Journal of Mineral Resources Engineering, 7(4): 39-57, (2022)

Imam Khomeini International University

Vol. 7, No. 4, Winter 2022

نشریه مهندسی منابع معدنی

Journal of Mineral Resources Engineering (JMRE)

Research Paper

Design of A Sand Production Control System Using Particle Size Distribution Analysis in Two Oil Reservoirs in Southwestern Iran

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Received: 11 Mar. 2021 **Accepted: 15 May 2021**

Abstract: Sand production is one of the serious challenges in the petroleum industries all around the world which could damage the productivity of wells. In this regard, laboratory methods are being conducted to control sand production before using sand controlling systems or conventional methods to control sand production in wells or reservoirs. Particle size distribution (PSD) is essential to perform laboratory experiments needs. PSD is determined by screening and laser granulation analysis or wetting sieve device. In this paper, the PSD of sand particles from core samples in 18 wells has been analyzed. Selected wells and their PSD of cores represent a wide range of wells with sand production problems in two important oil reservoirs in southwestern Iran. The sand PSD in these samples has been analyzed statistically. Among the 18 samples discussed, 4 had moderately well-sorting, 5 moderately sorting, 7 poorly sorting, and 2 very poorly sorting. The average value of the uniformity coefficient of sand particles in the samples was equal to 2.568, indicating the uniformity of the analyzed sands. The 0.614 to 1.2495 mm was determined as a minimum and maximum size to estimate the size of the slot width for designing coupons of the sand retention teste (SRT)s apparatus. The results of this study can be used in the design and selection of sand production control devices.

Keywords: Sand Production, Sand Control, Particle Size Distribution (PSD), Sand Production Control Devices, Sand Retention Test (SRT).

How to cite this article

Ghobadi, H., Riahi, S., Nakhaee, A., and Madadizadeh, A. (2022). *"Design of a sand production control system using particle size distribution analysis in two oil reservoirs in southwestern Iran"*. Journal of Mineral Resources Engineering, 7(4): 39-57.

DOI: 10.30479/JMRE.2021.15215.1498

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INTRODUCTION

The best samples of the reservoir rock are obtained by using the continuous coring method utilizing appropriate tools and precise control upon sampling operations based on measuring the cores and their distances [1].

Selley proved that the particle size of sediment is the most essential physical property of that sediment, which is measured and classified by a wide variety of methods [2]. Wentworth introduced a classification approach based on sediment particle size, which is widely accepted in the scientific community [3]. Krumbein used the Wentworth classification scales to provide a logarithmic classification, generally termed as phi (ø), which is derived from Equation 1. In this article, Wentworth and Krumbein classifications are used and the terminologies of clay, silt, sand and gravel are by these classifications in terms of size [4].

$$\phi = \log_2^d \tag{1}$$

Where:

d : is the diameter of sediment particles (mm).

The number of filter apertures is correlated according to the Tyler standard and the Phi scale (ø) [2-5]. The novelty of this research is the detailed statistical analysis of PSD curves including clay, silt, sand, and gravel on a case-by-case basis in two oil reservoirs of southwestern Iran. Its results could be used in making liners (coupons) with slot width for use in SRT devices.

METHODS

In this study, the properties of 18 core samples taken from the wells located in sandstone reservoirs A and M were used. Based on the petrophysical evaluation of the sampled wells, they are mainly composed of pure sand, shale sand, carbonate sand shale and shale and have very good distribution in porosity.

The sand samples taken from the southwestern Iranian oil reservoir were carefully weighed in the first stage and then the RP58 standard was used to remove the undesired oleic materials were removed by ethanol. In the next step, the sediment was dried and the Lewis and Makonchi method was implemented to remove residual organic materials and carbonate cement between the sediment particles. In addition, before granulation by sieving, the sample was placed in an ultrasonic device for 15 minutes to separate the stuck clay particles [6]. Wetting sieve and granulation by laser are two methods applied to granulate the samples. The wetting sieve method was used for particles larger than 0.0625 mm and the laser granulation method was performed for silt and clay particles that are smaller than 0.0625 mm.

The granulation data obtained from the wetting sieve and the laser granulation devices were processed and combined with the aid of related software(Sediment Size). This software is designed based on Folk tables in 1974 and determines parameters such as gravel percentage, sand, silt, clay, sediments type and statistical parameters such as mean, mode, and median, etc. Then, the tables of results obtained from the integrated granulation of the sample taken from the wells are examined and, in these tables, the sizes of different categories of particles are prepared based on millimeters and Phi. Also, the weight and weight percentage of each category are determined and finally, the accumulated weight percent of different categories is determined [7]. The data obtained from the screening analysis are plotted as the frequency distribution of the weight percent of the particles according to their size range. Another parameter that is determined in the particle size distribution is the uniformity factor, which represents the uniformity of the particle distribution. This factor is defined in Equation 2.

$$C = \frac{d_{40}}{d_{90}} \tag{2}$$

Where:

d_{40} and d_{90} : represent 40 % and 90 % diameters, respectively.

C : illustrates the uniformity factor. For C>3 the sand type is uniform and otherwise, it is non-uniform[8].

FINDINGS AND ARGUMENT

In this study, screening tests and important parameters are shown for 18 samples taken from two oil reservoirs in southwestern Iran. In the next step, the samples were divided into two categories to obtain the design curve of the sand lining system for future tests. As shown in Figure 1, the values of the diameters at the 10, 40, 50, and 90 percent are calculated. According to this curve, the critical size and sand particle size are calculated.

Screening analysis of particle size distribution based on the data in Table 1 and Figure 1 is intended to use the information obtained in future experiments of this research. The sand retention test device has been designed and built for the lab-scale investigation of the effect of critical factors in controlling sand production and particle migration according to Figure 2. To do so, sand samples are placed inside the device, at the first stage. It is then injected into a sand holding chamber by injecting a fluid containing brine with various salinities or oil using a diaphragm pump. Before placing the different perforated liner in the sand storage chamber, the samples are analyzed for grain size distribution and then this test is replicated for the sands and output particles to replace the designed coupon as a restraint system. Sand should be properly designed and measured. This device is designed to use multi-layered sand controlling systems such as liner sand controllers. Many laboratory and field studies determine the size of the sieve holes as sand controllers. Cobrely suggested one of the preliminary studies to determine the size of the sieve based on the sand particle size of the formation, where the upper limit of the sieve's hole width is twice the particle size at 10% ($Ws \leq 2.d10$) [9]. Because of the associated problems and failures during the study, based on the design of such a system, Suman et al. suggested another standard, which states that the distance between the wires should be less than or equal to the size of a sand particle at 10% ($Ws \leq d10$) [10]. Kaye introduced a power function called the fraction distribution of the particle size [11]. Fermaniuk presented the width of the mesh hole at the minimum to be equal to twice the particle size at 70% and the maximum to be at 3.5 times the particle size at 50% as follows [12,13]:

$$2d_{70} < W_s < 3.5d_{50} \tag{3}$$

Where:

d_{70} and d_{50} : represent 70 % and 50 % diameters, respectively.

Table 1. Determining the slot width (mm)

Fermaniuk method		Suman method	Coberly method	Average sample
the most	The least			
1.6821	0.8726	1.213	2.466	Group 1
0.84	0.3708	0.46	0.92	Group 2
1.2495	0.614	0.8163	1.6326	Total

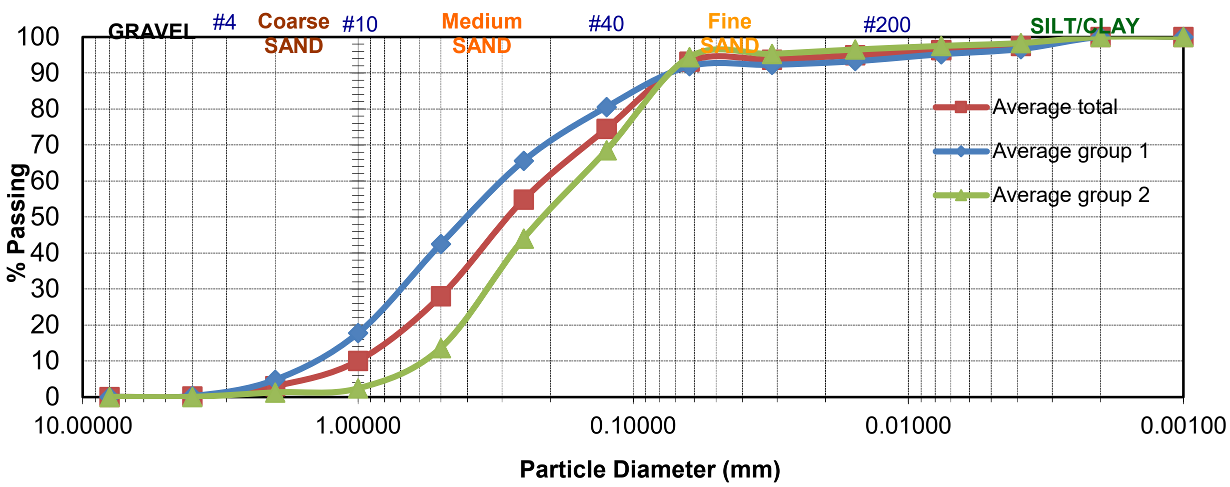

Figure 1. The average of groups 1, 2, and the total cumulative grains diameter distribution curve

(A) (B)

Figure 2. A: SCRT sand storage device (HP-HT) and **B:** barometers

CONCLUSIONS

1. Based on the results obtained from 18 well samples (core), the classification to determine the particle size distribution is presented with a good approximation.

2. Determining the PSD is basic in this research especially for designing methods of controlling sand production and sand retention experiments. Considering the selected samples and determining the PSD in the two main groups, the overall averaging of the data covers the screening analysis and PSD in two important reservoirs in southwestern Iran.

3. Among the 18 samples, 4 had moderately well-sorting samples, 5 moderately sorting samples, 7 poorly sorting samples, and 2 very poorly sorting samples.

4. The 0.614 to 1.2495 mm was determined as the minimum and maximum size to estimate the size of the slot width to design the coupon of SRT.

5. Considering the processing and integration of data and statistical studies and determining the calculated diameters at 10, 40, 50, 70 and 90%, a good agreement is observed in most of the data, which is widely used to determine and the mesh size design in the well that can be used to control sand production or in a sand retention testing machine.

6. PSD was identified for values smaller than 40 microns, including 5% of fine particles, which should be considered in future experiments with this device.

7. The average value of the sand particles uniformity factor in the samples was equal to 2.569, which indicates the uniformity of the analyzed sandstones since this factor is less than 5.

8. To estimate the size of the aperture or mesh, Fermaniuk’s method and model are recommended due to the coverage of a wide range of sand data.

9. The impact of flooding and the ionic effect of brine on sand production must be included in future researches because the average amount of clay in the samples is usually more than 5%.

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