Enhanced Oil Recovery: An Innovative Approach to Optimize Liquid Hydrocarbon Recovery in a Depleted Reservoir *

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Search and Discovery Article #40742 (2011)
Posted May 31, 2011

*Adapted from extended abstract presented at GEO-India, Greater Noida, New Delhi, India, January 12-14, 2011.

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Abstract

Under an attractive reservoir pressure, the reservoir fluids coexist as a mixture of liquid and gaseous hydrocarbon making it less viscous and more mobile through their onward migration from the deeper part of the reservoir overcoming the resistance offered by the forces like capillary pressure, surface tension, and heterogeneity to reach the exit with a high rate of recovery. Where as a depleted reservoir faces difficulties in recovery due to the separation of gaseous hydrocarbon from the parent fluid owing to drop in pressure and making it more viscous and less mobile to counter the resistance posed by overlying forces like capillary pressure and surface tension through its journey to the bore. Drop in pressure further enhances the problem by depositing finer particles in the migration path. To enhance the recovery factor in a depleted oil reservoir through an innovative method by exploiting the physical and chemical properties of reservoir water with that of alkaline earth metal resulting in to liberation of huge amount of gaseous Hydrogen in their reaction process. This will in turn help in clearing migration paths as well as enhancing oil recovery by decreasing the viscosity and increasing the mobility of the liquid hydrocarbon present in the reservoir.

Introduction

The Petrophysical studies carried out in the Laboratories on cores/core plugs generate sets of data on Porosity, Permeability, Relative and Effective permeability for effective exploitation of the reservoir. The cores are cut by the rotating and chipping actions of the bit, each peripheral particle on the core/core plug experiences a tremendous frictional force due to the rotational effect of the bit resulting in generation of huge pressure and heat around the core. These phenomena with short duration may have a definite impact on the original orientation of the particle placed in the peripheral portions. Similar impact occurs when core-plugging job is carried out. This again resulted in changing the original orientation of the particles lying in the peripheral part of the core plug. Under tremendous amount of frictional force/pressure and temperature of high magnitude, these peripheral particles lose some of their original petrophysical properties as well as orientations. Therefore, during the petrophysical studies at the laboratories we never consider these changes made through the making of plugs. The petrophysical data generated there after is bound to be erroneous what ever may be the magnitude. In addition, similar type of effects will be felt on the grains/particles lying on the skin of the drill hole during drilling and coring operations. These skins are involved in numerous experiments and undergo formation evaluation and production tests during reservoir and production testing in the well.

So by using suitable constants during these processes, this can be calculated to the nearest approximation by considering the amount of frictional forces, amount of heat generated and the mineralogical composition of the skin/wall under investigations. These corrections will help for better representation of the petrophysical characters and efficient Reservoir exploitation.

Discussions and Investigations

During the chipping and cutting actions of the bit the peripheral particles laying on the core/core plug as well as inner skin of the drilled well experiences great pressure and temperature.

i. Change in orientation of the particles/grains lying on both the walls. (Figure 1)
ii. Changes in petrophysical properties like porosity, permeability, effective porosity and effective permeability affecting a thin film on both the walls affected under the action of abrasion and heat under frictional forces during drilling and coring. (Figure 2)
iii. As the walls behave like either the entry point or exit point to reservoir. Production testing for the formations, formation evaluation testing and studies involving petrophysical properties of the cores/core plugs in the fields as well as laboratories is get effected due to this effect. Therefore, the change in alignment/orientations in the affected grains will generate some errors in the computations and final computed results.
iv. Degree of error in the orientation and petrophysical properties will vary in the skin will depend upon whether it happened to be along the dip or across the dip of the formation also. Depending upon this the petrophysical properties of the grains laying on the peripheral part will also vary.

In other words, the results thus computed for the sections under investigation should be corrected with proper correction coefficient. This correction coefficient will thus depend on the:

- Mineralogical constituent.
- Grain alignment.
- Type of matrix.
- Compactness.
- Drilling angle with formation dip.
- Rate of rotation of the bit.
- Weight on bit.

Factors Responsible for Alterations

- Mineralogical content of the formation and its effect under the exposure of varying amount of pressure and heat. (Figure 3 and Figure 4)
- The angle of coring/plugging/drilling with that of the formation dip.
- The mechanical parameters like WOB and RPM of the bit will produce/enhance the generation of heat through friction with varying magnitude.
- Compactness of the formation will be deciding the time span of exposure to pressure and temperature to the peripheral grains.

Minimum heat/time of exposure under that heat above which there will be physical/chemical changes in the mineralogy of the particles lying on the peripheral parts changing the primary petrophysical properties of the skin.

Identifying the Changes

Visual examinations of the affected parts can be carried out making thin sections out of the skin of the drilled hole as well as the outer wall of the core under powerful microscope. Two thin sections each from altered and unaltered part can also be compared under microscope for better understanding. (Figure 5)

Relation of the Correction Coefficient with Different Parameters Involved

Mechanical parameters

WOB is directly proportional to the changes in orientation/petrophysics of the peripheral grains.

RPM is directly proportional to the changes in orientation/petrophysics of the peripheral grains as increase in RPM enhances heat generation.

Lithological parameters

Mineralogical composition of the grains lying in the peripheral parts under investigation is susceptible in different way to abrasion pressure as well as heat. Softer mineralogy is prone to change, whereas harder mineralogy will have little impact. As compactness, expose the peripheral grain to heat for a longer span of time so as to changes. So the coefficient of correction for a given section of the thin film laying either on the outer wall of the core or the inner wall/skin of the drill hole can be considered and calculated considering all the above factors besides lot more parameters which can be considered along with these parameters. Further studies are in progress for the approximations of the coefficient.

Approximation of the Correction Coefficient

Considering the correction factors for each of the above-mentioned parameters involved through the process and their combined effect will probably give us an approximate value for the correction coefficient. This correction coefficient can then be used in the thin film of the area of concern to get the required corrected results.

For a section of thin film on the skin of the drilled hole or the thin film involving the outer wall of a core/plug under investigation:

Corrections for mechanical parameters: Let the correction factor for applied WOB is **w**. Let the correction factor for applied RPM is **r**.

Corrections for lithological and geological parameters: Let the correction factor for the mineralogy of the concerned section is **m**. Let the correction factor for compaction of the concerned section is **c**. If we take the correction coefficient as “**k**” for the concerned section, then **k = w*r*c/m** (approximately). Studies are going on further to include other relevant parameters to make the coefficient more vibrant.

Practical Correction Suggested

To remove the affected inner skin of the drill hole in pay formations, this is practically necessary to get better results in formation evaluation and production testing. A change in the configuration in the bit is suggested to tear and remove the skin effectively and giving rise to new skin with minimum effect of abrasion and frictional forces. (Figure 6)

Conclusion

In view of the above-mentioned factors affecting and altering the primary orientation and petrophysical properties in the thin film over which drill bit acted during drilling, coring and plugging jobs gives rise to errors in computation during the formation evaluation tests involving the skin of the drill hole as well as during the computation of the petrophysical properties in piece of core/plug involving grains/particles lying in the peripheral part. Considering the above facts, a proper correction coefficient can be worked out so that the thin skin involving walls of drill hole as well as cores/plugs which are affected to varying amount by drilling and coring operations. As these skins involves in several investigations involving formation evaluations to petrophysical studies, corrections of erroneous data will definitely help in generating qualitative data for the above studies.

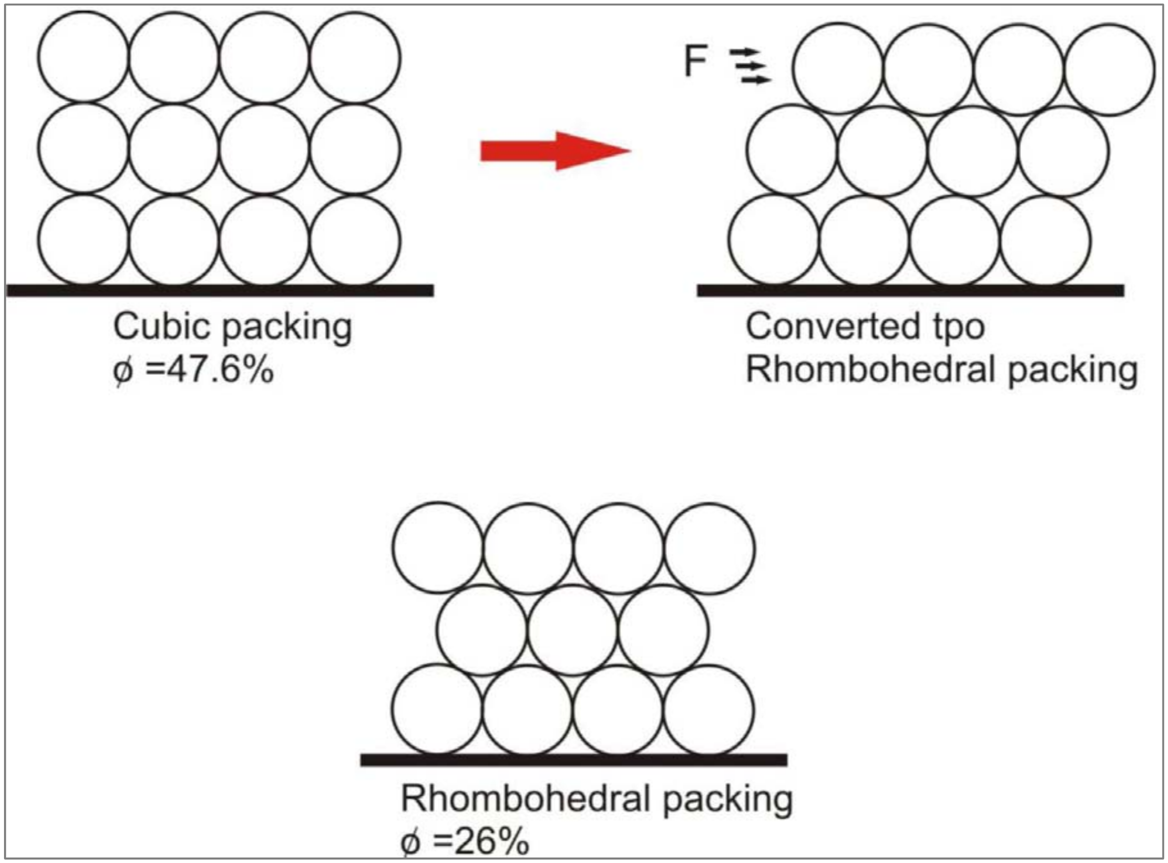

Figure 1. Effects of pressure on the peripheral grains and their orientation can change their nature of packing from cubic to rhombohedral packing hence decreasing the porosity.

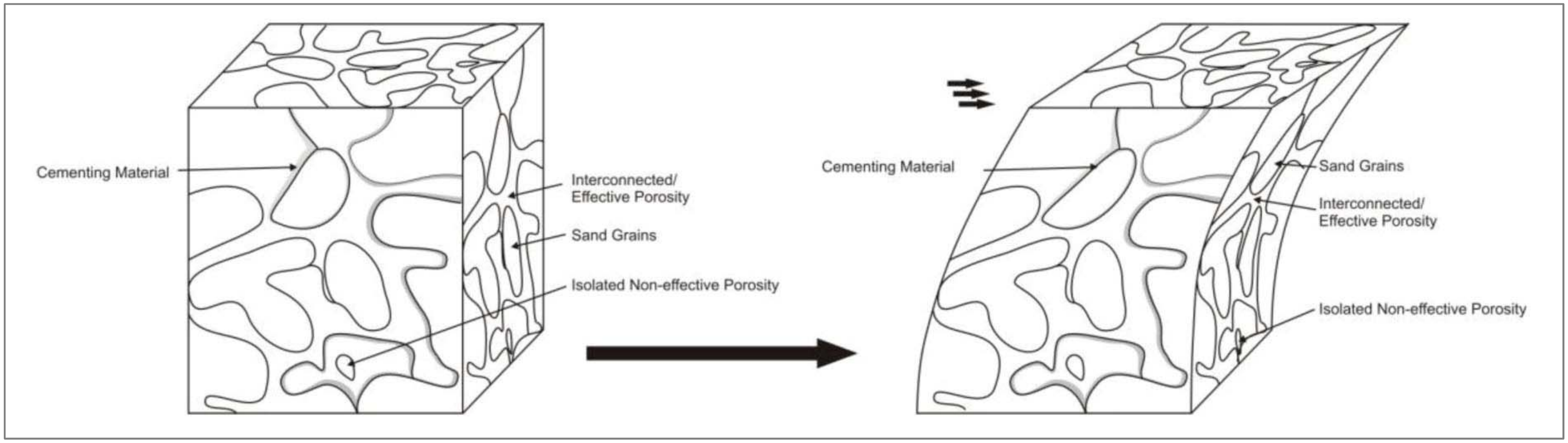

Figure 2. Effects of obliterations and abrasion as the force acts on the peripheral part of the core/wall shown as the top part of the block shows how petrophysical properties changes during drilling/coring.

Figure 3. Inner wall of the drilled hole showing alterations under influence of heat during coring.

Figure 4. Effect of pressure and temperature on different mineralogical constituents can be observed under a powerful microscope.

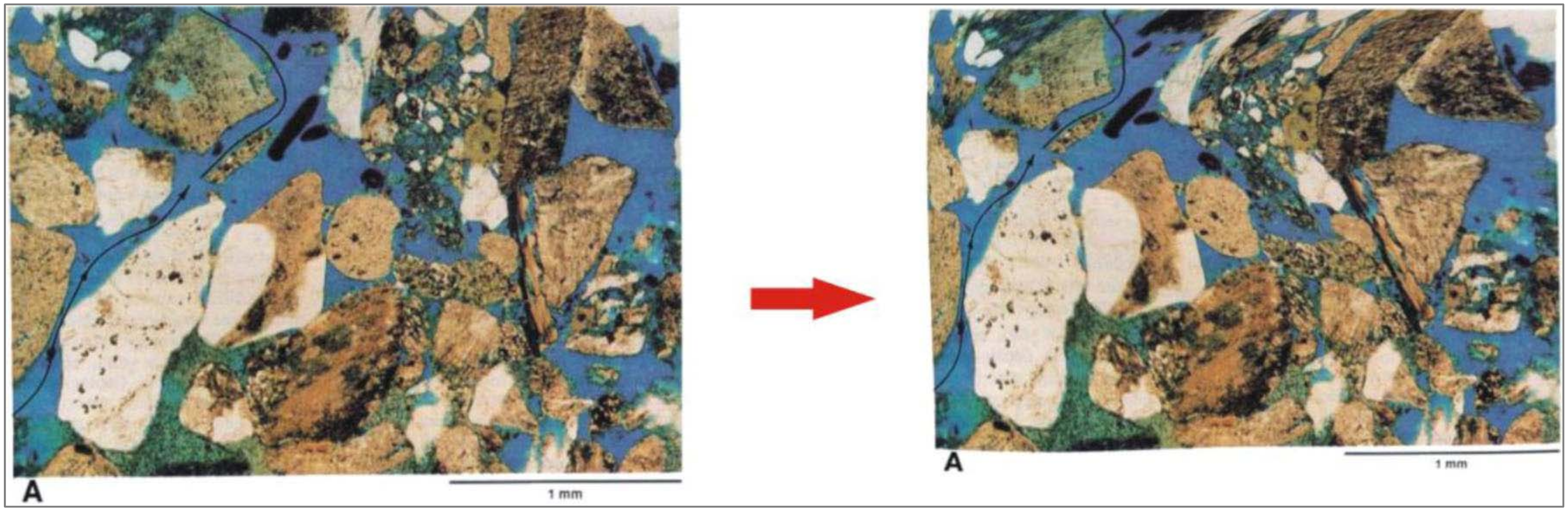

Figure 5. Change of petrophysical properties on the skin through drilling and coring operations observed as in thin section.

Figure 6. Extra piercing teethes are suggested to tear the affected skin and to produce the new skin with minimum effect.