

Temperature Calculation and Prediction of Gas Hydrates Formed Region in Wellbore in Deepwater Drilling

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ABSTRACT

The temperature distribution with depth of South China sea is obtained by regression analysis. The temperature distribution formulas in well bore during circulation or non-circulation terms are established based on the thermodynamics theory. Based on the calculation of temperature in well bore and the formation model of gas hydrate, the prediction of hydrate formation region in well bore and blowout preventer is done under different conditions. The results indicate that the region of hydrate formation under the condition of recurrent state is the smallest, and the region of hydrate formation under the condition of shut in state is the largest.

KEY WORDS: deepwater drilling, gas hydrates, temperature field, prediction

INTRODUCTION

During recent years, the petroleum industry has continued to extend deepwater exploration drilling efforts in many areas of the world. With the increasing number of deep offshore drilling operations, operators and service companies are now faced with new problems related to the possible formation of gas hydrates in drilling muds. The high seafloor hydrostatic pressures and low environmental temperatures encountered in deepwater drilling increase the likelihood of gas hydrates formation in well bore, blowout preventers, and subsea wellheads(Barker, 1989; Hale, 1989).

Well control is one of the most important problems in deepwater drilling(Records,1972; Oystein,2006). The theory of multi-phase flow in well bore is an important part of the well control theory(Nunes,2006). As the temperature field is complicate and gas hydrates form easily, the existent multi-phase flow models can not be used satisfactorily in well control calculation in deepwater drilling operations. The influence of the gas hydrates formed or dissolved in a wellbore must be considered.

1 TEMPERATURE FIELD OF THE SEA WATER

Based on the data bases of Levitus(Levitus,1994), taking one value per longitude and latitude in the area of 7°~12°N, 111°~118°E, the temperature distributions are obtained in the depth from 200 to 3500m by fitting. Compared with the data of surveyed by Academia Sinica(Zeng,2003), the error is no more than 1°C. The fitted regression equation is:

$$T_{sea} = a_1 + a_2 / (1 + e^{(h+a_0)/a_3}), \quad h > 200m \quad (1)$$

Where, $a_1=39.4$, $a_2=37.1$, $a_0=130.1$, $a_3=402.7$; T_{sea} is temperature of the sea water, °C; h is depth of the sea water, m.

The temperature field is complicated at the shallow water region where the depth is shallower than 200m(Luan,2003). The temperature is altering at the same area in different season. Assuming the temperature grade of discontinuity layer is fixed at given position, the fitted regression equation of shallow water depth is obtained:

$$\text{Spring: } T_{sea} = \frac{T_s(200-h)+13.68h}{200} \quad 0 \leq h < 200m$$

$$\text{Summer: } T_{sea} = T_s \quad 0 \leq h < 20m$$

$$T_{sea} = \frac{T_s(200-h)+13.7(h-20)}{180} \quad 20 \leq h < 200m$$

$$\text{Autumn: } T_{sea} = T_s \quad 0 \leq h < 50m$$

$$T_{sea} = \frac{T_s(200-h)+13.7(h-50)}{150} \quad 50 \leq h < 200m$$

$$\text{Winter: } T_{sea} = T_s \quad 0 \leq h < 100m$$

$$T_{sea} = \frac{T_s(200-h)+13.7(h-100)}{100} \quad 0 \leq h < 200m \quad (2)$$

Where, T_s is the temperature of the sea surface, °C; h is depth of the sea water, m.

2 TEMPERATURE FIELD OF THE WELLBORE

2.1 TEMPERATURE FORMULAS UNDER CIRCULATION CONDITION

To obtain expressions for the temperature of fluid in the annulus and the drilling pipe, we set up an energy balance over a differential element of length, dz , of the annular fluid as shown in Fig. 1. Noting that z is positive in the downward direction. The law of conservation of energy is writing as: