Improved Model for Predicting the Required Minimum Gas Injection Rate for Removal of Cutting during Underbalanced Drilling

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Abstract

It has been widely recognized that maintaining adequate air/gas injection rate is vitally important to achieving hole cleaning both against drilling cutting and liquid accumulations. It is highly imperative

to accurately predict the annulus pressure drop for determining the critical air/gas injection rate required for cleaning formation both cutting and liquid influx during underbalanced drilling.

A new numerical model for determining annulus pressure drop model has been developed that is required for accurately predicting minimum air/gas injection rate for simultaneous removal of both cutting and liquid during underbalanced drilling. The new model has incorporated the influence of cutting volume which has been overlooked by most researchers. Since the required minimum flow rate needs to be determined at the surface condition, temperature and pressure dependent variables such as gas formation volume factor, (Bg), Oil formation factor, (Bo), and water formation factor, Bw has been considered in the model. The results generated show that the existing models have underestimated the required minimum air/gas flow rate for continuous lifting of both cutting and liquid during underbalanced drilling. Engineering charts have also been generated for predicting cutting and liquid-carrying capacity of air/gas that is injected into the borehole at various rates. This project provides drilling engineers the necessary knowledge and a useful tool for minimizing complications in air/gas drilling operations

Introduction

When a well is drilled underbalanced, hydrocarbon production begins as soon as productive zone is penetrated1-5. It is possible to produce portion of the reservoir fluid while drilling or cleaning hole. With suitable processing equipments, some underbalanced wells may pay for their cost entirely from production before drilling operations were completed5. The technique requires the simultaneous flow of fine drilling cuttings and formation fluid (gas, oil and water). If the pressure profile in an underbalanced well can be predicted within reasonably accuracy, it would be possible to get good estimates of the power required to lift the accumulated cutting and formation liquid while drilling or cleaning the hole. Furthermore, the effect of injection rate, cutting transport and annulus sizes on these quantities can be evaluated before any design decision is made on the drilling, hole cleaning and operation of the flow string.

Studies on simultaneous flow of fine drilling cuttings and formation fluid influx (gas, oil and water) in vertical pipe have sought to develop a technique with which the minimum required gas rate for removal of cutting can be accurately calculated. A lot of research has been conducted to determine the effect of cutting transport in vertical flow but little information has been reported on effect of cuttings transport on pressure drop and cutting hold up along the vertical pipe. Bulter and Gregory6 (1995) and Smith et al7 (1998) presented the application of multiphase flow modelling to u