SUPPLEMENTARY MATERIALS

Experimental investigation on precipitation damage during water alternating flue gas injection

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The synthesized gas was generally consistent with the original solution gas with the extremely small error. Under the condition of 42 °C formation temperature and 15.0 MPa original formation pressure, an appropriate amount of separator oil was transferred into the recombination cell to which the excessive solution gas was then added according to 11.9 MPa bubble point pressure (saturation pressure: P_{sat}). The mixed oil and gas was stirred thoroughly until it was homogenous. At the constant pressure, the excess gas did not continue to dissolve due to the fixed gas-oil ratio (GOR) under the bubble point pressure, but it was not discharged in order to prevent the loss of some intermediate components extracted by the gas phase. Instead, a small amount of oil was added in gradually and stirred until it was homogenous. Vice versa, if the added oil was excessive, an appropriate amount of gas needed to be added in. After reciprocating several times, all the gas and oil was dissolved and saturated respectively in the cell, and then the fluid was the formation oil.

Table A-1 Comparison of molar composition between synthesized and original solution gas

Components	Original composition/%	Synthesized composition/%	Components	Original composition/%	Synthesized composition/%
CO_2	1.14	1.19	IC_5	0.03	0.03
N_2	1.11	1.00	NC_5	0.01	0.04
C_1	96.2	96.40	C_6	0.01	0.02
C_2	0.99	0.98	C_7	0.20	0.20
C_3	0.14	0.14	C_8	0.02	0.01
IC_4	0.09	0.09	C_9	0.01	-
NC_4	0.07	0.08	-	-	-

Table A-2 Comparison of single-stage flash results between recombined and original oil

Parameters	Recombined oil	Original oil
GOR/($m^3 \cdot m^{-3}$)	47.5	48.0
Bubble point pressure/MPa	11.7	11.9
B_o (42 °C，15.02 MPa)	1.11	1.1
Average GOR Coefficient/($m^3 \cdot m^{-3} \cdot MPa^{-1}$)	4.0	4.0
Viscosity under formation pressure/mPa·s	9.5	9.5
Oil density/($g \cdot cm^{-3}$)	0.8	-

Table A-3 Comparison of oil displacement efficiency of different flue gas composition cases

Type	Recovery/vol%	Difference from the recovery of original flue gas/vol%
Original flue gas	58.6	-
Without H_2S	58.5	0.10
Without CO	58.6	0.03
Without, H_2S, CO	58.5	0.09
Without O_2	58.5	0.12
Without H_2S, CO, O_2	58.4	0.17

Table A-4 Physical properties and order of cores

Lithology	Core number	Core length/cm	Core diameter/cm	Permeability/mD
	5(inlet)	3.5	2.5	173.4
	38	6.8	2.5	165.0
	20	6.7	2.5	160.9
	17	6.9	2.5	156.3
	8	6.9	2.5	150.9
	24	6.9	2.5	146.2
sandstone	25(middle)	3.5	2.5	144.7
	19	6.9	2.5	142.1
	1	6.9	2.5	136.9
	14	6.9	2.5	121.9
	16	6.9	2.5	106.4
	23	6.8	2.5	105.0
	37(outlet)	3.5	2.5	102.9

Table A-5 Physical properties and order of cores

Lithology	Core number	Core length/cm	Core diameter/cm	Permeability/mD
	12(inlet)	25.1	3.8	44.5
conglomerate	19(middle)	24.7	3.8	43.6
	5(outlet)	25.0	3.8	39.5

Table A-6 Analysis of formation water in H118 well

Cation/(mg·L^{-1})			Anion/(mg·L^{-1})				Total salinity/(mg·L^{-1})	water type	PH
K^++Na^+	Ca^{2+}	Mg^{2+}	Cl^-	SO_4^{2-}	HCO_3^-	CO_3^{2-}	13913.7	$NaHCO_3$	7.3
4739.2	140.2	110.2	6407.5	28.5	2488.0	0.0			

The JEFRI full-observation mercury-free analyzer of high-temperature and high-pressure formation fluid (DBR, Canada), as shown in Figure A-1, was used to carry out the PVT properties tests of the recombined oil. The basic parameters, such as bubble point pressure, gas-oil ratio, fluid density, viscosity and so on, were obtained by this device. It is mainly composed of injection pump system, PVT tube, flash separator, densitometer, temperature control system, gas chromatography and so on. Meanwhile, the Solid Deposition Test Device (SDTD) and laser device were added to perform the precipitation pressure tests.

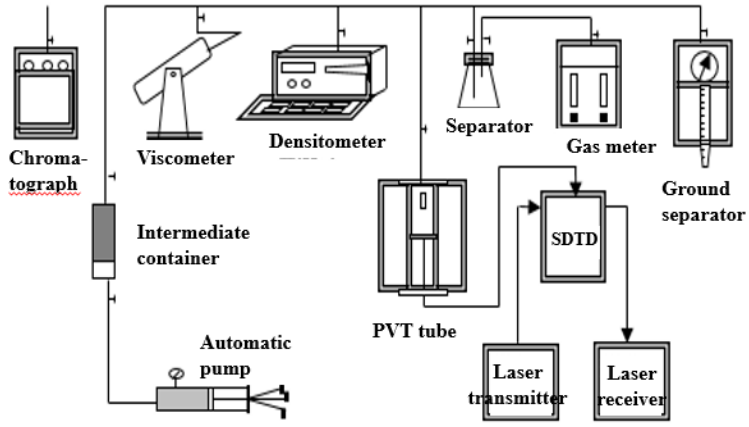

Figure A-1 Comprehensive schematic diagram of PVT properties and precipitation pressure tests

The experimental devices and methods in the Figure A-2 are self-developed. It is a part of the devices in Figure A-1, used to test the precipitation pressure by the laser method.

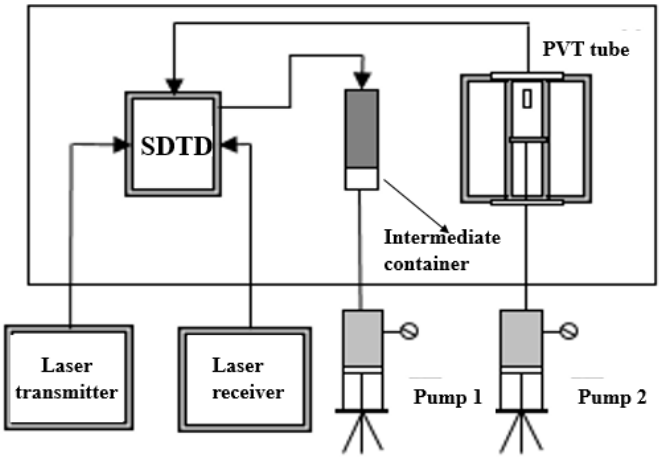

Figure A-2 Flow chart of laser tests

The displacement device consists of an injection system, a core holder system and a production system, as shown in the Figure A-3.

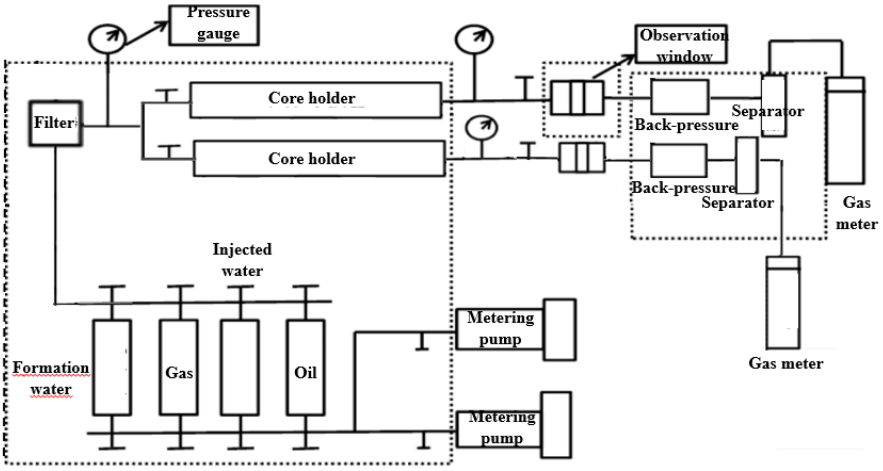

Figure A-3 Flow chart of long-core experiment