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Hydraulic Fracturing Program for an Oil Well from the Pannonian Depression

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Abstract

In the paper it is described a complete program of hydraulic fracturing applied for an oil well from the Pannonian Depression:

- *selection of the fracturing fluid;*
- *selection of the proppant;*
- *operation program;*
- *required materials and equipments.*

Key words: *hydraulic fracturing, oil, well*

Introduction

In the structure there were revealed oil and associated gas reservoirs in Sarmatian and in Pannonian „d".

Sarmatian – the most important horizon from the structure is composed from limestone. It has a good storage and flow capacity for hydrocarbons.

Pannonian – is composed from shaly limestone. It has a good storage capacity (porosity = 22,1%), but the permeability is low (1,2 md) and flow capacity for hydrocarbons is not good.

In order to improve the wells productivity from Pannonian „d", there were performed more than 30 hydraulic fracturing and and 50 acidizing operations, both when putting into production and during production.

After hydraulic fracturing operations analysis it was observed that about 80% were successful, the average production gain is 1 t/d, for a medium period of 2 years.

The acid treatments have eliminated the tubing scale.

From production history it was remarked that there were performed hydraulic fracturing operations in most of the wells from Pannonian d (excepting well 4) and there were carried out one or more acid treatments in most of the wells from Pannonian d.

In order to improve the wells productivity from Pannonian „d", it is proposed to apply in the future new solutions (eventually closing the old fissures and creating new ones gel based), for the purpose of increasing the oil flow rate for longer periods of time. It is planned also to continue the current acid treatments.

The cost of a hydraulic fracturing operation with 28 tonnes of proppant Jordan 12/20 Mesh and 170 cm of gel (fluid based polymer) is about 134 000 Euros. The operation assures a maximum production of 1.8 cm/d and after one year a minimum production of 1.3 cm/d.

In the paper is presented a hydraulic fracturing program proposal for the well 4.

Hydraulic fracturing program with reverse emulsion acid fluid and C-lite 16/20 Mesh proppant

Well data

Perforations = 928-942 m, Pannonian d;

Production = 1.96 x 88.1% = 0.19 t.

Preparing the well for frac

- Milling cutter + rotovert run.
- Multifinger logging for casing inspection.
- Reperforating the interval 942-928 m with Big Hole device.
- Optional well testing in order to evaluate reservoir pressure, effective permeability and skin factor for the purpose of optimizing the frac job.
- During workover it will be verified the casing seal to the head and the 5½ in casing pressure test.

Hydraulic fracturing program

Selection of the fracturing fluid

The fracturing fluid must create a large enough fissure to facilitate proppant introduction and should not block the formation. Because the reservoir rock is a shaly limestone it was selected a reverse acid emulsion fluid 15% RomFrac.

Selection of the proppant

The proppant is required to overlay the fissure closing pressure and to have a sufficient permeability so as to generate a high fissure conductivity at fissure closing pressure. As proppant it was picked C-lite 16/20.

Operation program

1. ***Well completion***

The well is equipped with $2^{7/8}$ in or 3½ in tubing and packer set at 900 m depth.

2. ***Necessary fluids preparation***

- It is prepared 30 cm of operation fluid of the following composition:
  - reservoir water…………………………………………………995 litres;

- Ecostim……………………………………………………..……5 litres;
- KCl……………………………………………………………….50 kg.

o It is prepared 150 cm of reverse acid emulsion fluid 15% of the following composition:

- oil……………………………………………………………300 litres;
- Pekamid……………………………………………………...…5 litres;
- acid solution 15% HCl………………………………………695 litres.

The composition of the acid solution 15% HCl + 5% KCl is:

- reservoir water………………………………………………555 litres;
- KCl…………………………………………………………..…27.8 kg;
- Cronox 42………………………………………………………5 litres;
- HCl…………………………………………………..……440 litres;
- citric acid…………………………………...……………..30 kg.

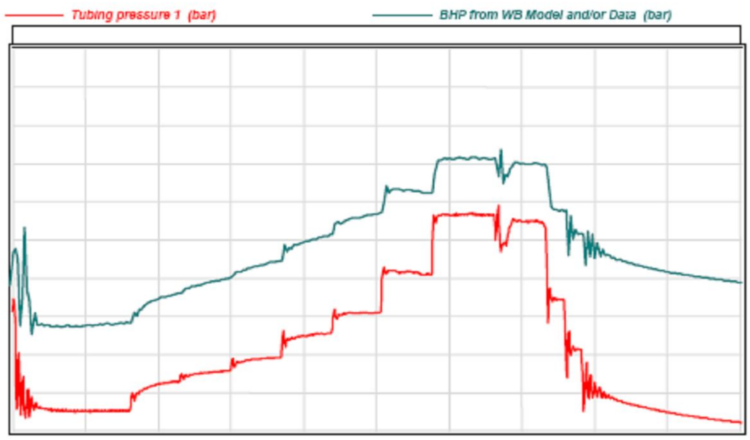

Fig. 1. Pressure variation.

Table 1. The pumping operation fluid flow rate program for step the variation test.

Step description	Fluid description	Injection flow rate (l/min)	Injection time (s)	Planned volume (cm)	Total planned volume (cm)
Rate 1	Operation fluid	200	60	0.2	0.2
Rate 2	Operation fluid	300	60	0.3	0.5
Rate 3	Operation fluid	400	60	0.4	0.9
Rate 4	Operation fluid	500	30	0.25	1.15
Rate 5	Operation fluid	600	30	0.3	1.45
Rate 6	Operation fluid	700	30	0.35	1.8
Rate 7	Operation fluid	900	30	0.45	2.25
Rate 8	Operation fluid	1100	30	0.55	2.8
Rate 9	Operation fluid	1300	30	0.65	3.45
Rate 10	Operation fluid	1500	30	0.75	4.2
Rate 11	Operation fluid	1700	30	0.85	5.05
Rate 12	Operation fluid	1900	30	0.95	6
Rate 13	Operation fluid	2500	20	0.65	6.65
Rate 14	Operation fluid	1500	20	0.5	7.15
Rate 15	Operation fluid	1000	20	0.33	7.48
Rate 16	Operation fluid	500	20	0.16	7.64

3. Flow rate step variation test and minifrac analysis

- Flow rate step variation test

The step up test should be performed before hydraulic fracturing with the aim of establishing the fissure closing pressure and the fissure extension pressure.

The step down test is designed with the purpose of evaluating the well bore friction.

- Minifrac analysis

The minifrac analysis ought to be executed before hydraulic fracturing to ascertain the following parameters:

- fissure closing pressure;
- fluid efficiency;
- stress profile and fissure geometry, for adjusting of the net pressure;
- formation reaction at the injection of the proppant plug.

Table 2. The pumping operation fluid flow rate program for minifrac.

Step description	Fluid description	Planned volume (cm)	Proppant ratio (kg/cm)	Injection flow rate (l/min)
Minifrac				
Tubing filling	SXE 15%	3		2500
PAD1	SXE 15%	6		2500
Proppant plug	SXE 15%	5	200	2500
PAD2	SXE 15%	6		2500
Displacement	SXE 15%	3		2500

After pumping the operation fluid at minifrac it is waited the fissure closing and the pressure decline is recorded. After decline data analysis the operation is designed again with new data.

4. Pumping execution program

Table 3. The pumping mainfrac execution program.

Fluid description	Injected volume (cm)	Injection flow rate (l/min)	Proppant type	Proppant ratio (kg/cm)	Proppant injected per step (t)
SXE 15%	25	2500	-	0	
SXE 15%	10	2500	C-lite 16/20	100	1
SXE 15%	17	2500	C-lite 16/20	200	3.4
SXE 15%	22	2500	C-lite 16/20	300	6.6
SXE 15%	10	2500	C-lite 16/20	400	4
SXE 15%	2.5	2500	-	-	-

Total proppant injected = 15 tonnes C-lite 16/20 Mesh injected at mainfrac + 1 tonne C-lite 16/20 Mesh injected at minifrac = 16 tonnes C-lite 16/20 Mesh.

Table 4. Average operation hydraulic parameters

Injection flow rate, (l/min)	2500
Bottom hole fracturing pressure, (bar)	237
Friction losses, (bar)	299
Medium pumping pressure, (bar)	215
Maximum pumping pressure, (bar)	450
Necessary hydraulic power, (HP)	2464
Maximum differential pressure on packer (P casing=80 bar), (bar)	69

Table 5. Fissure parameters at 928 meters

Fissure sustained length, (m)	21
Fissure height at operation end, (m)	31
Superior limit of the created fissure, (m)	909
Inferior limit of the created fissure, (m)	940
Medium width of the sustained fissure, (mm)	7
Net fissure pressure at operation end (BHP-P horizontal stress), (bar)	67
Hydraulic efficiency of the operation (fissure volume/pumped volume)	0.2
Medium conductivity, (md*m)	2380
Non-dimensional medium conductivity	100
Estimated shut down time, (min)	6.4

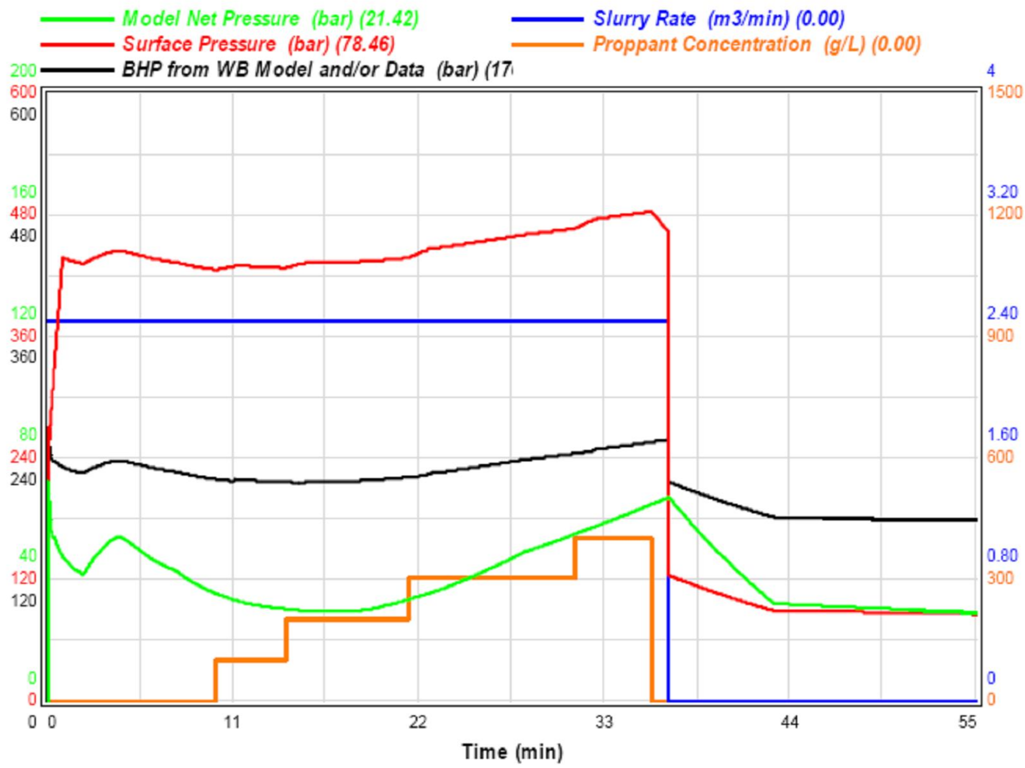

Fig. 2. Hydraulic parameters of the operation.

5. *Fissure geometry*

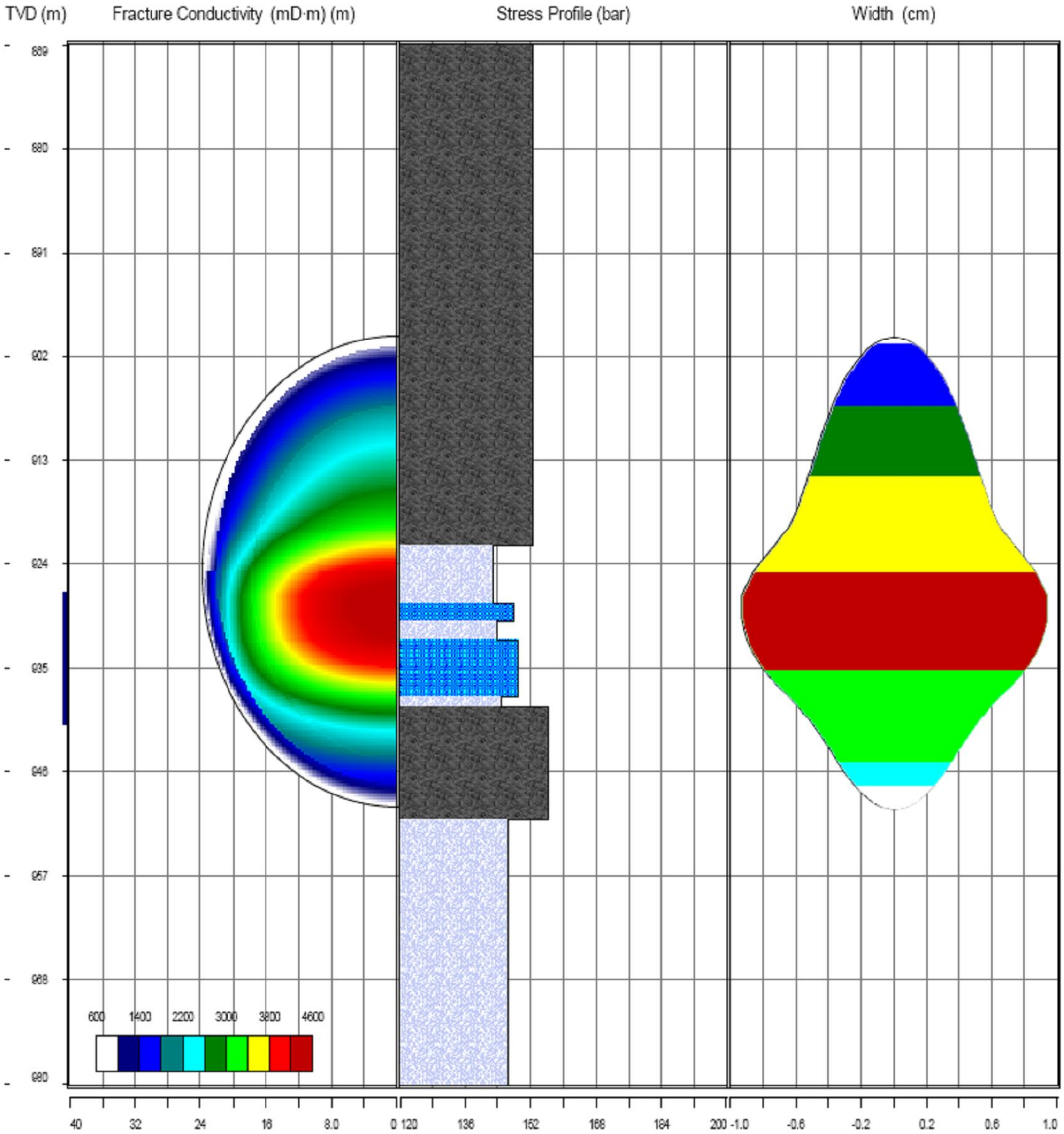

Fig. 3. Fissure geometry.

6. Production evolution

- Production evolution without fracking

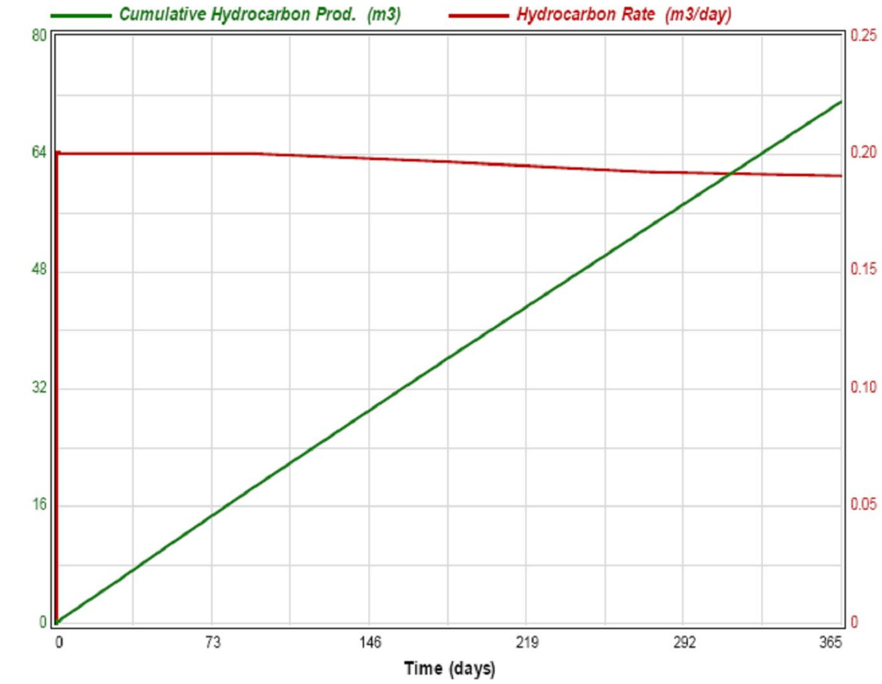

Fig. 4. Production evolution without fracking.

- Production evolution after fracking

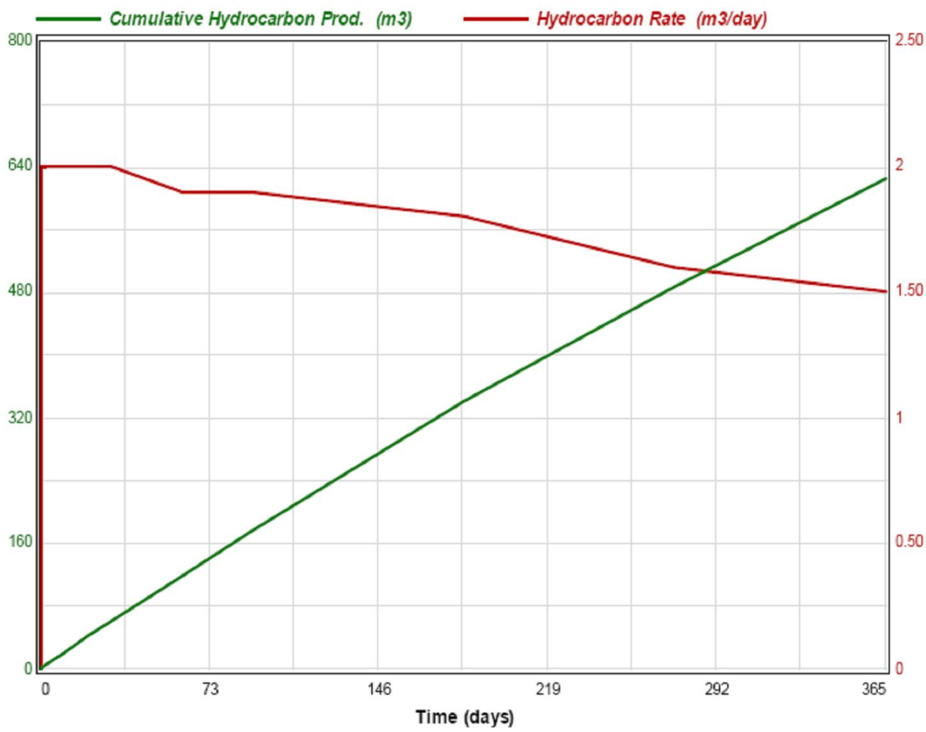

Figure 5. Production evolution after fracking.

Required materials and equipments

1. ***Materials required***
   - Operation fluid……………………………………………….………30 cm;
   - Gel type transportation fluid………………………...…...……150 cm;
   - Proppant C-lite 16/20 Mesh ……………..……18 tonnes+2 tonnes spare.
2. ***Sumps required***
   - 30 cm each for transportation fluid…………………………………5 pcs;
   - 30 cm for non-filtered water…………………………...………1 piece.
3. ***Equipments required***
   - 2000 HP pump……………………………………….……..……2 pcs;
   - Preparation fluid and pump feed blender……………….…..……1 piece;
   - Blender feed pump……………….…..…………………….....…1 piece;
   - 55 tonnes capacity truck……….……….…..……….....…………......…1 piece;
   - Data acquisition cab…….……….…..……….........…………......…1 piece;
   - Pumping unit ACF 700 for casing back pressure…….……......…1 piece;
   - Water filtration unit……………………………….……......…1 piece;
   - Non-filtered reservoir water transportation carload…………..…...3 pcs;
   - Materials transportation vehicle……………………………..…1 piece.

References

1. Grigoraş, I.D. et al.: *Actualizare sudiu de fezabilitate a exploatării şi evaluare a potenţialului tehnologiilor alternative de exploatare (IOR şi EOR) pentru un zăcământ comercial din Depresiunea Pannonică*, Ploieşti, octombrie 2008.

Program de fisurare hidraulică neutră cu susţinere pentru o sondă de ţiţei din Depresiunea Pannonică

Rezumat

În lucrare se descrie un program complet de fisurare hidraulică neutră cu susţinere pentru o sondă de ţiţei din Depresiunea Pannonică care cuprinde:

- *alegerea fluidului de fisurare;*
- *alegerea materialului de susţinere;*
- *program de operare;*
- *materiale şi utilaje necesare.*