.21 mpy after 7 month immersion in soil 1. Hence it has been resulted that steel pipe specimen exhibit passivation state nearly up to 3 month immersion in soil 1.

Similarly for the pipe specimen which are immersed in soil 2 and soil 3 has same trace for corrosion rate with respect to immersion period but rate of corrosion is minimum compared to pipe specimen immersed in soil 1. This is because of corrosivity properties of soil 1 are more than other two.

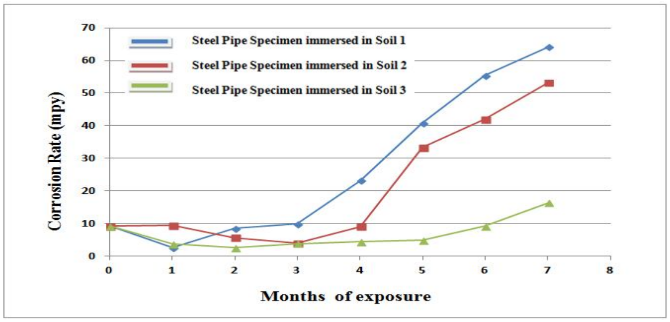

Figure 2. Corrosion rate of steel pipe after different immersion period in three different soils

Table 2.The queuing parameters and the time and source functions are given as follows.

Immersion period	Corrosion Rate (mpy)		
Months	Soil 1	Soil 2	Soil 3
0	9.15	9.15	9.15
1	2.685	9.504	3.789
2	8.492	5.673	2.531
3	9.835	4.019	3.859
4	23.24	9.112	4.388
5	40.97	33.35	4.935
6	55.40	41.93	9.23
7	64.21	53.22	16.35

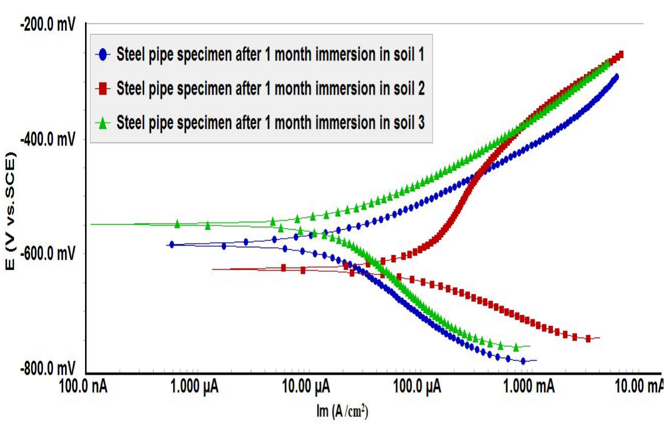

Figure 3. Polarization curves for Pipe specimen after 1month immersion in three different soils

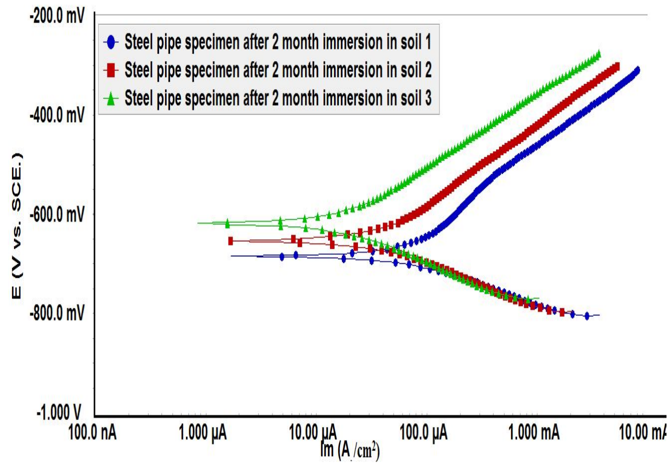

Figure 4. Polarization curves for Pipe specimen after 2 month immersion in three different soils

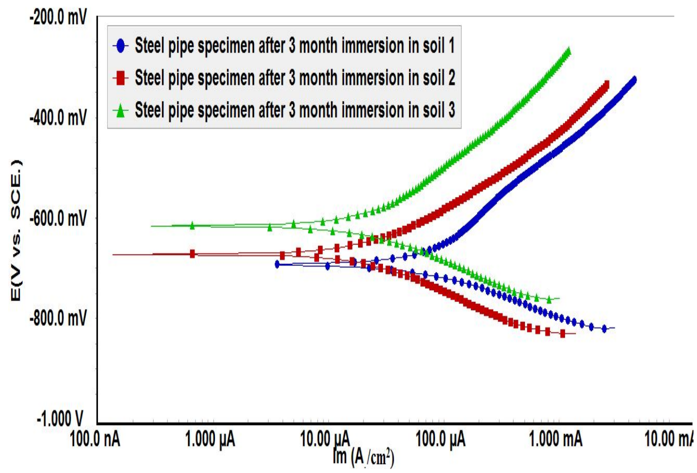

Figure 5. Polarization curves for Pipe specimen after 3 month immersion in three different soils

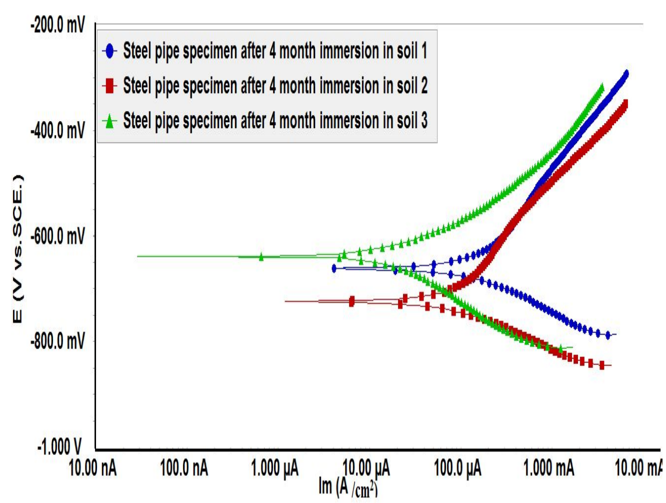

Figure 6. Polarization curves for Pipe specimen after 4 month immersion in three different soils

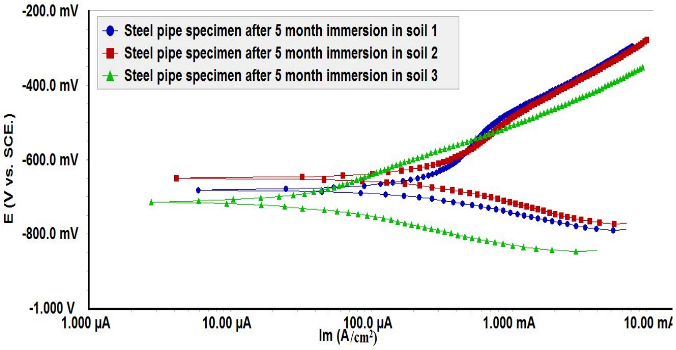

Figure 7. Polarization curves for Pipe specimen after 5 month immersion in three different soils

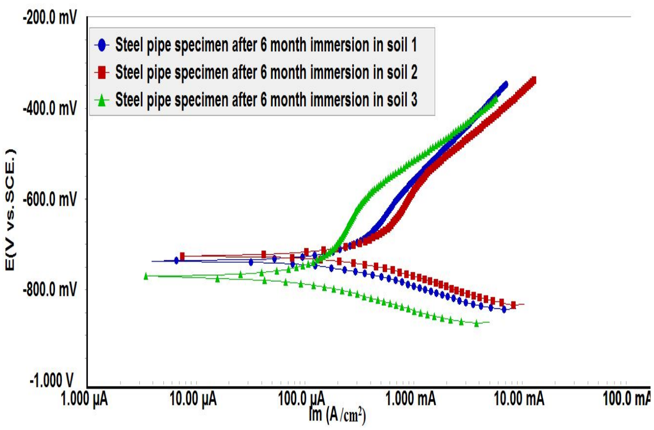

Figure 8. Polarization curves for Pipe specimen after 6 month immersion in three different soils

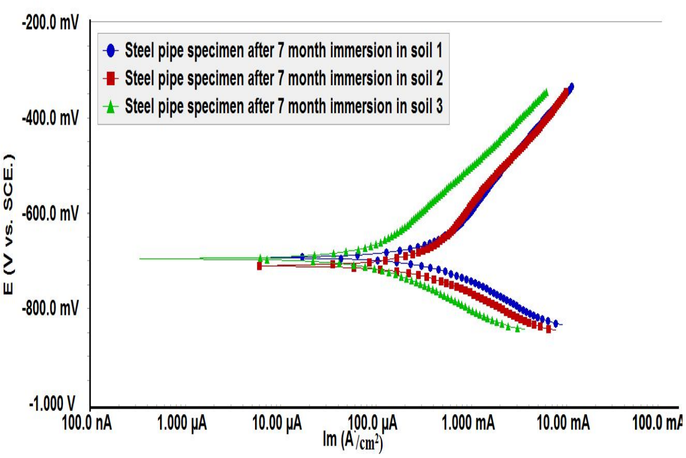

Figure 9. Polarization curves for Pipe specimen after 6 month immersion in three different soils

IV. CONCLUSION

The corrosion resistance of steel pipe specimens which were buried in three different soil compositions was studied by potentiodynamic polarization technique. The corrosion resistance of steel pipe in soil medium 3 is more than that of steel pipe in soil 1 and soil 2.

The steel pipe before immersion in soil has corrosion rate 9.15 mpy and after the 7 month of soil exposure corrosion rate of steel pipe in soil 1, soil 2 and soil 3 increased from 9.15 mpy to 64.21 mpy, 53.22 mpy and 16.35 mpy respectively. Corrosivity properties of soils in in the order of soil 1> soil 2> soil 3

Hence it can be concluded that the metal degradation rate of steel pipe is high in more corrosive soil.

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