Restartability of Sudanese Nile Blend Crude Oil

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Abstract: The Restartability of the Sudanese Nile Blend crude oil inside Test Loop pipeline was performed to understand the parameters determining the yield stress and describe the process of yielding up to final line clearing. Test Loop is designed to find the relationship between the required restart time and the pressure required and also to find the blend yield stress. The yield stress of the Nile Blend was found to be affected significantly by the shutdown time, static cooling rate after shutdown, and the final temperature after shutdown.

1. INTRODUCTION

Restarting flow inside a long pipeline occupies an important part in the planning and development of crude oil facilities. If the crude oil contains a significant percentage of wax, it will start to gel during cooling and high pressure is needed to put the pipeline into operation.

The precipitation of wax determines the restartability of the oil after the end of shutdown; this restartability is quantified by the yield stress property of the oil. If the yield stress of the crude oil is less than the stress applied during the restart, then the pipeline is said to be restartable. This stress should not be greater than the pipeline material yield stress with a factor of safety. The wax deposition will not affect only the pipeline, but also all the facilities like the tanks, treating equipment, heaters, etc. the phenomenon has also an economical impact [1].

The restarting of pipelines should have a plan to overcome all the side-effects, and to insure a safe operation due to the high cost of pipeline and associated facilities.

Sudanese crude oil called “the Nile Blend” is studied here, which contains a percentage of about 28.17% of wax. It is produced from Heglig fields in the south of Kordofan state.

The crude is transported from the Heglig fields in the south west of Sudan inside a 1504 km-71 cm pipeline to the Marine Terminal in the Red Sea via 6 pump-stations [2].

2. Experimental Apparatus and procedure

Nile Blend was loaded into the Test Loop at a temperature simulating GNPOC pipeline temperature before shutdown. Test Loop consists of a pump, tank furnished with one heater, 3 valves, thermometer scale, drain tank graduated scale and pressure gauges Figure 1 and 2. In this work the following procedure steps:

1. Sample preparation: the sample was heated to 90°C to melt all the wax in crude to destroy any crude history [3].
2. Left the crude to cool till it reaches 45°C to simulate the temperature of the GNPOC pipeline before the shutdown [3].
3. Pumping the crude in the test line and then left it to cool down to a temperature less than the pour point of crude, which is 28°C.
4. Global valve was used to control the pressure. The initial pressure was 0.1 bar and then increased by 0.1 bar every 15 min till the crude start to flow in the pipe [3].
5. The flow rate was calculated by using a drain tank No. 6 Figure 1 with Known size and filling it with the crude in a specific time.
3. Calculation of the yield stress

The yield stress is estimated by the Eqn. 1 [4]:

\[ \tau_y = \frac{\Delta P \times ID}{4 \times L} \]  
\[ \text{Pa} \]

Where:
\( \tau_y \) yield stress (Pa)
\( \Delta P \) restart pressure as measured by Test Loop2
ID pipe internal diameter (0.0127m)
L pipe length (12.4m)

4. Results and analysis of the experiments of Test Loop

Test Loop was used to measure the yield stress, this is not a stander test, but a number of models used very similar procedures [5]. After pre treatment oil is loaded into Test Loop at a temperature simulating main pipeline temperature before a shutdown. It’s then cooled to the test temperature at real main pipeline cooling rate. Traditionally pressure increases equivalent to 0.1 bar are used and applied for 15 min, the yield point is defined by a 2cm movement of the oil within any 15 min period [6].

In Test Loop pressure drop and shear stress are related by Eqn. 1. In addition to all important yield stress, the development of flow rate after the initial yield can also be monitor. This most conveniently achieved by measuring flow rate at a constant applied pressure or shear stress, also shear stress can be used in Eqn. 1 to predict pressure drop [6].

There are important factors in predicting the required restart pressure which include viscosity and temperature of crude. Many crude oils exhibit an inherent yield stress, so it is necessary to have a certain pressure to overcome jell structures within the oil before any flow can take place.

During the experiment, it is noticed that the pressure is not constant, but it starts to drop which necessitates the fixing of it many times Figure 3 to the value required. One of the causes of drop of the pressure is auto destruction of wax structure and thus lessening the yield stress in a part of the
pipe. Auto destruction is based on the shrinkage leads to the thus, leads to a shear stress on points along the pipe. Also for compressibility, if the movement of the crude due to its compressibility is higher than a specific critical value, thus in this location, the crude is considered to reach the yield point.

Test Loop allows better understanding of the behaviour of crude oil in the case of the shutdown, and thus knowing the required time for the restart and the value of yield stress which ranges between 20.69-36.12 Pa in addition to find out the required pressure for restart-up which ranges between 0.8-1.4 bar.

The start of creeping which in turn leads to destruction of wax structure depends largely on the time devoted during pressure. Also the yield stress is the major factor and normally indicated the yield point jell of crude oil. The sudden destruction followed by a sudden and fast drop in the resistance of crude at constant stress. Auto destruction and compressibility are two important factors in determining the pressure of restart and the yield stress. The result obtained found that the average restart pressure to the main pipeline per 100 km length was equal to 158.18 bar at shutdown temperature 26°C.

![Fig (2). Relationship between the time and pressure](image2)

![Fig (3). Show the creeping flow due to of the spread and compressibility](image3)
5. Conclusion

Test Loop allows better understanding of the behaviour of Nile Blend in the case of the shutdown, and thus knowing the required time for restart and the value of yield stress which ranges between 20.69-36.12 Pa in addition to find out the required pressure for restart-up which ranges between 0.8-1.4 bar. Auto destruction of wax structure and compressibility are two important factors in determining the restart pressure and the yield stress. Yield stress of the Nile Blend was found to be affected significantly by the shutdown time, static cooling rate and the final temperature after shutdown.

REFERENCES


