MEASUREMENT OF PHYSICAL ROCK PROPERTIES AND SELECTION OF IDENTIFIED CORE PLUGS FOR INJECTIVITY AND BLOCKING TESTS

by
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I. INTRODUCTION

An oil field on the island of Sumatra in Indonesia has excess water production problem. Its water-cuts are greater than 90 %. Excess water production is not only linked to poor sweep efficiency, but also causes many problems in oil industry, such as scaling, corrosion, cost of oil water treatment and cost of water disposal, and in effective hydrocarbon mobility. Optimizing oil production often requires considerable time, effort and challenge. Chemical injection (e.g. BW Polymer) is a method proposed to solve the current problem in the oil field. Hopefully, the excess water production will be blocked effectively by using chemical injection method in order to obtain maximum productivity and recovery. This paper is especially focused on measurement of physical rock properties, identification and selection of core plugs for injectivity and blocking test study.

II. SCOPE OF WORK

Scope of work in this research contains three main parts:

1. Measurement of physical rock properties from the oil field and well # A. This tests include basic parameter of core, such as : diameter (D, cm), length (L, cm), porosity (%), pore volume (cc) and air permeability (Ka, mD).
2. Identification of core plugs.
3. Selection of core plugs that will be used for injectivity and blocking tests.

III. PREPARATION, EQUIPMENT, METHOD AND STANDARD

A. *Preparation of core plugs*

At initial stage, the core will be analyzed. It must be prepared by using procedure below :

- Drill the core into 7 core plugs.
- Clean all core plugs for three days.
- Start drying all core plugs in the oven at temperature 55°C for three days.
- Stop drying all core plugs.
- Cool the samples in silica desiccators for five hours.
- Measure porosity and permeability as basic data.

B. *Equipment and Method*

DGP 200 Digital Gas Permeameter equipment is used to measure the permeability of the analyzed core. The permeability value is calculated by using the Darcy law. On the other hand, porosity value is determined by using Helium Gas Porosimeter and Boyle's law as the guiding principle.

The test itself is actually aimed at obtaining grain volume and pore volume from which porosity = [bulk volume – grain volume] / bulk volume] x 100 %) and , grain density = dry weight / grain volume.

C. *Standard*

All tests and subsequent calculation in this research were carried out by using American Petroleum Institute (API) Recommended Practice No. 40 and supported by the ISO 17025 Quality Control System.

IV. LABORATORY TEST RESULTS

This section shows laboratory test results for the analyzed samples that it can be divided into three main parts :

A. *Results of physical rock properties measurement*

As mentioned in Section III. A, there are seven core plugs prepared by LEMIGAS in plug size of 1.5 inch in diameter. Core plugs no. 7 to no. 13 have lengths in the range of 6.50 to 7.12 cm. Samples used in the tests are taken, based on depth and lithological characteristics shown by the cores. The results of basic parameter measurement can be seen in Table 1.

Table 1
The results of basic parameter measurement

Core No.	Depth ft	Diameter (D) (cm)	Length (L) (cm)	Porosity (%)	Pore Volume Volume (cc)	Ka
7	4631.70	3.83	6.72	21.852 (rechecked) 30.322 (old data)	16.90	500.60 (rechecked) 507.30 (old data)
8	4631.90	3.83	7.04	20.06 (rechecked) 27.392 (old data)	16.23	435.2 (rechecked) 435.6 (old data)
9	4632.10	3.83	6.73	18.717	14.47	380.5
10	4635.00	3.83	7.02	15.691	12.67	243.4
11	4635.10	3.83	7.12	21.564	17.65	701.1
12	4635.30	3.82	6.95	20.801	16.60	470.4
13	4643.90	3.84	6.50	21.924	16.47	800.8

Table 2
Results of core plugs identification

Sample Number	: Core # 7
Length, cm	= 6.72 cm
Diameter, cm	= 3.83 cm
Air Permeability	= 500.60 mD
Porosity	= 21.852 %

Remark:
Core # 7 was not used, core analysis uncertainty.

Table 4
Results of core plugs identification

Sample Number	: Core # 9
Length, cm	= 6.73 cm
Diameter, cm	= 3.83 cm
Air Permeability	= 380.5 mD
Porosity	= 18.717 %

Remark:
Core # 9 was used for chemical injectivity test.

Table 3
Results of core plugs identification

Sample Number	: Core # 8
Length, cm	= 7.04 cm
Diameter, cm	= 3.83 cm
Air Permeability	= 435.2 mD
Porosity	= 20.06 %

Remark:
Core # 8 was not used, core analysis uncertainty.

B. *Results of identification of core plugs*

The results of core identification for six core plugs can be seen in Table 2 to Table 8.

Selection of core plugs

After the obtained results of basic parameter measurement (see Section IV.A) and also core identification (Section IV.B), subsequently, selection of the core plugs that will be used for chemical injectivity and blocking test study, are discussed in Section IV.C The selection of core plugs that will be used for injectivity and blocking tests, must be based on depth and lithological char-

Table 5
Results of core plugs identification

Sample Number	: Core # 10
Length, cm	= 7.02 cm
Diameter, cm	= 3.83 cm
Air Permeability	= 243.4 mD
Porosity	= 15.691 %

Remark:
Core # 10 was not used, porosity low

Table 7
Results of core plugs identification

Sample Number	: Core # 12
Length, cm	= 6.95 cm
Diameter, cm	= 3.82 cm
Air Permeability	= 470.4 mD
Porosity	= 20.801 %

Remark:
Core # 12 was used for baseline
(formation water injection)

Table 6
Results of core plugs identification

Sample Number	: Core # 11
Length, cm	= 7.12 cm
Diameter, cm	= 3.83 cm
Air Permeability	= 701.1 mD
Porosity	= 21.564 %

Remark:
Core # 11 was used for blocking test.

Table 8
Results of core plugs identification

Sample Number	: Core # 13
Length, cm	= 6.50 cm
Diameter, cm	= 3.84 cm
Air Permeability	= 800.8 mD
Porosity	= 21.924 %

Remark:
Core # 13 was used for blocking Test

Table 9
List of all core plugs

No. Core Plugs	Depth (ft)	Porosity (%)	Air Permeability (mD)	Remarks
7	4631.70	30.22 *21.85*	507.30 *500.60*	Not used, core analysis uncertainty
8	4631.90	27.39 *20.50*	435.60 *435.20*	Not used, core analysis uncertainty
9	4632.10	18.72	380.50	Injectivity test
10	4635.00	15.69	243.40	Not used, Porosity low
11	4635.10	21.56	701.10	Blocking Test
12	4635.30	20.80	470.40	Baseline (formation water injection)
13	4643.90	21.92	800.80	Blocking Test

acteristics. Histogram of the re-
sults of air permeability measure-
ments for seven core plugs are
shown in Figure 1.

Based on the results of basic
parameter measurements, not all
core plugs can be used for fur-
ther stage of the scope of works
of this project. The reasons why
the certain core plugs are usable
or unusable for injectivity and
blocking tests, are related in
Table 9.

The list of selected core plugs
that will be used for chemical
injectivity and blocking tests study
can be seen in Table 10 and Figure 2.

V. CONCLUSIONS

Based on the laboratory test results by
using the analyzed core plugs, it can be con-
cluded as follows :

1. Core no. 9 with depth 4632.10 ft has
   the values of porosity 18.71 % and air
   permeability (Ka) 380.5 mD that it is
   used to see the effect of formation wa-
   ter on core.

2. Core no. 11 with depth 4635.1 ft has the
   values of porosity 21.56 % and air per-
   meability (Ka) 701.1 mD that it is used
   for chemical injectivity test.

3. Core no. 12 with depth 4635.3 ft has
   the values of porosity 20.80 % and air
   permeability (Ka) 470.40 mD that it is
   used for blocking test.

4. Core no. 13 with depth 4643.90 ft has
   the values of porosity 21.92 % and air
   permeability (Ka) 800.8 mD that it is
   used for blocking test.

5. Measurement of basic parameters for
   the analyzed core are very important
   and gives valuable information for se-
   lection of core plugs to be used and cal-
   culations that are required for chemical
   injectivity and blocking test.

Table 10
List of the selected core plugs for injectivity and blocking Tests

| Core No.	Depth (ft)	Porosity (%)	Ka mD	Job descriptions
12	4635.30	20.801	470.4	To see the effect of formation water (filtered and unfiltered) on core permeability
9	4632.10	18.717	380.5	For injectivity test.
11	4635.10	21.564	701.1	Blocking test for 1500 ppm polymer (1000 ppm surfactant and 1500 ppm polymer)
13	4643.90	21.924	800.8	Blocking test for 1000 ppm polymer (1000 ppm surfactant and 1000 ppm polymer)
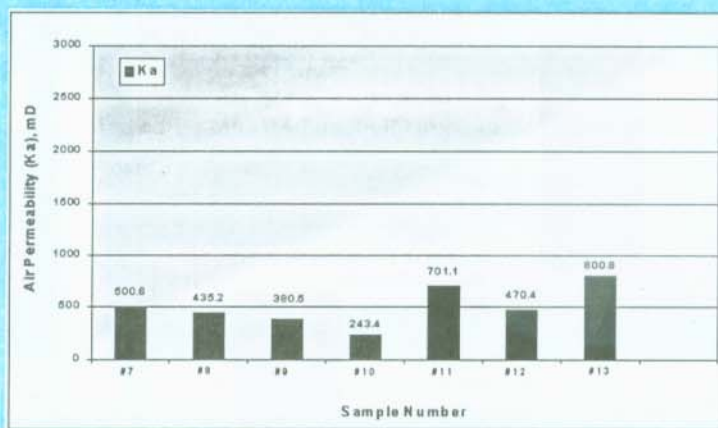
Figure 1
Histogram of air permeability values for seven core
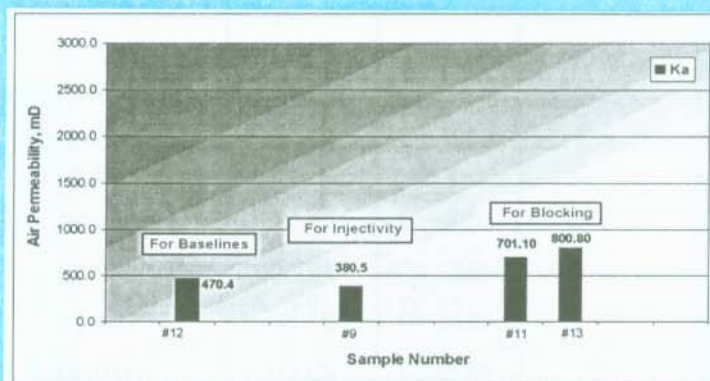

Figure 2
List of the selected of core plugs for baselines,
injectivity and blocking tests

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