Assisted production in salty oil fields -Algeria

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How to maintain the production of the salty oil wells?

1. Introduction:

Many fields in Algeria produce the salty oil. Depending on the quantity of salt contained in the oil, there are some technical solutions to improve the quality of oil by reducing its salinity.
These solutions pass from the simplest washing of the crude oil by fresh water to the specific facilities.

In this paper, I would like to highlight the risks associated with the two systems of assisted production (gaslift and pumping), under particular conditions, in order to ensure continuity in the production of wells.

The great salinity of produced water and the salt depositing which could appear at the bottom of the wells and in the tubing are the principal concerns for which it is necessary to face to ensure a good production of these fields. The high salinities (360 to 380 g/l) exist in Triassic reservoir on the nearby fields of Hassi – Messaoud (El-Gassi, Haoud- Berkaoui, NGoussa…). The low salinities of 150 g/l, for example, are encountered on the Carboniferous in Zarzaitine field (Illizi basin). So, actions to prevent salt problems would be different, for different salty water concentration.

The GOR from the Triassic reservoir is relatively high and the quantities of produced gas are important. This factor must be considered in the choice of artificial lift system.

I was interested, in this paper, in the fields of Block 438 B (see map - Fig.1), for which the final choice of assisted production system is not yet fixed. These fields, scattered over an area of 4365 km², must be fully assisted in a time not exceeding six years after their first commissioning.
According to reservoirs studies, only the third of production of these fields will be produced by natural flowing. The remaining reserves will be produced by artificial lift for at least 20 years. The choice of artificial lift system (gaslift or pumping) is very important to insure the maximum of oil recovery.

2. Treatment of the salt deposits:

For the salinity of about 360/380 g /l, the recourse to injections of chemical products and dilution water are necessary to prevent the salt from depositing in the bottom hole and at the production tubing. For this level of salinity, the dilution water injection must be continuous in the majority of the cases.
In the case of good producing wells, with high basic pressures, there are no risks of drown of the well by dilution water, or stopping of its production. On the other hand, if the well is on the limit of its natural flowing, in the absence of an assisted production, any excess of dilution water can cause the shutdown of the well.

3. Production assisted by artificial lift:

When the two type of artificial lift (gaslift and pumping) are possible, the technical and economic comparison must be conducted to get the best choice.
For the specific case concerned - production of salty and gassy oil - what is better to use to maintain the continuity of production?

4. Completion of the wells with gaslift and dilution water:

This is a real case, and which is related to some oil fields in Algeria. The wells are eruptive, but, when the reservoir pressure decrease and water cut increase, the pressures at the wellhead quickly become not enough to ensure the transport of the fluids from the wellhead to the treatment unit. The wells are thus gas lifted and a continuous fresh water injection is maintained in the bottom hole. <u>I considered, in this paper, only the dilution water and its effect on the salt formation process.</u>

<u>Two kinds of completion are possible</u>:

- The dilution water is injected through macaroni 1.66 in, placed inside the production tubing. The casing is used for the gaslift (fig.1).
- The gas for the gaslift is injected through macaroni 1.66 in, outside the production tubing and the casing is used for dilution water (fig.2).

The first type of completion doesn't give the ideal choice for gas lifted wells. Presence of the macaroni inside the tubing, impeaches the access of the gaslift valves and reduce the tubing size. Pull the macaroni, each time, for the operations on the valve is not economic. This completion is generally employed in natural flowing well.

In spite of difficulty of the second type of completion, this figure represents the best choice in this kind of situation.
The characteristic of this completion is to maintain the water injection through a valve activated by the gas pressure. In the event of a stop of the gaslift, the valve is closed and the water injection stops. So, there is no risk to kill the well by the excess of dilution water injection.

By using the casing for the dilution water injection, we ensure the counter pressure in the annulus to avoid any collapse of the casing. In some fields, the existence of high pressure layer at 2800 m deep, called Horizon B with around 580 bar of pressure, can cause the damage of the casing, in case of bad cementing and/or corrosion. If the annulus is used for the gaslift, the pressure of the gas, when the well stops, could not be sufficient to balance this probable high pressure behind the casing. Real cases of collapse due to this pressure were observed. The cementing of casing and their uses has been deeply reconsidered.

Fig.2- Dilution water through the 1.66 in

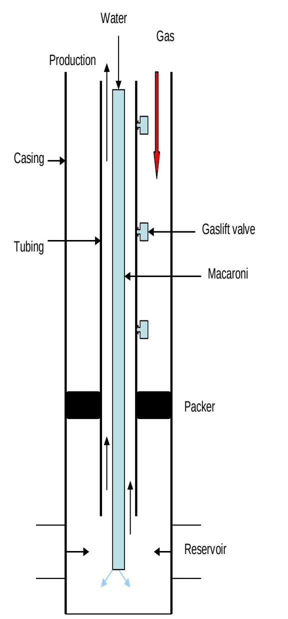
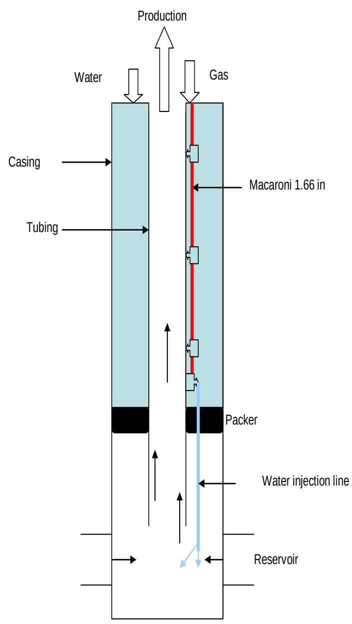


Fig.1- dilution water through the casing



5. **ESP completion**:

a- Free completion:

By using the ESP to produce the well, the annulus remains open to the fluid coming from the reservoir.
Due to the high GLR, the gas separated before the pump intake is vented in the annulus. This gas must be recovered in the surface.
Protection of the casing against the corrosion is not insured and this situation increases the risk associated with the horizon B, described above.
In addition, to ensure the injection of the dilution water, a double completion of the well should be necessary. In this case, the dimensions of the casing must be sufficient to ensure this type of completion.

b- Completion with packer:

By using the packer, annulus is protected and can be used for water injection.
Since the bottom hole pressure is lower than the bubble pressure, new equipment, such as gas handling system must be used. The multiphase pump will be the sole solution in this case[2].

6. The shutdown of the well - consequences:

In case of natural flowing and small water cut, the stopping of the well doesn't cause salt depositing in the bottom hole or in the tubing. The conditions of these deposits are not met.
In fact, the salt crystallization could appear under flow conditions. With the drop in temperature during production, salt dissolved in the water, gradually separates and forms crystals that will settle to the perforations. The natural production decline when water cut increases, and stops at certain level.

Example of Well's performance versus water cut: (N'goussa well)

Conditions:

- Reservoir Triassic
- Perforations: 3600 m
- Tubing $3^{1/2}$
- Reservoir pressure: 180 bar
- Reservoir temperature: 108 °C
- GOR: 376 m3/m3
- Water cut: 60%
- Liquid rate: 900 barrel/day

After simulation, using pipesim software, it's easy to see that the level of liquid in the well is at -900 meters for 60 % of wcut and near the surface for wcut 45%. The well cannot produce without an artificial lift in these conditions.

7. Salt characteristics:

The type of salt is Nacl.
For this kind of salt, it is known:
Tab.1

Temperature (°C)	solubility (g/l)
80	384
50	366
40	363
30	360
20	359

8. What is happening in the well?

a- It's observed in the site[3], when the continuous injection of dilution water is stopped on the producing wells, the salt deposit in the tubing appears in the few hours and production declines. To avoid the total plugging of the well, the gaslift is stopped and some fresh water is injected inside the tubing to dissolve the salt. The well will be restarted, only, when the problem of dilution water is resolved.

b- When the gaslift is stopped, the flow stops, the temperature inside the well decrease and can reach critical temperature of solubility. Depending on the static level inside the well, the conditions could be favourable for the salt to form in the top of liquid level. The separation of water from the oil is not sufficient to destroy totally the emulsion. Some quantity of water remains in the oil at higher level in the well and the salt start to crystallize. These deposits may become increasingly important with the duration of the shutdown and variation of temperature.
The salt formed rushes to the bottom hole. The re-starting of the gas lifted wells doesn't pose problems.

c- There is no well equipped with an ESP pump in this site, but the following approach may be advanced: When the conditions of paragraph (b) are met, the crystals falling to the bottom of the well are caught by the pump and may cause damage to the restart.

The wells equipped with ESP could be more vulnerable to salt deposits.
Even in the case of non stop pumping, the ESP pump is under risk. An uncontrolled shutdown of dilution water injection may be fatal, because of the quickly salt formation and plugging of tubing.

Remark: normally, if the dilution water is stopped simultaneously with the production of the well, water in the tubing may be at a low concentration. We will be, in this condition, outside the salt crystallization range.

9. Risks assessment:

For both types of lift, production losses can be caused by the salt deposits. The reasons leading to these deposits have been mentioned above.
If for the gaslift the risk is not high to intervene in the well, it is not the same for pumps.
Thus, it's necessary to consider the potential risks and found the solutions to avoid them.

Gas lock risk:

Situation of existing oilfields after 6 years of production:
Reservoirs' bubble pressure (183 to 220 barg)

Tab.2- block 438 B fields' information
(Sonatrach/CNPC source)

Fields	GOR m3/m3	Wcut %	quantity of gas m3/d/well
NGS	220	13	20800
GLNE	170	0.70	18800
BHT	170	0.00	25500
HEB	167	11.5	17300
KG	246	38	14200
MEL	156	0.00	14000

Average oil production per well = 600 to 1000 bopd

The gaslift or the pumping is, after 6 years, normally generalized in the totality of fields.

For ESP completion, it's necessary to integrate the separator before the pump. At 90 % of separator efficiency, the quantities of gas vented in the annulus remain important and the volume passing through the pump is high (around 21 %).
There is a warning for the gas lock and the efficiency of the pump is only 48.8 %.
We can observe, through the table above, for the main 3 fields (NGS, GLNE and BHT), that the risk of gas lock is real. Is expected that the separator efficiency will be good, but the gap is too tight.

Salt deposit:

The solution to avoid the gas lock could be found by using the gas handling system (see 6 b), but there is no way for the salt problem.
It would not be possible to divert the eyes from the pump operating indicators in the wells.
This requires a lot of resources and sophisticated instruments, for not guaranteed results.

Some solutions can be proposed for salt deposit:

- Insure the continuous dilution water injection by the redundancy of principal equipments, such as the injection pumps.
- Stop the ESP in case of dilution water shutdown (to avoid pump destroying).
- Stop the Gaslift in case of dilution water shutdown (to avoid the tubing cleaning).

✓ Its important to note here, that the slick line salt scratching and water flushing of the tubing are not possible in case of ESP use, for evident reasons.

Note 1- see figure 3
Note 2- take into account the cost of this equipment
Note 3- Berkaoui Fields

10. Gaslift and pumping comparison for the mentioned existing fields:

Gaslift system:

The associated gas produced with oil is used, after treatment, for the gaslift. Excess gas is routed to a gas treatment plant to recover GPL, Condensate and Dry gas.
For the average of 400 to 500 000 sm3/d of gas necessary for the gaslift (20 wells), 2+1 compressors (250 000 sm3/d each) and high pressure network (120 bar) will be installed.
Gaslift system must be conceived in such manner to minimize the cost of equipments and gas network.

ESP system:

The mechanical equipments for the gaslift are replaced by electrical equipments for ESP and gas network by electrical lines. The parameters of pumps must be continually monitored and displayed in the control room.
The presence of operators, on the wellhead, would be often necessary. In the desert, that will not be easy.
Due to gas lock and salt deposit possibilities, the risk of pumps shutdown is high. The production losses must be estimated as well as the Operating cost.

11. Economic aspect:

The question arises on the comparison of cost of the surface facilities necessary to the gaslift and the pumping.
The goal of the operator is to build the facilities at lower cost and which it would respect the required quality of the product as well as the safe operability.
In addition to CAPEX, the difficulties of operations on the wells and their frequencies have to be estimated.
Therefore, the choice of one or other of systems, in terms of cost can be fixed.

However, by envisaging flexibility and to avoid the operating problems, the system providing the best level to production safety must be chosen. For some choice, the initial cost would maybe higher in term of equipment and construction; but, the investment granted for the equipments and construction will be easily recovered while keeping, under the production, the wells which could be frequently stopped.

12. Conclusion and recommendations

By this example I would like to highlight the necessity to consider, for the design of the surface facilities, particularly, the constraints related to the activities of the wells and their exceptions. If the main parameters, such as the reservoir and wellhead pressures and temperatures, the production profile of the different fluids, the fluids' characteristics (PVT data), are considered for the facilities design, some elements such as salt and paraffin are neglected and their effects on the design of the treatment unit are not taking into account. In more of the cases we make the effort to eliminate these elements inside the treatment unit without really thinking of the actions to take in the upstream.
The surface facilities, the wells and the reservoir are an integrated system which must deeply be considered as it is. It is thus necessary to study the impact of each element of the system, in the whole arrangement, before fixing the final philosophy of the facilities.

According to what is demonstrated above, for the salty oil environment considered, it's recommended to use the gaslift in such kind of wells. ESP can be used, but the operating costs and production losses will certainly be important. When the gaslift* benefit is not known, the use of pump seems to be the solution. The services companies and pumps manufacturers will be happy to find you attractive solutions. It can be successful or maybe no, but how much money you will pay for the continuous monitoring and the maintenance?

- * The gaslift is used in lot of oil fields in Algeria, for more than 50 years.

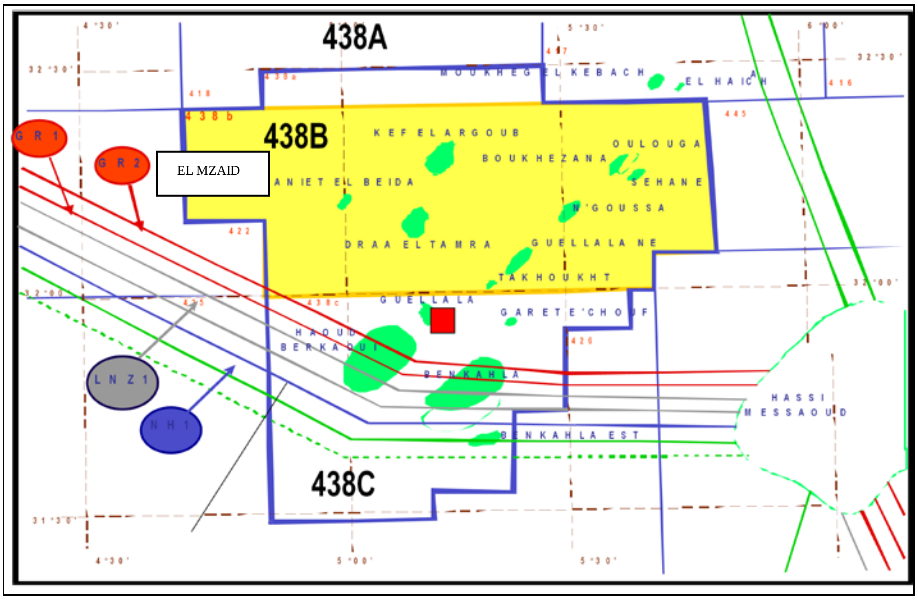


Fig.3: El-Mzaid location (Sonatrach/CNPC source)