Interpretation of a well interference test at the Hamzeh Oil Field

Dr. Mehaysen Ahmed Mahasneh

Abstract—Production in the liquid-dominated Hamzeh Oil field is moderately from a fractured blocks composed of Cenomanian and Turonian formation. The horst block which contains wells A,B, in Shueib Formation. The parameters reservoir data indicate a possibility of linear-flow geometry on a field, from the bottom hole build up and draw down which done in previously time. This was confirmed by re-analyzing the results of a well interference test performed in 1986. linear-flow models were used in this processes and wells were indicated that a linear model fitted the interference test data significantly and estimation of the Hamzeh Oil Filed reservoir. The results of interference test between well A and well B through Shueib Formation indicates good communication between the two wells ,due to the good reservoir properties.

Index Terms—horst block ,well interference , Shueib communication , piezo conductivity

I. INTRODUCTION

Interference test (Matthews and Russell,1967) [1] and pulse testing (Johnson et al ,1966 [2];Brigham, 1970)[3] require two wells :the tested well and the responding well. Basically both tests are the same . In interference tests ,a normal constant rate drawdown is run on a well and the pressure behavior at observation well is also recorded . The mobility-thickness $kh/\mu$ and porosity-compressibility these values can be estimated from interference test in homogenous isotropic reservoirs and calculated by the normal drawdown or build up analysis homogenous anisotropic reservoirs .

Both interference and pulse tests, also known as multiple-well testing, involve more than one well. These types of tests can be used to obtain an adequate reservoir description for homogeneous (both isotropic and aniso-tropic) and heterogeneous systems. Numerical solutions must be used to analyze pressure transient data from heterogeneous systems. At the same time, it is one of the most important and useful tests to understand the well behavior in a water flood and enhanced oil recovery projects.

Interference tests are used to determine whether two or three wells are in pressure communication (i.e., in the same reservoir) and, when communication exists, to provide estimates of permeability $K$ and porosity $\Theta$ in vicinity of the tested well. Convenient analysis techniques for interference tests are the use of type curves. These type curves, presented by Earlougher [4] which are plot of the logarithm of $p$ versus the logarithm of $t$ or $t_D$.

The objective of the study presented here is the reinterpretation of the 1986 interference test data in order to calculate the reservoir fluid-in-place, as part of a project to evaluate the feasibility of resuming commercial exploitation of the Hamzeh Oil Field.

II. STRUCTURAL GEOLOGY

Well A is located 650 m to the Northwest of Well B on a horst Block in the up thrown side of a major fault closure trending NW—SE in Azraq Basin (Egypt Interpretation1985) [5]. The combined effect of the tectonic events led to an intense structuring of fault blocks composed of Cenomanian and Turonian formation. The horst block which contains wells A, B, and C. Hydrocarbon shows are in Shueib and Hummar formations .The interested intervals were evaluated, intervals Shueib Formation(9426.31-9460.76 ft), dolomite brown, slightly hard – medium hard ,fine crystalline, porous ,sacharonidal with oil shows ,with limestone ,whitis beige –buff,compact in the lower part of Shueib , with average porosity10.96% and average water saturation 21.2%,and Hummar formation (9555.91-9578.87 ft)with average porosity 10.9 % and average water saturation 17.88 %.The analysis of porosity for both intervals which illustrate the water and Hydrocarbon content in the pore space , can be seen in the Fig.1 .

Figure 1: horst block which contains well-1, well-12 and well-14 is illustrated in the correlation between well-6, well-14 and well-5. [6]

Hummar formation reservoir limestone brownish grey-grey ,medium hard ,fine crystalline, compact ,brown ,slightly –medium hard ,fine medium partly recrystalized
III. WELL DRILLING, COMPLETION AND DEVELOPMENT

The drilling fluid used at Hamzeh was bentonite slurry treated with chrome lignosulfonates. In order to prevent wellbore, the mud was always maintained at a specific gravity of 1.10 to 1.25 and at a Marsh funnel viscosity of 40 S. Heavy circulation losses occurred when the drill bit penetrated major fracture zones. During completion, fresh water was injected into the well to wash out the drilling mud and remaining drill cuttings. The casing program for the production wells was: 59 m(20 in.) conductor, 710m depth (133/8 in.) surface casing, 2596 m depth (9 5/8 in.) production casing, and 3084 final depth (7 in.) casing was cemented in one stage with top of cement at 300 m above 9 5/8 in.) casing shoe. All casings, were cemented. the completion and capacity data for all the Hamzeh Oil Field [8].

IV. INTERFERENCE TEST

Identification of the prevalent reservoir fluid flow model is a pre-requisite for reaching a correct evaluation of well test data, and thus of fluid-in-place, and for developing drilling and field management programs. Hummar and Shuieb formations production wells (A, B, C). In this paper we describe a new interpretation of the data of the well interference test. In the original interpretation by Bourdet - Gringarten [9].

4.1. Linear-flow model

Kazemi et al[10] have been discussed under the assumption that the flow may be examined in two- dimensional flowing conditions, where gravity effects are negligible as well as the vertical pressure gradients. The validity are similar to time t0 and the distance between production and observation wells.

An evaluation of computed reservoir transmissivities and well capacities indicated that a linear model fitted the interference test data significantly better than a radial model. The linear- flow model that was developed for the Chingshui reservoir was also instrumental in obtaining an improved estimation of the geothermal fluid reserves [11].

We have developed a conceptual linear-flow model of the Shueib formation reservoir, based on the geological data of the area, from the bottom hole build up and draw down log –log analyses it is clear that the infinite acting radial flow is not existing ,and the boundary effects encountered immediately after the early time where the liner flow is dominated from the formation to the fracture. On the basis of the trend of the fractures in the production zone, a linear-flow model should more accurately represent the Shueib reservoir and the flow regime between wells.

<table>
<thead>
<tr>
<th>Time (hr)</th>
<th>Observing Well B</th>
<th>Flowing Well A</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>W.H.P psi</td>
<td>B.H.P psi</td>
</tr>
<tr>
<td>0.00</td>
<td>383</td>
<td>3726.23</td>
</tr>
<tr>
<td>24</td>
<td>380</td>
<td>37223.79</td>
</tr>
<tr>
<td>48</td>
<td>377</td>
<td>3716.47</td>
</tr>
<tr>
<td>72</td>
<td>374</td>
<td>3713.43</td>
</tr>
<tr>
<td>96</td>
<td>371</td>
<td>3710.62</td>
</tr>
<tr>
<td>120</td>
<td>366</td>
<td>3708.09</td>
</tr>
<tr>
<td>144</td>
<td>366</td>
<td>3705.76</td>
</tr>
<tr>
<td>168</td>
<td>363</td>
<td>3703.63</td>
</tr>
<tr>
<td>192</td>
<td>361</td>
<td>3701.66</td>
</tr>
<tr>
<td>216</td>
<td>360</td>
<td>3699.83</td>
</tr>
<tr>
<td>240</td>
<td>360</td>
<td>3698.15</td>
</tr>
<tr>
<td>246</td>
<td>359</td>
<td>3697.78</td>
</tr>
</tbody>
</table>

4.2. Interpretation of interference test data

During the 1986 test, well B Shueib formation was open hole tested and the plotting and interpretation of the D.S.T. data showed that the zone was highly damaged .So the interval 9423- 9439.43 ft was perforated and acidized to eliminate the damage . well started to flow through 6.5 mm and 5 mm choke,and run the Quartz Pressure Gauge to depth 9416.47 ft to observe the bottom hole pressure .

Interference test between well A flowing through 12/64 " choke) and well B Observing by Q.P.G) was carried out. The data relative to the 11-day interference test are presented in Table (1). Table 1. show the flow rate Q=310 bbl/day and the total production were 3410 bbls ,wellbore radius rw = 0.258 ft, distance between Well A and well B= 650 m ( 2133 ft ). For the 11-day interference test, the wellhead pressure, Oil production rate of flowing well A stabilized at 338 psi,and range production rate between 375 bbl/day and 305.9 bbl/day respectively. Wellhead pressures were monitored at the observation well B was stabilized at 359 psi . The results of interference test between well A and well B through Shueib formation indicates good communication between the two wells, due to the good reservoir properties ,such as permeability and porosity.

The type –curve of a producing well under constant rate conditions for a natural fractured reservoir well will have only a limited qualitative value Bourdet – Gringarten [9] , the well A( flowing well )pressure versus time data, transient interporosity flow by the Bourdet and Gringarten linear-flow solution . Fractured permeability and orientation
from unsteady – state flow. The use of a fractured-well type curve for a natural fractured reservoir well will have only a limited qualitative value and will not indicate any particular characteristics of the fractured reservoir. Bourdet and Gringarten, Da prat . . . , and et al.[9,12] have developed specific fractured reservoir type – curves for the case of a well producing under a constant rate [9 ] and another for a well producing under constant pressure drop [12 ] at the wellbore. Transient pressure in case an anisotropic permeability may be developed with sufficient accuracy. Considering the production well A and the observation well B, from the production well A a slope m is obtained from the pressure log time relationship from which the permeability results using the same data.

The general data:
flow rate \( =310 \text{ bbl/day} \)
wellbore radius \( r_w =0.258 \text{ ft} \)
distance between Well A and Well B =\( 650 \text{ m} = 2133 \text{ ft} \)

1-Log – Log plot : Matching with infinite acting reservoir with double porosity behavior . transient interporosity flow by Bourdet Gringarten :

\[
\Delta P = 10, \quad pD = 0.28 \text{ d} / \text{rD}^2 = 2 \text{ Pr D} = 4
\]

\[
\Delta P = 10
\]

\[
\Delta t = 100
\]

\[
W = 0.3
\]

\[
k = \frac{141.2 \times Q.B \times \mu}{h} \frac{\text{PD}}{\Delta P}
\]

\[
K = 109 \text{ md}
\]

\[
(\Phi V C t) F = 0.000264 \frac{\Delta K T}{\mu r^2} \frac{1}{tD^2 / rD^2}
\]

\[
(\Phi V C t) F = 1.245 \times 10^{-7}
\]

\[
(\Phi V C t) F + m = \frac{(\Phi V C t) F}{W} = 4.150 \times 10^{-7}
\]

\[
\lambda = 3 \text{ w} \cdot \frac{B r D^2}{(r / r w)^2} = 5.3 \times 10^{-8}
\]

Table. 2 Type – Curve matching using Bourdet-Gringarten,1980, our data.

<table>
<thead>
<tr>
<th>Liner flow</th>
<th>Observation Well B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Matching Point</td>
<td></td>
</tr>
<tr>
<td>PD</td>
<td>0.28</td>
</tr>
<tr>
<td>tD/rD^2 (100h)</td>
<td>2</td>
</tr>
<tr>
<td>Br D^2</td>
<td>4</td>
</tr>
<tr>
<td>Distance</td>
<td>650 m</td>
</tr>
<tr>
<td>K</td>
<td>109 md</td>
</tr>
<tr>
<td>w</td>
<td>0.3</td>
</tr>
<tr>
<td>\lambda</td>
<td>5.3 \times 10^{-8}</td>
</tr>
<tr>
<td>OCt</td>
<td>2.83 \times 10^{-7}</td>
</tr>
<tr>
<td>\Theta</td>
<td>4.85 \times 10^{-2}</td>
</tr>
</tbody>
</table>

In case \( \lambda <<10^{-6} \), which corresponds to either a very significant fracture matrix contrast in permeability or very large block dimensions.

The \( \lambda = 10^{-8} \), corresponding to a very high contrasting matrix fracture relationship indicates substantial changes in \( p_D \) during the first period of pressure drop recordings in the observation well B.

Fig. 2 Shows the match for well A (flowing well) and well B (observing well) by Q.P.G. The linear-flow type-curve matching results by Log – Log plot matching with infinite acting reservoir with double porosity behavior, Table 2 summarizes the curve matching results for all the well pairs assuming the linear flow model.

2-Semilog Plot: we have the flowing data:

\( P_c = 3726.53 \text{ PSI} \)

\( P_1 \text{ hr} = 3792.25 \text{ PSI} \)

\( m = 39 \text{ PSI/log/cycle} \)

\[
K = \frac{162.6 \times Q \cdot u \cdot B}{m \cdot h}
\]

\[
K = 114 \text{ md}
\]

\[
\Phi C t = \frac{K}{r^2 u} \text{ antilog} \left( \frac{P_1 \text{ hr} - P_c}{m} - 3.2275 \right)
\]

\[
\Phi C t = 2.83 \times 10^{-7}
\]

\[
\Phi = 4.85 \times 10^{-2}
\]

Based on the recorded pressure with log time in the observation well, the data obtained may be used as in diagram figure 3 . when the relationship pressure with \( \log t \) expresses a straight - line . Its slope \( m \) will indicate the pressure drop per time cycle 39 psi /Log/cycle as in conventional Reservoir analyses.

Evaluation of fractured permeability . Based on slope \( m \), the fracture permeability is obtained from the equation :

Where :
Interpretation of a well interference test at the Hamzeh Oil Field

$$K = 1.15 \frac{Q \mu o Bo}{2\pi h \ast m},$$

$$Q = 570.5 \text{ cm}^3/\text{sec} ,$$

$$m = 39\text{ psi/ log/cycle} ,$$

$$H = 1000 \text{ cm}$$

$$K = 112 \text{ md}$$

Figure(3) Semi log plot interference test between well B(observe well) by Q.P.G. and well A(flowing well).

Fig. 3: Semi log plot is a match with infinite acting reservoir with double porosity behavior, of the well A (flowing well) pressure versus time data, transient interporosity flow by the Bourdet and Gringarten linear-flow solution. Evaluation the piezo conductivity $a'$ . From the extrapolation of the asymptote at $\Delta P = 0$ by reading the time as shown in figure.3 it results that:

$$a' = 0.445 \frac{r^2 (\text{cm})}{tD (\text{sec.})}$$

$$a' = 12584.5$$

Evaluation of composite storage capacity $\Phi C$. Based on some equation and using $a'$, which was previously determined it results that:

$$\Phi C = \frac{K}{ua'} = 0.112$$

fracture porosity

$$\Phi = 0.042$$

Evaluation of relative storage capacity $W$ is based on the equation

$$W = \frac{\Phi_1 c_2}{(\Phi_1 c_2 + \Phi_2 c_2)}$$

Small $W$ values indicate a small storage capacity of fractures and a good storage capacity of the blocks and the behavior of the solution as a large plate of quasi-constant pressure in the transition between the early stages of production and asymptotic behavior.

The Log-Log and Semi log plot indicate that the reservoir is high conductivity vertically fractured reservoir, in a closed outer boundary system. It seems that the location of the well B is near or close to the northwest boundary of the Horst closed block. The reservoir is Heterogeneous with double porosity system. The results of interference test between well B and well A through Shueib formation indicates good communication between the two wells, due to the good reservoir properties, such as permeability and porosity and reduce the Skin effect after acidizing job required, and also wells prove the variation in porosity and permeability of the reservoir between the two wells, well A (producing well) and well B (observation well). So the pressure response at the observation well, using log-log plots and type curve matching indicates the double porosity behavior of the reservoir (transient interporosity flow). The main importance of the permeability – porosity reservoir formation product obtained from interference testing is that it can provide an estimate of the Oil-in-place. The Oil-in-place can be calculated by a Material Balance method. The initial oil-in-place for Hamzeh Oil Filed reservoir Shueib Formation is 17.5 x10^5 STB.

CONCLUSION

The application of a linear-flow model in the interpretation of data from an interference test carried out in the Hamzeh Oil Field was discussed. The analysis showed that the data can be matched to type curves for the linear-flow model. However, when the values of permeability–porosity products are correlated with the well productivities, the correlation is very good for the linear model. As initially indicated by geologic and well drilling information, the interference data analysis confirms that the flow regime in the reservoir is predominantly linear.

Well B is the second well in the horst block which is producing oil from Shueib formation; this formation was completed and tested in the well B, which put on production. Excellent connection existed between two wells has been detected and significant the drop in pressure drawdown during the reservoir test which has been carried out on well A.

The results of interference test between well B and well A through Shueib formation indicates good communication between the two wells, due to the good reservoir properties, such as permeability and porosity, and also wells prove the variation in porosity and permeability of the reservoir between the two wells, well A (producing well) and well B (observation well). So the pressure response at the observation well, using log-log plots and type curve matching indicates the double porosity behavior of the reservoir (transient interporosity flow). The amount of reservoir Oil-in-place is significant more than 17.5×10^5 STB.

REFERENCE