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Optimization of drilling parameters in Raniganj Formation, Essar coal bed Methane Block – A case study

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ABSTRACT

Coal bed methane is one of the proven and most accepted unconventional energy resources. Commercial viability of coal bed methane play depends on minimum investment during exploration as well as in development and production phases. To develop a coal bed methane field more number of wells is required. Therefore, during development phase one of the important aspects is to bring down the drilling time by optimizing rate of penetration and other related drilling parameters without compromising on wellbore stability. In this paper an effort has been made to understand the drilling parameters to achieve optimized ROP (Rate of Penetration), based on real time drilling data gathered from directional wells within Raniganj Formation in Essar Oil Limited Raniganj Coal bed Methane Block. In this paper data used are from three directional wells. Conclusions are based on relationship between different drilling parameters.

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Introduction

Energy is fundamental to the economic development in any nation and India is no different. High level of growth in the demand for gas in India on the back of economic growth, coal bed methane (CBM) an unconventional source of natural gas is becoming an alternative source of energy to meet part of the growing demand. The environmental, technical and economic advantage of CBM has made it a global fuel of choice.

Having the 4th largest proven coal reserves and being the 3rd largest coal producer in the world, India holds significant prospects for commercial recovery of CBM. Being a low profit business, commercial viability of CBM plays depend on minimum investment during exploration as well as during development and production phases. Depletion of conventional resources, and increasing demand for clean energy, forces India to hunt for alternatives to conventional energy resources. Intense importance has been given for finding out more and more energy resources; specifically non-conventional ones like CBM, shale gas & gas hydrates, as gas is less polluting compared to oil or coal. With growing demand and rising oil and gas prices, CBM is one of the most feasible alternative supplementary energy sources.

The Raniganj CBM block of Essar is located in the eastern most part of Raniganj Coalfield, in the state of West Bengal, India. Case study has been done from three directional wells in Raniganj Formation to find the best possible drilling parameters to drill a stable well in Essar CBM block achieving optimum ROP. Only rotating sections are taken into consideration and not the sliding section. The main parameters that affect drilling are mentioned in Table 1 (Reza Ettehadi Osgouei, 2007).

Method

In this paper case study has been done with the data generated during drilling of the wells. Different plots have been prepared for different parameters and compared with the classical plots available in the literature to find the best possible drilling parameters to achieve optimum ROP to drill a stable well in Raniganj Formation.

Parameters considered and their effect observed in the case study

The main controlling parameters for ROP that has been discussed in this paper are Lithology, WOB, Bit, RPM and Mud Weight. The units that are being used are mentioned in Table 2.

Lithology

International standard drilling practices ROP is one of the oldest yet still valuable tools to recognize the lithology, if other parameters remain same. Lithology is a major and uncontrollable factor. The elastic limit and ultimate strength of the formation are the

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Table 1
Drilling controlling factors.

Environmental factors	Controllable factors (Alterable)
Depth	Bit wear state
Formation properties	Bit design
mud type	Weight on bit
Mud density	rotary speed
Other mud properties	Flow rate
Overbalance mud pressure	Bit hydraulic
Bottom hole mud pressure	Bit nozzle size
Bit size	Motor/turbine geometry

Table 2
Units used in the paper.

Parameter	Unit used in the paper	Unit in SI system
ROP	m/h	m/h
WOB	klbs	ton (1 klbs = 0.5 ton)
Mud weight	ppg	kg/m^3 (1 ppg = 119.83 kg/m^3)
Torque	ft.lbf	Nm (1 ft.lbf = 1.3558 Nm)

important formation properties affecting penetration rate (Reza Ettehadi Osgouei, 2007).

Compaction of the rock is another major factor affecting ROP (Walker et al., 1986). It is mentioned that the crater volume produced beneath a single tooth is inversely proportional to both the compressive strength of the rock and the shear strength of the rock, e.g. – Igneous or metamorphic rocks are much tough to drill than sedimentary rocks.

Permeability of the rock is also a controlling factor for ROP. More the pore space or void space is connected, more the permeability and as a result the rock becomes more easily breakable. e.g. – Shale has greater porosity by very less permeability and it is relatively hard to be broken.

The mineral composition of the rock also has some effect on penetration rate (Walker et al., 1986).

Structural control also plays roll on the strength of the rock and in turn affects the ROP, e.g. in faulted region the rocks become brittle and very friable and as result in such zone ROP is generally very high. Whereas, silicified faulted zone causes relatively much less ROP if other drilling parameters remain same.

Raniganj Formation is the most important coal-bearing formation in RG (E)-CBM-2001/1 block. It is represented by light grey to dirty white micaceous fine, medium and coarse grained sandstone, with alternating sequence of shale, carbonaceous shale and coal. Six regionally co-relatable coal seams are present in Raniganj Formation (RN-1, bottom to RN-6, top).

MWD log recorded during drilling in Raniganj Formation is represented in Fig. 1. Observed ROP is high in coal while ROP reduces in sandstone to shale to igneous bodies respectively.

Bit type, condition and hydraulics

Drilling bit selection is Bourgoyne et al. (1984) based on following considerations:

(a) Drag, or "fishtail," bits work by scraping or shearing the bottom of the hole. For poor to moderately consolidated clays, silts, and sands fishtail bits are preferred because they peel the rock or make a mush.
(b) Tri-cone roller bits with chisel- style, longer teeth are used in fairly drillable rock, where tooth penetration and crushing is adequate. Roller bits with carbide buttons are generally used to crush harder rock. TCR bits can be of different grade and they are to be selected based on the formation property.
(c) Polycrystalline diamond compact (PDC) bits cut by a shearing action similar to that of drag bits, but PDCs can handle harder rock.

The Panchet Formation (Triassic) which overlies Raniganj (Upper Permian) is light green, fine to medium grained soft micaceous sandstone with thin bands/intercalations of green shale in the lower part, and chocolate brown claystone and siltstone in the upper part. Generally, in this section 1-1-7 TCR bit is found to be most effective, while for Raniganj Formation 4-3-7 TCR bit or PDC bit gives better meterage (Fig. 2).

Weight on bit

Weight on bit (WOB) plays a critical role in formation drilling controlling both the inclination of directional well and ROP.

To drill the formation a threshold WOB is required (Point-a, Fig. 3a). When all other drilling parameters are kept constant the ROP behavior is determined by WOB (a–b–c–d, Fig. 3a). In some cases, the decrease in ROP is observed at very high WOB (segment d–e, Fig. 3a). This type of bit behavior is called bit floundering (Irawan et al., 2012).

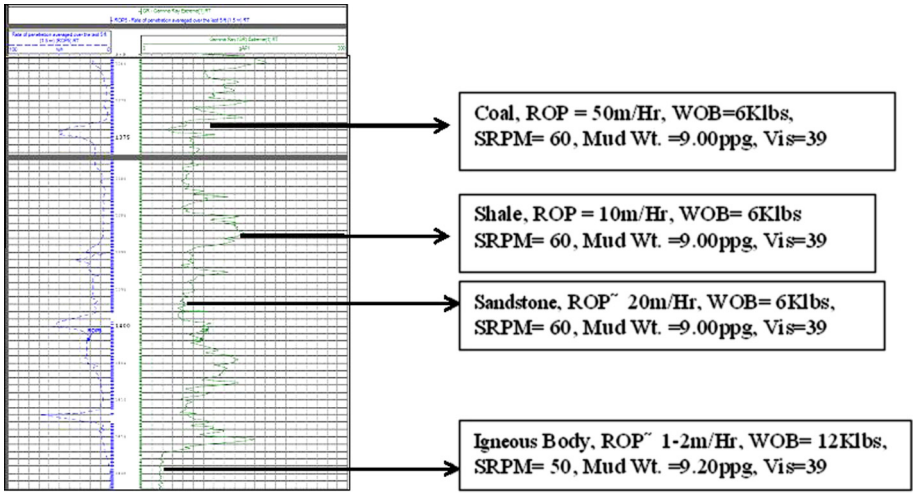

Fig. 1. ROP variation with lithology.

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