CONTRIBUTIONS TO THE PRESSURE BALANCE OPTIMIZATION WHILE DRILLING THROUGH GAS PRODUCING FORMATIONS

ABSTRACT

PhD Coordinator
Prof. Dr. Eng. LAZAR AVRAM

PhD Candidate
Eng. ION FOIDAS

The growth of natural gas reserves, the exploitation optimization and the gas safe supply has become, in the last decade, a geopolitical priority of general interest, sharpened by the unpleasant events that have recently happened in the Middle East, North Africa and Japan.

Clean and cheap, natural gas represents the best energy source we are currently using to ensure both the economic growth and the environment protection, offering the opportunity to profit by it wherever possible. Thus, in Europe only there could be a 40% rise in gas demand, since approximately 60% of the power is being generated by coal and nuclear power plants which are so old that they should be decommissioned and replaced with plants that use gas as fuel.

On the other hand, the natural gas production industry is peculiar, like any industry that produces mineral resources, in the sense that these resources are exhaustible and non-renewable. Hence the production decline, sometimes controllable, but which cannot keep up with the market growing demands. For this reason, efforts should be made to find solutions for this rather difficult problem.

There are some actions undertaken to make the natural gas offer keep up with the market needs. One of them is the diversification and globalization of natural gas markets using liquefied natural gas (LNG) and exploiting the non-conventional gas reservoirs. A convincing example is the USA natural gas production which, instead of running down, has significantly grown (due to the non-conventional gas exploitation) to values that could cover the current gas consumption of North America for some tens of years. Thus, significant LNG reserves have been released to other markets.

Another important action is the production technology updating so that the wells could be exploited at potential flow rates and for that some operations are necessary to clear the blockage (formation damaging) ingenerated by drilling and completion, in order to stimulate their productivity.

The productive formation damaging leads to the reduction of the capacity of the fluid that flows from the reservoir rock into the well, pursuant to some unhappy events occurring during drilling, completion or some operations inside the well. This aspect has become more acute along with the hydrocarbon reservoir depletion. Thus, a performing, non-damaging drilling into these depleted reservoirs has become a real challenge for the branch specialists, who make considerable efforts to find the most adequate technologies to meet the demand.

At the same time, the development and usage of new techniques and technologies, in order to optimize the drilling process by reducing the down times, the costs and minimizing the risks, have extended the interest for research.

Having considered these, this thesis deals with a subject matter in close connection with the above, namely the optimization of the pressure balance when productive gas formations are crossed while drilling, the author tries to make his contribution, at least from the gas producer's point of view, to the improvement of the drilling technology, applicable especially to depleted reservoirs.

In extenso, the current thesis provides an insight to possible situations during drilling, connected to the relationship between the pressures in the layer-well system, to the causes and consequences of some major disorders and the assessment of their impact and to the technologies currently available for the pressure control. On basis of these analyses and of the experience gained as well drilling team leader, the author makes at the end of the thesis a series of proposals for an optimized underbalanced drilling technology in depleted layers.

All these aspects are covered over the 7 chapters that are completed and sustained with several case studies based on real data obtained on site.

Therefore chapter 1 defines and characterises pressures, which are also referred to in the next chapters. We are referring to following pressures: litho static pressure, pore fluid pressure, fracturing pressure and well fluid pressure. An important part in determining the depth of the tubing and in choosing the drilling system and fluid is the estimation, as exactly as possible, of the pressure gradients.

Crucial factors in anticipating and avoiding some drilling complications are detecting and estimating fluid pressure anomalies, present in pores during drilling, especially for geological research wells where some discrepancies with the initial project may appear, related both to the pressure value estimated on basis of correlation wells and to the depth where a formation is reached. For this reason, chapter 2 deals with the methods by which these pressure anomalies can be highlighted, and which can be checked on basis of some case studies.

Chapter 3 describes the difficulties and complications caused by the pressure imbalance during drilling; phenomena that make the drilling process more difficult, more costly and which slow it down. The most important are: instability of the well bore walls, circulation losses, losses through wall sticking and differential pressures, unexpected inflow of fluids from the formation pores, formation that are crossed while drilling the well.

The damage brought to productive formations while drilling is analysed in detail in chapter 4. The interaction of shale minerals with mud filtrate is considered to be the main cause that led to a decrease of the permeability in the area around the well. This is highlighted by the results obtained by using computer programs and also by performing lab tests. The author used these methods for the case studies described in this chapter.

The current technologies used in well drilling are presented in Chapter 5. Although developed more than one century ago (1901), the classical overbalanced technology based on a weighted drilling mud, and well cuttings removal through the annulus to the surface, in the open, was and still is "conventional" from the point of view of the drilling hydraulics. Despite the encouraging results, achieved by taking high risks on the side of the decision makers of the drilling industry, the experimentation and implementation of new technologies are far from being generalized or at least known to those who could benefit from them. That is why, in this chapter, the author makes a list of new technologies without aiming at approaching all the innovations in this field.

Reflecting the contribution of the author to the improvement of underbalanced drilling, chapter 6 is the most important part of the thesis. In the above mentioned chapter the author makes a series of proposals regarding the selection of candidate reservoirs for underbalanced drilling, the use of said technology in the assessment of gas reservoir properties, well control and completion as well as proposals for improving the underbalanced drilling technology. Also presented in Chapter 6 is a computer program developed by the author for determining the parameters required for drilling, a very useful tool which can be used both in the design and, especially, in the execution of drilling works due to its capacity to deliver, in due time, the data necessary for adapting the hydraulic regime to the actual conditions encountered during drilling.

The last chapter summarizes the main conclusions and the original contributions of this thesis.