THE INFLUENCE OF DRILLING FLUID ON THE CORROSION RATE OF TUBULAR MATERIAL

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ABSTRACT

Corrosion is a chemical, biochemical or electrochemical process of degradation on the surface of metals in contact with aggressive agents. Drill pipes are constantly in contact with the drilling fluid which has a corrosive action on its components. This paper aims to analyze samples prevailed from 5 1/2 in. drill pipes, made of S135 type steel, which were introduced in several variants of drilling fluids containing potassium ions.

Keywords: drilling fluid, corrosion rate, drilling pipes

INTRODUCTION

Drilling of deep wells is the field in which frequent and high intensity corrosion problems are reported. It is considered that 70% of the total damage to the drilling equipment is conditioned by internal and external factors [4].

The internal factors refer to the composition, the structure and the condition of the metal surface.

The external factors refer to the type, the composition and the characteristics of the fluid, temperature and pressure, the flow regime and the conditions of use.

The main corrosion problems of the drill pipes determined both by the composition and by the characteristics of the drilling fluids are due to the contamination of the drilling fluid with corrosive agents that affect the rheological-colloidal properties. Corrosive agents are: O_2, CO_2, H_2S, H, dissolved salts, bacteria, solid abrasive particles [1, 3].

The oxygen accumulates in the fluid as it passes through the surface installation and contributes to the initiation and propagation of the "pitting" corrosion process.

The carbon dioxide accumulates in the drilling fluid in the traversed formations or is formed as a result of the activity of bacteria or the thermal decomposition of carboxymethyl cellulose sodium (CMC) type additives.

The hydrogen sulfide accumulates in the drilling fluid in the traversed formations or results from the activity of bacteria and the degradation of some additives. Its aggressiveness is due to the reduction of the *pH* of the fluid and the formation of atomic hydrogen. It penetrates the crystal lattice of the steel at high voltage points, producing corrosive cracks.

The soluble salts encountered in the drilling process or added from the surface, give to the fluid a strong corrosive character. They increase the electrical conductivity of drilling fluids and since most corrosion processes involve electrochemical reactions, the corrosion phenomenon is intensified.

In the case of alkaline metal chlorides, the highest corrosion is produced by potassium chloride solutions, followed by sodium chloride solutions and the lowest corrosive action is that of lithium solutions [4].

In the case of chloride solutions of alkaline earth metals there are very small differences in terms of corrosion rate.

Higher atomic weight metal salts are generally more corrosive. The use of seawater in the development of drilling fluids has led to obtaining systems with very high aggressiveness compared to that of freshwater systems.

EXPERIMENTAL DATA

This paper aims to study the corrosive effect of drilling fluids with K ions. For this, drilling fluids based on KCl and K_2CO_3 were prepared. The fluids were contaminated with clay (5%), salt (10%) and gypsum (2%).

The working methodology followed was [2, 5]:

- preparation of KCl drilling fluid and K_2CO_3 drilling fluid;
- mixing each prepared fluid with 5 % clay, 10 % salt and 2 % gypsum;
- measuring the density of the drilling fluid by weighing with graduated cylinders;
- measurement of the apparent viscosity with the help of the Marsh funnel;
- measurement of rheological and thixotropic properties, plastic viscosity, yield point, and gel strenght at 10 s and at 10 minutes with Fann viscometer;
- measurement of the filtrate volume and filter cake with the Baroid filter press, at the ambient temperature and a pressure of 7 bar;
- pH measure with the pH Meter.

The composition and measured properties of the prepared fluids are presented in the tables 1 to 4.

Table 1 Compositon of KCl fluid

No.	Component	Function
1	Water	Base fluid
2	Bentonite	Viscosity and filtration control
3	Soda Ash	pH reducer
4	CMC	Fluid loss control
5	Barite	Weighting agent
6	KCl	Clay inhibitor

Table 2 Composition of K_2CO_3 Fluid

No.	Component	Function
1	Water	Base fluid
2	Bentonite	Viscosity and filtration control
3	Soda ash	pH reducer
4	CMC	Fluid loss control
5	FCLS	Viscosifer
6	Barite	Weighting agent
7	K_2CO_3	Clay inhibitor

Table 3 Measured properties for KCl fluid

Drilling fluid type / Drilling fluid property	KCl fluid	KCl fluid +5% clay	KCl fluid +10% salt	KCl fluid +2% gypsum
Density, kg/m^3	1400	1420	1428	1400
Marsh funnel viscosity, s	61	76	140	149
Plastic viscosity, cP	16	36	50	48
Yield point, N/m^2	14	16	44	58
Gel strength at 10s, N/m^2	6	8	16	18
Gel strength at 10 min, N/m^2	27	45	133	80
Filtrate volume, cm^3	3.4	3.2	4.1	8
Filter cake, mm	0.5	0.5	1	1.5
pH	10	10	9.5	10

Table 4 Measured properties for K_2CO_3 fluid

Drilling fluid type / Drilling fluid property	K_2CO_3 fluid	K_2CO_3 fluid +5% clay	K_2CO_3 fluid +10% salt	K_2CO_3 fluid +2% gypsum
Density, kg/m^3	1400	1420	1428	1400
Marsh funnel viscosity, s	61	64	144	91
Plastic viscosity, cP	30	34	50	46
Yield point, N/m^2	14	18	44	20
Gel strength at 10s, N/m^2	6	6	17	12
Gel strength at 10 min, N/m^2	27	35	135	35
Filtrate volume, cm^3	3.4	1.8	4.2	4.5
Filter cake, mm	0.5	0.5	1	1
pH	10	10	9.5	10

The evaluation of the corrosive action of the drilling fluid based on potassium ions was performed statically by the method of weight loss over time (4 days), at high temperature (120° C).

For this purpose, samples were taken from 5 1/2 in. drill pipes, made of S135 type steel. It was considered that the samples have approximately the same surface. They were initially weighed and every 24 hours afterwards.

RESULTS AND DISCUSION

The results obtained useing the method of weight loss are presented in tables 3 and 4.

Table 5 The results for the sample introduced in KCl fluid

The initial weight of the sample, g	**45 g**			
The weight of the sample, g	after 24 h	after 48 h	after 72 h	after 96 h
KCl fluid	44.999	44.997	44.9938	44.991
KCl fluid+5% clay	44.999	44.998	44.9983	44.997
KCl fluid+10% salt	44.998	44.997	44.9958	44.995
KCl fluid+2% gypsum	44.999	44.995	44.992	44.989

Table 6 The results for the sample introduced in K_2CO_3 fluid

The initial weight of the sample, g	**45 g**			
The weight of the sample, g	after 24 h	after 48 h	after 72 h	after 96 h
K_2CO_3 fluid	44.999	44.999	44.999	44.999
K_2CO_3 fluid+5% clay	44.995	44.998	44.998	44.997
K_2CO_3 fluid+10% salt	44.998	44.999	44.996	44.995
K_2CO_3 fluid+ 2% gypsum	44.999	44.995	44.992	44.989

After weighing the analyzed samples, a variation of the corrosion rate was found, which varies depending on the type of fluid in which the samples were introduced.

Table 7 The corrosion rate of the samples introduced into KCl fluid

Drilling fluid type	**Corrosion rate, mm/ year**
KCl based fluid	0.01 - 0.2
KCl based fluid+5% clay	0.011 - 0.055
KCl based fluid +10% salt	0.04 - 0.12
KCl based fluid + 2% gypsum	0.0078 - 0.262

Table 8 The corrosion rate of the samples introduced into K_2CO_3 fluid

Drilling fluid type	**Corrosion rate, mm/ year**
K_2CO_3 based fluid	0.001 – 0.004
K_2CO_3 based fluid+5% clay	0.01 – 0.05
K_2CO_3 based fluid+10% salt	0.03 – 0.1
K_2CO_3 based fluid +2% gypsum	0.0075 – 0.25

The samples introduced in KCl-based drilling fluids showed little black corrosion products and the weight loss recorded in the first 24 hours was 0.0011%, reaching 0.0018% after 96 hours.

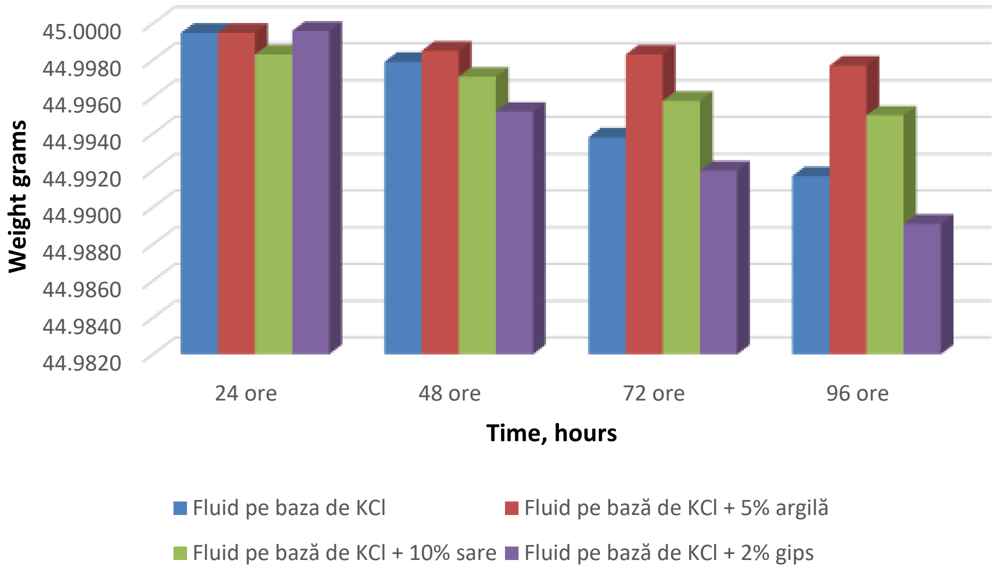

Figure 1 The evolution of the sample weight in 96 h for the KCl based fluid

The samples introduced in drilling fluids based on K_2CO_3 did not show visible corrosion products, and the weight loss registered in the first 24 hours was 0.0002%, reaching 0.0004% after 96 hours.

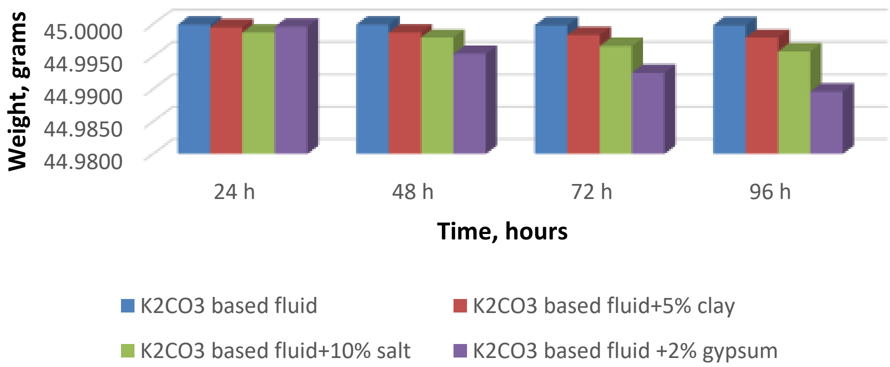

Figure 2 The evolution of the sample weight in 96 h for the K_2CO_3 based fluid

Both the KCl-based fluid and the K_2CO_3-based fluid, in the variant of 5% clay contamination, showed a uniform corrosion and very close values in terms of weight loss.

If the contamination was with salt (10 %) the analyzed samples showed corrosion products in the form of scales and the weight loss was from 0.0028 % in 24 hours to 0.009 % in 96 hours for the fluid based of K_2CO_3 and 0.003 % in 24 hours to 0.011 % in 96 hours for KCl-based fluid.

If the contamination was with gypsum (2 %) the analyzed samples showed corrosion products in the form of stains and the weight loss was from 0.0008% in 24 hours to 0.023% in 96 hours for the fluid based on K_2CO_3 and 0.0008% in 24 hours to 0.024% in 96 hours for KCl-based fluid.

CONCLUSIONS

The K_2CO_3-based drilling fluid has a much lower corrosive action than the KCl-based fluid. Even when mixed with clay, salt or gypsum, the results obtained reflect the same reduced variation compared to the KCl-based fluid mixed with clay, salt or gypsum.

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