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Evaluation of Internal Gravel Packing and Sand Consolidation Methods used in the Crude Oil Industry

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Abstract

When crude oil is produced from moderately weak reservoir rocks, some quantity of small particles and sand grains which are inconsequential and relatively of no economic value are extricated and carried along with the flow, thus resulting to the production of sand. Internal gravel packing and the sand consolidation method are the two primary sand management techniques employed in Nigeria's oil industry. Also, it is crucial to assess the well's performance, the effectiveness of the measures for sand control, and the longevity of the procedures for sand control so as to appropriately enhance production and keep an eye on sand control wells. This present study is therefore focused on the evaluation of internal gravel packing and sand consolidation methods used in the crude oil industry. Crude oil production data was collected from a well in the Niger-Delta, Nigeria. To evaluate how effectively the sand control strategies were working, the well inflow quality indicator was used. The results obtained show that internal gravel packing is more effective and long-lasting than sand consolidation method.

Keywords: ***Crude oil, Oil well, Internal gravel pack, Sand consolidation method, Well inflow quality indicator***

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1. INTRODUCTION

With the increasing global demand of crude oil, large quantities of crude oil need to be produced from oil wells [1-3]. Also, sandstone reservoirs contain the majority of the world's hydrocarbons, and an estimated 70% of all crude oil reserves worldwide are unconsolidated [4-5]. However, when crude oil is produced from moderately weak reservoir rocks, some quantity of small particles and sand grains which are inconsequential and relatively of no economic value are extricated and carried along with the flow, thus sand production. The earliest issue with oil fields has been sand production [4-6]. More so, it usually results from shallow formations due to the tendency of compaction to get higher with depth, although, in other formations, production of sand could be found down to a certain depth of 12000ft and even more [7]. On the other hand, sand production greater than 0.1% (volumetric) can be viewed as being excessive and the practical limit could be significantly lower or greater depending on the situation. Sand production in crude oil fields result in several production problems and these include; collapsed casing due to a lack of formation support, erosion of down-hole tubing, valves, fittings, and surface flow lines [8–9].The reservoir, surface equipment, and subsurface equipment are all directly impacted by these issues [10]. Some of the repercussions include decreased productivity, reserve loss, restricted access to production intervals, sporadic operation of ground and underground equipment, equipment failure, downtime, casing/tubing buckling, etc. Sand that has been produced has almost no commercial worth. An important component for operating unconsolidated oil and gas wells effectively is the capacity to forecast and manage sand production [11–12]. Therefore, it would be ideal to find a way to stop sand production without significantly reducing production rates.

Production of sand from oil and gas reservoir formations can be minimized using internal gravel packing and sand consolidation method [13]. When these screens are plugged due to fine or crushed prop pants the productivity of oil producers declines sharply. There are several screens less sand control methods like oriented perforation, selective perforation (Exclude weak zones screen less fracturing sand consolidation etc. The techniques that are employed to control sand production can be divided into three categories: chemical, mechanical, and combination procedures. By building a physical barrier that prevents sand from moving while yet enabling reservoir fluids to get through, sand is mechanically excluded. Fine gravel that has been sized so that formation sand cannot enter via the gravel's pore throat surrounds the screen-like barrier. Thus, the link between the size of the formation sand, the gravel, and the screen slot width forms the basis for the mechanical exclusion of the sand. This is accomplished using the Expandable Sand Screen method, Standalone screens, Wire wrapped screens, Frac packs, and Gravel Size Packing (open hole and cased hole). Chemicals are injected into the formation—typically resins—through perforations in the chemical control method to cement the sand grains. These substances combine the rock fragments to surround the casing with a stable matrix of consolidated, porous grains. A clay stabilizer is frequently employed as a pre-flush because clay concentration can make the process of sand consolidation less successful. The four main steps that make up the sand consolidation process are as follows;

i. Insertion of resin using a carrier fluid into the formation
ii. The resin is extracted from the carrier fluid.
iii. The resin building up near the grain contact point.
iv. Resin curing.

In addition to sand control techniques using chemicals and machinery, a few gravel and plastic-based combination techniques have also been used. After it has been laid, the gravel pack is to be strengthened, but not with a screen or slotted liner. Resin-coated gravel is a surface mixture that was injected into the well. in the epoxy and furan techniques. The plastic gravel slurry is then given time to settle and harden. Before the well is put into production after curing, the residue is dug out. The phenolic coated, partially polymerized gravel is used in the phenolic resin gravel operations.

2. MATERIALS AND METHODS

In this study work, the following techniques were used;

2.1 Performance of the Sand Control Methods

To evaluate the performance of both techniques, the well inflow quality indicator (Z), which, provided no formation damage is present, is the ratio of the actual productivity index (PIActual) to the ideal productivity index (PIIdeal). Equation (1) explains it[12].

$$Z = \frac{\mathrm{PI}_{\mathrm{Actual}}}{PI_{Ideal}} \quad (1)$$

Where [12],

$$\mathrm{PI}_{\mathrm{Actual}} = \frac{q}{\Delta p} = \frac{q}{P_r - P_{wf}} \quad (2)$$

$$\mathrm{PI}_{\mathrm{Ideal}} = \frac{7.08E-3 \times k_0 \times h}{\mu_{0\times} B_0 \times l_n \times \frac{re}{rw}} \quad (3)$$

Where,
PI = Productive Index
PIactual = Actual Productive Index
PIideal Ideal = Productive Index
re (ft) = Drainage radius
rw (ft) = Wellbore radius
Ko(md) = Permeability
H(ft) = Reservoir thickness
Bo(rb/stb) = Oil Formation Volume Factor
Pr(psi) = Reservoir Pressure
Pwf(psi) = Flowing Well Pressure
Q(bbl/D) Oil Production Rate
q = Flow rate post sand control job
Z = Well Inflow Quality Indicator
ΔP = Pressure difference
$\mu_0 = Viscosity$

If $Z \leq 1$; it simply means that Z is closer or equal to 1, thus, the better the performance of the well [12].

2.2 Sand Control Effectiveness

The volume of sand produced from each well, expressed in pounds per thousand barrels (lb/1000bbl), is added together and compared to the sand control measures in a histogram to assess their efficacy.

2.3 Durability of the Techniques

To assess the effectiveness of the sand control techniques, the difference between the years the treatment types were put in place and the year sand production began is gotten for each well to determine the duration (in years) of the sand control methods for each well. The duration (in years) is then matched against each well in a histogram.

Figure 1 shows the schematic diagram for internal gravel packing (IGP). The procedure used for the internal gravel packing (IGP) are as follow;

i. Cleaning the well: Brine is injected into the well to clear out trash and to regulate the well, add weight and loose sand as needed.
ii. Inserting the chosen screen: At a depth of around 6660 feet, Then, a 0.02-inch gravel pack wire wrapped

screen is positioned directly opposite the perforation. A centralizer is employed to hold the screen in place in the center of the well bore.

iii. RIH gradually the gravel pack assembly, which is made up of the following parts: a cross-over sub, a snap latch, a seal assembly, welded screen, blank pipe, safety joint, and wash pipe.

iv. Injection of chosen gravel: A high viscosity fluid is used to inject about 0.02 inches of gravel into the well bore (water pack of viscosity 240cps and pressure of 500psi). In the gap between the screen and the perforation, the gravel pack is placed there and filled to the reservoir's depth interval.

v. The gravel pack's performance is evaluated, and any remaining pressure is released.

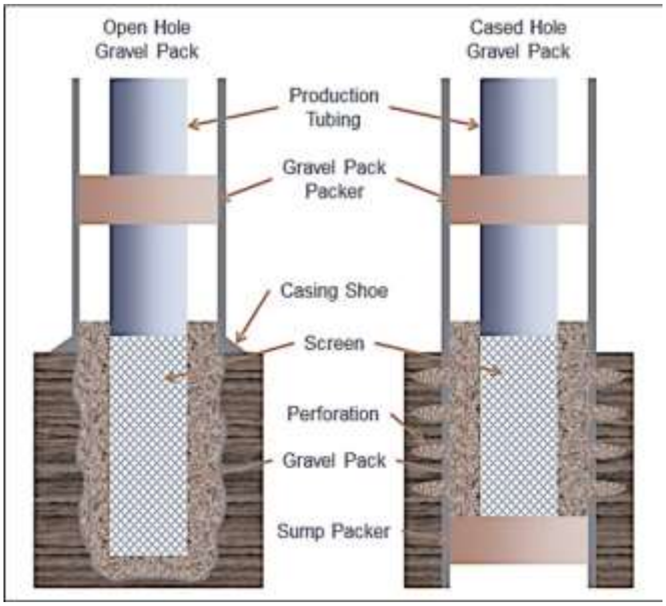

Figure 1: Internal Gravel Packing [13]

3. RESULTS AND DISCUSSION

Figure 2 shows the volume of sand production, It is evident that the wells under control of sand consolidation (SCM) produced more sand than the wells under control of internal gravel packing (IGP). This is because, according to [14], the generating fluids have a tendency to wash away the chemicals employed in sand consolidation, weakening both the chemicals and the SCM process.

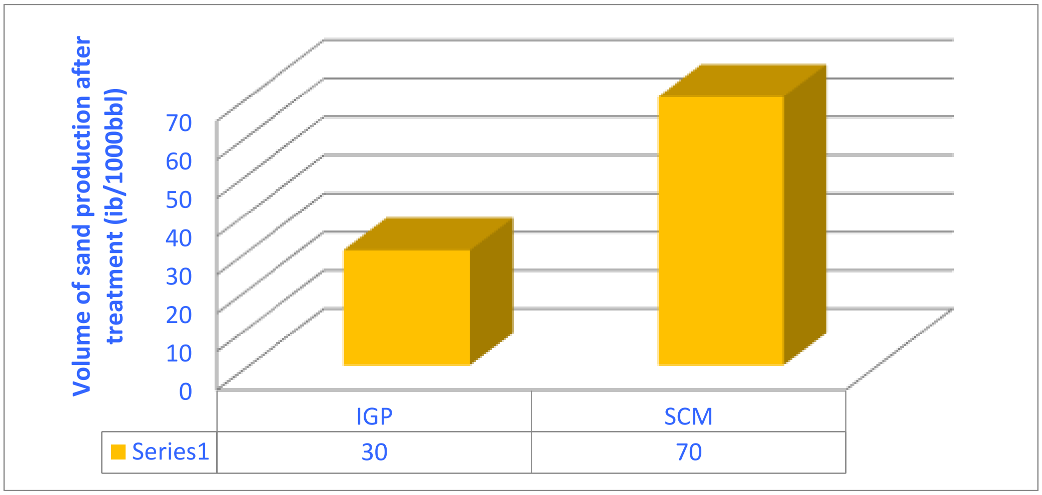

Figure 2: Volume of Sand Production

As depicted in Figure 3, the wells treated with SCM has a Well Inflow Quality Indicator (Z), which are nearer to 1 (0.78) than those getting IGP treatment (0.22). The ineffective placement method, improper gravel size selection, production-related debris and loose sand from the formation that obstruct the gravel pack's pore spaces, selecting the wrong screen slot to hold the gravel, or contaminated completion fluid may all contribute to the reduction in IGP performance. This finding agreed with the research work of [13].

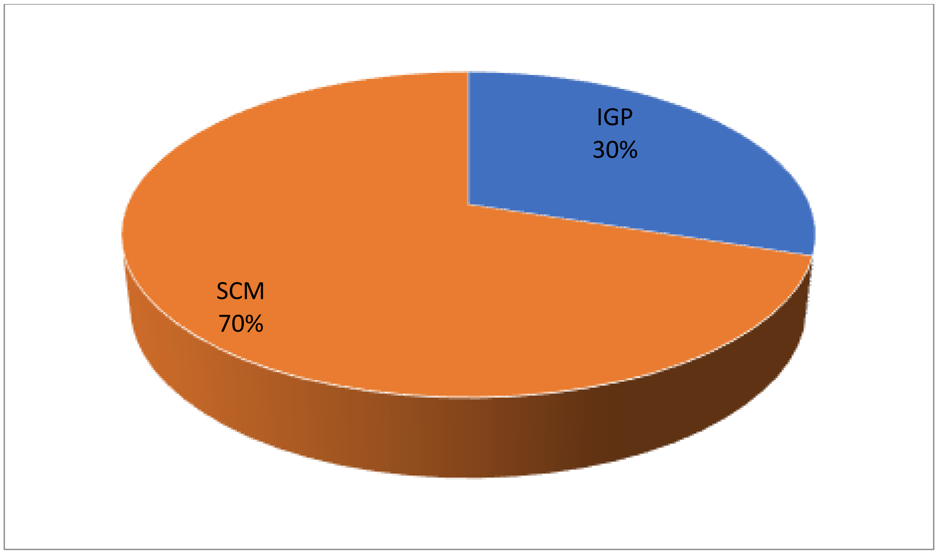

Figure 3: Performance Results of Sand Control Methods

Figure 4 showed the duration of the Sand Control Methods, it was observed that internal gravel packing (IGP) treatments extend the life of wells longer than sand consolidation treatments (SCM).This could be due to the fact that high temperatures underground limit the sand's capacity to consolidate over time, decreasing the technique's durability [13].

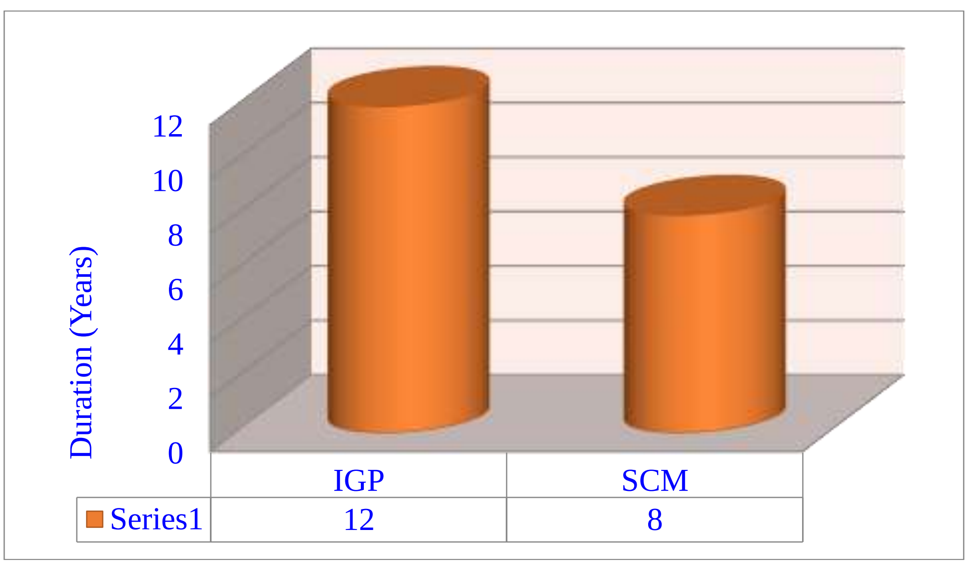

Figure 4: Duration of the Sand Control Methods

4. CONCLUSION

Sand production has been a significant problem in the production of oil and gas and has established itself to be one of the most difficult to address. When the formation tension exceeds the strength of the formation, it starts. The long-term productivity of a well can suffer if formation sand is produced using well fluids. When sands are produced using formation fluids, several potentially harmful and expensive issues arise. In this study, control of sand via internal packing of gravel and sand consolidation were evaluated depending on their efficacy at controlling sand, performance, and durability. It was found that wells constructed with sand consolidation function better than those constructed with internal packing of gravel. Also, internal gravel packing wells are more long-lasting than wells that were created with sand consolidation. Also, compared to wells fitted with internal gravel packing, as the mechanism wears out, those with sand consolidation create more sand.

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