Th SP2 14

Water-cut Metering by Flow Electrical Resistivity Measurement Method

H. Asaadian* (Petroleum University of Technology), B. Soltani Soulgani (Petroleum University of Technology), R. Najafi (Petroleum University of Technology)

Summary

Accuracy of well performance data increases the chance of success in field management. Similarity water-cut monitoring helps to control the well during drilling and production stages. In this paper it was tried to design an experimental setup and particular tests. Then based on the gathered data, the effect of flow water-cut changes in the test pipe on flow electrical resistivity value between two electrodes which are placed in the pipe is investigated. The higher water cut was, the less flow resistivity measured. Rate of mixture resistivity decreasing is higher in lower water cut (between 8 to 50%). Also two matched equations are gained to predict the water cut for known flow electrical resistivity in two different range of water cut.

Introduction

Availability and accuracy of well performance data guarantee the success of field management and development. Continuous monitoring provides useful information that causes corrective decision to better well and reservoir management and maximum production potential usage. Exact water cut monitoring can considerably help to decrease the number of dead wells. In oil and gas industry the term of water cut used the water which is produced with gained hydrocarbon. Oil and gas reservoirs usually contain amount of producible water that may exists in the payzone or sometimes underlie as a single layer below the payzone.(Black and Noui-Mehidi, 2014)

High increasing in production rate or excessive pressure drop makes brine to underlie the upward movement into the perforations of the production well. This mechanism is known as water coning. Coning seriously in influences on the degree of overall efficiency of the oil reservoirs and reduces the effectiveness of the depletion mechanism. In stage of a well drilling, exact monitoring of the outlet mud helps to detect kicks before happening. Any changes in proportion of water in mud are suspicious whether in oil base mud or whether in water base mud. Also several technical operations perform to reach the maximum oil recovery. Water flooding and steam flooding are the most commonly operations which are used as secondary enhanced oil recovery methods. Injected water into injection well pushes and forces the oil to deplete into the wellbore of production well. In the later stages of water flooding the injected water eventually reaches the production well. As a result it increases the water proportion (cut) of the production. Accuracy, fast data transfer rate and cost-efficiency play major roles for considering monitoring systems. In this work it is tried to introduce a capable method to measure the water cut in wells and pipes by flow electrical resistance property.(De Lima Ávila et al., 2015),(Zhang and Liu, 2009)

Method and Theory

As water-oil emulsion water droplets are dispersed in oil continuous phase in low water flowrates but in higher flowrates water flows in consistence phase through the pipe just like oil phase. These water droplets have ranged between 100 to 400 micron in diameter and for oil droplets their diameter is typically less than 150 micron. The changes in resistivity of water/oil emulsion due to proportion of water is the main idea for creating an exact water cut meter.(Lei et al., 2007)

An experimental setup that consists of two variable flowrate pumps and a mixer, wss used to create a uniform oil water mixture and send that through a pipe which has two cylindrical electrodes. Different water cut flows are made by setting different flowrates. Thus the electrical resistance has been measured for them. The salinity of water was constant in the whole experiment procedure. A multi-rate pump was responsible to pump oil with different flowrates in range 0.0195 to 0.9 litre per second. Another one was used to pump water just in two constant rate 0.29 and 0.082 litre per second. The electrical resistance between two electrodes was measured by a high accuracy ohm meter. The test pipe is a horizontal polyethylene pipe with 1 inch diameter and 3 meter length.

Results

The obtained electrical resistivity for each water cut is shown in table 1. It is obvious that increasing in water cut decreases electrical resistivity. These data points are shown in figure 1. Based on gathered data, for water cuts from 0 to 8% the amount of water droplets are not enough to create continuous phases and there is a uniform water/oil emulsion system in the test pip section. Thus it did not affect the mixture electrical resistivity so much therefore it almost equals to the oil electrical

Q_{water}(lit/s)	0	0.082	0.082	0.082	0.082	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29
Q_{oil} (lit/s)	0.9	0.9	0.775	0.625	0.517	0.46	0.494	0.42	0.365	0.297	0.204	0.174	0.069	0.02	0
W_{cut} (%)	0	8	10	11	13	15	37	40	44	51	58	62	80	93	100
Resistance(Ω)	5700	3500	580	330	230	190	15	12.8	11.2	7.8	6.67	7.3	6.8	6.5	6.5

Table 1 *Obtained test data*

resistivity. But for other test data it seems it's better to split them into two parts base on their behaviour. For the water cuts higher than 8% the water droplets connect each other and the emulsion system disappeared. Consequently the total resistivity approaches to water resistivity. The resistivity of the mixture with water cut higher than 50% is so close to the water resistivity. Because the amount of continuous water phase has overcame the oil phase in the pipe. Also for each part of the test data the best matched equation is illustrated in figure 1.The first equation for the water cuts from 8 to 50% is:

$$Y = \frac{a}{1 + bx + cx^2}$$

$$a = 2.34 \times 10^{12}, \quad b = -1.33 \times 10^{8}, \quad c = 1.73 \times 10^{8}$$

And the second equation for the water cuts from 50 to 98 is:

$$Y = a + (b \times exp(x)) + (c \times log(x))$$

$$a = 10.38, \quad b = 5.28 \times 10^{-45}, \quad c = -1.97$$

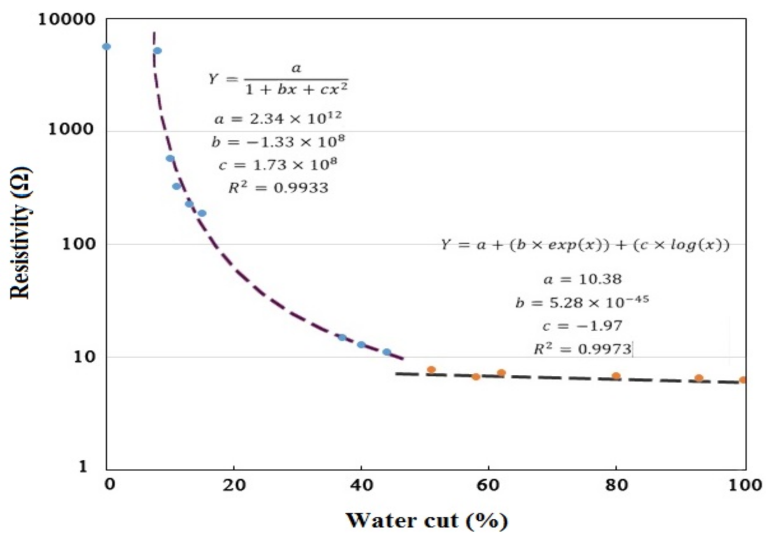

Figure 1 *Flow electrical resistances vs. water cut*

Conclusions

Measuring water cut provides useful information to optimize the well performance. One of the most valid methods is flow electrical resistance measurement when flow is passing through a pipe. The higher water cut was, the less flow resistivity measured between the electrodes which are placed in the pipe. Rate of mixture resistivity decreasing is higher in lower water cut (between 8 to 50%). Also two matched equations are obtained to predict the water cut for known flow electrical resistivity in two different range of water cut.

References

Black, M., & Noui-Mehidi, M. [2014]. High Salinity Permittivity Models To Aid Water Cut Meter Design. *9th North American Conference on Multiphase Technology.* Banff, Canada.

De Lima Ávila, H. E., Pagano, D. J., & De Sousa, F. R. [2015]. Improving the performance of an RF resonant cavity water-cut meter using an impedance matching network. *Flow Measurement and Instrumentation, **43***, 14-22.

Lei, L., Xingbin, L., Jinhai, H., & Yanjun, W. [2007]. Experimental research for response model of the impedance water cut meter. *Petroleum Instruments, **3***, 019.

ZHANG, B., & LIU, R.-h. [2009]. Design of Water-cut Meter for Crude Oil based on Capacitance conductance Technique. *Instrument Technique and Sensor, 7*, 014.