Available online www.jocpr.com

Journal of Chemical and Pharmaceutical Research, 2014, 6(7):2364-2369

Research Article

ISSN : 0975-7384
CODEN(USA) : JCPRC5

Comparative analysis of FRP and seamless steel pipe on crude oil transportation performance

Liqiong Chen[1], Shijuan Wu[1*], Hongfang Lu[1], Kun Huang[1] and Jianying Shi[2]

[1]School of Petroleum Engineering, Southwest Petroleum University, Chengdu, China
[2]NO.1 Oil Production Plant, Petro China Xinjiang Oilfield Company, Karamay, China

---

ABSTRACT

Oil transportation with traditional seamless steel pipe consumes more energy and produces corrosion problem easily. It is suggested that Fiberglass Reinforced Plastics replace seamless steel pipe when conveying crude oil of high viscosity. Temperature fields within a period of time of both kinds of pipeline were numerically simulated by means of Fluent software, and temperature drop and pressure drop were simulated by PIPEPHASE software. Analog results indicate that FRP offers a better thermal insulation property when transporting highly viscous crude and FRP requires smaller initial pressure when conveying the same medium, which is more energy-saving.

Keywords: FRP, Seamless steel pipe; Crude oil transportation; Temperature field; Temperature drop; Pressure drop

---

INTRODUCTION

FRP,a type of reinforcing material made of unsaturated resin, epoxy resin etc., which is referred to as fiberglass reinforced plastic, is widely used in oil and gas gathering system and water injection pipeline in the oil industry. Compared with the traditional steel pipe,FRP has many different outstanding advantages, such as excellent corrosion resistance, which solves the problem of the steel pipe corrosion; and the weight of FRP is only 1/3 of the steel tube, which facilitates the installation; also inner wall of FRP is very smooth with great hydraulic performance and a small friction coefficient which makes wax and scaling process difficult; what's more, FRP has a good anti-pressure ability, and is quick and easyin thread connection.

Crude oil produced from some oil field is of high viscosity and high solidifying point, and the produced water salinity is higher.In order to solve the following problems in the actual project, inadequatepipeline transfer ability, serious scaling, water injection system problems and lack of substation load, it is necessary to analyze the temperature field,pressure drop and temperature drop between FRP and normal steel pipe in the process of operation. The analysis has a certain practical significance for energy saving and cost reducing.

EXPERIMENTAL SECTION

Numerical simulation method and modeling
Pipeline temperature field analysis
The analysis of temperature field ofFRP and seamless steel pipeis done by comparing the soil temperature around the pipeline to determine the heat preservation performance of thesetwo kinds of pipe. Figure 1 shows the physical model design of pipeline, and table 1~3 indicates the pipeline physical model's boundary conditions, soil parameters and pipeline related parameters [1-2].

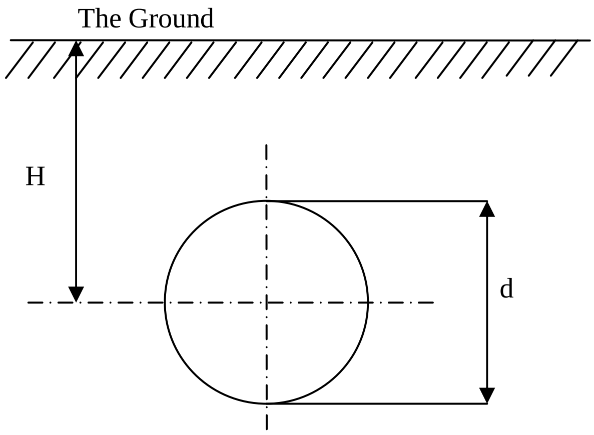

Figure 1 The physical model design of pipeline

Table 1 Boundary conditions

Heat exchange mode betweensoil surface and atmosphere	Heat exchange mode between soil surface and FRP	Boundary type (The level of the 8m below the ground)	Boundary type (The vertical plane besides both left and right sides of pipelineof 10m away)
Heat convection	Heat conduction	Constant temperature boundary	Adiabatic boundary

Table 2 Soil parameters

Density, kg/m^3	Specific heat capacity, J/kg·℃	heat conductivity coefficient, W/m·℃	temperature of at the lower boundary, ℃	Convective heat transfer coefficient between atmosphere and groundα_{ta} , W/m^2·℃	The exothermic coefficient between oil flow andthe pipe inner wall α_1 , W/m^2·℃	heat emission coefficientbetween pipe outer wall and the soil α_2, W/m^2·℃
1800	1163	0.6	2.2	25.06	117.88	1.99

Table 3 Pipe parameters

Oil temperature, ℃	Heat conductivity coefficient of FRP, W/m·℃	Heat conductivity coefficient of oil, W/m·℃	Oil density, kg/m^3	Heat conductivity coefficient of wax, W/m·℃	Average atmospheric temperature, ℃	Pipe buried depth, m	Pipe inner diameter, m	Pipe wall thickness, m
40	0.4	0.14	860.9	2.5	8.1	1	0.19	0.005

Based on finite volume method, Gambit is applied to mesh pipeline and the soil around pipeline.Due to the different type of the upperand the lower boundary, symmetrical simplified method cannot be applied. In order to reduce the amount of calculation and ensure the calculation precision, using the non-uniform grid model, that is usingrelatively dense grids at the site of the points which need to be focused on studying. In this study, the computation region includes 38135 grid nodes [3-4].

Pressure drop and temperature drop analysis along the pipe

Pipeline pressure drop and temperature drop is usuallyanalyzed byPIPEPHASE software developed by SimSci company. Through the temperature field analysis by Fluent, the temperature value can be used as environment temperature in the simulation of PIPEPHASE. According to a certain oilfield site data, for there are three different diameterpipelines, so the pipe model is divided into three sections, as shown in table 4. Two pipelines' fluid parameters and governing equations are set up in PIPEPHASE [5].Table 5 is fluid parameter setting. Figure 3 shows the pipeline elevation profile map.

Table 4 Pipe sections diameter values

	Pipe section one	Pipe section two	Pipe section three
Length, m	7044.88	17607.20	7057.88
Inner diameter, mm	187	190	175

Table 5Fluid parameters

Calculation equation	Inner diameter	Heat conductivity coefficient, W/m·℃	Heat transfer coefficient of soil	Pipe buried depth, m
Beggs-Brill	DN200	0.4	1.385	1

Figure 2 The pipeline schematic diagram in PIPEPHASE

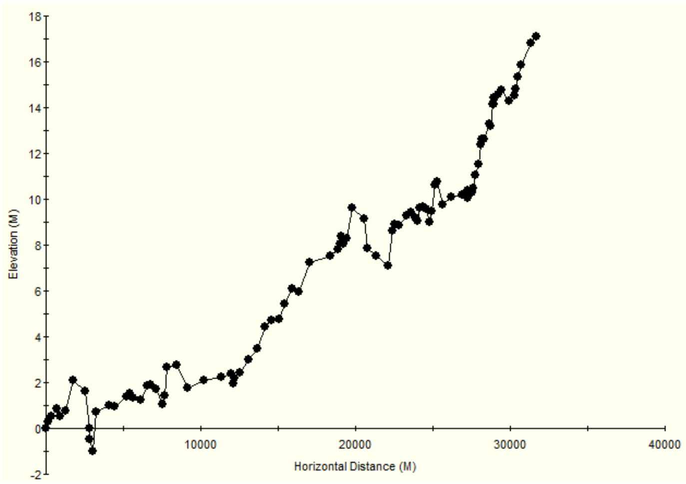

Figure 3 Pipeline model schematic diagram (horizontal distance-elevation)

RESULTS AND DISCUSSION

Pipeline temperature field analysis results

After simulation, stable soil temperature field distribution around the pipeline is shown in figure 4 and figure5.

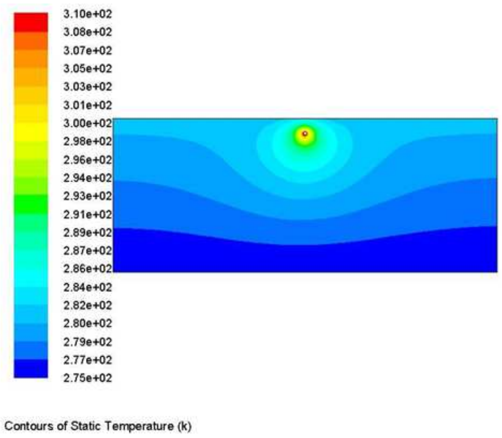

Figure 4 Stable contour of static temperature field distribution of FRP

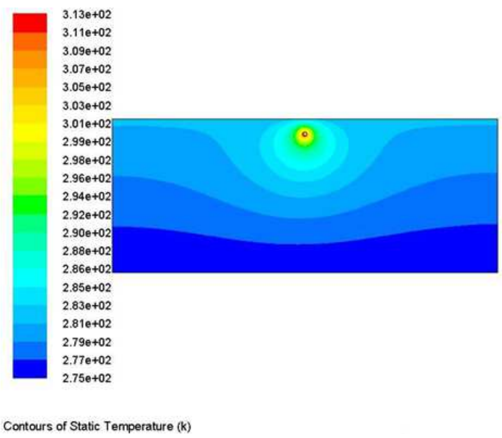

Figure 5 Stable contour of static temperature field distribution of Steel pipe

When it goes into steady state, soil temperature field distribution aroundFRP and steel pipe is basically the same. We useTec plotto highlight contour map for a better understanding.Figure 6 to figure13 are soil temperature field distribution comparison diagram of FRP and steel pipe.

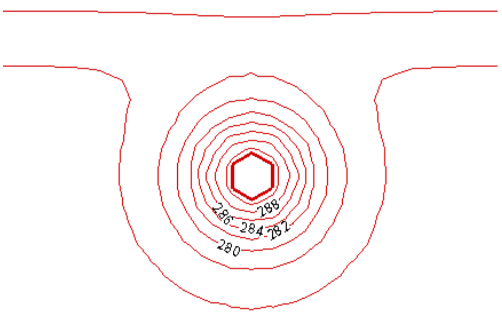

Figure 6 Temperature isotherm diagram in one day (FRP)

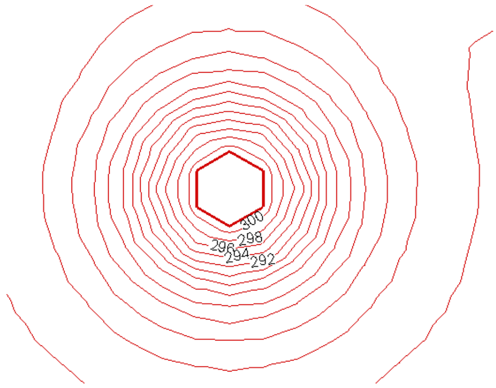

Figure 7 Temperature isotherm diagram in one day (Steel pipe)

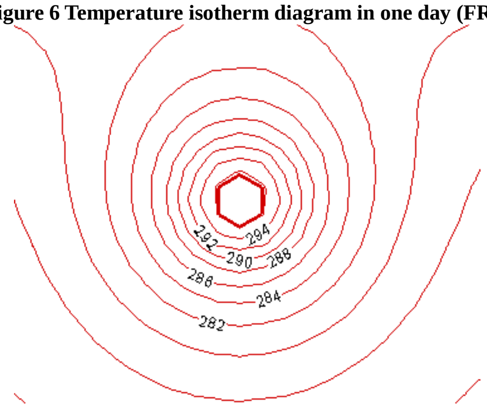

Figure 8 Temperature isotherm diagram in 5 days (FRP)

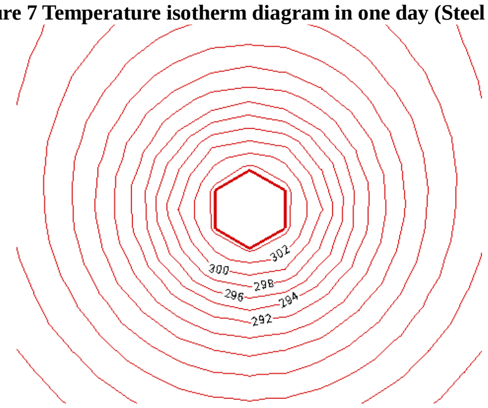

Figure 9 Temperature isotherm diagram in 5 days (Steel pipe)

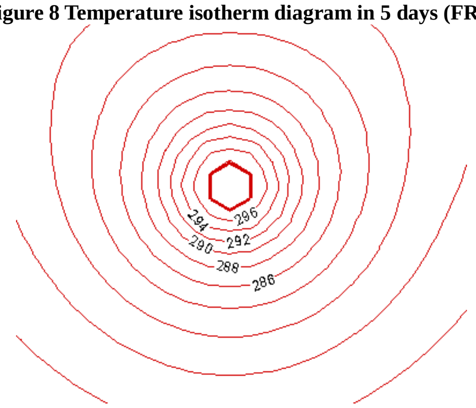

Figure 10 Temperature isotherm diagram in 10 days (FRP)

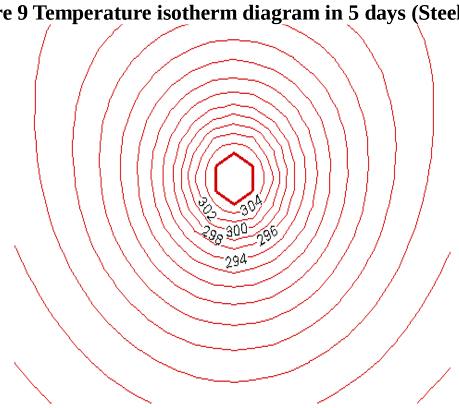

Figure 11 Temperature isotherm diagram in 10 days (Steel pipe)

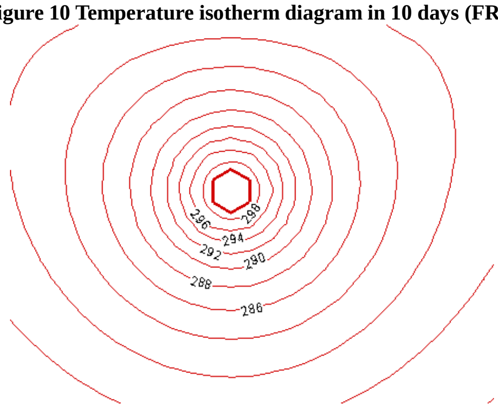

Figure 12 Temperature isotherm diagram in 20 days (FRP)

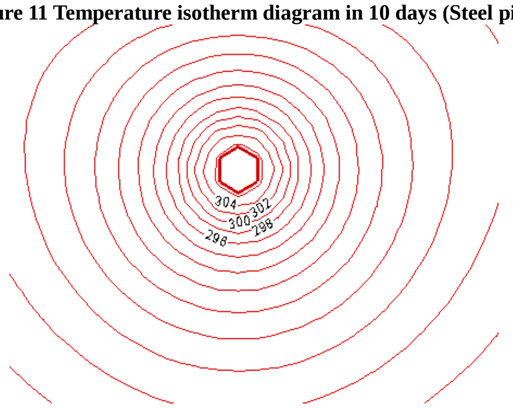

Figure 13 Temperature isotherm diagram in 20 days (Steel pipe)

From figure 6~13, it can be seen that FRP and steel PIPEhave differentinfluence on surrounding soil temperature.For example,afterpipeline being run for 20 days, temperature of soil next to steel pipe can reach 31℃ (Numerical unit of temperature isotherm diagram isKelvin), while soil temperaturearound FRP is 25℃.

Analysis results of pipeline pressure drop and temperature drop

FRPinner wall is smooth.The FRP used in the oilfield has absolute roughness of 0.0053mm, while absolute roughness of new seamless steel pipe or galvanized iron pipe is 0.1~0.2mm. We take 0.15mm in the simulation. Different roughness cause variousfriction losses during pipeline operation process andalso affect the operating pressure [6-7]. FRP and steel pipe initial data are listed in Table 6. The pressure distributions along FRP and steel pipeline with heated transportation are shown in figure 14, and the temperature distributions along the two type pipes are shown in figure 15.

Table 6 FRP and steel pipe initial data

FRP		Steel pipe	
Initial data: Flow rate is 65m^3/h; inlet temperature is 38℃; outlet pressure is 0.35MPa; soil temperature is 30℃.			
Inlet pressure(MPa)	Outlet temperature(℃)	Inlet pressure(MPa)	Outlet temperature(℃)
1.390	33.56	1.442	32.21

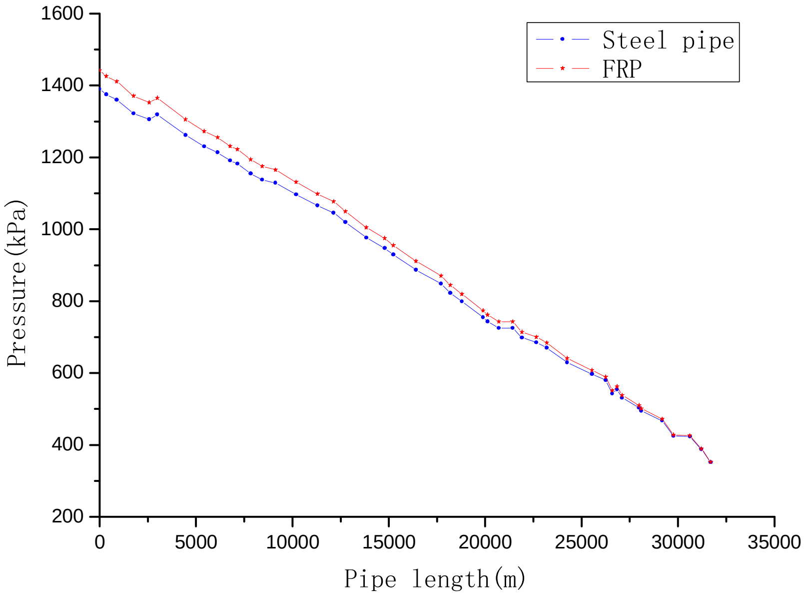

Figure 14The pressure distributions along FRP and steel pipeline with heated transportation

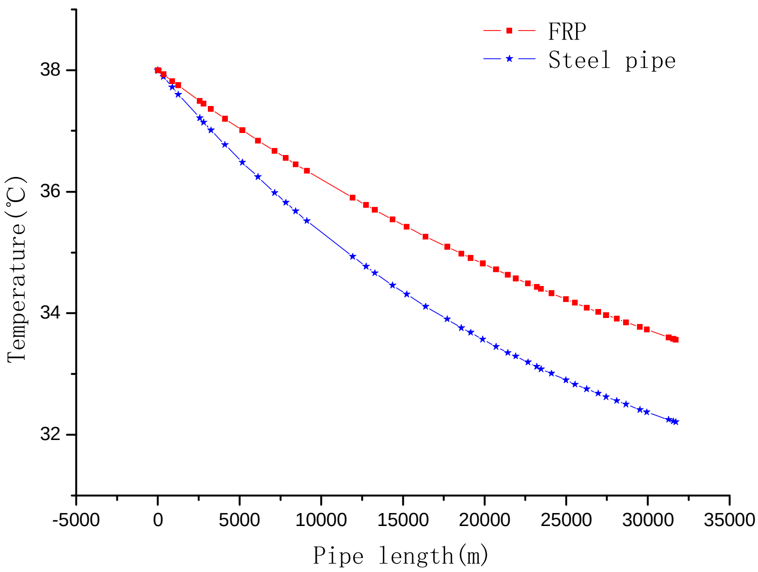

Figure 15Thetemperature distributions along FRP and steel pipeline with heated transportation

Through comparative analysis of temperaturefield, temperature drop and pressure drop of FRP and steel pipe, it can be concluded:

(1) FRP and steel PIPE have different influence on surrounding soil temperature. For example, after pipeline being run for 20 days, temperature of soil next to steel pipe can reach 31℃, while soil temperature around FRP is 25℃.Obviously, FRP has a great heat preservation performance, which means it doesn't need to add extra thermal insulation layer in the transportation process.

(2) With the same initial conditions, pressure drop and temperature drop of FRP are smaller than that of steel pipe, for the absolute roughness and thermal conductivity coefficient of steel pipeare far greater than FRP. Conveying the same medium, FRPrequiresrelatively smaller pressure. From the point of view of energy, FRP has more advantages.

(3) Friction coefficient of FRP inner wall is very small, about 10 times smaller than the steel pipe, which makes scaling and wax deposition process difficult.

CONCLUSION

Through comparative analysis results of temperature field, temperature drop and pressure drop of FRP and steel pipe,it is obviously to seeFRPis of a better heat preservation performance. And with the same initial conditions, pressure drop and temperature drop of FRP are smaller than that of steel pipe. From the point of view of energy, FRP has more advantages.

For crude oil produced in some oil field have the characteristics of high pour point and high viscosity. Andproduced water in some oil field is of higher salinity. Under this condition, it is recommended that FRP replace the normal steel pipe.This measure can help to reduce the amount of scale and wax deposition in the pipeline, and it has a certain engineering significance forthe actual production of oil field.

REFERENCES

[1] Daeho Kang; Richard K. Strand,*Energ. Buildings*, **2013**, 62, 196-209.
[2] ZH Zhang; KF Li; WW Zhang; et al.,*Oil & Gas Storage and Transportation*, **2013**, 32(6), 601-604.
[3] K M Liew; X Q He; T Y Ng; et al.,*International Journal for Numerical Methods in Engineering*, **2001**, 52(11), 1253-1271.
[4] Alfonso García-Gutiérrez; Juan Ignacio Martínez-Estrella; Abel Felipe Hernández-Ochoa;et al., *Geothermics*, **2009**, 38(3), 313-325.
[5] Hugo C. Biscaia; Rui Micaelo; João Teixeira; et al.,*Compos.Struct.*, **2014**, 116, 104-119.
[6] Tara Sen; H.N. Jagannatha Reddy,*Sustainable Cities and Society*, **2014**, 13, 105-124.
[7] K Junsuk; P Frazier; H Yoo Chai., *Eng. Struct.*, **2008**, 30(3), 588-594.