Gas Well Deliquification—A Brief Comparison between Foam Squeeze and Foam Batch Approach

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Abstract—With aging of gas fields in Germany, water accumulation and reduction in production was evident. Investigations suggested that the reduction in production in those fields were not merely a function of water accumulation but near wellbore damage also ally to that. Several conventional approaches were applied to cope with water accumulation and removing near well bore damage but they were not successful in all cases. An approach of pumping foam and additives has been tried in the field and named as foam batch (FB). It turns out to be successful but due to some limitation associated, it has been taken over by foam squeeze. Foam squeeze (FS) had been tested few years ago and it sets new standards to deliquify gas field and removing near wellbore damage in one treatment. Expanding the scope of application, FB was applied in whole field and it produced remarkable results by bringing dead wells (due to water flooding) back to production. Later FB treatment had been supplemented with additional additive pumping to achieve wide range benefits of near well bore damage removal and gas well deliquification. The paper will elaborate the difference between foam batch and foam squeeze. A case study will also be presented to show the difference among both approaches.

Index Terms—gas well deliquification, foam squeeze, foam application, treatment for water flooded gas well

1. INTRODUCTION

Foam Squeeze (FS) and Foam Batch (FB) both approaches involves pumping of foam. As a cardinal member of recipe, foam is used to reduce the surface tension of the water in near well bore region. Campbell et al (2001) also mentioned that adding surfactant to water gas system will reduce water/gas surface tension typically from 70 mN/m to 30 mN/m (approx.) [1]. The reduced surface tension of the water allowed them to be lifted even at low reservoir pressures. James F. Lea et al. (2008), wells with GLRs of 1000 to 8000 cu ft/lbbl are better candidate for foaming though there is no upper GLR limit [2].

W. Herans (2010) also mentioned foams or surfactants for dewatering liquid loaded gas wells changes the liquid in to bubble film the surface area exposure is increased, the density is decreased, the surface tension is decreased and the net impact on the critical velocity calculation is usually a reduction by a factor of 2.5 to 3 or in some cases higher [3]. Foam may help to get rid from water in near wellbore region but to address the near well damage; additionally different additives are pumped in small stages. The selection of additives is dependent on several factors like type of formation, downhole temperature, and type of damage & location of damage.

A. Foam Batch (FB)

Foam batch is defined as an approach in which foam, scale inhibitors and other chemicals (chelating agents, mutual solvents etc.) are being pumped in different steps, which are displaced by the water or some other liquids (but no natural gas).

As foam batch (FB) involves pumping of liquids during the treatment. It limits the application of this approach in low pressure wells. Pumping high quantity of liquids may lead to increase well kick off time after the treatment. It has been observed that in some cases it jumps up to more than 36 hours. Retreatment in water flooded well is required after specific period of time because water accumulates again after sometime and hindering the production at optimal rates. Experience also suggests that re-treatment duration were higher initially after applying foam batch (FB) approach but with passage of time the re-treatment duration shortens considerably and limited its application.

B. Foam Squeeze (FS)

Foam Squeeze (FS) is defined as an approach in which foam, surfactants, scale inhibitors and other chemicals (chelating agents, mutual solvents etc.) are being pumped comimgled with natural gas in different steps. Natural gas is also used to displace the pumped liquids and chemicals [4]. Foam Squeeze (FS) stands out as compare to foam batch (FB). It involves the pumping of natural gas during the liquid pumping steps and also for the displacement. The pumping of comingled natural as with the chemicals results in better distribution of the foam and additives. Later displacement with natural gas ensures effective and deep penetration of foam and additives.

Both of the treatment types, Foam Squeeze (FS) and foam batch (FB) can be used for the gas well deliquification. This is because as it involves the pumping of natural gas during the pumping of foam &
chemical pumping steps and also bullheaded during the displacement. In some cases de-foaming may be required at the surface, only if the foam concentration is too high in backflow fluids.

II. PRE AND POST TREATMENT LAB ANALYSIS

Laboratory testing and analysis is important at every step, either they are pre-job analysis or post job analysis. Pre-job test are being done to check the type and concentration of foam. It is essential to check the stability of foam at downhole conditions. Pre-job analyses are preferred to find the right concentration and type of scale inhibitor. In case of both approaches (FS or FB), job design is architected on the basis of pre-job analysis.

In a similar way the post job analysis are of same importance. The back flowing fluids are collected at regular interval of time to analyze several aspects like active foam concentration, dissolved solid, iron concentration etc. The direction of post-job analysis is dependent on the type of treatment and expected results. Post-job analysis allows us to optimize the job design for re-treatment. The concentration of chemicals can be fine-tuned for next treatments.

A. Difference b/w Foam Batch (FB) and Foam Squeeze (FS)

1) Foam batch (FB)
   - Pumping of water, foam, scale inhibitor and other additives (liquid pumping only)
   - No proper distribution of fluid(s) in formation
   - No effective well bore cleaning
   - Gas unit not required
   - Re-treatment duration shortens with time
   - More fluid pumping may hamper well kick-off

2) Foam squeeze (FS)
   - Pumping of comingled gas (natural gas or nitrogen) with fluids and also for displacement
   - Effective & deep penetration of fluid(s)
   - Removal of water and near well bore damage
   - Gas (natural gas or nitrogen) and mobile compressor unit availability is necessary
   - Retreatment required but after longer durations
   - Pumping of gas with fluid(s) and displacement ensures early kick after treatment

III. WHY NOT NITROGEN

Yes, nitrogen could be used but it has many disadvantages as compare to natural gas. They are given in brief comparison of nitrogen and natural gas hereunder:

A. Natural Gas
   - Ample availability of natural gas on wellsite
   - Cost less as compare to nitrogen
   - Less manpower involved so less safety risk and less personal cost
   - No longer flaring is required during backflow
   - Less environmental impact due to less flaring

   B. Nitrogen ($N_2$)
   - Require special equipment on site
   - Competitively expensive alternative to natural gas
   - More personal on site, more safety risk and personal cost
   - Nitrogen pumped disturbs the sale gas concentration, so longer flaring is required
   - Environmental damage due to longer flaring durations
   - Longer flaring results in production loss for longer period of time

Natural gas has been used effectively and successfully applied in German fields during last few years.

IV. CASE STUDY

The well presented in this case study is located in Germany and given name as Well 1 (an imaginary name). It is vertical well in a strong water drive reservoir. The field also got some slanted wells drilled at other location (see Fig. 1). Due to production from other wells in the field, the case well 1 was expected to be get water quickly. It has been evident at early stages but later on water accumulation got even worse. Well 1 stops production due to high water level in to the well.

Removal of accumulated water in well 1 was important to bring it back to production and also to avoid the flooding of other high production in the fields. The well has been initially treated by the application of foam batch (FB) treatment approach in 2010. Foam batch (FB) treatment has shown positive results by bringing the well back to the production. As shown in the Fig. 2, foam batch (FB) had been applied to that well for about one year but re-treatment duration went down (see Fig. 2). A re-treatment had been required after a short duration. This is also evident in Fig. 2 that the well 1 also losses production completely if not treated.

Well 1 had also been selected as candidate back in 2011 for foam squeeze (FS) treatments. The job design had been devised initially to remove the accumulated water. The job design plan was as follows:

![Figure 1. An imaginary view showing the location of Well 1 in the reservoir](image-url)
Step 1:
Pumping of water (60 °C), foam and oxygen scavenger comingled with natural gas

Step 2:
Displacement with Natural gas

Step 3:
Pumping of water (60 °C) foam and oxygen scavenger comingled with natural gas

Step 4:
Displacement with Natural gas

Step 5:
Pumping of water (60 °C), foam and oxygen scavenger comingled with natural gas

Step 6:
Displacement with natural gas

Step 7:
Pumping of water (60 °C) foam and oxygen scavenger comingled with natural gas

Step 8:
Displacement with natural gas

Step 9:
Pumping of water (60 °C) foam and oxygen scavenger comingled with natural gas

Step 10:
Displacement with natural gas (Over-displacement foam deep to the formation approx. 10 m)

Figure 2. Showing the production history and treatment

The set target of water removal from well 1 had been successfully achieved by application of foam squeeze treatment approach. It had also been observed that the re-treatment duration was also increased as compare to foam batch (FB) treatment. After convincing results, re-treatments were also included with some steps involved in pumping of scale inhibitors.

V. CONCLUSION

Foam batch (FB) and foam squeeze (FS), both approaches are applicable depending on well conditions.
In old fields with less reservoir pressure, foam squeeze (FS) is an effective approach.
Foam squeeze (FS) application require a natural gas connection on wellsite.
Mobile natural gas compressors are also required to pump foam and gas comingled and also for displacement.
During foam squeeze (FS) treatments well kicks off quickly after the treatment.
Foam squeeze (FS) application brings the dead well (due to water accumulation) back to production.

Foam batch (FB) are usually applied where no natural gas connection is available on the wellsite.

Abbreviations & Acronyms

FB=foam batch
FS=foam squeeze
GLR=gas liquid ratio
NG=natural gas
Nm³ =normal cubic meter
N₂=nitrogen
Well 1=an imaginary name for well
mD=millidarcy
Scm=standard cubic meter

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Reference [5]-[7] were taken to consideration and hence acknowledged for approach applications.

REFERENCE


He got the experiance of working as Production Engineer with Fauji Fertilizer Bin Qasim limited during (2005-2008). He joined well stimulation department of Fangmann Energy Services(2010-Present) as oilfield services engineer. He worked about well stimulation projects majorly about application of environmental friendly stimulation fluids and also production enhancement from watered and damaged gas wells in Germany. Currently he is looking after the international operation for expanding the scope of stimulation and gas well deliquification technology applications.