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Research and Application of the Dynamic Simulation of Fire Flooding Corrosion

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Abstract: This article do research into experimental technology of corrosion simulation at high temperature and high pressure and has formed an integral set of simulating experimental device basing on the technology. This technology includes injection system, simulated reaction still, research on vapour-liquid equilibrium in the reaction unit, research on reaction still sealing performance at high temperature and high pressure. We also do the research on the corrosion detecting technology, mainly refer to applying the inductance probe to this simulation experimental device. This newly developed corrosion simulation at high temperature and high pressure experimental device has completed a research on corrosion behavior of different metal materials under simulated condition of fire flooding. This device can be flexible with different corrosive medium and the durable temperature/pressure is 500℃/50-MPa.

Introduction

In the processing of recovery from fire flooding drive reservoirs, the air humidity of most steam injection well's annular is very high, the external of the pipe is easy to appear the phenomenon of corrosion due to exposure to oxygen. As fire flooding causes mineral dissolution and produces carbon dioxide, hydroxide and surplus oxygen, both of them can react with formation water to show the acidic and causes the acidic corrosion. These all lead to serious corrosion on the pipes. So we launch the research of dynamic simulation of fire flooding corrosion to provide more insight into better aseptic techniques for fire flooding.

Research and Experiment of Dynamic Simulation of Corrosion at High Temperature and High Pressure

Research of Gas Injection System

The gas injection systemis mainly made of a gas booster pump, a quiet air compressor, a flow controller, a low pressure air tanks and a high pressure gas storage tanks. The System can simulate the pressure of fire flooding gas injection, insure the gas flow smooth in the experimental device, and can choose different experimental gas according to operating mode circumstance. The maximum injection pressure is 50MPa and maximum injection flow is 1000mL/min.

Research of Liquid Injection System

The liquid injection system is mainly made of a tranquil flow pump, two piston design storage tanks and the heating warmer. The system can simulate the flow of output liquid of fire flooding production well, insure the liquid flow smooth in the device, and can choose different experimental liquid according to operating mode circumstance. One of both piston design storage tanks has a

heating warmer, the temp range is minimum -90ºC at normal indoor temperature, the precision is ±1ºC.

The Reactor of Dynamic Simulation at High Temp and High Pressure

The reactor of dynamic simulation at high temp and high pressure has the following characteristics:

Both the gas injection port and exit is on the top of the device, and the liquid injection port is on the top and the exit is in the lower part of the device. This design is to make sure both the gas and liquid are always circulating.

A. The temperature control system is outside the reactor and the thermodetector is inside the reactor. This design is to ensure the reactor being heated safely and has a high precision in temp controlling.

B. The coupon uses the hook type installment, which is a super-quick way.

C. The reactor is exclusively manufactured by hastelloy to accommodate an excellent corrosion resistance to various conditions.

D. The reactor has a magnetic stirrers with self cooling equipment which is high temp resistance.

E. The reactor has a fast cooling system to make sure rapid chilling as soon as the experiment finished.

F. The reactor parameters is as follows:

G. The controller can achieve any temp at indoor temperature, the maximum is -500ºC，also can achieve any pressure with a range of 0~50MPa.

The Dynamic Balance Feature of Gas&liquid in the Reactor

To make sure the experimental gas&liquid achieve the dynamic balance in the specific pressure range at high temp&pressure in the reactor, finally we adopt the method of constant rate injection and discharge to simulate the operating condition of the fire flooding.The detailed information is as follows:

A. Inject the experimental gas&liquid into the reactor, set the temp and the pressure, then wait for reaching the desired point.

B. Set the injection flow rate of constant flux pump the same as the reactor’s.

C. Set the gas injection flow rate of gas flow controller the same as the reactor’s.

The Research of Reactor’s Sealing mechanism

A. The sealing mechanism of cover plate

(1) Using the expanded graphite to seal the plate.

(2) Using 6 screw made of Ni-base superalloys to fixation the plate and compress the graphite.

(3) The 6 screw is malleable to accommodate the high temp.

B. The sealing mechanism of corrosion probe

Using double layer of expanded graphite to seal the part of the probe in case of the damage of tighten the screws.

The Research of Dynamic Detection of the Reactor’s Corrosion

We made the real-time monitoring of the simulated fire flooding corrosion possible by combine the advanced inductance probe with the simulated fire flooding corrosion experimental device.

A. Automatically and rapidly computing corrosion data.

B. Monitor the process of corrosion and draw a diagram.

Over-fitting data and diagrams of different experiment (before and after medicate the corrosion inhibitor)

Research and Application of Influence Factor of Corrosion Behavior

Research of Influence Factor of Corrosion

Using this device we complete the experiment of oxygen concentration, pressure, temperature as factors influencing the corrosion rate, then research the influence law of vary oxygen concentration, vary pressure, vary temp,.This may have an positive effect on optimization of corrosion-resistant material and corrosion evaluation.

We picked several screenshots of experiment data of influences of vary factors on corrosion as follows:

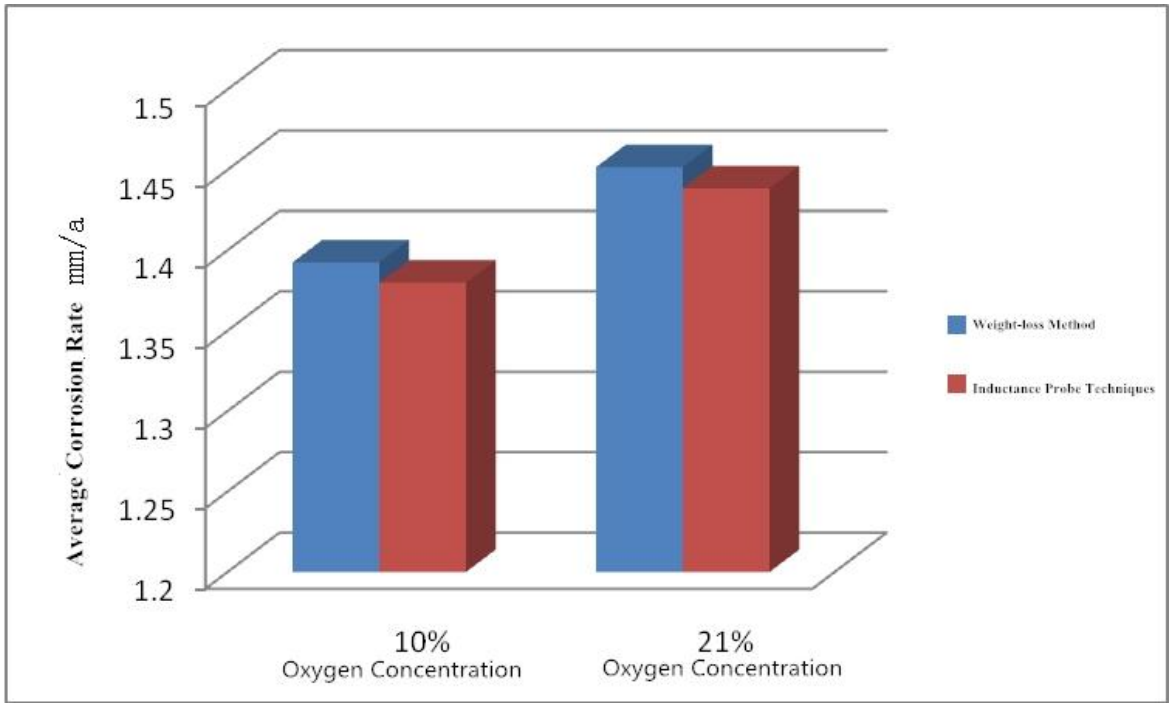

Fig. 1 Influences of Oxygen Concentration on Corrosion

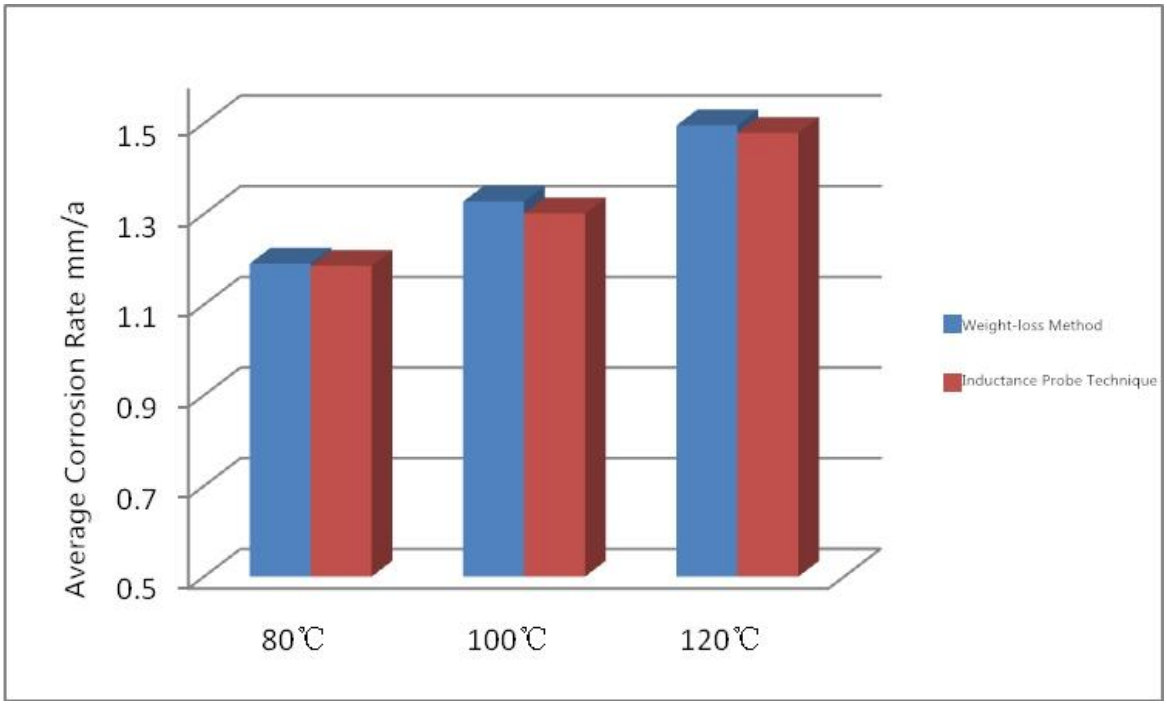

Fig. 2 Influences of Temperature on Corrosion

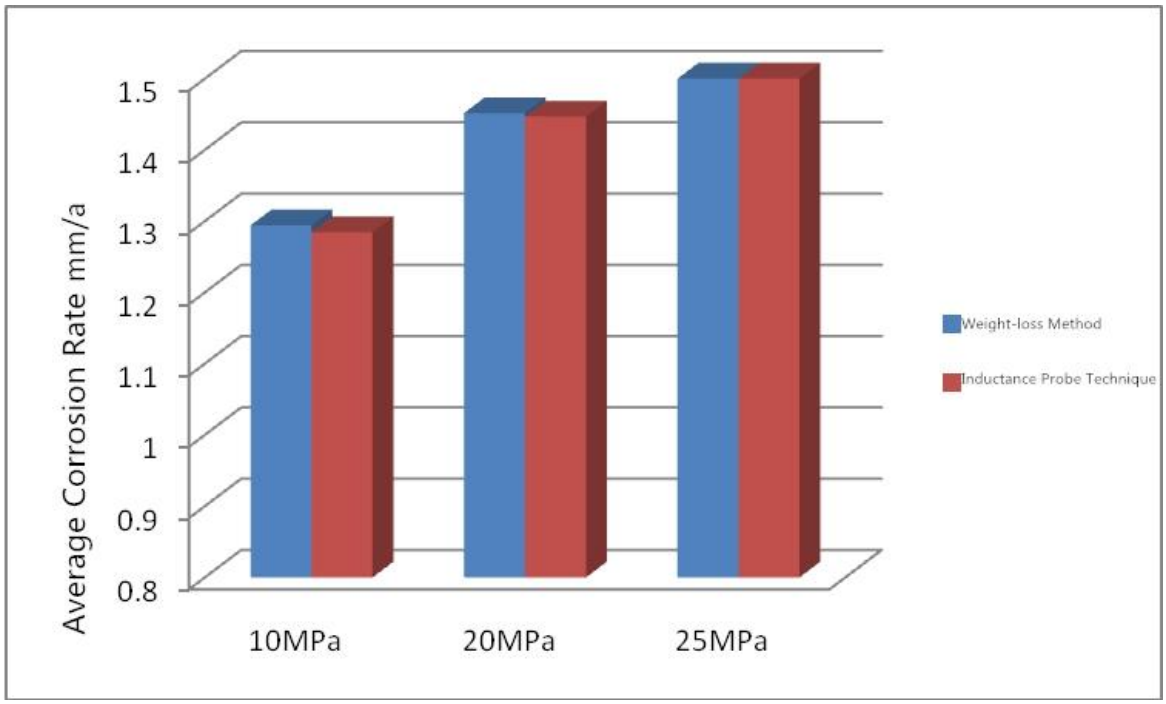

Fig. 3 Influences of Pressure on Corrosion

Research of Pipe Corrosion of Fire Flooding Injection Well

Optimization of Anti-Corrosion Material of Pipes

By simulating the operating condition of fire flooding (400ºC,4MPa), we complete experiment of 7 different materials' anti-corrosion performance assessment, the details of the results as table 1.

Table 1 Experiment Data of Optimization of Anti-corrosion Material

Texture	Corrosion Rate[mm/a]
13CR	0.0193
J55/K55	0.4911
P110	0.9441
BG110	0.2351
N80	0.5740
L80-13CR	0.0187
L80-3CR	0.2701

The results shows that the model L80-13CR has the best anti-corrosion performance and its corrosion rate is 0.0187mm/a. The most widely used pipe material model N80 is the most easy-corrosion one, its corrosion rate is up to 0.574mm/a. So we recommend selecting Model L80-13CR as pipes material for fire flooding.

Optimization of Corrosion Inhibitor

By simulating operating condition, we complete experiments of performance assessment of 5 corrosion inhibitors, the results of the experiment as table 2.

Table 2 Experiment Data of Optimization of Corrosion Inhibitor

Corrosion Inhibitor	Concentration [mg/L]	Corrosion Rate [mm/a]
1#	200	0.5512
	500	0.4712
2#	200	0.5412
	500	0.4614
3#	200	0.5308
	500	0.4504
4#	200	0.4121
	500	0.0721
5#	200	0.4801
	500	0..3212

The results of the experiments show that 4# inhibitor has the best anti-corrosion performance when concentration is 500ppm, it can lower the corrosion rate from 0.5740mm/a to 0.0721mm/a.

Conclusions

A. The new developed dynamic simulated corrosion experiment device can satisfy the requirements of carrying out a research of fire flooding corrosion.

B. Optimized the model L80-13CR is the best material for anti-material pipes.

C. Developed the new type of high temp resistance inhibitor, the new type inhibitor can decrease corrosion rate to 0.0721mm/a.

Acknowledgments

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