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NUMERICAL SIMULATION STUDY ON INTERNAL CORROSION OF MIXED PIPELINES IN PIPELINE ROUTING

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ABSTRACT

The purpose is to study the internal corrosion rate through the analysis and Simulation of pipeline routing factors in multiphase pipelines. Methods theoretical analysis and numerical simulation are adopted respectively. Multiphase flow simulation software OLGA is used to collect and analyze pipeline related operational parameters, routing parameters and transport medium components. A corrosion prediction model for oil-gas mixing pipelines in OLGA is selected. Results the influence of pipeline pressure, temperature, fluid velocity, liquid holdup and flow pattern distribution on internal corrosion rate was analyzed. After setting up the model and setting up the model parameters, the simulation results are analyzed and the results of the corrosion rate in the pipeline are predicted. For the study of single factors on mixed transportation pipeline corrosion rate, simplify the pipeline model, retaining only the pipeline uphill and downhill two pipe sections, by modifying the parameters of pipeline parameters and medium, effect of single factor on mixed transportation pipeline internal corrosion. Conclusion pipeline routing has a great influence on the internal corrosion rate of mixed pipeline, but even in the uphill and downhill stage of the mixed pipeline, the same factor also has a different impact on the internal corrosion rate.

Key Words: Multiphase pipeline; Multiphase flow; Internal corrosion; OLGA

Introduction

In the Gathering Pipeline, the use of oil and gas multiphase transportation pipeline to deliver crude oil and natural gas is compared with the use of single-phase pipelines for the delivery of crude oil and natural gas has many advantages, not only can greatly reduce the workload of the staff to improve the gathering process, but also reduce the investment and significantly improve the economic efficiency of oil and gas exploitation[1-4]. Especially in certain circumstances, it is not convenient to install in the oil and gas separator and processing equipment such as city area, desert, lake, ecological protection zone and swamp and so on. It is necessary to use the mixing pipeline to transfer the oil and gas produced to the nearby processing plant for processing. Therefore, the application of mixed pipelines is becoming more and more widespread in the oilfield ground gathering system[5]. With the development of technology, the pipeline of oil and gas transportation has developed from small diameter and short distance to large diameter and long distance gradually. In this paper, we mainly study the internal corrosion of internal corrosion of mixed pipelines in pipeline routing and analyze the different factors in the pipeline routing, and establish a model to predict the internal corrosion rate in the pipeline. It is of great significance to the study of internal corrosion of mixed pipeline.

1 Establishment of pipeline corrosion model for OLGA software

The software builds the model, as shown in figure 1.

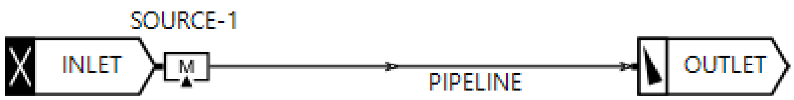


Fig.1. Model establishment

（1）*Pipeline operation parameter setting*

Pipeline material for the carbon steel, with the antiseptic layer of polyethylene material. Pipeline length is 13KM, pipeline diameter is φ457×11, internal diameter of the pipeline is 435mm. The pipeline roughness is 2.8e-005.Pipeline and outer antiseptic layer thickness, thermal conductivity, specific heat and density as shown in Table 1.

Tab.1. Pipe material parameters

	Pipeline	outer antiseptic layer
thickness	11mm	6mm
thermal conductivity	50W/m·K	0.12W/m·K
specific heat	485J/Kg·C	1675J/Kg·C
density	7850Kg/m^3	960Kg/m^3

（2）*Boundary condition setting*

The inlet boundary condition of the pipeline is temperature, and the inlet temperature is set at 40℃ of the typical working condition, and the mass flow rate is 30Kg/s；The outlet boundary condition is the pressure condition, the outlet pressure is set to the typical working condition, the outlet pressure is 5Mpa, and the soil temperature is set to 22℃.

（3）*Pipeline routing settings*

This paper takes the prototype of big drop area and long-distance oil pipeline in the northwest of China as the research object. and some simplified pipeline length is 8900m, Pipeline where the terrain conditions are more complex, ups and downs change is very obvious. The pipeline mixes crude oil and natural gas to transport.

Multiphase pipelines extending line specific elevation data shown in Table 2.

Tab.2. Pipeline elevation distribution

number	PIPE-1	PIPE-2	PIPE-3	PIPE-4	PIPE-5	PIPE-6	PIPE-7
mileage（m）	800	500	800	800	800	500	800
elevation（m）	20	-20	200	-150	50	-50	200
number	PIPE-8	PIPE-9	PIPE-10	PIPE-11	PIPE-12	PIPE-13	
mileage（m）	800	500	500	800	800	800	
elevation（m）	-150	50	-50	100	-100	50	

PIPE-1 mileage is 800m, refers to the first pipeline horizontal distance is 800m, elevation is 20m, refers to the end of the pipeline 1 from the horizontal plane height of 20m. PIPE-2 has a mileage of 500 m, meaning that the horizontal distance of the second pipe from the first pipeline is 500 m and the elevation is -20 m, which means that the vertical distance of the end of the second pipeline relative to the end of the first pipeline 20m, the remaining 11 pipelines and so on.

2 Analysis of prediction result of internal corrosion rate in pipeline

The results of simulation in the pipeline tend to be stable, and the simulation results are almost unchanged with the increase of simulation time. But in order to ensure reasonable simulation results, set the continuous running time of 48 hours. The operation parameters of each part of the pipeline have been stabilized[6-11]. The De Waard (DW95) corrosion model was used to study the corrosion rate in the pipeline, and the corresponding software CORR1 was used.

The use of OLGA corrosion module, using Norsok M506 and De Waard (DW95) pipeline internal corrosion prediction model is calculated, the calculation results are shown in Figure 2, where CORR1 denotes the prediction results of Norsok M506 model, CORR3 indicated De Waard (DW95) prediction model.

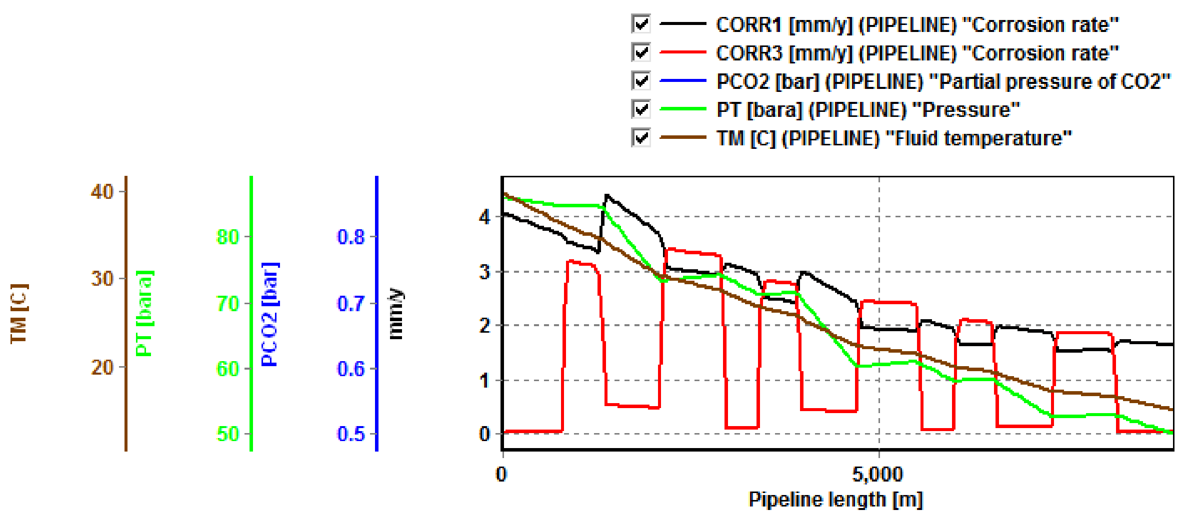


Fig.2. Norsok M506 and De Waard (DW95) model predictive results

As can be seen from Figure 2, there is a big gap between the Norsok M506 model and the De Waard (DW95) model for predicting the corrosion rate along the pipeline. The corrosion rate predicted by the Norsok M506 model is higher than that predicted by the De Waard (DW95) model.Because Norsok M506 and De Waard (DW95) have their own scope of application, you must ensure that the parameters are used to meet the model requirements. Compared with the trend curve of temperature, pressure and CO2 partial pressure distribution along the pipeline, the CORR1 model (Norsok M506 model) is more consistent[12-15]. The CORR3 model (DeWaard (DW95) model) is quite different, and De Waard (DW95) is not suitable for the study of internal corrosion of oil-water mixed pipelines.

3Analysis of main factors of internal corrosion in mixed pipeline

From the above analysis results show that the internal corrosion of pipeline routing, a great impact on the single factor influence on the corrosion rate of mixed transportation pipeline. Pipeline simplified model, retaining only the pipeline uphill and downhill two pipelines sections, by modifying the parameters of pipeline parameters and medium, effect of single factor on mixed transportation pipeline internal corrosion[16]. The simplified model of the pipeline is shown in figure 3.

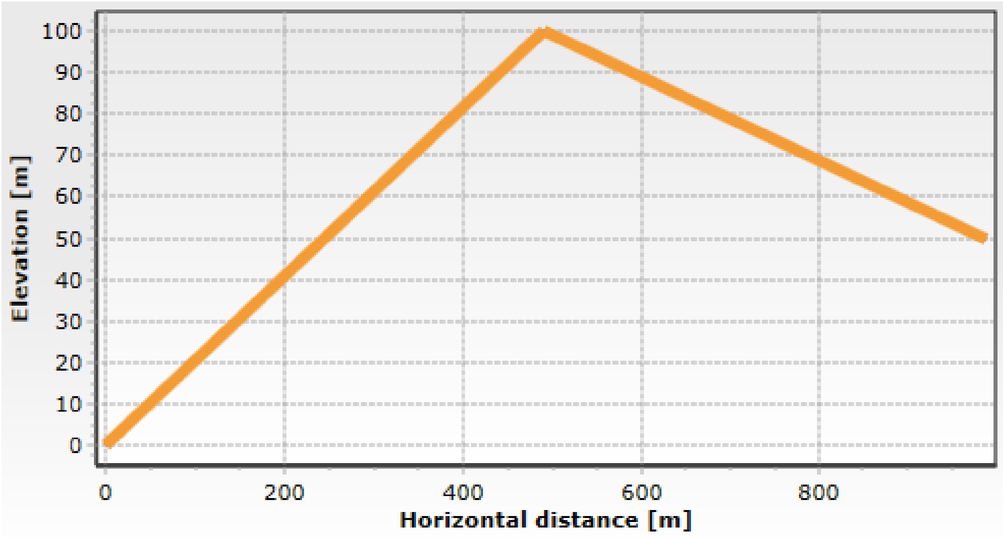


Fig.3.pipeline routing

Using the component model, the inlet boundary condition is temperature condition, the inlet temperature is 40℃, the outlet boundary condition is the pressure condition, the outlet pressure is constant 5MPa, the CO2 partial pressure is set to 0.1MPa, and the water content is 10%.

（1）*Influence of uphill dip angle on internal corrosion of mixed pipeline*

Keep the length and elevation of the downward section of the pipeline unchanged, the length of the pipeline in the uphill section is unchanged, and the inclination angle of the pipeline is modified to be 1, 15, 10, 15, 20, 30, 40, and 60 degrees, respectively. Norsok M506 prediction model is used to calculate the corrosion rate and parameters along the pipeline, as shown in figure 4.

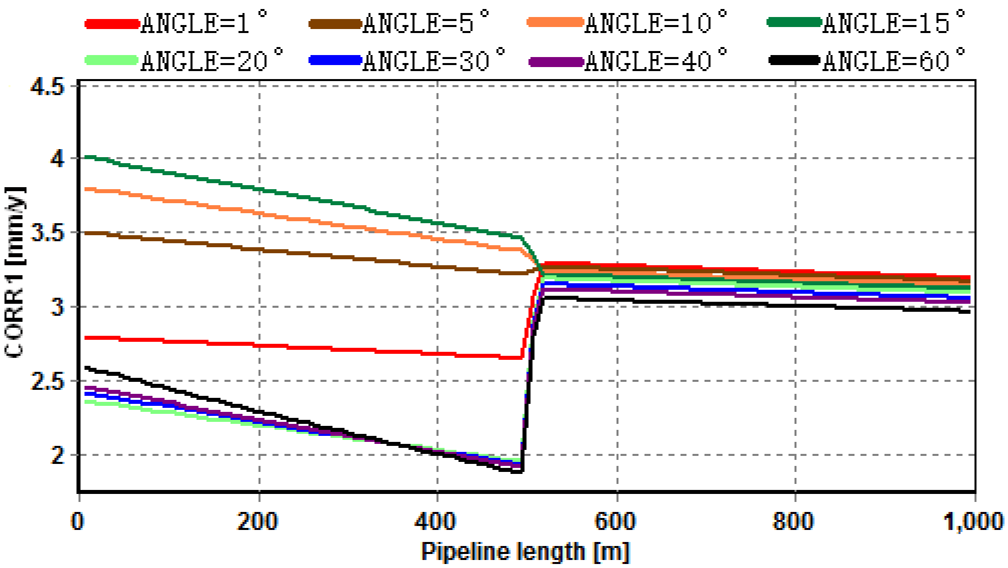
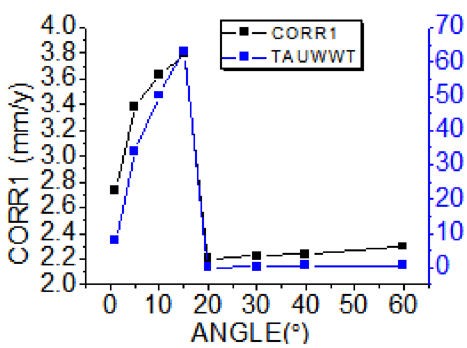


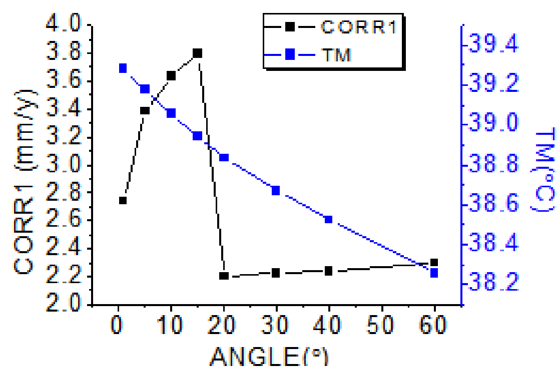
Fig.4.Corrosion rates along different uphill dip pipelines

As can be seen from Figure 4, when the uphill slope of the pipeline is 1 to 15 degrees, the corrosion rate increases with the inclination of the uphill slope, When the slope angle is 5 degrees, the corrosion rate increases greatly. When the slope angle is 15 degrees, the corrosion rate reaches the maximum value, and when the slope angle is 20 degrees, the corrosion rate drops sharply, When the slope angle is 20 degrees to 60 degrees, the corrosion rate varies slightly with the inclination angle of the uphill slope. When the length and inclination angle of the decline section of the mixed pipeline are constant, the corrosion rate of the decline section is smaller with the inclination angle of the uphill.

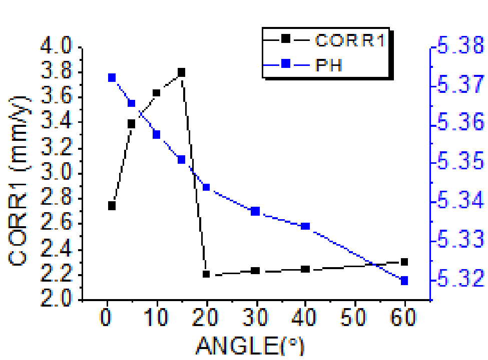
At the entrance 200m, the change trend of corrosion rate and wall shear force, temperature, CO2 partial pressure, pH value, liquid holdup and flow velocity with the inclination of uphill slope is shown in figure 5.



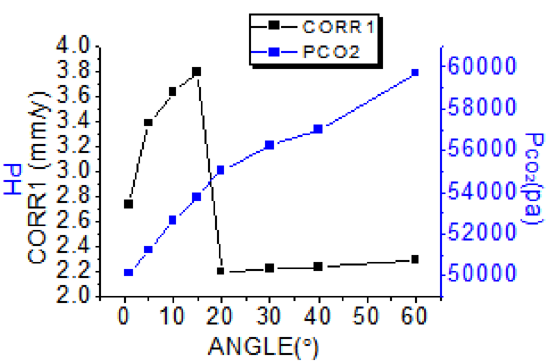
(a) The corrosion rate and the wall shear force change with the uphill angle



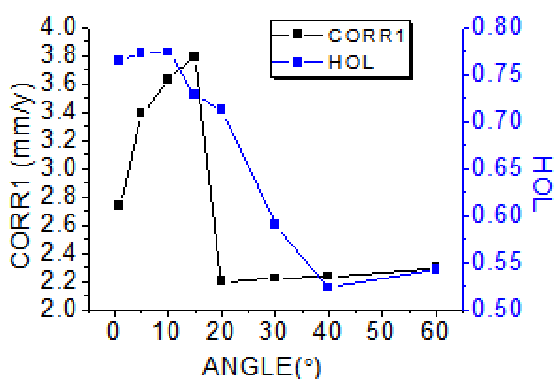
(b) The corrosion rate and the temperature change with the uphill angle



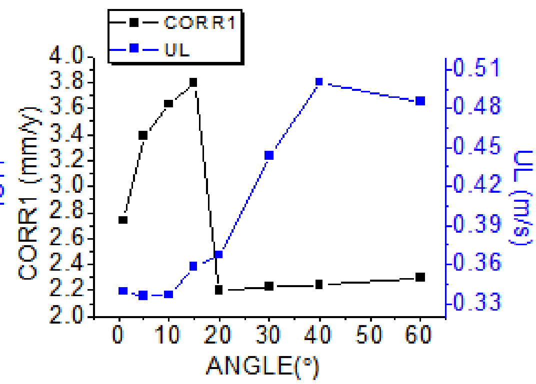
(c) The corrosion rate and the pH value change with the uphill angle



(d) The corrosion rate and the CO2 partial pressure change with the uphill angle



(e) The corrosion rate and the liquid holdup change with the uphill angle



(f) The corrosion rate and the flow velocity change with the uphill angle

Fig.5.The corrosion rate and the corresponding parameters change with the uphill angle at 200m

As shown in Figure 5, in the uphill section of the mixed pipeline, the corrosion rate and the wall shear force coincide very well with the inclination angle of the uphill slope, It shows that the shear rate has a great influence on the inclination angle of the uphill slope with the inclination angle and the wall shear force. The change trend of temperature, pH, CO2 partial pressure, liquid holdup and velocity with the uphill angle is not consistent, indicating less effect of temperature, pH, CO2 partial pressure, liquid holdup and flow rate on the corrosion rate changes with the uphill angle.

(2) *Influence of downhill dip angle on internal corrosion of mixed pipeline*

Keep the length and elevation of the downward section of the pipeline unchanged, the length of the pipeline in the downhill section is unchanged, and the inclination angle of the pipeline is modified to be -1, -5, -10, -15, -20, -30, -40, and -60 degrees, respectively. Norsok M506 prediction model is used to calculate the corrosion rate and parameters along the pipeline, as shown in figure 6.

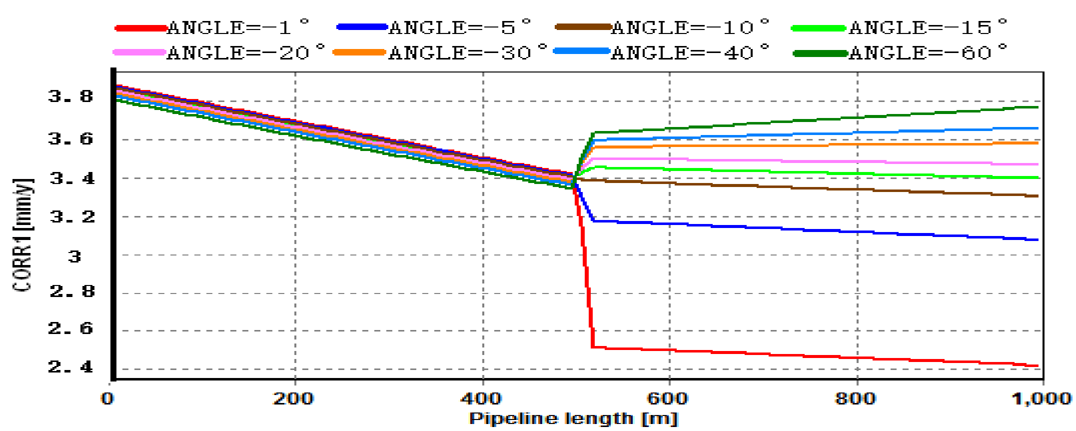
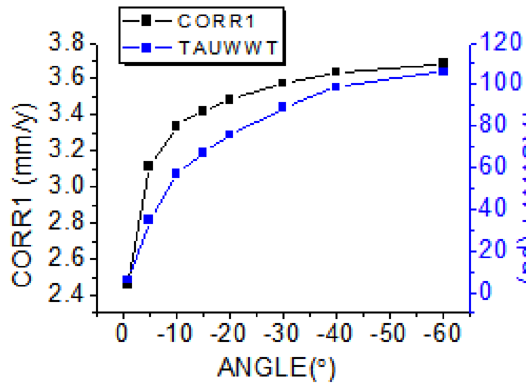


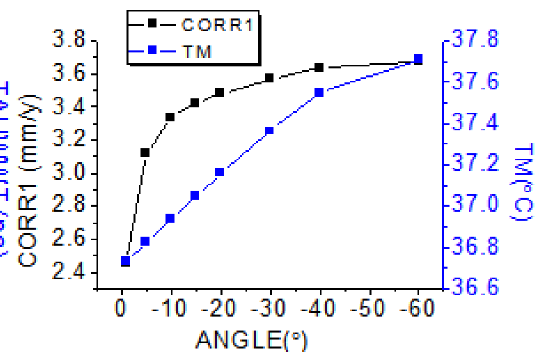
Fig.6.Corrosion rates along different downhill dip pipelines

As can be seen from Figure 6, when the length of the uphill pipeline and the inclination angle of the pipeline are unchanged, the corrosion rate of the uphill pipeline section is less affected by the change of the inclination of the downhill slope, which is not analyzed here.With the decline of the slope angle of the downhill pipeline, the corrosion rate increases gradually, and the corrosion rate increases greatly at -5 degrees.

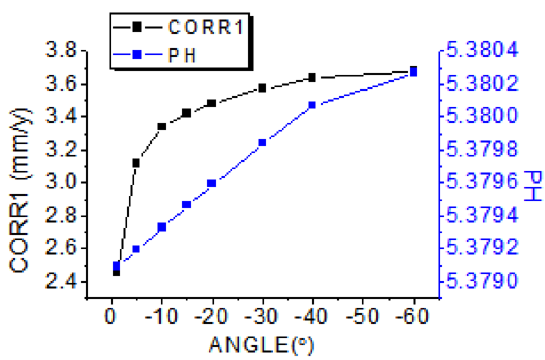
At the entrance 800m, the change trend of corrosion rate and wall shear force, temperature, CO_2 partial pressure, pH value, liquid holdup and flow velocity with the inclination of downhill slope is shown in figure 7.



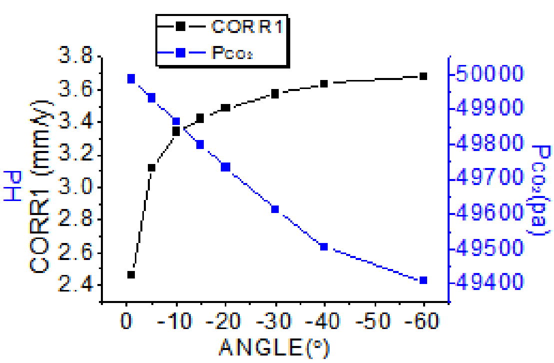
（a） The corrosion rate and the wall shear force change with the downhill angle



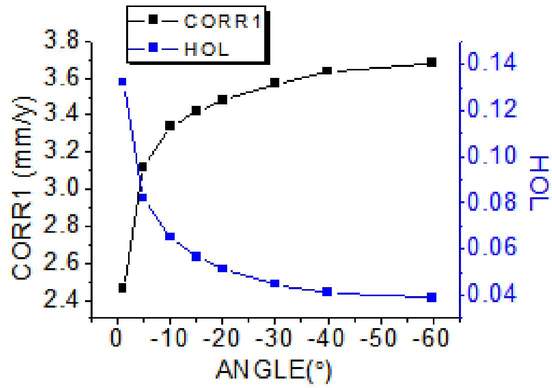
（b） The corrosion rate and the temperature change with the downhill angle

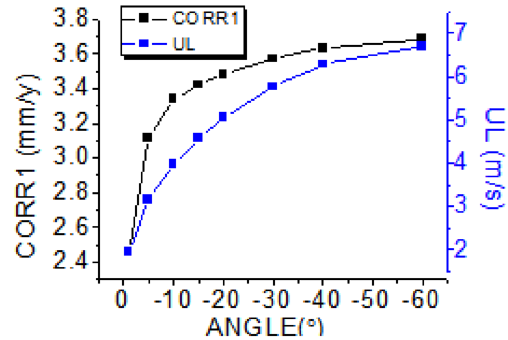


(c)The corrosion rate and the CO_2 partial pressure change with the downhill angle



(d)The corrosion rate and the pH value change with the downhill angle





(e) The corrosion rate and the liquid holdup change with the downhill angle

(f) The corrosion rate and the flow velocity change with the downhill angle

Fig.7.The corrosion rate and the corresponding parameters change with the downhill angle at 800m

Can be seen from Figure 7, in the downhill section of mixed transportation pipeline, the numerical changes with temperature and pH value of the downhill angle is almost the same and illustrate the relationship between corrosion rate with change with temperature and pH value inclination of the downhill section is not obvious. The CO2 partial pressure does not agree with the change trend of the dip angle, indicating that the CO2 partial pressure has little influence on the change of the slope angle with the change of the slope angle. However, the change trend of the liquid holdup with the dip angle of the inclined pipeline section is the same as the corrosion rate, and the change trend of the wall shear force and the flow velocity with the dip angle of the downward slope and the corrosion rate coincide very well with the inclination angle of the downhill slope. So in the downhill section of mixed pipeline, influence the corrosion rate of the main downhill angle by the liquid holdup, wall shear stress and velocity section.

4 Conclusion

The analysis results are as follows:

(1) In the uphill section of the mixed pipeline, the internal corrosion rate increases with the increase of the outlet pressure, and reaches the extreme value at 7Mpa. The influence of the outlet pressure on the corrosion rate is mainly affected by the pH value and the CO2 partial pressure. The corrosion rate increases with the increase of outlet pressure, and the influence of outlet pressure on corrosion rate is affected by pH, CO2 partial pressure, liquid holdup and flow velocity.

(2) Mixed transportation pipeline uphill pipes, the corrosion rate varies with slope inclination, reaches the maximum at 15 degrees, 20 degrees in the corrosion rate decreases, the wall shear stress is the dominant factor affecting the inclination uphill corrosion rate.

(3) The corrosion rate increases gradually with the increase of dip angle, and the change of corrosion rate with the dip angle is mainly affected by liquid holdup, flow velocity and wall shear force.

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