COMPARISON OF LOCAL AND IMPORT SANDS QUALITY LABORATORY TESTS RESULTS FOR USED IN HYDRAULIC FRACTURING OPERATIONS

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ABSTRACT

Sand quality laboratory tests have been carried out on local and import uncoated sands. Based on results of sand sieve, roundness, sphericity, turbidity, acid solubility and crush resistance at 3000 psi quality tests of import uncoated sand has better quality than local sand. The import sand fulfills API – RP 56 specification requirements and will be able used in hydraulic fracturing operation. Whereas, the local uncoated sand does not achieve API - RP 56 specification requirements.

Key words: local and import uncoated sands, API – RP 56, sand quality laboratory tests.

I. INTRODUCTION

Sand is the most commonly used proppant, especially in wells with low closure stress in oil industry. Sand quality, cross link gel and chemicals that are used in hydraulic fracturing, play significant role in determination of the value of conductivity and productivity. Sands quality laboratory tests were divided into two parts: local and import uncoated sands quality tests with using the American Petroleum Institute, API RP 56, year 1983 as sand quality tests procedure standard. Comparison of local and import uncoated sands quality laboratory tests results are discussed in this paper.

II. PROPPANT

Sand was the first material used as a proppant. It is used in hydraulic fracturing operation in order to enhance productivity. Since the late 1940, several material have been used. Some of the successful efforts and more commonly used agents today include sand and resin-coated sand. A fracturing treatment designed to enhance the productivity of a reservoir may not be as effective as planned because of permeability damage to the proppant pack and/or to the formation. Fracturing fluids may cause formation and/or fracture conductivity damage by number of routes, including emulsions or precipitates, clay or fines migration and plugging, and high viscosity or insoluble residues. Permeability damage in the proppant pack has a major effect on productivity reduction. Reduction of permeability within the fracture may result from several factors, including proppant embedment or crushing, formation fines, and flow restrictions caused by fracturing fluids. Relation to this, before using proppant in hydraulic fracturing operation, it is very important to carry out sand quality tests. Expected, results of sand quality laboratory tests will give extremely valuable information which sand is to have better quality.

III. RESULTS & DISCUSSIONS

Local and import uncoated sands quality laboratory tests refer to API – RP 56 includes :

a. Sand sieve 12/20
b. Sand shape (roundness and sphericity)
c. Turbidity
d. Acid solubility
e. Crush resistance

Sieve analysis

Calculate the percent by weight of the total sand sample retained on each sieve and in the pan. The cumulative weight should be within 0.5 percent of the sample weight used in the test. If not, the sieve analysis must be repeated using a different sample.

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Sand size analysis

A minimum of 90 percent of the tested sand sample should fall between the designating sieve sizes, that is, 12/20. Not over 0.1 percent of the total tested sand sample should be larger than the first sieve size and not over 1.0 percent should be smaller than the last sieve size.

Sphericity analysis

Particle sphericity is a measure of how closely a sand particle or grain approaches the shape of a sphere. The most widely used method of determining sphericity is with a visual comparator.

Determination of sand sphericity

Using the photomicrograph and the visual comparator chart (refer to Figure 3.1) determine and record the sphericity of all sand grains within the photo- micrograph. Using this information, determine the average sphericity for the sand sample. Refer to frac sand sphericity recommendations.

Determination of roundness

Grain roundness is a measure of the relative sharpness of grain comers, or of grain curvature. Evaluation of sand grain roundness should be made on the same sample as that used for the sphericity determination. Roundness of each grain should be determined, recorded, and an average roundness obtained for the sample. Frac sand should have a roundness of 0.6 or greater.

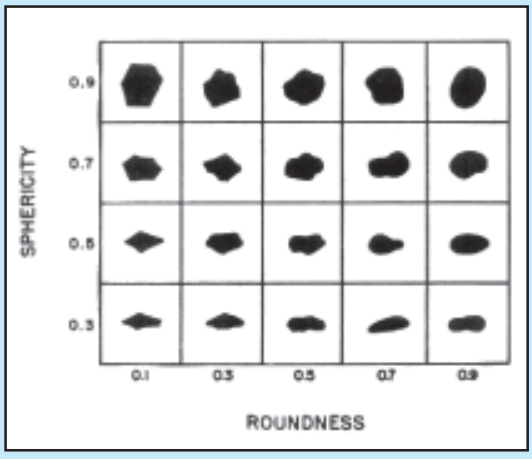

Figure 3.1
Chart for Visual Estimation of Sphericity and Roundness, API-RP 56

Determination of sand roundness

Using the photomicrograph and the visual comparator chart (refer to Figure 3.1) determine and record the roundness of all sand grains within the photo- micrograph. Using this information, determine the average roundness for the sand sample.

By using principle of calculation as explained above, particle sphericity of local sands is measured based on how closely a sand particle or grain approaches the shape of a sphere with using the photomicrograph and the visual chart (refer to Figure – 3.1). While, grain roundness of local sands is measured based on the relative sharpness of grain comers, or of grain curvature with using the photomicrograph and the visual comparator chart (refer to Figure 3.1). Results of local sand grain sphericity and roundness are indicated in Table 3.1. The sphericity and roundness values of the local sand grains are in a range of 0.5 to 0.9. It has average sphericity (0.67) and roundness (0.70) values.

Determinations of particle sphericity and grain roundness of import uncoated sand use the same principle of the calculation as mentioned above. Results of sphericity and roundness laboratory tests on import uncoated sand are tabulated in Table 3.2. The sphericity and roundness values of the import uncoated sand grains are in a range of 0.5 to 0.9 with average sphericity (0.73) and roundness (0.76). The local sand and import uncoated sand samples have difference in sphericity, roundness and also performance. The average values of sphericity and roundness of local sand are 0.67 and 0.73 which are lower than the average values of sphericity (0.73) and roundness (0.76) of import uncoated sand. Then, difference of performance of sphericity and roundness for both sands samples can be seen clearly in Figures 3.2 and 3.3.

Turbidity in water is the result of suspended clay, silt, or finely divided inorganic matter being present Frac sand samples that can be placed in distilled water and the turbidity of the resulting liquid measured. Properly washed and processed frac sand will pass the turbidity test. The turbidity tests measure an optical property of a suspension that results from the scattering and absorbing of light by the particulate matter present. The amount of turbidity registered is dependent on such variables as size, shape, and refractive indices of the particles. Local sand turbidity is higher than import sands. The value of local sand turbidity are 51 and 44 for the import sand.

Table 3.1
Local uncoated sand shape tests sphericity and roundness

Number	Roundness	Sphericity
1	0.7	0.7
2	0.7	0.7
3	0.7	0.5
4	0.5	0.5
5	0.9	0.7
6	0.5	0.5
7	0.5	0.5
8	0.9	0.9
9	0.5	0.7
10	0.7	0.7
11	0.7	0.5
12	0.9	0.9
13	0.9	0.7
14	0.7	0.7
15	0.7	0.7
16	0.5	0.5
17	0.7	0.5
18	0.9	0.9
19	0.7	0.7
20	0.7	0.5
21	0.7	0.5
22	0.7	0.9
23	0.5	0.7
24	0.7	0.7
25	0.7	0.7
26	0.7	0.7
27	0.7	0.7
28	0.7	0.5
29	0.9	0.9
30	0.7	0.5
31	0.7	0.5
32	0.7	0.5
33	0.5	0.5
34	0.5	0.5
35	0.7	0.7
36	0.7	0.5
37	0.7	0.9
38	0.7	0.7
39	0.7	0.9
40	0.9	0.9
41	0.7	0.7
42	0.7	0.9
43	0.7	0.7
44	0.7	0.9
45	0.7	0.7
Average	**0.70**	**0.67**

Table 3.2
Import uncoated sand shape tests sphericity and roundness

Number	Roundness	Sphericity
1	0.9	0.5
2	0.7	0.5
3	0.7	0.7
4	0.9	0.9
5	0.7	0.7
6	0.9	0.5
7	0.7	0.5
8	0.9	0.5
9	0.9	0.9
10	0.9	0.5
11	0.5	0.9
12	0.7	0.7
13	0.9	0.9
14	0.9	0.5
15	0.7	0.7
16	0.7	0.7
17	0.9	0.9
18	0.9	0.7
19	0.9	0.7
20	0.7	0.9
21	0.7	0.7
22	0.7	0.7
23	0.9	0.7
24	0.9	0.7
25	0.9	0.7
26	0.7	0.7
27	0.9	0.9
28	0.5	0.7
29	0.7	0.7
30	0.5	0.5
31	0.7	0.9
32	0.7	0.7
33	0.9	0.9
34	0.5	0.5
35	0.9	0.7
36	0.9	0.9
37	0.7	0.7
38	0.9	0.9
39	0.9	0.9
40	0.7	0.9
41	0.9	0.9
42	0.5	0.5
43	0.5	0.9
44	0.7	0.7
45	0.5	0.9
Average	**0.76**	**0.73**

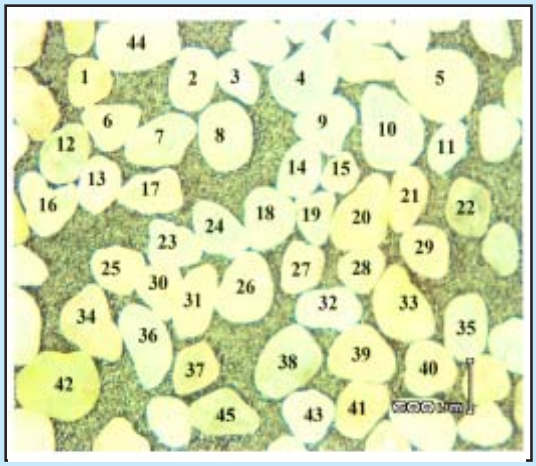

Figure 3.2
Photograph of local uncoated sand shape

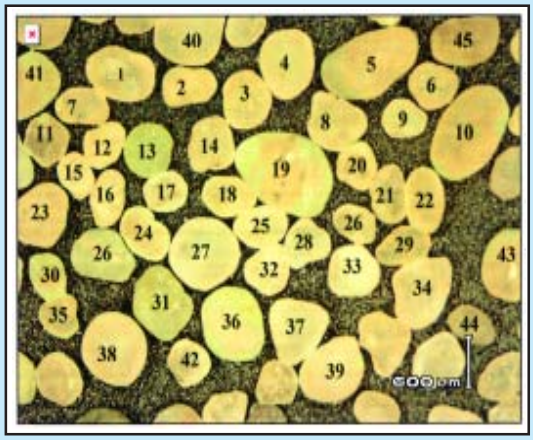

Figure 3.3
Photograph of import uncoated sand shape

The solubility of a sand in 12-3 hydrochloric-hydrofluoric acid (HCI-HF) is an indication of the amount of undesirable contaminants (for example, carbonates, feldspars, iron oxides, clays) present in the sand. The solubility is calculated with using the following equation:

$$S = \frac{(W_s + W_r - W_{fs})}{(W_s)} X\ 100$$

When:

S = sand solubility, weight percent
W_s = sand weight, grams
W_f = weight of filter, grams
W_{fs} = weight of filter containing sand, grams.

Results of acid solubility values of both local and import sands are 0.27 and 1.48.

Frac sand crush resistance test is useful for comparing the crush resistance of different samples of sand. The test is to be conducted using a given volume of sand particles, all of which have been sieved and found to be within the specified frac sand size range. Recommended test procedure is written in the API – RP 56 specification requirement. At 3000 psi API pressure standard condition, result of local sand crush resistance test is 25.50 % wt fine and higher than import sand (13 % wt fine). All results of local and import uncoated sands quality laboratory tests are summarized in Table 3.3. In general, based on

Table 3.3
Results of local and import uncoated sands quality laboratory tests (Average)

Requirement	Unit	Local sand	Import sand
Sand sieve 12/20	% wt.	97.30	97.33
# 8 mesh	% wt.	0.00	0.00
# 12 mesh	% wt	0.00	2.37
# 16 mesh	% wt	29.40	65.30
# 18 mesh	% wt	46.70	25.33
# 20 mesh	% wt	21.20	6.70
# 30 mesh	% wt	2.57	0.30
Pan	% wt	0.13	0.00
Larger then # 12	% wt	0.00	2.37
Smaller then # 20	% wt	2.70	0.30
Sand shape			
Roundness		0.70	0.76
Sphericity		0.67	0.73
Turbidity	FTU	51	44
Acid solubility	% wt	0.27	1.48
Crush Resistance			
@ 3000 psi (API)	% wt fine	25.50	13
@ 1500 psi (CPI)	% wt fine	1.70	1.25

laboratory tests results, the local uncoated sand doesn't show good quality or doesn't fulfill API – RP 56 specification requirement.

IV. CONCLUSIONS

Based on all results of the local and import uncoated sands quality laboratory tests can be concluded as follows:

1. The local uncoated sand does not achieve API-RP 56 specification requirements.
2. The import uncoated sand fulfills requirements of API – RP 56 specification.
3. The result of local sand crush resistance test at 3000 psi for sand sieve 12/20 is higher than API – RP 56 specification requirements.
4. Based on sand quality laboratory tests results, import sand shows better quality than local sand, so that the import sand can be used in hydraulic fracturing operation.

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