Journal of Petroleum & Environmental Biotechnology
ISSN: 2157-7463

Khair and Faried, J Pet Environ Biotechnol 2016, 7:3
DOI: 10.4172/2157-7463.1000276

Research Article Open Access

Preliminary Evaluation of Silica Sand in Sudan with Respect to Fracture Sand

Mohammed Khair EM* **and Mohammed Faried**

Sudan University of Science and Technology, Sudan

Abstract

Hydraulic fracturing is a well stimulation method performed on reservoirs with low permeability to improve the flow of hydrocarbon into wellbore. Certain chemicals are injected into the well under very high pressure; propping agent, such as sand is added to the fracturing fluid to keep the fracture open. Silica sand was appeared as ideal proppant agent due to its high performance in USA. Many areas in Sudan contain sources of silica sand that may have the potential to act as proppant agent. Recently, no study was conducted to characterize and evaluate the use of this sand as proppant; the current study try to primary evaluate some Sudanese sand with respect to proppant agent. Three samples were collected from different areas in Sudan and a series of laboratory tests were performed according to the API recommended practice API RP 19C. Two samples were taken from Khartoum State (AL-Markhiyat and Hattab zones) and one sample was taken from AL-jaded al- Thawra in Al-jazeera State. The clay content, roundness and sphericity, acid solubility, crush resistance and grain size were measured for all samples. The results of sphericity and roundness show that the sand is satisfy with the API requirements for hydraulic fracturing; the turbidity of samples is also agreed with the API. On the other hand more than 10% of fine has been produced from the different samples under stress of 3000 Psi; which indicate that the sample can be used as proppant for reservoir with the closer pressure less than 3000 Psi; for pressure above 3000 Psi, the samples have to be coated for strength improvement.

Keywords: Hydraulic fracturing; Proppant agents; Sphericity; Roundness; Crush resistance; Acid solubility

Introduction

Since its introduction in 1948, hydraulic-fracturing has been one of the primary engineering tools for improving well productivity in tight or low permeability reservoirs; it is used to increase or restore the rate at which fluids, such as petroleum, water, or natural gas can be produced from reservoirs. Due to its effective performance, the technique has progressively expanded so that by the end of 1955 more than 100,000 individual jobs had been performed (Economides 1989); the process has been employed to enhance the production of oil and gas from underground reservoirs for more than sixty years. Recently, the exploration of the unconventional resources was widely increased; then, the need for massive hydraulic fracture job was also increased. The technique in generally use to by-pass formation Damage and increase drainage Area; also, it can be used to connect the wellbore with disconnected zone, and was widely used to control sand production from friable formations.

The process requires an array of specialized equipment and materials; it is involves injection of frac-fluid at a high pressure into a selected section of wellbore; this fluid pressure creates a fracture extending into the rock medium which contains oil or gas. When the fluid pumped into a well, necessarily the pressure rises, and at some point something breaks (either the rock or the equipments); as the rock is generally weaker than steel, the formation will breaks, resulting in wellbore fracturing along its axis. To maintain fracture opening during the production life of the well, solid substance with specific characteristics (known as proppant) injected to the fracture to suspend the fracture.

The optimization of the best proppant for any job requires understanding of reservoir geological conditions and general properties; also fracture parameters need to be included. Any substance used as proppant in frac job has general requirements such as: good size, enough spherical and rounded shape, and has high crush resistance.

Because of its relative low cost, sand is the most commonly used proppant; and it was the first material used as a proppant. Since the late 1940's, it is the most common proppant when sieved to a particular size; especially in wells with low closure stress. Other several materials have been also used included aluminum pellets, metal shot, glass beads, walnut shells, plastic beads, and polymer spheres; sintered bauxite and zirconium oxide has an extremely high crushing strength, and ceramic proppant is an intermediate strength proppant. Synthetic intermediate proppants are used at depths up to 3000 while the high-strength proppants are used at depths up to 5000 m. Although natural sands are low-strength proppants, they are the most commonly used proppant because of its relative low cost, they are usually attractive at depths less than 2000 m sand is, which have low closure stress. Natural sands are in typical sizes from 12/20 mesh to 20/40 mesh (average particle diameter is 2×10^{-4} m to 1×10^{-4} m). Frac sand require certain characteristics and properties such as purity, Grains need to be rounded, and uniform in size, and have high silica/quartz content. Due to it are easily accessible, naturally occurring silica sand remains the standard proppant used for hydrofracking in the USA [1].

During the early years of 2000, most of the minded sand in USA has been used for glassmaking, other parts of sand was used at foundries; small parts was used in construction industry while less than 15% was used in hydraulic fracturing; however, with the new explorations of the uncongenial resources in USA, the need for silica sand was increased by 2.5 times more than just a few years ago; The Geological Survey of USA estimated that USA produced over 55 million tons of industrial sand in 2013, only 38% was used in construction and glass

*Corresponding author: Mohammed Khair EM, Sudan University of Science and Technology, Sudan, E-mail: elham_mmk@yahoo.com

Receive April 06, 2016; **Accepted** May 03, 2016; **Published** May 11, 2016

Citation: Mohammed Khair EM, Faried M (2016) Preliminary Evaluation of Silica Sand in Sudan with Respect to Fracture Sand. J Pet Environ Biotechnol 7: 276. doi:10.4172/2157-7463.1000276

industries and 62% of the total production was used in the oil and gas industry [2]. On the other hand, the prices was jumped from 22.6$ / metric Ton in 2005 to 56$ /metric Ton in 2014 and as 72% of the sand mined in 2014 have been used by oil industry (hydraulic fracturing and well-packing) [2]. Because of the large amount of the proppants, the American Petroleum Institute (API) has established test procedures for the proppant properties to differentiate between the different qualities of each proppant. The sands employed as fracturing proppant have been historically qualified for that purpose based upon their ability to meet quality standards described by the American Petroleum Institute [3]. More recently in 2008, American Petroleum Institute and the International Organization for Standardization (ISO) were established for new recommended practice [4]. Ideal sand for fracking comes from specific sandstone in USA: such as St. Peter (Ottawa Sand in commercial use), Wonewoc, and Jordan (known as Northern White Sand). These formations are prevalent in eastern Minnesota and central and western Wisconsin and are relatively easily reachable [5].

Ismail et al. [6] evaluated two samples of Malaysian sand with a commercial proppant. They found that the sphericity and roundness for the both sample in range of 0.5 – 0.7, the density and the turbidity agree with the density and the turbidity of the commercial proppant, and that the conductivity of local sand is 16% – 20% lower than the commercial proppant.

Phillip Courtney [7] evaluated several physical and chemical properties of sand in Colorado State (USA) to evaluate their suitability as frac sand. Phillip presented that all samples met the minimum requirements for sphericity and roundness and possessed grain sizes that could be screened and sorted to meet the size designations for proppant sand specifications [8,9].

Tests Procedures and Instruments

A series of standard laboratory tests were performed to address the characterizations of the samples; all the measurements were performed according the recommended practice [5]. The experimental procedures are summarized as follows:

Sample preparing

First, three kilograms of each sample have been washed using tab water to clean sand grains; then the samples were dried at a temperature of 110°C (230°F) till the measured weight of each samples was stabilized for two different reading; this sample will then be used for the all tests.

Sieve analysis and grain size

This test was conducted in the Central Petroleum Laboratories (CPL) in Sudan JEL 200 mechanical shaker was used to analyze the samples using sieve sizes of 40/60 - 6/10. Different weight of each cleaned dried sample was passed through the shaker. The sieves were then shaking for 10 minutes. The weight of the retained sand portions of each sieve has been recorded and the percentage by weight retained in each sieve was calculated; then the cumulative percentage was calculated; Table 1 presented the USA mesh size required by API RP 19 C.

Gravel size (U.S. mesh size)	Gravel size range (Smallest x largest) (in)	Medium diameter D_{50}	
		in	Micron
40/60	0.010 x 0.017	0.014	350
20/40	0.017 x 0.033	0.025	630
16/30	0.023 x 0.047	0.035	880
12/20	0.033 x 0.066	0.050	1260
12/18	0.039 x 0.066	0.053	1340
10/20	0.033 x 0.079	0.056	1410
10/16	0.047 x 0.079	0.063	1950
8/12	0.066 x 0.094	0.080	2020
6/10	0.079 x 0.132	0.106	2670

Table 1: US mesh size used in sieve analysis.

Sphericity and roundness measurements

Stresses on the proppant grains are more evenly distributed (when the grains are round and about the same size), visual examination with a 15 power microscope and the Krumbein Chart (Figure 1) have been used to estimate both roundness and sphericity.

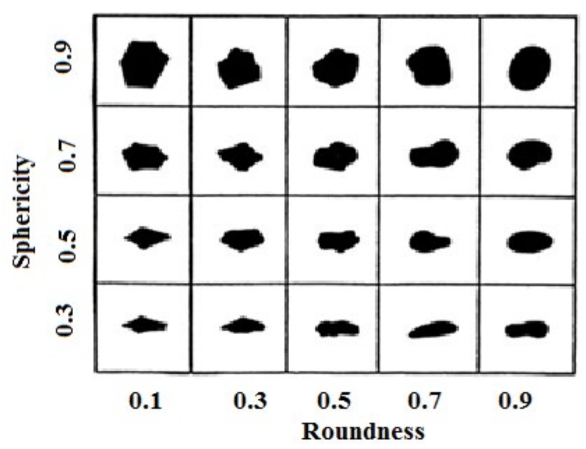

Figure 1: *Krumbein* roundness and sphericity chart.

Turbidity test

The Turbidity is the measure of clay Content and soft particle content in the sample; in order to determine sample's turbidity, 5g of each sample have placed in a galls tube, and then 100 ml of distilled water was added to the samples. After 30 min the tube has been shaken for 30 sec; 25 ml of the water was extracted from the centre of the fluid and compared with other standers known turbid fluid to estimate the turbidity.

Acid solubility

1000 grams of washed sand samples were placed in a Hydrochloric Acid with a concentration of 10%. The sample was left for 24 hours with stirring every 2 hours; then, samples were washed and dried at 105°C until constant weights were obtained; and the acid solubility was expressed in percent using the following equation:

$$AS\% = \frac{ms - MSafter}{ms} \qquad (1)$$

ms = The mass of dry sample before the acid bath, grams

ms_{after} = The mass of remaining sample after the acid bath, grams

AS = Acid Solubility, percent

Crush resistance test

This test was conducted to estimate the strength of the samples at different stress; which is the measurements of the amount of produced fines under certain stress. First, sieve analysis was applied with a mesh size of (-20/40+) for the cleaned samples. A cretin amount of the sieved sand is filled into the stainless steel crush cell Figure 2; a uniform loading rate is applied to the cell to reach the desired stress level (500, 1000, 2000 and 3000 Psi) and the stress is held for 2 minutes before released. The samples were then sieved again after the crush test is carried out and the amount of the crushed material is calculated as percent of the first decimal place.

Aggregate crushing Value = (WB/WA) × 100.

Results and Discussion

Grain size analysis

The results of the Grain Size Analysis for the different samples were presented through Table 2 and Figure 3. According to API RP 19 C, a minimum of 90% of the sand should fall between the sieve sizes of 12/20, 20/40, and 40/60 for Fracturing Proppant; the results presented that the samples from Hattab and AL-Markhiyat have more than 80% of the sand fall between sieve sizes of 12/20, 20/40, and 40/60, these samples was obtained from depth 20 cm from the surface; for the sample from AL-jaded al- Thawra, it contains high amount of find sand which cannot meet the API standard ; this sample was collected directly from the surface (0 depth), and it have been influenced by weathering and stripping; therefore, deep depth sample is required for accurate values.

Sphericity and roundness

Typical sand proppant should possess the value of more than 0.6 for both roundness and sphericity according to API RP 19 C. from the three samples results it was observed that for the samples from Hattab and AL-Markhiyat the two samples possess the value of 0.6 (0.65, 0.6 and 0.6, 0.6) for sphericity and roundness respectively; while for the AL-jaded al- Thawra, the value is approximately 0.7 for roundness and sphericity, hence all the samples satisfied the requirements for sphericity and roundness.

Turbidity test

Fracturing proppant sand has the maximum turbidity value of 250 FTU. The three samples has turbidity value of 218 -243 FTU which is meets the requirement for API RP 19 C.

Acid solubility test

Table 3 presented the result of the samples after washing by HCL 10% the result presented that the solubility of the three samples in acid is very low and only less than 10% was dissolved, regard to the sample from AL-jaded al- Thawra, as discussed before the samples is surface sample and weathering may have effect on the result of the sample.

Crush resistance test

Table 4 presented the results of the three samples; the table it presented that the sample meet the requirement for stress less than 3000 Psi while the three samples cannot satisfy the API RP for stress more than 3000 Psi, her risen coating for the sand grain may yield to good crush resentence. Figure 4 is a sample of the crush resentence diagram for sieve size of 20/40 (AL-Markhiyat).

Conclusion

Three samples of Sudanese sand from AL-jaded al- Thawra "Al-

Figure 2: Crush resistance cell.

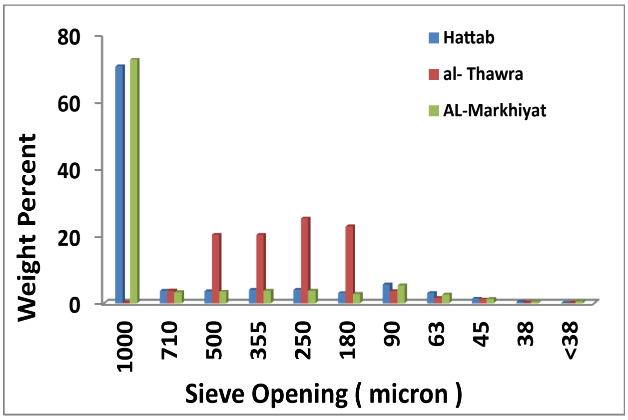

Figure 3: Grain size analysis.

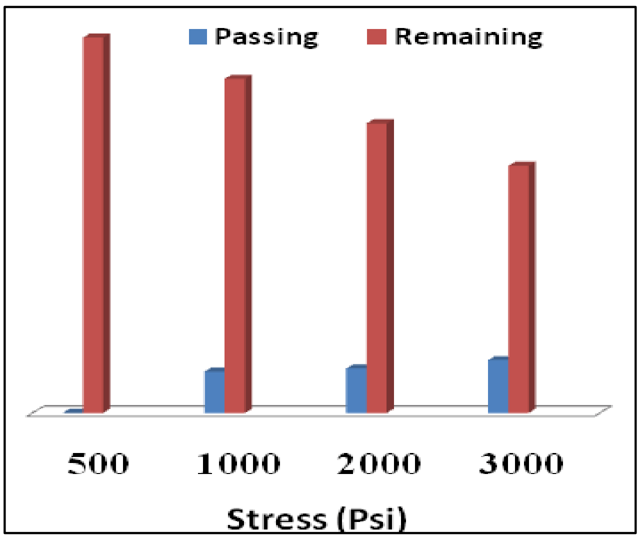

Figure 4: Crush resistance chart for size 20/40 (AL-Markhiyat).

Size Grade	Sieve Opening (micron)	Phi	Weight (Gram)	Weight Percent	Cum. (%)	Weight (Gram)	Weight Percent	Cum. (%)	Weight (Gram)	Weight Percent	Cum. (%)
			Hattab. Kh. North			AL-jaded al- Thawra			AL-Markhiyat Omdurman		
Very Coarse Sand	1000	0	28.06	70.64	70.64	2.26	0.24	0.24	641.9	72.65	72.65
Coarse Sand	710	0.49	1.47	3.7	74.34	36.3	3.85	4.09	29.33	3.32	75.97
	500	1	1.43	3.6	77.94	192.78	20.42	24.51	30.18	3.42	79.39
Medium Sand	355	1.49	1.6	4.03	81.97	192.59	20.4	44.91	33.02	3.74	83.13
	250	2	1.61	4.05	86.02	238.73	25.29	70.2	33.11	3.75	86.88
Fine Sand	180	2.41	1.19	3	89.02	216.16	22.9	93.1	24.43	2.76	89.64
Very Fine Sand	90	3.47	2.23	5.61	94.63	34.23	3.63	96.73	46.91	5.31	94.95
	63	3.98	1.21	3.05	97.68	15.26	1.62	98.35	22.95	2.6	97.55
Silt	45	4.47	0.54	1.36	99.04	11.1	1.18	99.53	11.6	1.31	98.86
Bottom	38	4.71	0.14	0.35	99.39	2.25	0.24	99.77	3.94	0.45	99.31
Fine to Very Fine Silt and Clay	< 38	Pan dish	0.02	0.05	99.44	1.64	0.17	99.94	6	0.68	99.99
Sieve Loss			0.22	0.55	99.99	0.56	0.06	100	0.23	0.03	100
Total			**39.72**			**943.86**			**883.6**		

Table 2: Grain size analysis.

Solubility %	Weight (Gram)		Sample
	After acid bath	Before acid bath	
8.02	919.8	1000	Hattab
0.88	992.2	1000	AL-jaded al- Thawra
1.61	985.9	1000	AL-Markhiyat

Table 3: The acid solubility results.

Stress (Psi)	Crushed Material weight % Maximum @ 2000 Psi		
	Hattab	AL-jaded al- Thawra	AL-Markhiyat
1000	3.8 %	6.7	5.3
2000	8 %	8.7	7.8
3000	11.6 %	13.5	14.3

Table 4: The crush resistance results.

Jazeera State" AL-Markhiyat and Hattab "Khartoum State" have been characterized according to API RP 19 C, and the possibility of using as frac- sand was addressed. The result of the three samples presented that the results of sphericity and roundness for all the samples is more than 0.6. Turbidity of sand sample is less than 250 FTU and Sample started to produce more than 10% fine under the pressure of more than 3000 Psi and resin coating is required to improve the strength of the san for stress higher than 3000 Psi. The results of sieve analysis for the samples under study shows that the sand is not in the range of desired particle size that required in oil industry; however, this can be solved by discovering a new area and deeper formation.

Recommendation

Based on this work, as many other tests were not conducted in this study it is better to check the ability of the samples to exceed the API standards for bulk density, mineralogy tests and conductivity test.

References

1. Silica: Minerals year books 2002–2012 (2012) United States Geological Survey.
2. Mineral commodity summaries (2015) United States Geological Survey.
3. American Petroleum Institute (1995) Recommended practice API RP 58, Recommended practice for testing sand used in gravel packing operations. Washington, DC.
4. ISO, ANSI and American Petroleum Institute (API) (2008) API RP 19C - Measurement of proppants used in hydraulic fracturing and gravel-packing operations. (1stedn). Washington, DC.
5. Brown B (2011) Frac sands: Resources and issues in Wisconsin". UWBC webcam recorded lectures presented at Wednesday nite, at the Lab, University of Wisconsin-Madison.
6. Ismail MS, Dahlila K, Suhaila M (2011) Characterization of Malaysia sand for possible use as proppant. American International Journal of Contemporary Research 1: 37-44.
7. Courtney P (2014) Frac sand potential on selected state trust lands, Colorad state Land Board, Department of Natural Resources.
8. Dahlila K, Ismail MS, Iskandar D (2011) Comparative characterization study of Malaysian sand as Proppant" IEEE, National Postgraduate Conference (NPC), Kuala Lumpur.
9. Dolley TP (2015) Sand and gravel (Industrial). United States Geological Survey, Mineral Commodity Summaries.