Prospects of Hydraulic Fracturing For Recovery of Niger Delta Shale Formation

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***Abstract*— There is now a global interest in unconventional petroleum exploitation. This of course is to meet up with the demand for energy by the growing world population. Conventional petroleum reserves although cheaper to exploit and produce are no longer sufficient to meet up with this demands. Newer pools of conventional reserves are seldom discovered and some petroleum analysts are beginning to say that the age of 'cheap' oil has passed. Unconventional petroleum reserves which includes shale gas, shale oil, tar sands, oil sands, heavy oils and bitumens etc. hold great potentials for exploitation. Nigeria needs to diversify in the energy sector. This diversification entails moving beyond conventional petroleum production. Since the Nigerian economy enormously depend on crude oil, conventional reserves may not be sufficient to meet up with growing demands and national needs. For this reason and more the Nigeria government must veer to exploitation the vast unconventional reserves in the country. Virtually all of the unconventional petroleum exist in Nigeria which include, heavy oils, bitumen, tar sands, shale oil/gas, tight gas etc. among these shale gas has received rapid global attention since the United States began the massive development of its shale. Since then other countries have followed suit leaving Nigeria behind. This paper evaluates the method to develop and exploit shale reservoirs using hydraulic fracturing methods. The various approaches, prospects and limitation of the hydraulic fracturing technology is discussed and analyzed. The results when a viscous oil reservoir was produced shows that more oil is recovered from hydraulically fractured reservoirs than reservoirs flowing without hydraulic fracture.**

***Index Terms*— Flowback, Hydraulic fracturing, Shale formation, Unconventional reserve**

I. INTRODUCTION

Fossil fuels will continue to remain the dominant energy source in the foreseeable future. Due to increasing demand and usage the conventional reserves may not match up with current growth in utilization. For a country like Nigeria whose economy almost entirely depends on petroleum, there is need to venture into productions from her unconventional petroleum reserves especially now that less conventional reserves are being discovered and the ones discovered are heavily declining to increased production. For Nigeria to maintain her status as one of the largest producer of oil and natural gas, then her unconventional petroleum reserves must be put into development. Unconventional petroleum reserves are those whose physical, chemical or geologic conditions hampers their production by normal conventional production means. Most operators and governments have neglected these reserves because of its complexity, difficulty and cost of development which reduces its economic viability [1]. For instance, in the Niger Delta, production have been grossly limited to the conventional reservoirs, this reservoirs are comparatively easier to produce by utilising the primary energy of the reservoir, or supporting it with artificial lift techniques or in some extreme cases injecting water into the reservoir to help mobilize the oil and mobilize to the production interval where it flows to the surface. Shales are regarded as unconventional reserves and holds great exploitative potentials for Nigeria just like the US that has developed its shale unconventional reserve and has greatly reduced its importation of crude oil.

Hydraulic fracturing has been identified as the most effective well stimulation method in the development and production of shale reservoirs. Hydraulic fracturing involves injecting pressured water and chemicals into a well in order to break into underground reservoirs. It involves a well stimulation technique in which rock is fractured by a hydraulically pressurized liquid made of water, sand, and chemicals. The technique is commonly applied to wells for shale oil/gas, tight gas, tight oil and coal seams gas. Such well stimulation is used to increase flow rates [2].

II. SHALE RESERVES

Among the various unconventional reserves are the shale reserve, the heavy and extra-heavy oil reserve, tight gas etc. Shale oil is regarded as an unconventional oil resource; embedded in low permeable sandstone, carbonate, and shale rock. Shale contains Kerogen, a type of organic matter that yields oil and gas. Different kinds of shale exist in different parts of the world which may include shale and bituminous shale which are important sources of different kinds of unconventional oil Shale became a strategic asset during the Second World War, when the United States sought a more secure source of oil [3].

Commercial development of shale reserves began in the 1960s, but the difficulty in extracting and producing oil from shale made it less attractive resources compared to unconventional wells.

The recent advent of shale reserve development and production by the US has largely opened the corridors for commercial shale reserve development. Now many countries such as china, Venezuela etc. have followed suit in the development of their shale oil and gas reserves [4]. Nigeria is not left behind in terms of shale formations. Studies in fact suggest that shale deposits are abundantly located in Nigeria, mostly in Benue, Borno, Adamawa and on other south-eastern and north-eastern parts of Nigeria, notably the Okigwe region of Imo and in Abia states [5]. There are also potentials for shale gas in the Niger Delta and in the south-south and south-western parts of Nigeria. For example, within the Anambra Basin, the Eze-Aku Shale Formation has been identified as holding considerable shale gas reserves as to warrant active evaluation [6]. Other significant shale formations in Nigeria are the Agwu shale formation, the

Nkporo/Enugu shale formation and the Afowo shale formation of the Dahomey Basin [7].

III. HYDRAULIC FRACTURING OF SHALES

Hydraulic fracturing is a process used to stimulate a natural gas, oil, or geothermal energy well to maximize the extraction. The broader process, however, is defined by EPA as including the acquisition of source water, well construction, well stimulation, and waste disposal. A hydraulic fracture is formed by pumping the fracturing fluid into the wellbore at a rate sufficient to increase pressure downhole at the target zone (determined by the location of the well casing perforations) to exceed that of the fracture gradient (pressure gradient) of the rock. The fracture gradient is defined as the pressure increase per unit of the depth due to its density and it is usually measured in pounds per square inch per foot or bars per meter. The rock cracks and the fracture fluid continues further into the rock, extending the crack still further, and so on. Fractures are localized because of pressure drop off with frictional loss, which is attributed to the distance from the well. Operators typically try to maintain "fracture width", or slow its decline, following treatment by introducing into the injected fluid a proppant – a material such as grains of sand, ceramic, or other particulates that prevent the fractures from closing when the injection is stopped and the pressure of the fluid is removed. Consideration of proppant strengths and prevention of proppant failure becomes more important at greater depths where pressure and stresses on fractures are higher. The propped fracture is permeable enough to allow the flow of formation fluids to the well. Formation fluids include gas, oil, salt water and fluids introduced to the formation during completion of the well during fracturing. During the process, fracturing fluid leak-off (loss of fracturing fluid from the fracture channel into the surrounding permeable rock) occurs. If not controlled properly, it can exceed 70% of the injected volume. This may result in formation matrix damage, adverse formation fluid interactions, or altered fracture geometry and thereby decreased production efficiency. The location of one or more fractures along the length of the borehole is strictly controlled by various methods that create or seal off holes in the side of the wellbore. Hydraulic fracturing is performed in cased wellbores and the zones to be fractured are accessed by perforating the casing at those locations [8]. Hydraulic-fracturing equipment used in oil and natural gas fields usually consists of a slurry blender, one or more high-pressure, high-volume fracturing pumps (typically powerful triplex or quintuplex pumps) and a monitoring unit. Associated equipment includes fracturing tanks, one or more units for storage and handling of proppant, high-pressure treating iron, a chemical additive unit (used to accurately monitor chemical addition), low-pressure flexible hoses, and many gauges and meters for flow rate, fluid density, and treating pressure. Chemical additives are typically 0.5% percent of the total fluid volume. Fracturing equipment operates over a range of pressures and injection rates, and can reach up to 100 megapascals (15,000 psi) and 265 litres per second (9.4 cu ft/s) (100 barrels per minute) [9]. A distinction can be made between conventional or low-volume hydraulic fracturing used to stimulate high-permeability reservoirs to frac a single well, and unconventional or high-volume hydraulic fracturing, used in the completion of tight gas and shale gas wells as unconventional wells are deeper and require higher pressures than conventional vertical wells. In addition to hydraulic fracturing of vertical wells, it is also performed in horizontal wells. When done in already highly permeable reservoirs such as sandstone-based wells, the technique is known as "well stimulation" [10]. Horizontal drilling involves wellbores where the terminal drillhole is completed as a "lateral" that extends parallel with the rock layer containing the substance to be extracted. For example, laterals extend 1,500 to 5,000 feet (460 to 1,520 m) in the Barnett Shale basin in Texas, and up to 10,000 feet (3,000 m) in the Bakken formation in North Dakota. In contrast, a vertical well only accesses the thickness of the rock layer, typically 50-300 feet (15-91 m). Horizontal drilling also reduces surface disruptions as fewer wells are required to access a given volume of reservoir rock. Drilling usually induces damage to the pore space at the wellbore wall, reducing the permeability at and near the wellbore. This reduces flow into the borehole from the surrounding rock formation, and partially seals off the borehole from the surrounding rock. Hydraulic fracturing can be used to restore permeability, but is not typically administered in this way [10].

IV. METHODS

Hydraulic fracturing process is compared with production conventional production strategy to evaluate the relative input of hydraulic fracturing process
The table below gives the production history for a well in the absence and in the presence of hydraulic fracturing. This compares the strength of the hydraulic fracturing process

V. RESULTS

The results of oil productions for a field with and without hydraulic fracturing is given in the table below

Table 1: Average Daily recovery volume comparison for convention process and hydraulically fracture process

year	Average daily productions (b/d)	
	Without hydraulic facture	With hydraulic facture
1	400	1500
2	398	1450
3	387	1400
4	365	1387
5	344	1325
6	287	1300
7	267	1288
8	253	1256
9	231	1243
10	200	1200

The table above shows high increase in recovery from the reservoir in the case of hydraulic fracturing. This is because of the induced permeabilities from the hydraulic fracturing process.

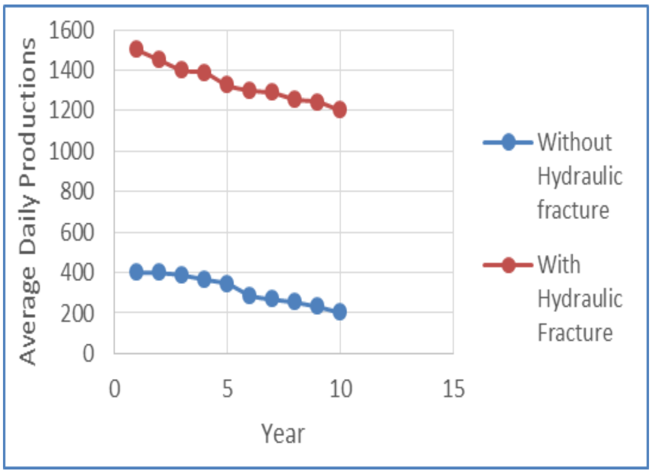

Fig. 1: Influence of Hydraulic fracturing on production from reservoirs

From fig. 1 above, it is seen that the case of hydraulic fracturing gives more recovery from the unconventional reservoir.

CONCLUSION

Extensive evaluation of hydraulic fracturing technology has been done. The method was for the development of shale reservoir in the Niger Delta. From the work it is seen that although hydraulic fracturing holds good promise for the development and production of shale reservoir, inherent problems associated with formation damage and fluid flowback is usually encountered. Appropriate post fracture clean-up is therefore necessary to maintain desired fluid production rate from the reservoir. The use of hydraulic fracturing for the Niger Delta shales will be a major breakthrough in Nigeria oil and gas sector. It is therefore imperative to perform proper evaluation of the Niger Delta formation characteristics to enable high performance of the hydraulic fracturing process and minimize impacts both to the humans and to the environment at large.

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