FIELD HYDRODYNAMICAL TESTING OF GAS CONDENSATE WATERING WELLS

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ABSTRACT

The watering out of gas-condensate wells on Urengoi field at existing cluster well production gathering system can become the strong negative factor lowering performance of gas and condensate recovery. At the first stage creation of method of calculation of the well behavior in these conditions conducting complex hydrodynamic and gas condensate tests of several gas condensate wells with adjustable feeding water-methanol mixture into the well bottom was required. For the adequate description of a multiphase flow moving with the help of the Peng-Robinson equation the method of calculation interaction coefficients of the basic gas condensate system components at the presence of water and methanol is advanced.

On the basis of treating outcomes of such tests held on several gas-condensate wells, the updated dependences for calculation true gas-content of a multiphase upward flow in vertical tubes are obtained at a dispersion-ring-type regime of stream. Using these dependences allows to calculate values of bottom hole pressure on measured well head pressure with satisfactory for practice by accuracy.

INTRODUCTION

The outlooks of neokom objects development in Urengoi field are connected to progressing watering out of wells by formation and condensed water and precipitation of a retrograde condensate in the altered zone of wells and tubes. In conditions of these factors affecting on work of gas-condensate well clusters and well production gathering system is essentially boosted interference of wells through gathering line: tubing lifts of more watery wells are characterized raised hydraulic resistances and are subject to the heightened backpressures on a formation, in consequence of which their output down to the termination of flowing.

To determine the technological regimes of gas-condensate watering wells, to lead and interpret the results of the field hydrodynamic and gas condensate well tests it is necessary: a) the adequate analytical specification statement three-phase gas-condensate-water mixtures flowing in the lift tubes; b) a substantiation of hydraulic resistance coefficient value of the multiphase lift tubing; c) an opportunity of reliable diagnosis of fluid up building conditions in a well. The correctness of well technological regimes determination at those or diverse pressures in a gathering line and estimation of the current compositions of a field mixture in neighborhood of wells depends from successful decision of these tasks.

Hydrodynamic and Gas-Condensate Testing

"Urengoigazprom" has organized the special testing of several gas-condensate wells, equipped with under controlled water-methanol mixture injection through annulus space on well bottom. Well bottom and well head parameters were monitored by the electronic pressure and temperature gages with the reselected step-type behavior of measuring record.

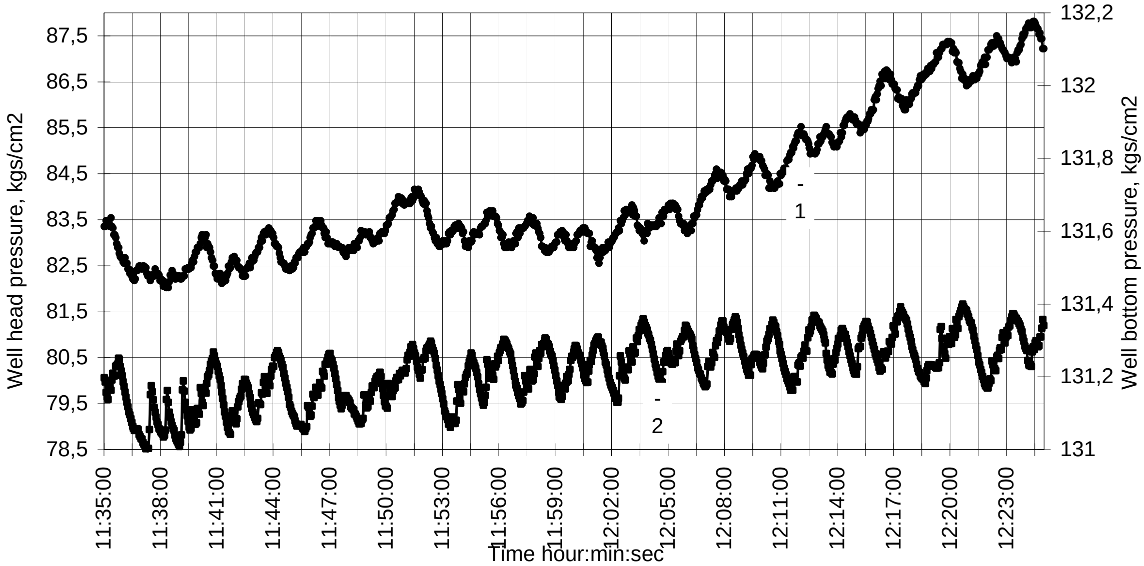

Fig. 1 Time lines of well head and well bottom pressure
1- Well bottom pressure, 2 - Well head pressure

The flow line of a tested well was connected with a separator and gas well production meter. For each regime of its work the output on gas and liquid (hydrocarbon and water) phases, and for some regimes - composition and physical-chemical properties of a condensate samples were determined.

Analytical Description and Data Processing

The gas-condensate-water mixture behavior was described by Peng-Robinson equation of state, in which the pair interaction coefficients of components, including methanol and water, were determined separately for hydrocarbon and water phases. Some effective physical-chemical characteristics of saturated condensate and water-methanol mixtures are improved. Such method was used in calculations of gas holdup streams in tested lift tubes.

For processing synchronized measurements of deep and well head pressures was used correlation and spectral analysis methods. This data processing received with reselected step-type behavior in time, allows determining delay time, propagation rate of perturbation in a gas-liquid stream, other statistical characteristics of an upraise vertical multiphase environment stream as random process.

One of the purposes of special testing treating is creation of the simple and reliable method of bottom and head well pressures calculations. As a basis was adopted the procedure of engineering calculations, suggested V.Mamaev and his coauthors [1]. The given procedure is based on generalizing of a numerous laboratory experiments on moving of gas-liquid mixtures in the vertical tubes, which have been carried out by domestic and foreign explorers. However direct applying of this method has shown, that it is not suitable for scrutinized conditions - in overwhelming majority of cases calculated values of bottom hole pressures have appeared extremely high as contrasted to by measured values (average inaccuracy is peer 25%, and in some cases reaches 60% and more).

At calculations of moving of gas-liquid stream in tubes always there are two unknown quantities – true gas contents of a stream φ and coefficient of hydraulic resistance of gas-liquid mixture λm, which one are determined from a different kind of experience correlations and depend on a set of the factors – flow regime of gas-liquid mixture stream, mode of input of fluid in a stream, availability or lack of fluid in a gas core, physical-chemical properties of fluid and gas, account characteristics etc.

First of all it is need to mark, that in occasion of our experiments we deal with moving of three-phase mixture: water-methanol mixture (WMM), unstable condensate and gas, and what's more one phase - WMM is introduced directly into a gas stream, and unstable condensate is formed in a gas stream in process of pressure and temperature in the form of very small-sized drops [2]. The conditions of input WMM, strictly speaking, us are obscure, it is possible only to state, that they considerably differ from those, which one are used in laboratory experiments (input through a porous wall, input through a central nozzle etc.). From communal reasons follows, that most likely given in circular well space WMM from a lift tubes shoe is caught by gas stream, and then during some spacing interval in lift tubes from a shoe the major part of WMM is pushed aside on a wall of a tube, forming a fluid ring. Thus during formation fluid ring major part of a falling out unstable condensate hits into WMM, formed emulsion such as " condensate in water" ("c/w") . Later, when steady structure of dispersion- circular stream will be formed, the dynamic balance between an amount fluid which is carried away from a film into a stream core and an amount of fluid passing from a core in a film will take place [2].

Now there are no exact dependences allowing to evaluate magnitude of fluid ablation from a film in a core of stream in represented subject. It is clear only, that this magnitude depends from the physical-chemical characteristics of gas and fluid and from mixture flow velocity in well conditions. The most simple dependence is given in [3], according to which one the ablation estimates as 10…13 % for representative conditions of our experiment. For calculations by us it is accepted, that 90 % of WMM and 10 % of unstated condensate from their rates in average well conditions are in the film, and the film represents emulsion such as “c/w”.

In [3] it is recommended λm to determine by results of field experiments (as a solution of an inverse problem). In our case it has appeared possible only at acceptance of an assumption about equaling of true gas content φ and account gas content β. The outcomes of data processing of well test are shown at this assumption on the fig. 2 .

On other hand, well-known, that the item describing pressure losses on definition gravity force in an equation of momentum conservation of a vertical gas-liquid stream is in

10…100 times exceeds an item describing friction losses.

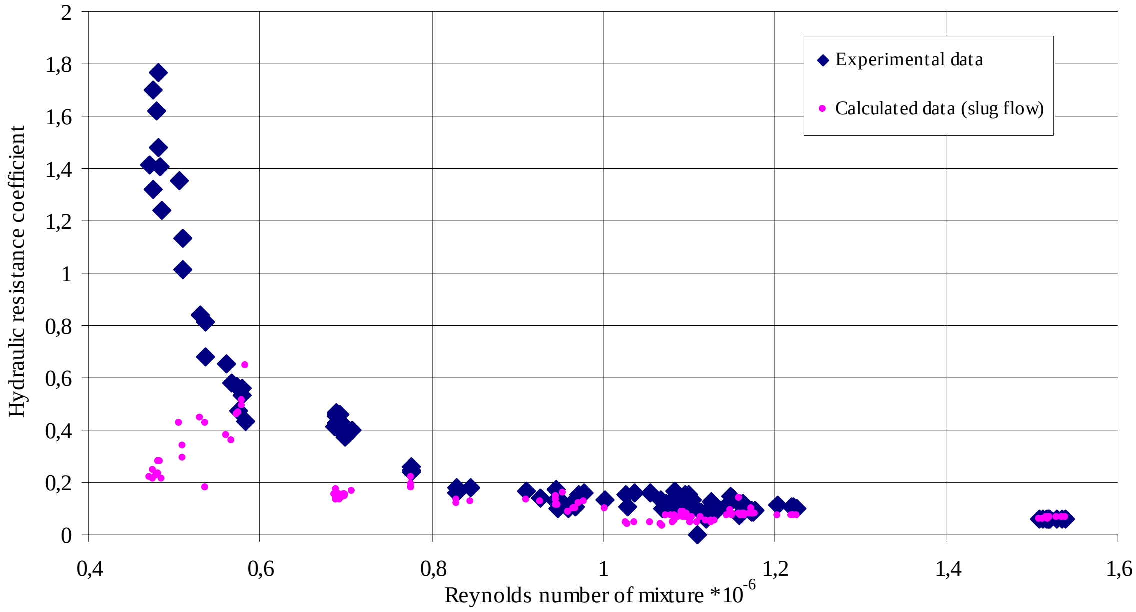

Fig. 2. Dependence of hydraulic resistance coefficient from Re mixture

As magnitude φ includes in the first item of an equation of momentum conservation only, and magnitude λm does not include, the definition values φ under the data of special tests in vertical tube is more relevant problem, than definition λm.

Therefore, using well bottom and well head pressure and temperature gagings, it is possible to decide problem of definition φ in each experiment on a well. Thus for calculation λm the dependences from [1] were used.

The problem is decided in following order.

1. The general molar ratio of driving in tube mixture is definite under the measured WMM rate, content of a methanol in WMM, gas-condensate mixture rate and it’s composition.

2. Using well bottom and well head pressure and temperatures gagings, the phase equilibrium of base mixture is counted and the quantity and composition of all three phases - gas, liquid hydrocarbon and water-methanol are calculated at average temperature and pressure in the lift tubes.

3. The properties of phases (viscosity, density, interfacial tensions), and also viscosity both density of a core and film are determined. For definition of properties of phases we used the nomograms, constructed by us, for a tested well. The viscosity of a film was counted as viscosity of emulsion "c/w". By influencing of pressure on variation of viscosity and density of WMM was neglected, and the temperature effect and concentration of methanol were allowed only [5]. As a core viscosity is accepted gas viscosity in view of very minute

volumetric concentration of liquid drops (as a rule less 1 %).

4. All indispensable dimensionless characteristics of stream - Reynolds' and Frude's numbers for a core of a stream, film, all mixture, and also Weber's number are counted.

5. The boundary velocity Wb and dimensionless velocity of a mixture in well conditions W* is counted and on their relation the regime of stream is defined.

6. The equation linking among themselves values well head and well bottom pressures, were decided rather φ by a method of half dividing. Thus for calculation λm the dependences taken from [1] were used.

Some Results of Testings

The treating has shown, that, at first, regime of stream in the majority of the reviewed cases is dispersible-ring-type, secondly, approximately in 27 % of experiments a well worked in conditions of gradual upbuilding of fluid and, thirdly, value true gas-content, computed on V.Mamaev [1], are strongly undervalued.

We selected empiric dependences for true gas-content φ from account gas-content β and reduced velocity of a mixture W*. The task was decided as follows. The form of dependence started same, as in [1], and the numeric values of coefficients were retrieved only.

In outcome we obtain following dependences:

at W*i>3,3

$$\varphi_i = 1 - (0,731 + 0,0605 W_{*i})(1 - \beta_i)^{(0,565+0,0545 W_{*i})} \tag{1}$$

at W*i≤3,3

$$\varphi_i = 1 - 0,1040467(3,3 - W_{*i}) - [1,00501 - 0,0179964(W_{*i} - 2)^2](1 - \beta_i)^{(0,62996 - 0,1001 W_{*i})} \tag{2}$$

We held inverse check of the obtained dependences (1) and (2). For each experiment the relative error and mean inaccuracy was counted. For a case W* > 3,3 dependences (1) give mean inaccuracy of account modulo 1,077 %, for a case W* ≤ 3,3 - 1,999 %. On our sight, for field experiment such outcome is quite satisfactory.

CONCLUSIONS

The held studies, on the one hand, testify to complication of polyphase flows processes at gas and condensate recovery and poor them learning. On the other hand, the outcomes allowing much more precisely are obtained to count technological parameters of work of gas condensate wells in watering out conditions. Continuation of well testing allow to hope that the work control methods for well clusters of gas-condensate wells under watering conditions will be created.

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