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Effect of Gas cycling on Oil recovery "Algerian Field case study"

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The objective of the cycling in gas condensate reservoir is to maintain pressure close to the dewpoint and recover more wet gas with a maximum condensate yield. The problem is that during the life of the reservoir, breakthrough appears and the condensate yield decreases in some wells located close to the gas injectors. For a gas condensate reservoir with an active aquifer, the problem is twofold since care should be taken to avoid water and gas breakthough.

It is somewhat difficult to achieve an economic development for well spacing and doubt may appear for the prediction forecast in the Trias Argileux Greseux Superieur (TAGS) reservoir, which is a fluvial deposit, very complex in term of heterogeneity and fluid movement.

The TAGS formation reservoir is an anticline north south direction, with the presence of some faults. The big reservoir development problem is mainly geological because of the varying dip of the different beds, the heterogeneity, and the presence of different heavy minerals. One field well showed an early breakthrough. The well was shut in after three years and a half of production after condensate yield decreased from 130 g/m^3 to 30 g/m^3.

The present work discusses the analysis of the different results obtained in terms of simulation of different cases with and without cycling and by shutting injector wells to study the effect on condensate recovery in this complex gas condensate field. The results show that the condensate yield is increased after reducing the rate of reinjection by completely shutting injectors or by reducing the total injection rate of the field. The cumulative recovery is increased by 2 to 3 % compared to the base case considered.

Gas cycling is not economically justified after a certain period of time, therefore a blowdown has to be initiated. A blowdown case is also considered, when the gas injectors are completely shut in, the condensate yield of the field increases more but the aquifer support effect is demonstrated.

Objectives

Condensate reservoirs are complicated as pressure drop provokes condensate dropout in the reservoir. Using PVT calculations based on the Peng–Robinson model or other models, authors have shown that after a pressure decrease of a few bars, dropout occurred, and about 10% of the condensate would be lost in the reservoir. Compositional simulation models characterize reservoir performance using the equation of state. Emphasizing the importance of the maximum recovery of condensate without condensation in the reservoir, the present work discusses the effect of gas cycling. This is not economically justified after a certain period of time, unless there is a need to stock lean gas in the reservoir.

Reservoir Description and Field Feature

The reservoir is an anticline north south direction with the presence of some faults. It is 5 km wide and five times as long, the average porosity is about 18% and the permeability varies between 100md and 3.5 Darcies. The gas cap column is about 160m, the water gas contact is found to be the same over all the field, the original gas in place is estimated at 120 billions stdcm. The original GOR is about 3500, an OGR of 218 sm^3-sm^3. Initially the reservoir pressure is at the dewpoint pressure, equal to 220-at and a reference depth of –1780m. The reservoir is subdivided into seven simulation layers, perforation are set in most of them for producing and injecting wells. The reservoir pressure decline is about 6 bars in six years of cycling started at the same time is preferal production begun. The injection scheme is peripheral and includes eight injectors for eleven producers. The field showed one well with premature breakthrough. The well was shut in since its condensate yield decreased from 130 g/m^3 to 30 g/m^3 after three years and a half production. This breakthrough can be attributed to the presence of a channel in the third layer of the reservoir.

Geologic and simulation model:

The geological model is elaborated by setting the map of top of the structure with faults deduced using seismic 2D, the net to gross, the porosity and permeability. The maps are established after cutoff porosity, clay volume (Vsh) and water saturation model based on, the correlation of facies and a technological model based on the logs of different wells.

The relative permeability is selected by rock type properties based on the initial water saturation for each layer reservoir. Consideration the capillary pressure is also included.

PVT

Behavior of gas condensate reservoir is mainly controlled by fluid proprieties, and accurate knowledge of this PVT characteristics is required. The PVT package is included in the model after matching the equation of state by the Peng–Robinson model by the CVD and CCE depletion. The dewpoint, compressibility factor and cumulative gas producing are well matched, and very close to the real data for oil recovery.

History

The history match is based on the rate of production and injection measured periodically on the field, the perforation KH is evaluated from Production Logging Tests (PLT) done on the field each year. The percentage of the participation to flow of each layer is deduced, the bottomhole pressure is also measured for all wells once a year.

It is acknowledged that the best value of permeability is obtained by welltest interpretations since the drainage radius is higher than that of cores. So it is very important to find a correlation or a relationship to estimate the permeability for the wells that are have no test data (Build up or Fall off). This correlation is obtained by lotting the KH values obtained by welltest versus the geometric KH for five wells, a regression is done and a correlation of good coefficient of regression (R^2=0.97) is obtained as shown in **Fig. 3** BUP KH=0.847 (GEOM KH)

Simulation Cases and Results Analysis:

During history matching, the maximum rate of production and injection introduced in the model monthly is reproduced by the model and matched carefully. The water in the field is not produced as well as by the model. During forecasts for different cases, a water limit of 03m^3 /day is put as a constraint to shut perforations, and a program to take in a count to pressure loss in the tubing is include.

Remarks

It is important during the history matching to match the gas rate, the pressure, and essentially the condensate yield. A depletion of one bar per year is observed; this is small and can be attributed to the high voidage replacement, all the gas production is reinjected after removing the fuel gas and the 8% OF shrinkage.

Economics

An economics study was conducted to see which case is best to manage the field, the delta VAN compared to the based case (c1) showed that the third case (c3) is best. This is due to the increase in the condensate yield and the 2% grained from the base case to case3 in terms of oil recovery by reducing the injection gas rate. The same things are observed for the blowdown, as we can see in the following table

Cases/C1	Delta VAN (M$) No blowdown	Delta VAN (M$) with blowdown
C2/C1	65	130
C3/C1	90	175

The calculation is based on the lean gas, condensate and GPL sales with the actual prices

Conclusions

1- To achieve a good history matching, it is important to do measurements on wells at least once a year for pressure and condensate yield.
2- A gain of some grams per ton in condensate yield is observed when reducing the gas injection in all cases.
3- The reduction of the injection rate (from 87% to 73%) does not affect a lot the pressure decline of the reservoir, from 5 bar to 10 bar after 15 years of production.
4- Gas cycling is not economically justified after a certain period of time, therefore a blowdown has to be initiated
5- The date of blowdown must be decided from numerical simulation. The effect of the aquifer must be assessed.
6- The PVT package should be well done, matching different factors (Z, Vrel, Liq) for both the CCE and CVD tests is recommended since PVT is the heart of the compositional simulation study.
7- It is very useful to simulate differents cases with reduction of the injection rate, when we need to export gas for sales or to do make up for another field.

Nomenclature
PVT=Pressure, Volume, Temperature
BUP KH=Permeability obtained by welltest analysis
Khgeom=Geometric permeability obtained by cores
OGR=Oil Gas Ratio
GOR=Gas Oil Ratio
CCE=Constant Composition Expansion
CVD=Constant Volume Depletion
Z=Gas Compressibility Factor
PLT=Production Logging Tool
VAN=Actualized Net Value

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Metric Conversion Factors
Cp x1.0 E-03=Pa.sec
ft x3.048 E-01=m
ft^2 x9.29 E-02=m^2
ft^3 x2.831 E-02=m^3
gpm x 6.308 E-02m^3 /sec
in. x2.54 E+00=cm
lb/ft^3 x1.602 E+01=kg/m^3
lb.sec^n/ft^2 x1.488 E+00=Pa.sec^n
psi x0.07 E+00=Kg/cm^2