Nitro-Lift Technologies Tech Tips:

Prevention of Formation Damage During Shut-in

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Formation damage from shutting in a well can result in a loss of capital in terms of lost production but also lower ultimate recovery. This paper provides a brief background on why formation damage occurs during production or shut-in conditions and recommends the treatment of the near wellbore region with nanoActiv® before shut-in. **The primary purpose of treating with nanoActiv® is to preferentially coat the rock surface in pore throats to prevent asphaltene and/or paraffin deposition**. No other treatment exists that can accomplish this.

Amaefule et al. (1988) state that "Formation damage is an expensive headache to the oil and gas industry." Remediation of formation damage is not only costly but may further complicate the overall reservoir production challenge by changing the original characteristics of the near-wellbore formation and even throughout the reservoir in an adverse manner if treatment selection and application are not properly designed and implemented. Porter (1989) states that "What gets into porous media does not necessarily come out." Porter (1989) called this phenomenon "the reverse funnel effect." Therefore, it is better to avoid formation damage than to try to restore it.

It is apparent that prevention, not remediation pays off in the long run. However, certain types of formation damages, for example those induced by production throughout the reservoir, may not be totally avoidable (Tague, 2000a,b,c,d, Wang and Civan, 2005a,b,c). Examples of such damages include fines migration and paraffin and asphaltene deposition. Nevertheless, it may be possible to minimize the formation damage in petroleum reservoirs by taking proper measures based on the understanding of the behavior of the rock-fluid-particle system during flow through the reservoir formation under varying in situ conditions. This can help determine the optimal strategies necessary for designing formation damage minimizing production schemes for petroleum reservoirs.

Organic scaling can be classified in two groups: (1) natural and (2) induced (Houchin and Hudson, 1986; Amaefule et al., 1988). Invasion of the near-wellbore formation by high pH filtrates, ***and injecting low surface tension fluids, such as light paraffins including pentane, hexane, diesel, gasoline, and naphtha, and gas condensates into asphaltenic oil reservoirs can cause asphaltene precipitation (Amaefule et al., 1988)***. Asphaltenic/paraffinic sludges can be formed with the spent acid at low pH conditions that can be created during acidizing (Amaefule et al., 1988). In contrast, paraffins deposit primarily by cooling.

Generally, the organic deposits encountered along the production string and surface facilities contain larger proportions of paraffins, some asphaltenes and resins co-precipitated with the paraffins, some oil trapped within the deposits, and various inorganic substances, including clays, sand, and other materials (Khalil et al., 1997). The paraffin deposition primarily occurs by temperature decrease, whereas asphaltene and resin deposition occur because of a number of complicated phenomena, including the polydispersivity, steric colloid formation, aggregation, and electrokinetic deposition processes (Mansoori, 1997).

Leontaritis et al. (1992) state, "Probable causes of asphaltene flocculation are: (1) Drop in the reservoir pressure below the pressure at which asphaltenes flocculate and begin to drop out; (2) Mixing of solvents, CH_4, CO_2 with reservoir oil during EOR.... After flocculation asphaltenes exhibit an intrinsic change, which is usually positive. As a result, they show a strong tendency to attach to negatively charged surface, such as clays and sand."

As soon as the wells in asphaltenic reservoirs begin to produce, the organic deposition begins within the upper section of the wells over which the pressure drops to below the asphaltene flocculation pressure, and then the organic deposition zone gradually progresses toward the bottomhole and eventually enters the near wellbore formation (Minssieux, 1997). Especially, the reservoir formations containing clays of large specific surfaces, such as Kaolinite, can initially adsorb and retain the polar asphaltenes and resins rapidly (Minssieux, 1997). As a result, multilayer molecular deposits are formed over the pore surface (Acevedo et al., 1995). However, as the asphaltene precipitates suspended in the oil phase combine and form sufficiently large aggregates, these particles cannot pass through and are captured at the pore throats (Minssieux, 1997). The pore throat plugging causes the severest permeability loss because the gates connecting the pores are closed and/or an in situ cake is formed by pore filling if the plugged pore throat still allows some flow through the jammed particles. Simultaneously, the flow is diverted toward larger flow paths (Wojtanowicz et al., 1987, 1988; Civan, 1995a; Chang and Civan, 1997; Minssieux, 1997).

“Organic deposits usually seal the flow constrictions because they are sticky and deformable. Therefore, the conductivity of a flow path may diminish without filling the pore space completely” (Civan, 1994a, 1995a).

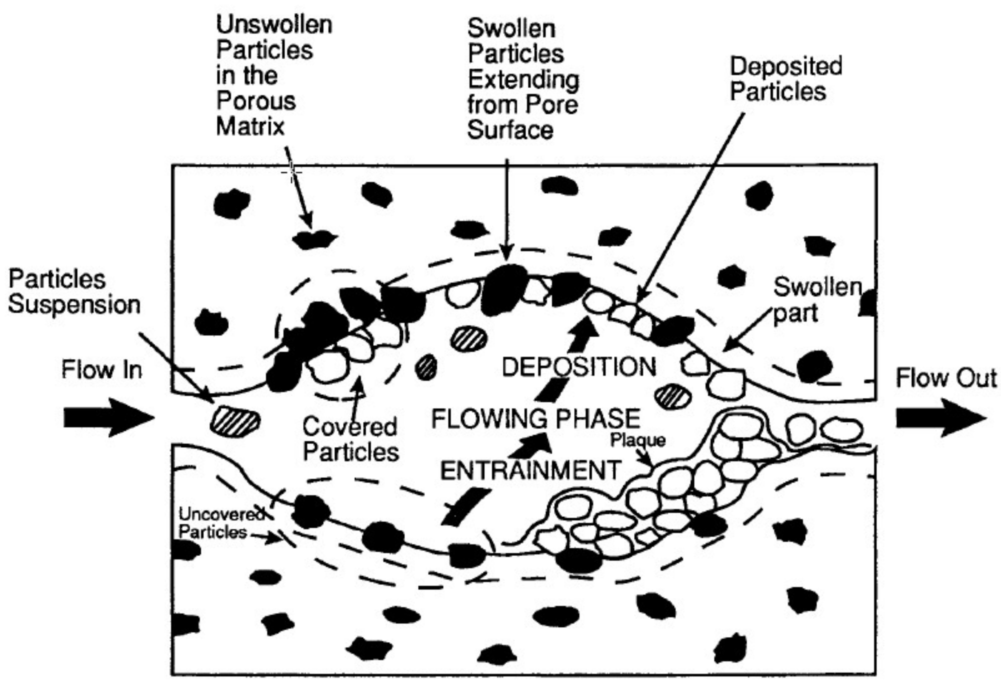

Figure 1 – Example of a Pore Throat and Permeability Damage.

Leontaritis (1998) stresses that the organic damage in oil reservoirs is primarily caused by asphaltene deposition and the region of asphaltene deposition may actually extend over large distances from the wellbore, especially during miscible recovery. Wang and Civan (2005a,b,c) have confirmed that asphaltene deposition is not only limited to the near-wellbore region, but it can occur throughout the reservoir formation, whereas the wax deposition is rather limited to a short distance (less than 1 feet) from the wellbore, because wax deposition in the near wellbore region usually occurs by the cooling of the oil caused either by high perforation pressure losses during oil production or by invasion and cooling of the hot oil saturated with the wax dissolved from the well walls as a result of the overbalanced, hot oiling treatments of the wells.

The decline of productivity of wells in asphaltenic reservoirs is usually attributed to the reduction of the effective mobility of oil by various factors (Amaefule et al., 1988; Leontaritis et al., 1992; Leontaritis, 1998).

Leontaritis (1998) states that the asphaltene-induced damage can be explained by three mechanisms:

The first is the increase of the reservoir fluid viscosity by formation of a water-in-oil emulsion if the well is producing oil and water simultaneously. The oil viscosity may also increase by the increase of the asphaltene particle concentration in the near-wellbore region as the oil converges radially toward the wellbore. But experimental measurements indicate that the viscosity increase by asphaltene flocculation is negligible.
The second mechanism is the change of the wettability of the reservoir formation from water-wet to oil-wet by the adsorption of asphaltene over the pore surface in the reservoir formation. However, this phenomenon is less likely because, usually, the asphaltenic reservoir formations are already mixed-wet or oil-wet, due to the fact that asphaltenes have already been adsorbed over the pore surface during the long periods of geological times prior to opening the wells for production.
The **third and most probable mechanism** is the impairment of the reservoir formation permeability by the **plugging of the pore throats by asphaltene particles**. The problems associated with organic deposition from the crude oil can be avoided or minimized by choosing operating conditions such that the reservoir oil follows a thermodynamic path outside the deposition envelope and, therefore, the deposition envelope concept can provide some guidance in this respect (Leontaritis et al., 1992). For example, Wang and Civan (2005a,b,c) accomplished this condition by an early water injection process. However, mathematical models implementing the deposition phase charts are also necessary in developing optimal strategies for optimal mitigation of the deposition problems during the exploitation of the petroleum reservoirs.

Conclusions

- The purpose of treating with nanoActiv® before shut-in is to preferentially coat the rock surface in pore throats to prevent asphaltene and/or paraffin deposition.
- Asphaltene deposition near the wellbore will likely occur during shut-in for various reasons as described earlier.
- While it may seem a good preventative measure - ***"injecting low surface tension fluids, such as light paraffins including pentane, hexane, diesel, gasoline, and naphtha, and gas condensates into asphaltenic oil reservoirs can cause asphaltene precipitation"***.
- During shut-in, Brownian Motion of nanoActiv® nanoparticles will persist and provide a physical mechanism to minimize asphaltene deposition on the pore walls, i.e. rock surface.
- Paraffin deposits occur primarily by cooling which should be minimal during shut-in.
- In the event paraffin deposition occurs, nanoActiv® nanoparticles are proven to dislodge and fragment the paraffin.
- Chemical treatments before shut-in will not coat the pore throats (rock surface) and their effectiveness will be gradually decreased until fully "spent".

References

1. Faruk Civan, *"Reservoir Formation Damage",* 2007.