ABSTRACT

Formation consolidation is a form of sand control that had been used extensively in the past until it was replaced by mechanical systems. This change arose because the level of uncertainty regarding effective chemical placement and reliability. Alternative ways to prevent sand production in effective and efficient ways have been developed to reduce production cost. Resin treatments have been known as one way to stop sand production when the amounts of both resin and catalyst are suitable.

Plastic consolidation involves the injection of plastic resins, which are sand grains attractive. The resin hardens and forms a consolidated mass, binding the sand grains together at their contact points. If successful, the increase in formation compressive strength will be sufficient to withstand the drag forces of matrix formation while keeping the production at the desired rates.

Three types of resins are commercially available: epoxies, furans (including furan/phenolic blends), and pure phenolic. Resin is in liquid form when injected to the formation and catalyst or curing agent is required to harden it. Some systems use “internal” catalyst that is mixed into the resin solution at the surface and require time and suitable temperature to harden the resin. Other systems use “external” catalyst, injected after the resin is already in the formation. The advantage of internal catalyst is its positive placement because all resin will be in contact with the catalyst required for efficient curing. The disadvantage of using internal catalysts is the possibility of premature hardening in the workstring. Thus, the composition both resin and catalyst must be carefully chosen and controlled for the specific well conditions.

This study has used data from “I” reservoir. A success method understanding concentration has developed to inject polymer in formation.

INTRODUCTION

The objective of Sand Control and Management research is to boost oil and gas production without producing sand. Sand control has been a problem for many years. Gravel packs, special liners and plastic consolidation have been used with varying degrees of success. The advantages of gravel packs and liners are relatively low cost and easy to apply while the disadvantages are its high susceptibility to plugging by formation fines and their tendency to complicate multiple completion operations when they are installed in the wellbore.

Plastic sand consolidation has advantages over gravel packs and special liners. The consolidated formation prevents its fines from flowing. Furthermore, the outer perimeter of a typically consolidated formation is larger than that of a gravel pack or of a prepacked liner so that plugging of the outer perimeter is reduced. The weakness of plastic sand consolidation is its relatively high cost, difficulty to inject resin uniformly throughout production period and complexity of handling chemicals at the well site.

A number of sand consolidation processes have been described in the literature, but few of these processes meet all desired sand consolidation characteristics. This paper describes a new laboratory method that meets the desired characteristics. Laboratory process, discussion of laboratory experiments and the experience obtained from field applications.

Process, Resin and Consolidated Formation Characteristics

A number of techniques are known to deal with sand production from wells. Plastic consolidation involves the injection of plastic resins, which are sand grains attractive. The resin hardens and forms a consolidated mass, binding the sand grains together at their contact points. If successful, the
increase in formation compressive strength will be sufficient to withstand the drag forces while maintaining production at the desired rates.

There are two types of plastic consolidation systems; phase separation system and overflushed system. Phase separation systems contain only 15-25% active resin in an otherwise inert solution. The resin is preferentially attracted to the sand grains, leaving the inert portion that will not be harden to fill the pore spaces. These systems utilize internal catalyst which is mixed into the solution at the surface. A very accurate control of displacement is required to place the resin through the perforations. Overdisplacement will result in unconsolidated sand in the critical near the wellbore area.

Phase separation system may be ineffective in formations clays above 10%. Clays, which also resin attractive, have extremely high surface area compared to sands. The clays will attract more resin and because phase separation systems contain only a small percentage of resin, there may not be enough resin to consolidate the sand grain.

Overflush system require high percentage of active resin. When first injected, the pore spaces are completely filled with resin, and overflush is required to push the excess resin away from the wellbore area to reestablish permeability. Only a residual amount of resin saturation, which should be concentrated at the sand contact points, should remain following the overflush. Most overflush systems use an external catalyst, although some include an internal catalyst.

All plastic consolidation system requires a good primary cementing job to prevent the resin from channeling behind the casing. Perforation density should be a minimum of 4 shots per foot to reduce drawdown and improve the distribution of plastic. Shale zones should not be perforated. A clean system is essential for plastic consolidation treatments because all solids which are in the system at the time of treatment will be glued in place. The perforations should be washed or surged, workover rig tanks should be scrubbed and fluids should be filtered to 2 microns. Workstrings should be cleaned with a dilute HCL acid containing sequestering agents, and pipe dope should be used sparingly on the pin only. A matrix acid treatment, which includes HF and HCL is recommended for dirty sandstones.

Both phase separation and overflush system require a multistage preflush to remove reservoir fluids and oil wet the sand grains. The first stage, generally diesel oil, serves to displace the reservoir oil. Epoxy resins are incompatible with water, and therefore, isopropyl alcohol follows the diesel to remove formation water. Finally, there is a space which prevents the contacts between isopropy alcohol and resin.

The main advantage of plastic consolidation is makes the wellbore open. This becomes important where large OD (Outside Diameter) downhole completion equipment is required. Also, plastic consolidation is suitable for through tubing applications, and may be applied in wells with small diameter casing. For many applications, the problem associated with plastic consolidation outweigh the possible advantages. The permeability of a formation is always decreased by plastic consolidation. Even in successful treatment, the permeability to oil reduced because the resin occupies a portion of the original pore space, and because the resin is oil wet. The amount of resin used is based on uniform coverage of all perforations. However, perforation plugging or permeability variations often cause some perforations to take more plastic than others. The perforations which received excess plastic may be plugged, and little, if any, strengthening will occur in the perforations that don't receive resin. In a system which utilizes an external catalyst, there will be no sand control in areas which are not contacted by both resin and catalyst.

METHODS

Resin consolidation involves injection of resin into the formation with coupling agents to improve the bonding between the grains. Cementing the sand grains provides strong consolidated matrix. Subsequent post flush, after the resin has been placed in the perforations, displaces the excess resin further into the formation to clear the pore spaces between the grains, allowing the best possible permeability for oil and gas flow. No mechanical restrictions, in case of resin consolidation are needed to restrict the flow of oil and gas into wellbore, so it’s keeping the wellbore free from any obstructions. The main problem in using resin systems is how to store the chemicals completely and evenly in the formation. For this reason, plastic consolidation is only suitable for less than 10 feet length of interval. Longer intervals can be treated using packers to isolate and treat small sections of the zone at a time, but such operations are difficult and time consuming. Plastic consolidation treatment also do not perform well in formations with
permeability's less than 50 milidarcies and bottom hole temperatures in excess of 225°F.

Plastic consolidation was used extensively in the late-1950’s through the mid-1970’s for completing wells in the Gulf Mexico (GOM). Despite the common use in GOM, this technique currently represents less than 1% of all sand control completions worldwide. The lessening popularity of plastic consolidation is the placement difficulties described above, as well as tight regulations on the handling of the chemicals, which are generally quite toxic (the furans is the least toxic of the three). In addition, these treatments tend to be very costly. There have been some success stories of sand consolidation in Africa where the formations fit the general screening criteria. This paper aims to develop new method and to find the appropriate combination of chemicals despite the challenges of the problem in plastic consolidation way.

There are three principal steps (1) injecting resin, (2) establishing formations permeability and (3) activating the resin to consolidate the formation. Depending on its condition, additional steps may be necessary to prepare the formation for consolidation. For example, connate brine and crude oil should be removed from the area around the wellbore. To accomplish this, diesel oil is injected into the formation to displace most of the formation crude oil and brine. The diesel oil is followed by a fluid that removes the residual brine and remaining crude oil. To do this effectively, the fluid should be miscible both with brine and with crude oil. Acetone, alcohol or low molecular weight aldehydes and esters are examples of such fluid. In the present process acetone is used. Because acetone is a solvent for the epoxy resin, the acetone, in turn, is displaced by diesel oil.

**Flow Laboratory Test**

A laboratory test has been conducted to find new concept for well application. Packed cylinder and Hassler core holders have been used to begin the process of evaluating consolidation system potential. A number of resin treatment were considered as candidate sand control treatment methods. A new generation system was selected because of its characteristic of providing adequate strength without reducing permeability.

To prepare Hassler cell (Fig.1), dry sand was poured into the rubber sleeve, the cell was poured into the rubber sleeve and the cell was vibrated to insure uniform packing of the sand. The sand pack was then evacuated and saturated with brine and crude. Three samples of artificial cores were selected at the same characteristic for measurement of permeability and compressive strength. These samples were saturated with oil, and single phase permeability was measured at flow laboratory test. Table 1 shows the result for permeability measurement.

**Compressive Strength Test**

Sandstone formations are categorized into consolidated, poorly consolidated, and unconsolidated, based on their elastic properties, mechanical strength and cementation materials. Sand formations can fail due to mechanical or chemical effects. The mechanical properties relevant to sand production are: Uniaxial Compressive Strength (UCS), cohesive strength, and tensile strength. However, mechanical properties such as Young’s modulus and Poisson’s ratio are also used to characterize sand formations.

Consolidated formations should strong enough to withstand stresses induced by adjacent rock strata and stresses imposed by the flow of fluids into the wellbore. This consolidation strength should be maintained under producing conditions. Furthermore, the consolidated formation should have sufficient permeability to permit unobstructed flow of fluids into the wellbore. Table 2 shows the result for compressive strength measurement.

Chemical test encompassed a wide range of variables in which the polymerization characteristic of several resin system were studied. In addition, batches of different resins were polymerized at different temperatures and were mixed to contaminants that might be encountered in oil field operations such as drilling mud, acids, brine and different solvents. After a promising resin system had been created, standard procedure to evaluate the chemical resin was used. Fig. 3 shows the procedure to evaluate and finding appropriate chemical resin that is suitable for the case condition.

**CONCLUSIONS**

The chemical epoxy resin systems were developed for sand consolidation. A laboratory test has demonstrated applicability to a wide range of flow conditions. The consolidated sand resulting from these resin system demonstrated excellent durability, indicating that the sands maintain adequate strength in formation fluids for many years.
REFERENCE

Completion Technology for Unconsolidated Formations, Rev. 2 / June 1995.


**TABLE 1 - EXAMPLE OF FLOW LABORATORY TEST RESULT**

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**TABLE 2 - EXAMPLE OF COMPRESSION STRENGTH TEST RESULT**

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</table>
Figure 1 - Flow Laboratory Test

Figure 2 - Compressive Strength Equipment Design
Figure 3 - Work flow of Chemical Treatment Trial

Activity in Polymer Laboratory