Chapter 3
Risk Due to Wellbore Instability

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ABSTRACT

Exploration and production as one of the most important parts of the petroleum industry encounters different problems, usually resulting in nonproductive time and additional expenses. The most common and most expensive of them are related to wellbore instability and associated problems. Wellbore instability problems are usually related to drilling operation, but they can also appear during completion, workover, or the production stage of a certain well. The traditional solution for wellbore instability problems is composed from the early recognition of specific wellbore instability problems, the main cause identification and swift response. For more effective solution it is necessary to incorporate wellbore stability and risk assessment in the early phase of well design. This chapter gives one general overview of wellbore instability problems and their causes as well as an overview of actual approaches and methods in wellbore stability and risk assessment.

INTRODUCTION

The petroleum industry as well as other industries, encounters different problems because of the specific nature of the job itself and always presents a possible human fault. Unlike other industries, the petroleum industry employees, especially engineers in the exploration and production department (petroleum engineers, geologists, geomechanical engineers, geophysics etc.) work in very specific conditions and environment, and with limited data availability. The main objectives of this part of the petroleum industry are discovering hydrocarbons reservoirs and creating facilities for their economical, safe and ecological acceptable production. One of the most important parts in the exploration and production activities is drilling a borehole, a subsurface object that connects a reservoir with the surface facility and provides a pathway for hydrocarbon production. In general, drilling is a specific technical and technological process and because of that, it requires specific engineer's skills and the usage of specific equipment and instruments. On the other hand, drilling is very expensive. Aldred et al. in their work published in 1999 estimate that

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oil and gas companies spend about 20x10^9 dollars annually on drilling worldwide. Today, drilling implies drilling in harsh surface environment (artic areas, deep seas, etc.) as well as drilling though complex lithology (tectonically active areas, fracture and faulted zones, areas with salt or magma intrusions etc.). Additionally, drilling an extended reach or slim hole wells especially in such environment make drilling process more complex and expensive.

From the beginning of the drilling up to nowadays, oil and gas companies have probably continuously encountered a certain wellbore instability problem or problems. Wellbore instability can simply be explained as any change in wellbore diameter in comparison to the bit diameter used for the hole drilling. The appearance of the wellbore instability in a certain well can result in different problems like hole cleaning problems (cuttings volume increase, caving appearance, hole pack-off etc.), in the inability to run a casing string into the hole, or the inability of performing the cementing or logging operation and etc. In some cases, wellbore instability problems can cause the abandonment of one portion of the hole or in the extreme case of a whole wellbore. The most important consequence of wellbore instability problems are Non Productive Time (NPT) and additional (unscheduled) expenses. The petroleum industry spends more than 1x10^9 of dollars annually for solving wellbore instability problems (Tare et al., 2002; Zhang et al., 2004; Khodja et al., 2010) what is about one tenth of the entire drilling expenses today. From the comparison of this data with the available date from the last decade of twentieth century it can be concluded that unscheduled expenses are continually increasing and that they have increased for about 100% in the last 20 years. Additionally, based on ten year researching and data collecting, Muniz et al. (2005) concluded that 30% of all additional expenses during drilling have been spent for solving wellbore instability problems.

In the past, the wellbore instability problems were solved most frequently on trial/failure bases (van Oort et al., 1996; Tare et al., 2002). This method can provide a possible solution for the wellbore instability problems on the certain well, but it doesn't provide the ultimate solution for a particular wellbore instability problem or wellbore instability problems as a whole. There isn't a unique solution for all wellbore instability problems because each well represents an individual case and demands an individual approach. The well individuality is the result of difference in lithology (sandstone, shale, limestone etc.), rock properties (compressive/tensile strength, in-situ stress conditions, fractures, anisotropy etc.), local tectonics (faulted zones, local magmatic and salt intrusion etc.) and wellbore properties (depth, trajectory, azimuth, inclination etc.). Because of this, wells on the same field sometimes experience quite different wellbore instability problems.

As mentioned earlier, wellbore instability problems can occur during drilling or during a different operation on a certain well (e.g. completion, workover, production, stimulation etc.). Since the wellbore instability problems become more complicated with elapsed time (time between problem spotting and the solution), the key factor for efficient solving of a distinct wellbore instability problem is in time detection. Possible indicators (symptoms) of wellbore instability which are primarily caused by wellbore collapse or convergence are shown in Table 1. McLellan (1994) has classified the indicators of wellbore instability into two groups: direct and indirect indicators respectively. A direct indicator includes observations such as an oversized or undergauged hole (readily observed from caliper logs), caving at the surface and etc., as the unmistakable evidence of existing wellbore instability problems. The caving from the wellbore wall, circulated to the surface, and the hole fill after tripping confirm that spalling processes are occurring in the wellbore. Large volumes of cuttings and/or cavings, in an excess of the volume of rock which would have

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