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Productivity enhancement: Pretreatment of coal seams for removal of coal fines from CBM wells during hydro fracturing

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1. Abstract:-

Coal is a prolific source of methane, a natural gas, found in most coal deposits popularly known as coal bed methane (CBM). India has sixth largest coal reserves in the world and estimated to be at 206 billion tons and it ranks 10th in CBM resources, found at depth from 300 to 1300 m. The CBM reservoir is having 0.5 % average porosity and 0.5-5 md average permeability with more than 90 % gas saturation. Its reservoir temperature varies between 35-70°C and pressure varies between 800-1300 psi with average closure stress of 1400 psi. As of now 17 numbers of wells were drilled Jharia, Bokaro & North Karanpura and 25 are planned to be drilled in Upper pack, Middle pack and Lower pack of Barakar coal formation.

As porosity and permeability is very less in CBM reservoir, therefore, over 50 no of hydro fracturing job have been done so far to exploit the methane gas by reducing the pressure below critical saturation pressure through dewatering. In some fracturing job, fines migration with unbroken gel problem has been observed due to large fine and debris generation during the hydro-fracturing job due to fragile nature of coal.

As the coal fines are hydrophobic in nature that tries to settle down into the fracture that leads to screen out consequently desired length is not achieved and These coal fines & particulate does not come out during the flow back from the proppant and reduces the conductivity of the fracture. For fine mitigation during hydro fracturing, pre treatment of coal seam is suggested with innovative chemical formulations that will be able to mitigate the coal fines problem during hydro fracturing. This method increase the fracture length by 1.5 fold fracture length so the production of HC than the conventional method and help in enhancing the overall performance and enhance the HC production.

2. Introduction:-

Coal is a prolific source of methane, a natural gas, found in most coal deposits popularly known as coal bed methane (CBM). India has sixth largest coal reserves in the world and estimated to be at 206 billion tons and it ranks 10th in CBM resources. As per this classification Indian Coal bearing basins were subdivided into 4 categories in which Jharia, Bokaro, Raniganj and North Karanpura basins having depth between 300 to 1300 m, were grouped under Category-1, being most prospective. CBM reservoir is having 0.5 % average porosity and 0.5-5 md average permeability with more than 90 % gas saturation. Its reservoir temperature varies between 35-70°C and pressure varies between 800-1300 psi with average closure stress of 1400 psi. As of now 17 numbers of wells were drilled Jharia, Bokaro & North Karanpura and 25 are planned to be drilled in Upper pack, Middle pack and Lower pack of Barakar coal formation.

As porosity and permeability is very less in CBM reservoir, therefore, over 50 no of hydro fracturing job have been done so far to exploit the methane gas by reducing the pressure below critical saturation pressure through dewatering. Coal is a weak substance and small pressure can cause the coal to fail and generate fines, hence enormous coal fines are normally produced during hydro fracturing of coal seams. In some fracturing job, fines migration with unbroken gel problem has been observed and satisfactory result is not found.

As the coal fines are hydrophobic in nature that tries to settle down into the fracture that leads to screen out consequently desired length is not achieved. These coal fines & particulate does not come out during the flow back from the proppant and reduces the conductivity of the fracture.

CBM coal seams have large volumes of both water and hydrocarbon gas (e.g. methane) or other gases trapped therein. Such reservoirs are water saturated with the methane i.e.

adsorbed onto the surface of the coal. This methane represents a valuable resource if it can be produced economically.

Presently, methane is produced from coal reservoirs through wells which are drilled into the coal seam from the surface. Once a well has been drilled and completed, the coal seam is usually hydraulically fractured much in the same way as are more conventional sandstone or like oil and gas bearing formations. Fracturing of the coal seam is believed to aid in:

- *By-passing wellbore damage;*
- *Distributing the pressure at or near wellbore to alleviate the formation of coal fines; and*
- *Accelerating dewatering & pressure drawdown in the coal seam thereby increased gas production.*

However, the results from actual fracturing operations in coal formations indicate that the fracture mechanics and fluid flow behavior in the cleated, coal formations are substantially different from those which are believed to occur in the more conventional sandstone or like formations. In a typical fracturing operation, a "pad" (i.e. volume of fracturing fluid without proppant) is first pumped down into the well and formation under high pressure to initiate and propagate the fractures in the formation. The pad is followed with proppant-ladened slurry that forces the pad further into the formation thereby extending the fractures into the formation. As will be understood in the art, the proppants are deposited into the fractures as the ladened slurry flows through to prop the fracture and prevent it from closing once the fracturing pressure is relieved. The pad, in addition to propagating the fracture, serves to replenish fluid to the proppant-ladened slurry, as it is lost to the coal formation to thereby aid in preventing early or premature "screen-out". This buildup of proppant forms a barrier, usually near the leading edge or tip of the fracture which eventually blocks the flow of fracturing fluid there through thereby preventing any further extension of the fracture into the formation.

Even though hydraulic-fracturing has been widely used to stimulate the production of methane from coal seams, it has not produced the degree of stimulation expected or *desired. It is believed that one reason that it has failed to perform as expected is due to the large amounts of coal fines that are formed during the fracturing operation or subsequent production. These fines are picked up by the fracturing fluid and become more and more concentrated therein since*

- *Fines are continuously being formed by breaking & abrasion of coal and*
- *Liquid from the fracturing fluid is continuously being lost to the formation.*

Coal fines are hydrophobic in nature that they do not "like" water and do not readily disperse in water or water-based solutions (e.g. fracturing fluid). Instead, they want to "float" on the fracturing fluid rather than forming slurry therewith. Accordingly, the fracturing fluid picks up large volumes of fines, which accumulate and quickly settle out of the fracturing fluid as it flows in the fracture. The coal fines carried by the fracturing fluid readily "screen-out" near the tip of the fracture and form a barrier which blocks further flow into the formation, thereby prematurely terminating the fracture before it would otherwise be terminated. Further, these fines are also likely to screen-out at other locations along the length of a fracture and form impermeable barriers at those locations, which block both the flow of fracturing fluid during the fracturing operation and reverse flow through the fracture during production.

Therefore, it can be seen that if the coal fines can be better dispersed so that the fluid can carry higher concentrations of fines without settling, a fracture can be substantially extended into a coal seam and production (i.e. reverse flow) from the seam can be improved.

3. Innovative Initiative in Hydrofracturing of CBM

*The present study provides a method for fracturing coal seams to improve the production of methane and/or water. The fracturing is carried out by injecting a water-based fracturing fluid into the coal seam under pressure wherein the fracturing fluid contains both a **wetting agent** and a **dispersant**. The wetting agent contacts the coal fines and* *converts it from **"hydrophobic" to "hydrophilic"** while the dispersant serves to disperse and suspend the fines within the fracturing fluid whereby large concentrations can be kept in suspension before the fines begin to settle in any substantial amounts. This prevents early screen-out of the fines from the fracturing fluid to allow the fluid to propagate fractures of longer lengths into a coal seam before the fines settle out to block further flow through a fracture.*

3.1 Laborotory Studies:-

Many chemical has been evaluated for changing the Wettability of coal fines and ability to get suspended in the water base fluid and tested in laboratory. Wetting agent and surfactants specification is given below-

- ***Wetting agent** – The wetting agent converts the coal fines from hydrophobic into hydrophilic so that they are easily dispersed into the fluid. Normally non ionic surfactants can be used for this. Some non ionic surfactant is given below -*
  - *Poly alkyleneoxide having a hydrophilic portion comprising less ethylene oxide units*
  - *Nonylphenoxy polythyleneoxide having less ethelyne oxide unit*

- ***Dispersant**- It disperses & suspends the coal fines within the fracturing fluid whereby large concentrations can be kept in suspension before the fines begin to settle in any substantial amounts. Most common non ionic surfactant are -*
  - *Poly alkyleneoxide having hydrophilic portion comprising about high ethylene oxide units*
  - *Nonylphenoxy polythyleneoxide having high ethylene oxide*

In the laboratory study, Wettability change and settling profile of coal fine and coal particle has been evaluated with different surfactants and its mixture. Optimum dose and ratio of wetting agent and dispersant is 0.4% and 1:2 respectively.

3.2 Sequenece of hydrofracturing

***3.2.1 . Pre-treating the Coal seams**- A pad of the fracturing fluid containing wetting agent and dispersant (without proppant) is first injected into the coal seam to initiate and propagate fractures in the seam. After the pad is injected, the well is immediately opened and flow back the pad & other formation fluids. The return pad picks up large volumes of suspended coal fines, which was formed during the injection of the pad. In some instances, large amounts of coal fines can be removed before completing the fracturing operation by pre-treating a coal seam.*

***3.2.2. Conventional Hydraulic fracturing**- Again pad with wetting agent and dispersant (i.e. no proppant) is injected into the coal seam to initiate and propagate fractures therein and is followed by proppant-ladened fluid to force the pad outward in the seam to propagate the fractures further. The wetting agent converts the coal fines to hydrophilic so that they are easily dispersed into the fluid where large volumes are suspended aided by the dispersant and are carried for further distances by the fluid in the fractures before the fines settle out to block flow.*

Further, as the pad of fracturing fluid is pumped down the well and into the coal seam, nitrogen gas can be mixed under high pressure with the fracturing fluid to form highly energized foam in the fractures as they are being formed in the coal seam. Upon flow-back, the pressurized gas increases the velocity of the produced fluid, which substantially aids in keeping the fines suspended in the fluid as it is produced out of the fractures.

4. Conclusion :-

The present study provides a method for fracturing coal seams to improve the production of methane and/or water. Pre-treatment of coal seam by injecting 40-50% volume of conventional fracture fluid volume with 0.4% surfactants (wetting agent & dispersant ratio 1:2) is more effective as the laboratory evaluation of surfactants with coal fines. The wetting agent converts it from "hydrophobic" to "hydrophilic" while the dispersant serves to disperse and suspend the fines within the fracturing fluid and prevents early screen-out . This innovative method and chemical formulations will not only be able to mitigate the coal *fines problem during hydro fracturing but also increase the fracture length by 1.5 fold than the conventional hydro fracturing job length (190 ft as per FIELDPRO). Therefore, overall performance of dewatering consequently HC production is increased.*

5. Bibliography :-

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