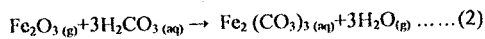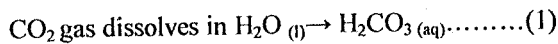# Analysis of Hydrogen Sulphide and Carbon (IV) Oxide Corrosion in Oil Exploration and Exploitation Operations

*DOSUNMU, A; ECHENDU, K C

Department of Petroleum Engineering, University of Port Harcourt P.M.B. 5323, Nigeria

ABSTRACT: This is an attempt to determine the susceptibility of carbon IV oxide (CO_2) and Hydrogen Sulphide (H_2S) corrosion of three different materials, namely; Type (316) Austenite Stainless Steel, Mild Steel and Conventional drill-pipe in sour environment -(H_2S/mud medium and CO_2/mud medium). The weight loss method was used. Results of the experiment showed that mild steel material was the most susceptible material to corrosion in the environment while Type (316) Stainless Steel material exhibited the best performance of all the materials. The result of this study can be used in the design of crude/product flow lines in the refining and producing operations. @JASEM

The oil industry has for many years recorded significant losses arising from corrosion. Corrosion in oil wells has resulted in loss of production, reduction of efficiency, production contamination over design and reduced savings. CO_2 gas dissolves in produced water or brine, to form carbonic acid, which lowers the pH of water. This makes it aggressive to carbon steel that forms the main constituent of production string and $Fe_2(CO_3)$ film is formed on the surface (Echendu, 1988).

$$CO_2 \text{ gas dissolves in } H_2O_{(l)} \rightarrow H_2CO_{3\,(aq)} \cdots\cdots\cdots(1)$$

$$Fe_2O_{3\,(g)} + 3H_2CO_{3\,(aq)} \rightarrow Fe_2(CO_3)_{3\,(aq)} + 3H_2O_{(l)} \cdots\cdots(2)$$

Similarly, dissolved H_2S causes pitting, corrosion of production string, and defects in the black iron sulphide film formed initially by general corrosion as shown below.

$$Fe_{(s)} + H_2S_{(g)} \rightarrow FeS_{(s)} + H_{2\,(g)} \cdots\cdots(3)$$

Thus, the concentrations of CO_2 and H_2S gases in an oil formation are critical in choosing the type of down-hole equipment during drilling and completion operations. This study aims at comparing the susceptibility of Type (316) Stainless Steel, Mild Steel and Conventional drill-pipe materials at different H_2S and CO_2 concentrations using weight loss method. Also considered, is the corrosion rate as a function of time at different concentrations of CO_2 and H_2S in drilling mud. Corrosion is a major problem in the drilling, production, refining and transportation sector of the oil industry. Several

authors have investigated different aspects of this subject. Some of these include Stanford (1984) who studied corrosion in production strings and concluded that combinations of chemical and mechanical problems were responsible for corrosion. Farshad and Bradhum (1983) evaluated the problem of corrosion and designed a completion and corrosion mitigation program that will afford the maximum rate of return on the investment made. Also Dosunmu and Alaka (1992) highlighted the use of corrosion inhibitors in the mitigation of corrosion in the oil industry.

MATERIALS AND METHODS

Mud/H_2S Mixture Preparation
Kipps apparatus is used for the experimental set up as. Iron II sulphide sticks are put in the apparatus and HCl acid is introduced. Enough acid is introduced so that it will enter the second chamber and the reaction starts. The tap is opened and H_2S gas produced is bubbled into the drilling mud solution through the delivery tube. Interval of 60seconds, 150seconds and 240seconds bubbling times are used for the experiment.

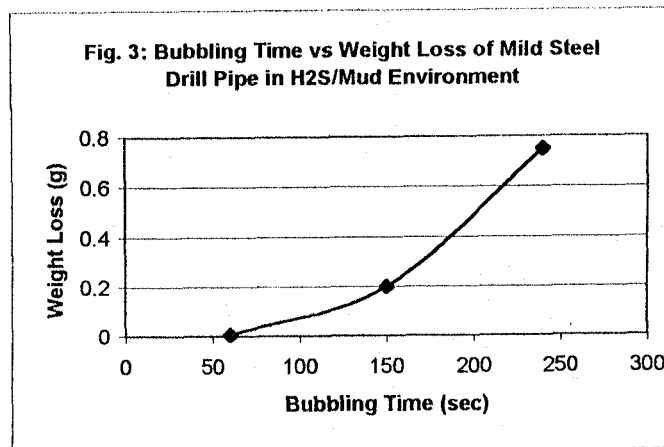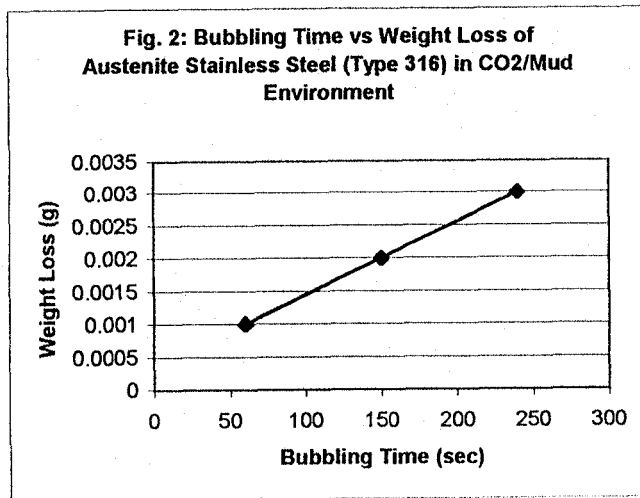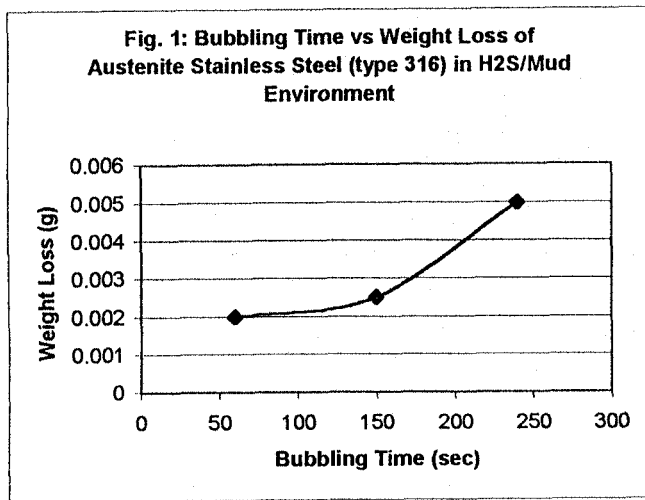### Mud/CO_2 Mixture Preparation
A similar apparatus is used for this preparation. Calcium Carbonate is kept in place of the Iron II Sulphide. Same procedure and bubbling times are used as reported above.

Preparation of Corrosion Coupons
The following Coupons were used;
  (i) Austenite Stainless Steel Coupon.

---

*Corresponding author

Fig. 1: Bubbling Time vs Weight Loss of Austenite Stainless Steel (type 316) in H2S/Mud Environment

Fig. 2: Bubbling Time vs Weight Loss of Austenite Stainless Steel (Type 316) in CO2/Mud Environment

Fig. 3: Bubbling Time vs Weight Loss of Mild Steel Drill Pipe in H2S/Mud Environment
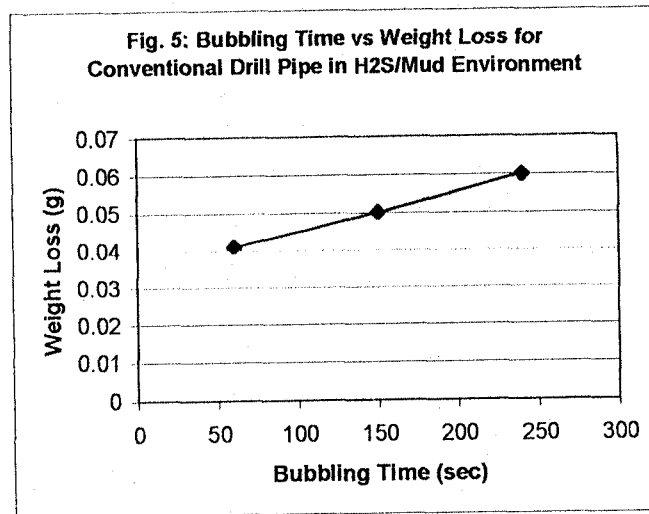
(ii)   Conventional Drill Pipe Coupon

Six Coupons, each of the three materials was cut. The Coupons were cut to size 1" x 1" heterogeneous thickness. Hole of 2.5mm in diameter was bored at one end of each Coupon. The Coupons were then individually fastened using ropes through the bored holes. The surface of each of the Corrosion Coupons was first mechanically cleaned with sand-paper and then immersed individually into a 200ml of pickling solution for 5 – 6 minutes at room temperature of $29 \pm 0.05^{\circ}C$. This is then followed by rinsing with distilled water and left to dry in air under fan for 10 – 15 minutes and then weighed and stored in a dessicator prior to the corrosion test

Fig. 5: Bubbling Time vs Weight Loss for Conventional Drill Pipe in H2S/Mud Environment

Corrosion Test for Drilling Mud (H_2S)

Three corrosion coupons of Austenite – Type 310 stainless steel, three coupons of mild steel (Mactesite – Type 410) and three coupons of conventional drill – pipe were immersed in three beakers containing varying quantities of H_2S gas. The immersion period varied from 3days to 2 weeks. At the end of each period, coupons were rinsed in distilled water and dipped in pickling solution for 10 – 15 minutes. It was then removed, flushed with distilled water again and dried in an oven for 3 minutes and reweighed.

Corrosion Test for Drilling Mud (CO_2)

The same procedure is followed for the drilling mud containing CO_2 as in the case of H_2S using the remaining three coupons of each material.

They were immersed in the beakers, as was done in the H_2S/mud mixture test. The immersion periods also vary from 3 days to 2 weeks. At the end of each period, the coupons were rinsed in distilled water and dipped in pickling solution for 10 –15 minutes, then removed and flushed with distilled water again and dried in an oven for 3 minutes and reweighed.

Fig. 6: Bubbling Time vs Weight Loss for Conventional Drill Pipe in CO2/Mud Environment
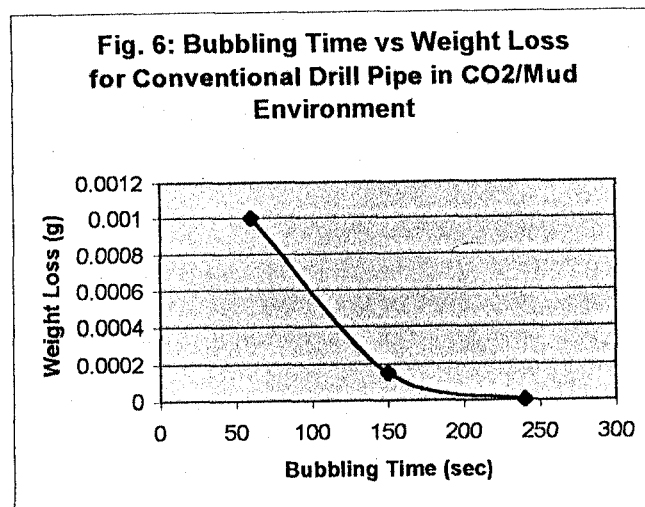
RESULTS AND DISCUSSIONS

Results of weight loss with time of Austenite stainless steel (type 316) drill pipe coupon immersed in H_2S/CO_2 environments at room temperature of 29 $\pm$ 0.05°C is presented in Figures 1 and 2 above. Results of weight loss with time of mild steel drill pipe coupon immersed in H_2S/CO_2 gas at room temperature of 29 $\pm$ 0.05°C are as shown in Figures 3 and 4. Results of weight loss with time of conventional drill pipe coupon immersed in H_2S/CO_2 gas at room temperature of 29 $\pm$ 0.05°C are shown in Figures 5 and 6. Figures 1 to 6 show the trends of weight loss versus bubbling times for the three materials in the two mediums. The progressive trend of weight loss with time in each medium shows that corrosion rate generally increases with time. Figure 1 reveals that as the concentration of H_2S gas in the drilling mud increases, the more susceptible Austenite Stainless steel (Type 316) is to corrosion. For CO_2/mud medium, as the quantity of CO_2 gas dissolved increases, susceptibility of Austenite Stainless steel (Type316) to corrosion also increases. This is shown in Figure 2. However the weight loss of this material is low. In H_2S/mud medium, mild steel corrosion rate increases as the quantity of dissolved H_2S gas increases. In CO_2/mud medium mild steel yielded to corrosion with low quantity of dissolved CO_2 gas. These are evident from Figures 3 and 4. From Figures 5 and 6, it can be seen that the conventional drill pipe is the most affected by corrosion in H_2S/mud medium. In CO_2/mud medium, this material showed excellent performance. The least weight loss was observed from this material.

Conclusion: The conventional drill pipe is the most affected by corrosion in H_2S/mud medium. It exhibits higher weight losses in the medium. In CO_2/mud medium, this material showed excellent performance. There was no observable corrosion or weight loss in this material in the CO_2/mud medium. The mild steel material showed the highest susceptibility to corrosion out of the three materials. Stainless Steel (Type 316) is in general the most suitable material for use pipes as it shows a moderate rate of corrosion in both mediums. However, the conventional drill pipe is recommended for use since in Niger Delta the crude generally contains insignificant amounts of H_2S.

REFERENCES

Dosunmu, A.and Alaka, C.O -Development of the Corrosion Inhibitors for Oil field corrosion froth local raw material, 1992.

Echendu, K.E -Corrosion Rates of Hydrogen Sulphide and Carbon IV Oxide in Oil Wells, B. Eng Project, University of Port Harcourt, 1988.

Farshad, F.F and Garber, J.D. -How to increase gas well production and temper corrosion; Part3- Petroleum Engineering International, June 1993

Stanford, A. Failure Analysis Isolates production problem Petroleum Engineering International, June 1984