

Underbalance well completion - a modern approach for mature gas fields

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Abstract: The exploitation of natural gas fields from Transylvanian Basin started a century ago. The majority of these fields were discovered and developed in the last century, from 1950 to 1970. So, these reservoirs have over 50 years of production historical. These are mature fields with a very low reservoir pressure. Now, for some of these reservoirs the pressure is 10 – 20 % of initial values. The biggest challenge for a production company is to make completions and recompletions in depleted reservoirs wells. At the beginning was not a problem to do a workover in these wells because the completion fluids were lost in the reservoir and the pressure helped the wells to clean up. Now, because the reservoir pressure is very low, it takes time for well to be cleaned. From time to time, some net pays have to be bypassed because the fluid can be lost in the reservoir. So the best method to do recompletion works in these wells is to work underbalance or even with the well under pressure. This paper presents some of the technologies used by Romgaz to accomplish this goal.

1 Introduction

Romgaz operates mainly in the natural gas mature fields located mostly in the Transylvanian Basin. There are reservoirs which are producing from over one century. In present, some of these reservoirs have dropped the pressure to 10 – 20 % of initial values.

These reservoirs are producing using natural gas elastic drive mechanism. Reservoir history matching shows us that once these fields are put in production, the pressure is dropping irreversibly. This phenomenon can be described by the so-called natural decline pressure curve.

In these depleted fields, the overbalanced workovers at higher pressures can lead to undesirable phenomena such as completion fluid invasion near the wellbore zone. In turn, this can lead to a drop in the well productivity and can produce even well blocking.

Conventionally gas wells are drilled, cased and cemented using fluids with high density, $\rho > 1 \text{ kg/m}^3$, which because of their weight generate a hydrostatical pressure higher than the pressure of porous-permeable media. This phenomenon is called overbalance.

Working overbalance is a safety measure in well completion. This prevents technical accidents, like eruptions. But this safety measures must take in consideration the actual reservoir conditions not the initial ones.

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Over time there were studied and tested the possibilities of avoiding and minimizing as much as possible the formation damage phenomenon due to reservoir contamination with various types of fluids in balance or underbalance conditions.

In the green fields the invasion phenomenon is not too accentuated and normally the wells could clean up from the undesirable fluid contamination in short time.

In mature fields things look much different. Besides reservoir contamination are present partial and total loses in the reservoir which can lead to formation damage. So to avoid these situations, the state – of – the art technology offers solutions for every type of workover. If there are needed completion fluids these could contain bridging elements which can avoid or reduced reservoir losses. Perforating operations are mostly made in balance or underbalance conditions, even with empty well, for avoiding salt water or completion fluids to flood the perforations. Tubing handling can be done with well under pressure, so the perforated area is not possible to be damaged by various fluids types. Partly reservoir abandonment can be achieved by introducing expandable plugs trough the tubing with well under pressure.

Taking this into account, the company' specialists have to use the last technologies applied to mature fields. So in many cases, the operations during workover are made at balance conditions taking in consideration the actual reservoir pressure if it is necessary to kill the well. In this case to minimize productive layer contamination most often is used filtered reservoir salt water or completion fluid.

2 Underbalance well completion alternative solution for traditional well completion

2.1 Snubbing unit

Science people invented equipment for tubing handling under pressure, in order to eliminate any productive layer contamination with different type of fluids. This equipment is called “snubbing unit” which can perform tubing handling without killing the well.

The equipment is provided with a blowout preventer system which seals the tubing and a hydraulic system which permits lifting and lowering the tubing string in well (see fig. 1 and 2).

Unfortunately this unit cannot perform the operation in wells with any type of wellhead. It can be used only on wells with API Christmas Tree (oil type). The workover under pressure is not possible for non API Christmas Tree (gas type) because the tubing is screwed in tubing hanger so you the wellhead must be lifted and rotated if the tubing must be lifted up.



Fig. 1. Snubbing unit working in the field

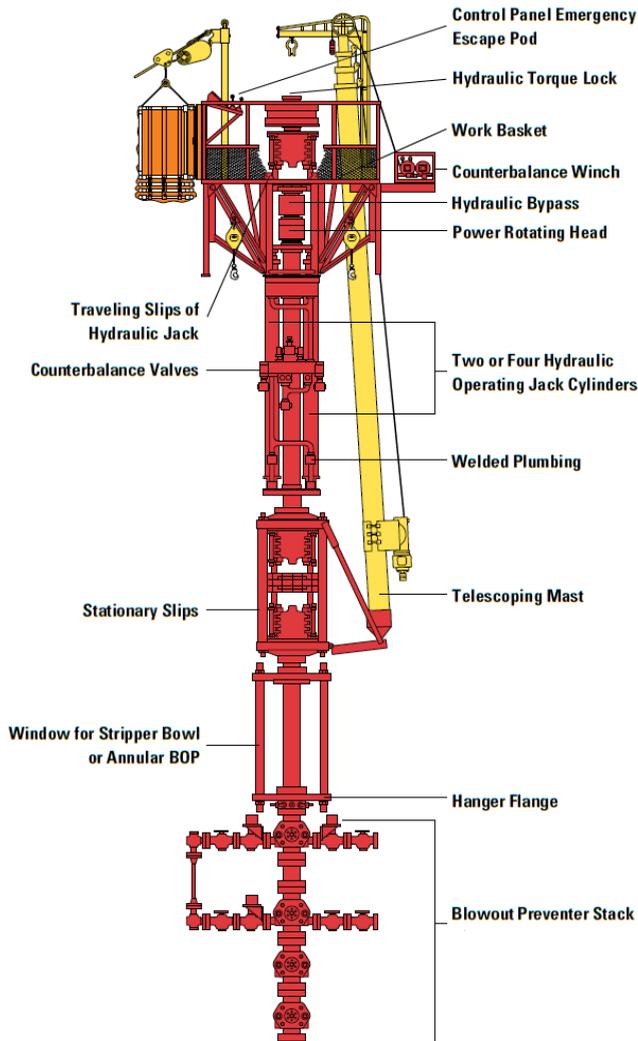


Fig. 2. Snubbing unit scheme

The snubbing unit can perform the operation of repositioning the tubing in well (pull out from the perforated zone or run in the perforated zone), with the well still under pressure, by setting up a plug in tubing. After the tubing is out from the perforations zone it is possible to perform cased hole logging operations like PLT, thermometry or throughout tubing perforation jobs.

The snubbing unit can perform also the following operations: tubing pulling out of the hole, underbalance deep penetration perforation or casing logs as MIT or RBT.

After the desired operations are performed the snubbing unit is used to reinsert the tubing back into the well with the well under pressure and if is needed can be used to introduce tubing strings together with a packer which can be set up.

Romgaz performed all these operations with the snubbing unit in different situations.

So, there were performed the following operations like tubing repositioning like tubing run in hole for a better liquid unloading and tubing pulling out from the bottom of perforations zone to an upper zone for a better communication between top perforations and tubing.

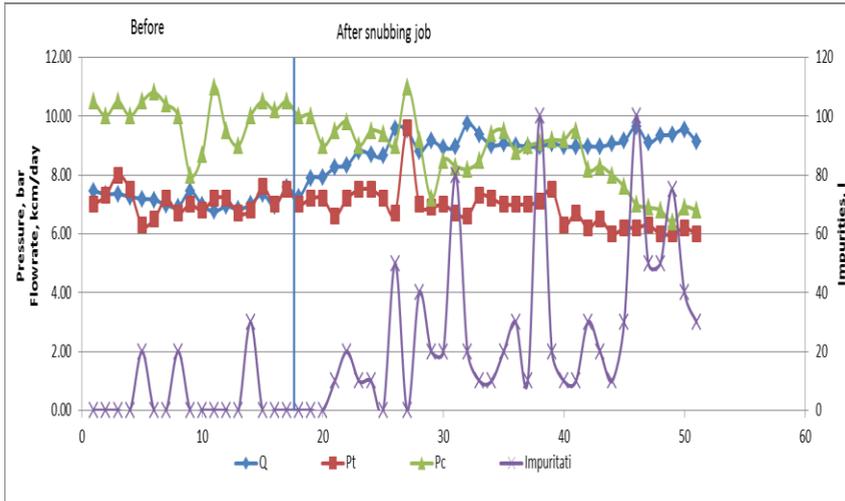


Fig. 3. Production behavior of a well before and after the snubbing job

Chart 3 presents the production behaviour of a well which had the tubing set up with 50 m above the top of perforations and a perforated interval of 100 m. After analysing we decided to introduce the tubing in the middle of the perforated area for a better unloading of the liquids accumulated in the wellbore. The presence of these liquids are lowering the well productivity. After the tubing was set in the perforations zone there were a gain 3 kcm/day and the well was lifting the reservoir water by itself.

Chart 4 presents another example of production evaluation for well were have been performed several operations. First the tubing string was pulled over the perforations and the well was reperforated underbalanced with 2” guns. After this job, we observed that the flowrate has been doubled from 2 ksm/day to 4 ksm/day. Because we consider that this job was not a real success, we decided to pull out of the hole the entire tubing string and we have reperforated this well with 4” deep penetration casing guns. After the reeperoration job, we obtain an 11 ksm/day flowrate.

The main advantage for all these performed operations was the possibility of handling the tubing under pressure so the introduction of fluids, in order to kill the well, was no longer necessary.

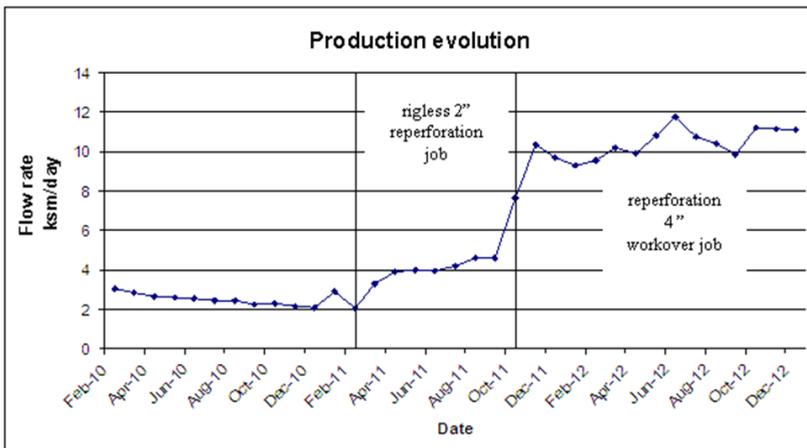


Fig. 4. The production behavior for a reperforated well using the snubbing unit

2.2 Underbalance perforation

If in the past all the perforation operations were performed with the well filled up with fluid, now sealing systems are developed allowing performing underbalance or even with empty well perforation jobs.

There are several advantages for underbalance perforation such as:

- Avoiding the phenomenon of fluid invasion near wellbore zone;
- Less time spent for well testing or well set up into production;
- Less time = lower operational / job costs.

To perform the underbalance perforating operations are taking safety measures such as:

- If it is planned to do a perforation job with deep penetration guns like 3 3/8" or 4" guns it is necessary to set up a 7" safety valve upper the tubing-hanger;
- Above this valve it will be set up the pressure retriever string, wireline blow out preventer and / or other safety devices;
- If it is planned to do a trough tubing perforation job then on top of the Christmas tree it will be set up the pressure retriever string, wireline blow out preventer and / or other safety devices.

Using these safety measures there could be performed perforating or re-perforating operations with the well under pressure. In recent years there are performing more often these types of operations due to mature reservoir conditions.

2.3 Water shut off

Since the investigations regarding the actual fluid saturation in the open hole for most of the wells in mature fields are not updated and so accuracy is not very high, there can be situations after the perforation job to open accidentally a depleted or water flooded layer. Such situations can happen and they can be solved by performing different investigations like thermometry or production logs to see the water influx.

After these logging operation were performed there were took measures for closing (isolating) the opened aquifers and putt the well back in production.

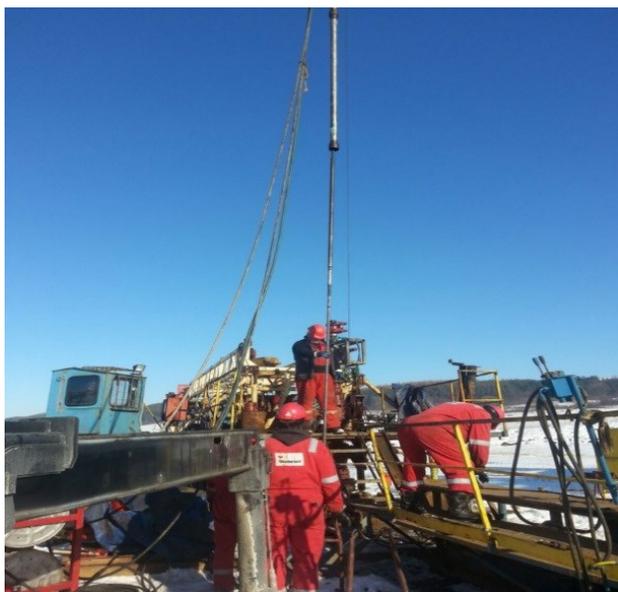


Fig. 5. Rigless underbalance perforation job

There are many solutions to solve this type of issues but doing this job with the well under pressure is a challenge. It depends from where the water is coming. If it is coming from the lower zones, one good option is to set up a non-retrievable trough tubing inflatable plug with the mention that it is very difficult to do a reentry for the lower part of the well. For the upper zones a good option is to set up a packer or a casing patch to isolate the water influx.

As follow we present one case where a well was perforated underbalanced 70 m split in 4 intervals. After these layers were opened there were recorded a gas influx and large quantities of water. It was performed a thermometry which shows that there is a big water influx from the lower part. (see results in picture 6)

This well had an opened interval between 1090 and 1230 m and the reservoir pressure was 16 bar. So we decided to do an underbalance water shut off job using a trough tubing inflatable plug to avoid other water loses in the productive layers. The whole job finished in 5 days (setting up the plug and putting 2 times a quantity of cement above the plug).

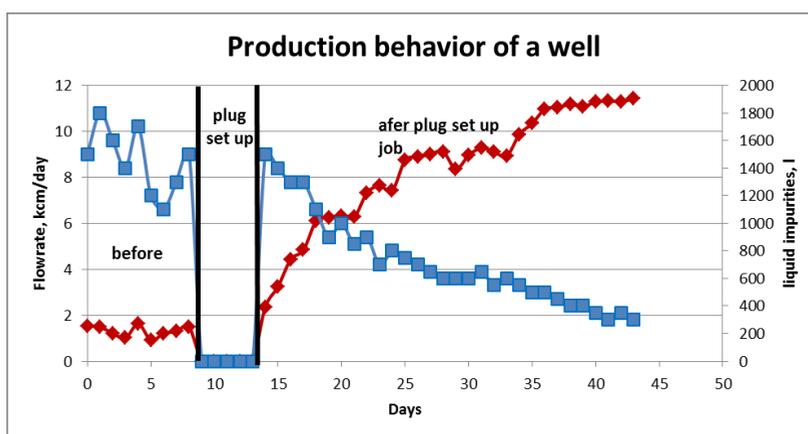


Fig. 6. Production behavior of a well were a water shut off was performed

These operations were successful and currently the well is producing with a flow of 11 kmc/day and 300 liters salt water/day. The results can be seen in chart 6 were presented the values recorded before and after the water shut off job.

3 Conclusions

In Transylvanian Basin are several major mature reservoirs. In these fields is better to apply the underbalance completion technology instead the traditional completion technology to avoid formation damage and to improve flow conditions as much as possible.

Especially in mature fields it is preferable to perform the underbalance completion because compared to a traditional workover it takes less times for the well to clean up.

Working underbalance in this type of reservoirs is mandatory because in most cases killing fluids are hard to recover and it can take months for the flow rate to reach the same value as it was before the workover involving high costs operations like nitrogen kick off and coil tubing jobs.

Learning from our experience performing these types of operations in mature fields we suggest to run a saturation log before a re-perforation job or adding new perforations in the wells where this operation are possible.

As we have seen, performing snubbing operations is not a major risk for well abandonment. In most of the cases, these types of operations help us to maintain or increase the production.

In the future, we will continue to perform underbalance jobs in the rehabilitation process.

The big advantage is that we can optimize the production rate, minimizing the formation damage and maximizing the recovery reserves. Using this technology the wellbore is isolated from undesired flow of water which can be easily controlled.

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