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Application of Production Chemical Foam Sticks for Compatibility of Gas Wells in Niger Delta, Nigeria

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ABSTRACT

Production chemical foam stick (PC F20) was applied into three natural gas wells in Niger Delta namely WSI, WS4 and WS7 respectively to ascertain its compatibility to the wells in terms of gas production and impact on well parameters. Results obtained shows that 28.4, 15.7 and 44.2 % of water produced from WS1, WS4 and WS7 respectively were stripped off these wells after treatment with PC F20. The increase in gas production obtained from WS1, WS4 and WS7 were 15.8, 4.0 and 25.9 % respectively. WS7 with the highest bottom hole temperature (BHT) of 140 oC had the highest increase in gas production while WS4 with the least BHT of 97.9 oC had the least increase in gas production. The higher the BHT of the gas well above the melting point of PC F20 which is 122 oC the faster the dissolution time of the foam stick. The solubility rates of WS1, WS4 and WS7 were 35.0, 78.0 and 22.0 minutes respectively, this is inversely proportional to the stick falling rates which were 109, 74 and 128 ft/mins respectively. The higher the gas produced from each well the higher the condensate produced. The lower the water produced from each well the lower the fluid salt content of the well. PC F20 increases the gas production of natural gas wells while reducing the hydrostatic and well head pressure of the wells as such is recommended for old and ageing wells with high propensity for water production and reduced pressure.

Keywords: Temperature; Pressure; Solubility; Surfactant; Condensate

Introduction

The use of foam sticks in the oil and gas industries have lasted for over forty years and it provides an economical way of removing water from gas wells thereby boosting gas production. Production chemical foam stick application presents a more affordable approach compared to other well service operations such as swabbing, nitrogen kick off, coiled tubing jet pumps and installation of artificial lift and siphon strings[1,2]. The high production of water in ageing gas and oil wells results in the entrance of water in well bores resulting in production problems when the water column gets over a few hundred feet in height. Gas production is depleted as soon as the water height creates enough pressure that equates with the formation pressure[3,4].

Production chemical foam sticks are water soluble sticks containing a blend of surfactants, they are formed when natural gas bubbling through the water column combines with surfactants. Foam sticks comprise of gas and liquid emulsions with the gas bubbles separated from each other in foam by a liquid film[2,5]. The surface active (surfactant) component of the foam is employed to reduce the surface tension of the liquid to enable an increased gas-liquid dispersion[6]. The liquid film between bubbles has two surfactant layers back-to-back with liquid contained between them, the combination of liquid and gas in this fashion is very effective in removing liquid from depleted gas wells[7].

The most commonly used production chemical foam stick is PC F 20 and its foaming action decreases the hydrostatic backpressure thereby increasing gas production which further enhances the foaming action until the well unloads. PC F 20 sticks are combined with oil foam sticks for gas condensate wells with more than 75 % condensate, these sticks are used to increase the swabbing efficiency and life of swab cups which allows the wells to flow easily[2,8]. Surfactants contained in production chemical foam sticks helps in treatment of scales by removing oil coatings on the exposed scales thereby exposing them to acid treatment[9]. The compatibility of production chemical foam sticks with gas wells is dependent on the age of the well which in turn influences other well parameters such as bottom hole pressure, water and condensate produced etc[10]. The productivity of natural gas wells deteriorates with time due to the loss in reservoir pressure, this may lead to flooding arising from the ingress of water and hydrocarbon (condensate) from the surrounding formation. Some of the characteristics of flooding includes drop in gas velocity or erratic flow caused by liquid aerosols condensing and accumulating on the sides of the casing to form slugs of fluid[11]. The use of production chemical foam sticks is very critical in liquid removal so that the fluid level and hydrostatic pressure does not increase over a period of time until it reaches a point where it effectively prevents or blocks the flow of gas to the surface and from the reservoir to the well[12]. The volume of gas enhancement achievable with the application of production chemical foam sticks is time dependent, it is easier to apply foam stick treatment to remove a small amount of water from the well as against when the well is nearly dead or dead[13]. The aim of this study is to carry out the application of production chemical foam sticks (PC F 20 sticks) on some gas wells in Niger Delta area of Nigeria to ascertain the compatibility of the foam sticks to the gas wells and its impact on gas production enhancement and well recovery.

Materials and Methods

Sample collection

The components of the production chemical foam stick (PC F 20) used include the following:

i. A primary surfactant made of alkyl ampho hydroxypropyl sulfonates
ii. Binding agent consisting of C16-C24 fatty alcohol ethoxylates,
iii. iii. Dispersant made of polymeric surfactant obtained from hyper branched polymers such as poly fatty acid esters,
iv. Weighting agents comprising of water-soluble salts of alkali metals such as sodium chloride, potassium carbonate etc.
v. Secondary surfactants obtained from non-ionic surfactants such as C12-C18 alkanolamines, glycol fatty acid esters or alkyl ethoxylates.
vi. Chelating agents such as citrates and iminosuccinates and / or at least one antioxidant chosen from vegetable waxes and natural soap bases such as butylated hydroxy anisole
vii. Further active ingredients chosen from scale inhibitors suitable for oilfield applications such as polycarboxylates, phosphonates or polysulfonates and its copolymers[2].

Preparation of Production Chemical Foam Stick (PC F 20)

The surfactants comprising 57.5 and 2.0 % w/w primary and secondary surfactants respectively were added slowly to the molten wax base containing 5.0 % w/w binding agent and 4.0 % w/w dispersants at a temperature of about 80 – 90 0C with stirring to avoid aeration. The addition of the surfactants was carried out in small amounts to prevent the wax base from cooling down and setting. The viscosity of the formulation increased as the wax base began to set hence the temperature was further increased in order to melt the base. The remaining ingredients (12.0 % w/w weighting agents, 5.0 % w/w chelates and 14.5 % w/w further active ingredients) were added to the base and mixed thoroughly and then the hot melt was poured into molds and allowed to set at ambient temperature before usage[3].

Procedure for the Application of Production Chemical Foam Stick (PC F20)

PC F20 stick was used on three natural gas wells in the Niger Delta region namely WS1, WS4 and WS7 respectively, the quantity of the foam stock applied on each well was about 10 % of the water produced from the well. The well was shut-in while the PC F20 stick (4.0 % water produced) was dropped through a lubricator, the foam stick made contact to the top of the fluid after 45 seconds before the well was then returned to normal production. High-rate wells were flowed at about 25% of pretreatment rate for about 20 minutes until foam reaches surface before returning to normal rate. The quantity of PC F20 stick dropped through the lubricator was reduced (3.0 % of water produced) after the gas regained its gas production along with substantial amount of water, however the gas flow rate was not allowed to drop below 25 % before dropping additional sticks (2.0 % of water produced) to keep the fluid from building back up down hole in the formation and producing string. The quantity of PC F20 sticks dropped was further reduced (1.0 % of water produced) after the well was unloaded and flowing effectively to keep the well flowing at its optimum flow rate ensuring that there were no restrictions in the flow line of candidate wells such as small or closed chokes. The parameters of the wells before and after application of PC F20 sticks were documented appropriately[2].

Results and Discussion

Production chemical foam stick (PC F20) is completely soluble in water and insoluble in oil however its solubility is highly dependent on certain parameters such as the bottom hole temperature (BHT) of the wells, well head pressure and salinity of produced water. The melting point of PC F20 is 122 0C as such will dissolve at a slower rate in wells with BHT below its melting point and at a faster rate in wells with BHT above 122 0C. The dissolving time decreases if the sticks are broken before dripping through the lubricator or if they break upon impact with

the top of the fluid[14,15].

Table 1: Characteristics of Gas Wells Before Foam Stick Treatment.

	GAS WELLS		
PARAMETERS	WS1	WS4	WS7
BHT (deg F)	118.0	97.9	140.0
WHP (Bar g)	122.3	136.8	119.7
SALT CONTENT (mg/l)	19700.0	16800.0	17700.0
WATER PRODUCTION (m^3)	5569.4	5815.0	6785.0
COND PROD (m^3)	1314.7	1927.0	2201.0
TOTAL FLUID (m^3)	6884.1	7742.0	8986.0
GAS PROD (Ksm^3)	9277.0	9605.0	8899.0

Table 2: Characteristics of Gas Wells After Foam Stick Treatment.

	GAS WELLS		
PARAMETERS	WS1	WS4	WS7
BHT (deg F)	118.0	97.9	140.0
WHP (Bar g)	108.6	123.8	101.1
SALT CONTENT (mg/l)	15760.0	14650.0	13320.0
WATER PRODUCTION (m3)	3987.0	4901.0	3789.0
COND PROD (m3)	2715.0	2545.0	3451.0
TOTAL FLUID (m3)	6702.0	7446.0	7240.0
GAS PROD (Ksm3)	11496.0	10006.3	12010.5
STICK SOLUBILITY RATE (mins)	35.0	78.0	22.0
STICK FALLING RATE (ft/min)	109.0	74.0	128.0

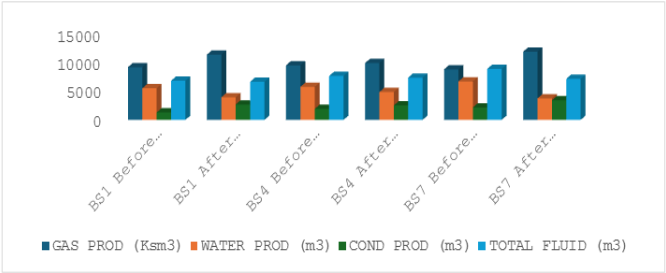

Figure 1: Bar Chart of Total Production of Gas Wells Before / After Foam Treatment

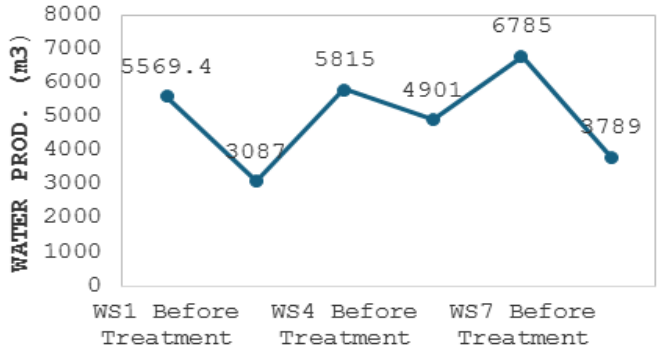

Figure 2: Water Produced from Wells Before / After Foam Treatment.

(Tables 1 and 2) shows the characteristics of gas wells WSI, WS4 and WS7 before and after treatment with PC F20 respectively. Results obtained from Table 1 shows that the BHT of WS1 and WS7 were above the melting point of PC F20 (122 0C) while that of WS4 was below its melting point, this resulted in WS4 having the fastest stick solubility rate (dissolving time) and least stick falling rate as shown in Table 2. The higher the BHT above the melting point of the foam stick, the lesser the stick solubility rate. The stick solubility rate is the time duration at which a foam stick dissolves in water. Effective foam sticks have very low stick solubility rates. The impact of PC F20 on gas production is dependent on the rate at which it dissolves in water which in turn affects the stick falling rate. The lower the stick solubility rate of a foam stick, the faster its dissolution in water and the greater the volume of water it can strip off from the gas well[16,17]. Comparing **(Tables 1 and 2)** shows that PC F20 stripped off the highest percentage of water (44.2 %) in WS7 and the least percentage (15.7 %) in WS4 well., the percentage of water stripped off from the gas well WSI was 28.4 % which is between that of WS7 and WSI. A graphical representation of the water produced from each well before and after foam treatment is shown in **(Figure 2)**.

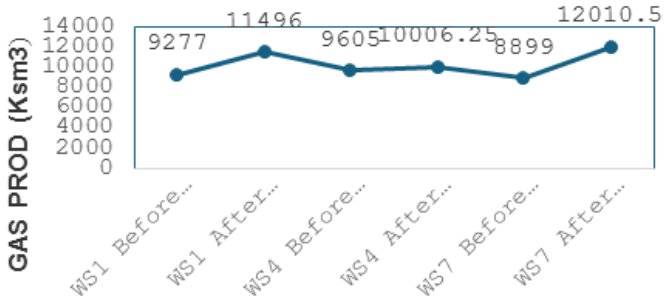

Figure 3: Gas Produced from Wells Before / After Foam Treatment.

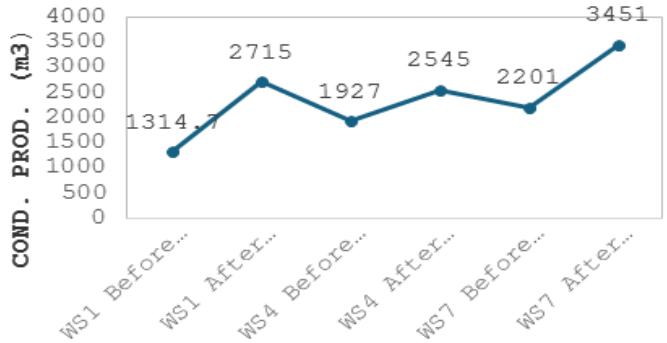

Figure 4: Condensate Produced from Wells Before / After Foam Treatment

Results obtained from Tables 2 also shows an increase in condensate and gas production after treatment with PC F20. The positive impact of the BHT of WS7 on the solubility rate and stick falling rate of PC F20 enabled the well to have the highest percentage increase in gas production (25.9 %) compared to WSI (15.8 %) and WS4 (4.0 %). Increase in condensate production was a function of the increase in gas production while the total fluid in this context is a combination of the condensate and water produced.

Results obtained showed a reduction in well head pressure (WHP) after treatment with PC F20. Flowing pressures are sufficient in carrying undesired water through the wellbore and out of the well in the early stages of the life of gas wells, as reservoirs start depleting and wells begins to age reservoir pressure begins to reduce as well as the flow rate of hydrocarbons[18]. The reduction of the reservoir pressure has an adverse effect on the ability of gas wells to carry and remove the undesired water being produced by the well. The inability of

the gas well to discharge water out of the wellbore results in the accumulation of the water in the production tubing responsible for hydrocarbon production which can subsequently lead to the shutting down of the wells[15]. The foaming action decreases the hydrostatic backpressure which increases gas production that further enhances the foaming action until the well unloads, this principal is responsible for the removal of water from gas condensate wells with more than 75 percent condensate Foam stick application has the ability of maintaining higher gas production rates even as pressure drops and flow decreases[2]. The graphical representation of gas and condensate produced from each well before and after foam treatment are shown in **(Figures 3 and 4)** respectively.

The salt content of the water produced from each well was determined and results obtained shows a reduction after treatment with PC F20. The reduction of water produced from the gas wells is responsible for a reduction in the salt content of water produced. High salinity of water produced from gas wells results in corrosion of metallic parts of the production tubing of the wells[19]. **(Figure 1)** shows a representation of the total production from all three wells in bar charts.

Conclusion

Shut down or dead wells can be revived by inserting production chemical foam sticks (PC F20) into the well bore through the well head. The impact of PC F20 when used in gas wells is determined on its ability to strip off water from gas wells and increase gas production. The closer the melting of PC F20 to the BHT of gas wells the faster the dissolution time of the foam stick when inserted through the lubricator of the wellbore. The solubility rate of PC F20 is the time duration required for the foam stick to dissolve when applied to a gas well and it is inversely proportional to the stick falling rate. Production chemical foam sticks (PC F20) increase gas production of gas wells whilst reducing the hydrostatic and well head pressure.

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