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A CASE STUDY TO USING ACID SOLUBLE ABRASIVE MATERIALS FOR HYDRA JETTING GAS WELL

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Abstract: *Gas extraction is affected by the presence of condensate and water in the extraction wells, with gas flow decreasing as the liquid rate increases. In this case, it is unnecessary to increase the recovery factor by increasing the gas flow rate. That is precisely why the technique of dilating the pores of the rocks through an abrasive effect is useful in this operation. In this paper is presenting abrasive flow rate in test to dilating pores of the gas well.*
Keywords: *Coiled tubing, abrasive techniques, acid soluble, dilating pores*

1. Introduction

In oil and gas wells in many cases rocks transfer fluids to the filed in the production treatment and storage is carbonated.

These rocks have a good diameter pore to gas transfer, but in many cases this pore is blocked to the water and condensates (fluids of the gas fields).

In order to increase the diameter of the pores and the flow of gas transferred through the pores, works to increase their diameters are necessary, the most used method lately being coiled tubing (CT) [1, 2, 3].

In industrial practice, water treated with various compounds (acids or bases) is used as an expansion fluid (abrasive) depending on the type of rock. For carbonate rocks, the most common fluid consists of acid diluted with water and antibacterial solution. I also introduced coconut shells, caustic soda and molasses useful elements to create the chemical reactions needed to transform the carbonates in the rock into salts.

2. A new soluble chemical abrasive materials

The new chemical abrasive materials are particles that can be used for cutting, perforation, scale removal, temporary diversion, or surface cleaning (at reduced pressure).

The particles are also completely acid soluble, enabling removal of residual materials by dissolution rather than by conventional cleanout.

Some of the Physical and Chemical Properties of the abrasive material are shown in table 1.

Table 1. Physical and Chemical Properties

Physical State	Powder	Ph	Basic
Colour	White	Specific Gravity	2.423
Odour	Odourless	Water Solubility	Slightly soluble
Chemical Stability	Stable	Molecular weight	2

The use of an additive fracturing solution (by mixing with acid or caustic soda) and with filler materials (need to increase the pore volume) means that well interventions are reduced and the recovery time of gas production decreases by more than 30%.

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Also, no other fracturing steps are needed (since the formed salt can be taken up (dissolved) by the water or transported to the surface and separated.

3. Hydra jetting tool equipment

Abrasive jet fracturing is a method that replaces classic fracturing (by explosion or shot with explosive), the method being easy to implement and the fracturing parameters (fluid flow, its pressure and the composition of the fracturing jet) being easy to control.

A hydra Jetting technique is useful for simulating layer production, the major advantage being the ability to hydraulically and accurately perforate some layers [2, 3, 4, 5, 6, 7].

The equipment used has the role of creating an abrasive jet that cuts the rock without causing alternating cracks (which lead to the penetration of fluids from other productive layers).

Punching depth is controllable by cutting time.

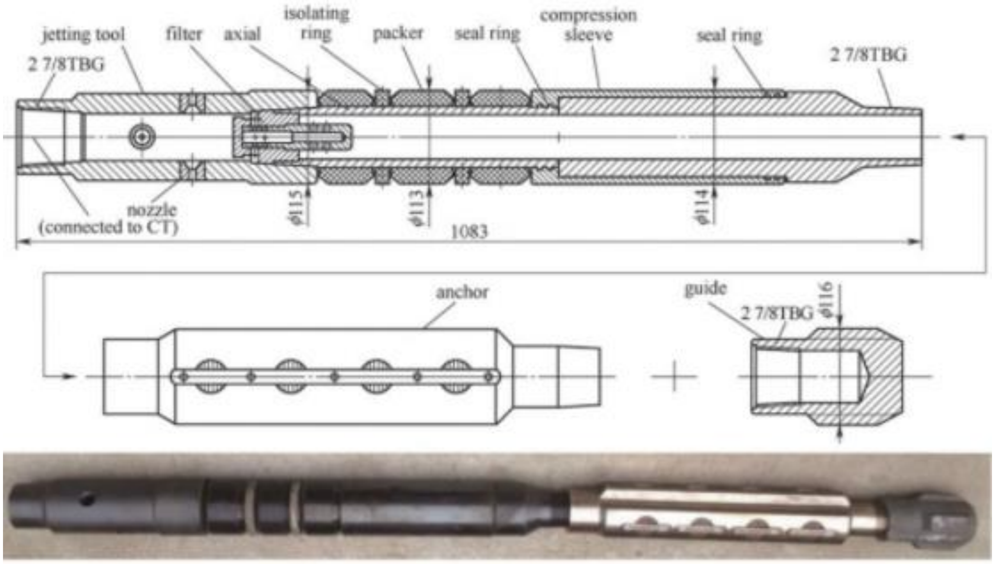

Fig. 1. Hydra-jetting tool internal configuration [7]

4. Design of the yard test

A yard test was set up to determinate if the material had the same abrasive characteristics as common 20/40 or 100 mesh sand. The goal of this yard test was to emulate several cuts at surface using the new acid soluble abrasive material.

It was constructed an standalone casing test stand to emulate cutting perfs on a piece of 6.625 inch (0,168 m) (casing (figure 2) that was cut in a 6-foot section designed for a surface test (1,8 m).

Specific acid soluble abrasive slurry recipes were provided for each cutting attempt.

Fig. 2. Casing test stand

5. Operational program

In order to confirm the optimum operational parameters (rate and Pressure) and the time required by the abrasive acid soluble slurry to cut holes in the casing.

The intervention program consisted of pumping acid-soluble slurry at different pumping rates and concentrations through the TS-tool. The TS-tool (figure 1) was set inside of the 6.625-in. (0,168 m), the tool was secured and connected to 2-in (0508 m) treating iron and back to the high pressure pump (figure 3).

As per the literature review the abrasive jetting tool often creates a hole that is irregular or even a long slot.

This irregularity is caused by the tool not being latched in place, or even mechanical cantered, and moving whiting the casing.

In order to avoid the before mentioned it was decided the use the anchor tool, to centralize the nozzle and get a better perforation [1, 2, 3, 4, 7].

Equipment and the acid soluble abrasive powder sacks were spotted and rigged up inside of a bay wash as showed in figure 4, a pre-job safety meeting was done prior to starting the operations, where details of the job were discussed, potential safety hazards and contingency plans were reviewed, and environmental compliance procedures were outlined.

The test was performed by circulating the abrasive slurry through the jetting tool to cut the casing.

The main fracturing treatment was spotted inside the annular space between the casing and jetting tool.

6. Results

The tests were performed several times to establish the operational parameters (rate, pressure and time) at which the acid-soluble abrasive slurry is capable of perforate holes in the casing.

Specific slurry recipes were prepared for each cutting attempt; four attempts to perforate the casing were done as follows:

- *First attempt*: 200 lb (90,71 kg.) of acid soluble abrasive powder were mixed into 10 bbl (1,599 m^3) of fresh water to prepare slurry with a concentration of 0.5 lb (0,276 kg) per 1000 gallons (3,785 m^3).

This mixture was prepared in the batch mixer and transferred to the back side tanks of the high pressure pump and was mixed for three minutes, once the mixture was ready, was pumped at different rates starting with 1 bpm (0,158 m^3/min) an increasing progressively to reach a pumping rate of 3.7 bpm (0,588 m^3/min) and a pressure of 3700 psi (255,11 bar).

The pumping time was 10 minutes.

However, the casing was not cut.

Fig. 3. Casing test stand and high pressure pump

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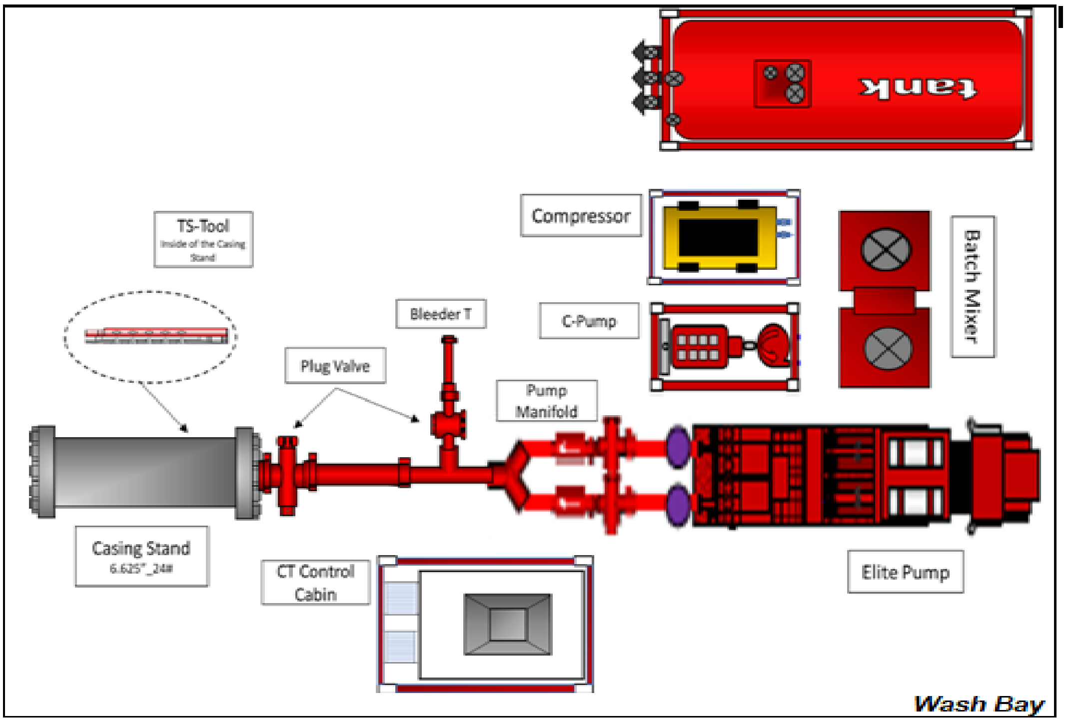

Fig. 4. Yard Test Equipment Layout

Table 2. First Cut Attempt

Pumping rate m^3/min	**Pressure bar**
0,158	6,89
0,317	68,9
0,476	151,68
0,588	255,11

- *Second attempt*: Again, 200 lb (90,71 kg.) of the acid soluble abrasive powder were mixed into 10 bbl of fresh water and mixed for three minutes providing as above mentioned a concentration of 0.5 lb per 1000 gallons (3,785 m^3).

Once the mixture was ready, was pumped at different rates starting with 2 bpm (0,317 m^3/min) an increasing the pumping rate till reach 3.8 bpm (0,6041 m^3/min) and a pressure of 3742 psi (258,19 bar). The pumping time was 10 minutes. The casing was not cut.

Table 3. Second Cut Attempt

Pumping rate m^3/min	**Pressure bar**
0,317	55
0,476	172
0,572	248
0,604	258

- *Third attempt*: 400 lb (181,43 kg) of acid soluble abrasive powder were mixed into 10 bbl (1,599 m^3) of fresh water and mixed for three minutes, in this case the concentration of the slurry was 1.0 lb (0,45 kg) per 1000 gallons (3,78 mc). Once the mixture was ready, was pumped at different rates starting with 2 bpm (0,317 m^3/min) and the pumping rate was gradually increased to reach 3.8 (0,604 m^3/min) bpm and a pressure of 3820 psi (263,71 bar). The pumping time was 10 minutes. The casing was not cut.

Table 4. Third Cut Attempt

Pumping rate m^3/min	**Pressure bar**
0,317	57,22
0,476	167,54
0,604	263,71

- *Fourth attempt*: The setting pressure of the HP-pump was changed. The pressure relief valve (PRV) of the high pressure pump was replaced for another with higher calibration to increase the capacity of the pump. The test was repeated successfully with a maximum rate of 4.1 bpm (0,651 m^3/min) and a maximum pressure of 4400 psi (303,36 bar).

During this test, 400 lb (181,43 kg) of the abrasive powder were mixed into 10 barrels (1,58 m^3) of fresh water and mixed for three minutes; the concentration of the slurry was 1.0 lb (0,45) per 1000 gallons (3,78 m^3).

The casing was cut after 3.8 minutes, only one hole was perforated and due to safety reasons the pump was immediately shut down.

In all cases the slurry was kept in agitation (in the back side tanks of the HP-pump) while it was pumped. The below table summarizes the maximum rate and pressure reached during each attempt during the yard test.

During each attempt the jetting tool was moved 3 inches between cuts to make new perforations

Table 5: Summary of the Cut Attempts

Test no.	Slurry Concentration m^3	Quantity of Abrasive Powder kg	Slurry Volume pumped m^3	Max. Rate m^3 /min	Max. Pressure bar	Holes Perforated
1	0.05 ppg	90,71	1,58	0,588	248	No cut
2	0.05 ppg	90,71	1,58	0,604	258	No cut
3	0,12 ppg	181,43	1,58	0,604	263	No cut
4	0,12 ppg	181,43	1,58	0,651	303	One hole cut

7. Points of Improvement for the yard test

1. It is necessary to keep the abrasive particles in suspension all time. It is recommendable a stirred tank for future tests. A stirred tank will provide a better agitation than the agitation provided by the back side tanks of the HP-pump. It is important to keep in agitation the slurry because at low injection rates the water may not have adequate transport properties to place the abrasive slurry in the casing.
2. The pH of the water used to prepare the slurry has to be measured before adding the hydrabrade particles. An acid pH can dissolve the acid soluble abrasive particles and affect its particle-shape and therefore its abrasive power will be reduced.
3. From the Safety point of view The standalone Casing stand have to be covered with a metallic frame or the test have to be done inside of a bigger metallic tank to avoid the flight objects (shrapnel or splinters) produced when the slurry breaks the metallic casing.
4. To increase the pumping time between 15 and 20 minutes with properly agitation to see if more hole can be cut.
5. Heat the mixture and observe the effect of viscosity on the transport of the particles, as the temperature increases, the viscosity of the fluid which transport the solids decreases and therefore the transport properties of the fluid are reduced (as we go deeper in the well the slurry is heated by the bore hole temperature). High temperature could cause a bad distribution of the acid soluble abrasive particles into the slurry and not arrive with the necessary concentration and abrasive power to cut the casing

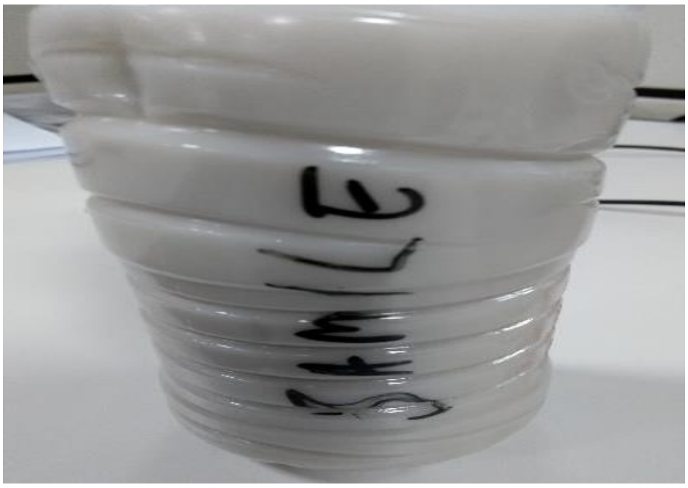

Fig. 5. Sample of the acid soluble abrasive slurry

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Fig.6. Perforation in the casing

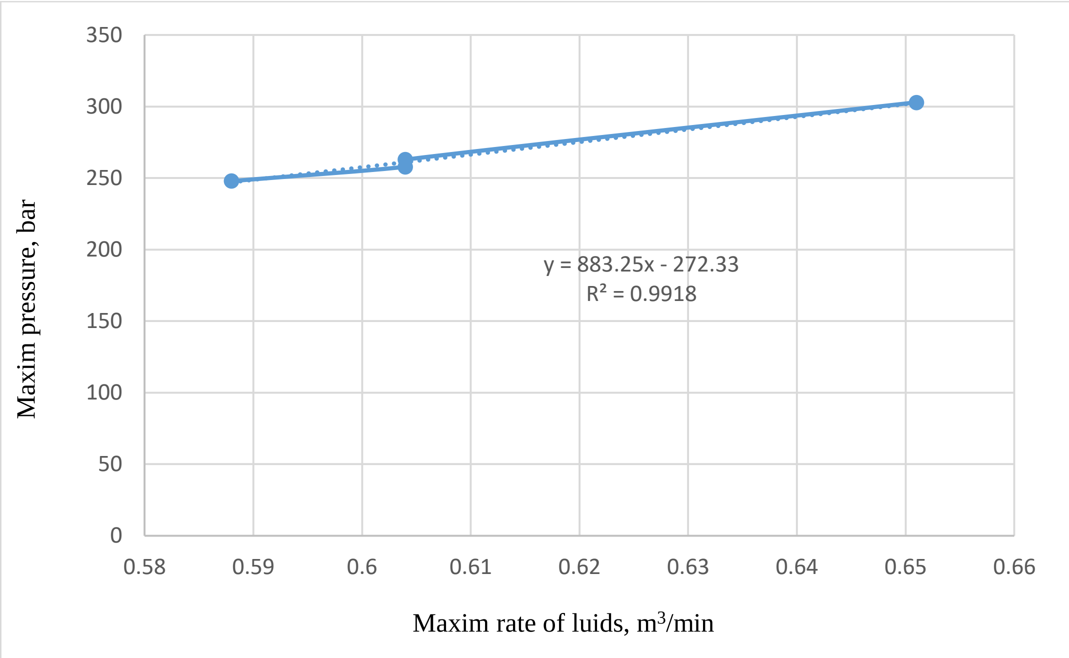

Fig.7. Maximal pressure (bar) equation function by maximal rate of fluids (m^3/min)

8. Conclusions

Four attempts were conducted during this yard test to determine if the new acid soluble abrasive slurry had the same abrasive characteristics as common 100 mesh sand.

The Test ended after achieving the objectives of the operation.

The operational parameters (rate and Pressure) at which the acid soluble abrasive slurry can cut the 6.625-in., casing were:

- Maximum rate: 4.1 bpm (0,488 m^3/h),
- Pressure 4,400 psi (303 bar),
- Concentration: 1.0 ppg (0,12 m^3),
- Acid soluble abrasive slurry cut the pipe after 3.8 minutes of pumping,
- Only one hole was cut (HP-pump was immediately shut down due to safety reasons),
- A equation of maximal pressure (bar) equation function by maximal rate of fluids (m^3/min) is laniary and have R^2=9918.

These tests helped provide a better understanding of the additional pumping time necessary to achieve the same penetration effect with the new product compared with the conventional sand.

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Nomenclature

CT – Coiled Tubing
OD – Outlet Diameter
ID – Internal Diameter
ft – feet
Lb – pounds
BHT – Bottom hole temperature
UOM – unit of measurement
ppg – pounds per gallon
bpm – barrels per minute
psi – pound per square inch
BHA – Bottom hole assembly
HP – High Pressure

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