Cementing

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Chapter 9

Squeeze Cementing

9.1 Introduction

Squeeze cementing — the process of applying hydraulic pressure to force or squeeze a cement slurry into a formation void or against a porous zone — is the most common type of down-hole remedial cementing. Its objective is to obtain a seal between the casing and the formation.

One of the earliest oilwell problems was to isolate down-hole water. The problem was partially solved by using cement slurry and squeeze pressure. It was observed that the higher the pressure, the greater the volume of cement that could be displaced and the more successful the isolation around the wellbore.[1] This high-pressure technique has been widely used for many years for remedial cementing.

The technical literature contains a wealth of material on squeezing wells[2-4]; still, many unanswered questions persist:

Where does the cement go on a squeeze job?

What is formation breakdown, and is it necessary?

Should water or mud be used for breakdown?

Will squeezed cement completely surround a wellbore?

Can perforations be plugged with cement?

Can the quantity of cement be controlled during placement?

Today, the most common use of squeeze cementing is to segregate a hydrocarbon-producing zone from those producing other fluids. The aim in squeezing, therefore, is to place the cement at the correct points to accomplish this. (See Fig. 9.1.)

9.2 Where Squeezing Is Required

The application of squeeze cementing technology has increased considerably with a better understanding of (1) the mechanics of fracturing rock and (2) the filtration properties of cement slurries pressured against a permeable medium.

Squeezing is widely used in wells for the following purposes.[4-6]

1. To control high GOR's. By isolating the oil zone from an adjacent gas zone, the GOR can usually be improved to help increase oil production.

2. To control excessive water or gas. Water or gas sands can be squeezed off below the oil sand to help decrease water/oil or gas/oil ratios. Independent water or gas zones can usually be squeezed to eliminate water or gas intrusion such as that illustrated in Fig. 9.2.

3. To repair casing leaks. Cement can be squeezed through corrosion holes in casing.

4. To seal off thief zones or lost-circulation zones.

5. To protect against fluid migration into a producing zone (block squeezing). (See Fig. 9.3.)

6. To isolate zones in permanent completions. It is common practice in many areas, after a well with multiple-producing-zone potential has been cased, to isolate the first zone by squeezing and produce the zone to depletion.[7]

7. To correct a defective primary cementing job. Problems resulting from channeling or insufficient fillup on the primary cementing job can often be overcome by squeeze cementing. Liners are commonly squeezed

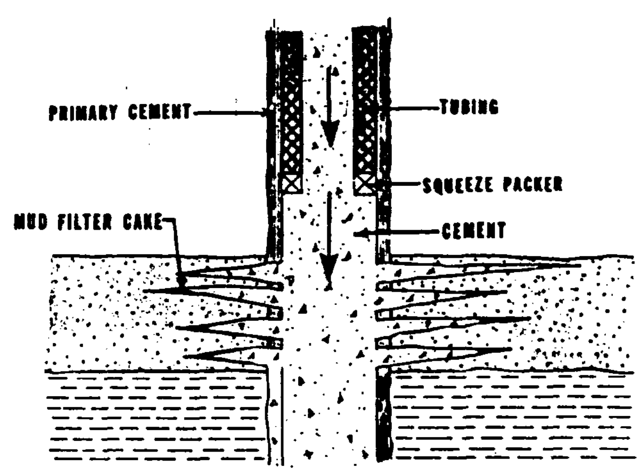

Fig. 9.1 Typical squeeze operation (packer set above perforations to control pressures and flow of cement slurry to formation).

was incomplete. The cement had dehydrated in the upper, more open section, causing a resistance to flow. (See Fig. 9.8.)

Filtration control helps avoid both premature loss of fluid from the slurry and rapid buildup of cement solids in the casing. Cement containing a fluid-loss-control additive loses filtrate to the formation much more slowly than does neat cement (Fig. 9.9), so the filter cake is denser and more pressure resistant. As fluid loss occurs in the formation, little or none is taking place in the casing; therefore, it is often possible to obtain cement plugging or dehydration in the formation and across perforations and still have sufficient time to reverse excess slurry from the casing, avoiding the time and expense of drilling out.

9.6 Squeezing Fractured Zones

In squeezing fractured limestone and dolomite formations, greater emphasis must be placed on effectively sealing the fracture network or channel system behind the casing.[9,10] It is necessary to modify the slurry design from that used to squeeze permeable sandstones, where the prime interest is slurry behavior within the perforations or nominal penetration of the perforations. In squeezing a fractured carbonate formation it is more important that the cement fill the fracture or channels than that it build up a filter cake. Larger volumes of slurry are required than for squeezing permeable sandstone reservoirs.

In the most successful squeeze technique, two cement slurries are used: (1) a highly accelerated slurry and (2) a moderate-fluid-loss slurry.

Accelerated slurries designed to set up shortly after reaching the formation are pumped into areas of least resistance and allowed to take an initial set. Once this has occurred, moderate-fluid-loss slurries can be forced into less accessible fractures.[9] The prime objectives in designing the slurries are that they be compatible with bottom-hole conditions and that they take an initial set within 10 to 15 minutes of placement. Pumping times for these slurries vary with bottom-hole conditions, and volumes of accelerated cement range from 35 to 100 sk. Because of the low permeability of most carbonate formations, cement slurries with moderate fluid-loss characteristics give satisfactory results.

In some instances a moderate-fluid-loss cement can be used as a lead slurry to fill the primary existing fractures and channel extremities. This slurry is followed by a high-strength slurry incorporating bridging agents.

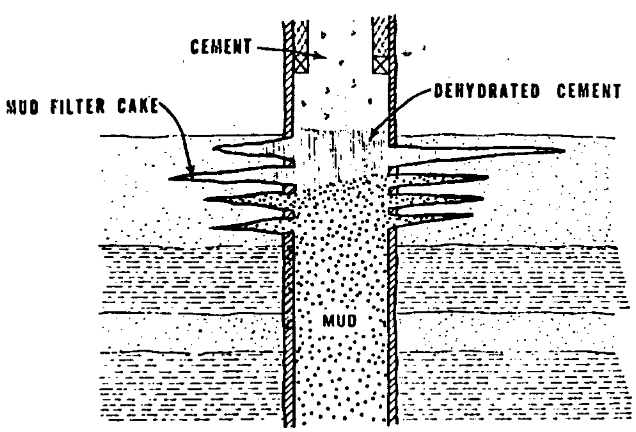

Fig. 9.8 Slurry dehydration across open perforations during a high-pressure squeeze operation.

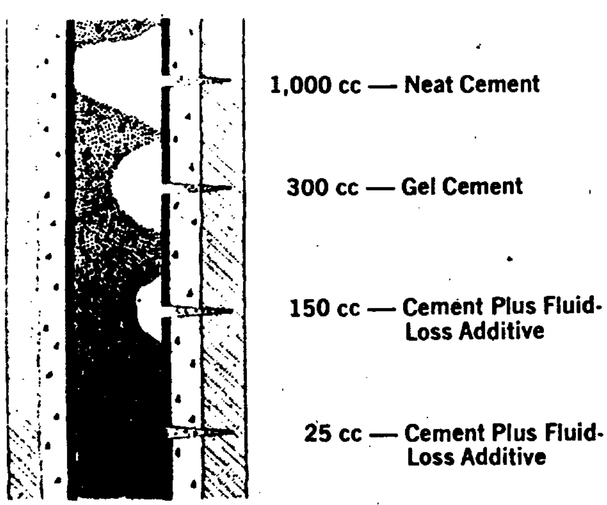

Fig. 9.9 Cement node buildup effect with filtration control (showing API fluid loss in cc/30 minutes at 1,000 psi).

9.7 Erroneous Squeeze-Cementing Theories

There are three predominant theories about squeeze cementing that contribute most to misapplication and improper field procedures.[11]

1. Whole cement enters the formation. This misconception leads to emphasizing the quantity of cement pumped behind the pipe and the amount of pressure applied, when actually these factors affect cementing results very little. The truth is that in low-pressure squeezing, cement filtrate — not whole cement — enters the formation (see Fig. 9.10). When the formation is fractured by exceeding the fracturing pressure, then cement slurry can be squeezed into the fractures.

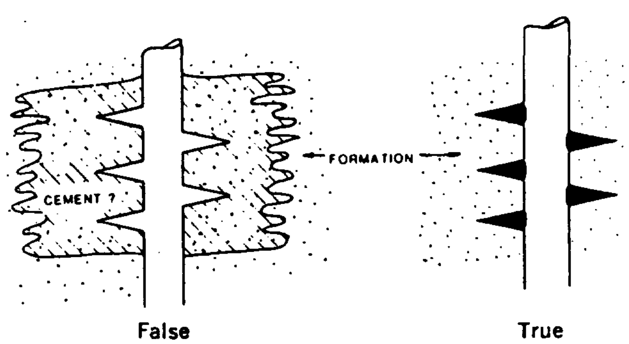

Fig. 9.10 Misconception 1 — Whole cement is squeezed into formation.[11]

2. Breakdown from injecting whole mud automatically opens all the perforations. In reality, it is rare to find all perforations open and receptive to fluid. To achieve this requires considerable effort. (See Fig. 9.11.)

3. A single, horizontal pancake or wedge of cement is formed around the wellbore. Indications are, rather, that because whole cement cannot enter the formation, the filtrate emanates from the perforations. When the formation is fractured, the cement slurry may enter in a series of irregular wedges. (See Fig. 9.12.) The orientation of these fractures depends upon the compressive forces on the zone being squeezed; in many instances it is northeast-southwest.

9.8 Job Planning

Planning is the most important single step in any squeeze operation.[12,13] Well conditions should be studied and objectives should be carefully established, as squeeze cementing can be complicated and expensive. In planning, the following questions should be posed:

1. Why are we squeezing? (Are we isolating a zone? repairing casing? filling up to seal the well?)
2. If we are not performing a bradenhead squeeze, what tools will we use?
3. Should the packer be drillable, or retrievable?
4. How far should we set the packer from the zone of interest?
5. Should we use high pressure, or low pressure?
6. How should we pump? (In hesitation stages? slowly? fast?)
7. What kind of fluid is in the well? (Acid? water? drilling mud?)
8. What kind of slurry should we use? (How much? with what characteristics?)
9. What mechanical equipment and other restrictions must we contend with?
10. What are the well conditions? (The fluids in the hole? the bottom-hole pressure and temperature?)
11. Is the target formation fractured? What is the fracture gradient?
12. What is the WOC time?
13. How will we test the squeeze job?

Every effort should be made to enhance hole conditions before and during the squeezing operation. The casing and tubing string should be as clean internally as possible — free of rust, paraffin scale, and perforation burrs. Wellhead packoff equipment should be used, or blowout preventers should be tested to the pressure expected to be exerted on them.

If squeeze work is to be performed through casing it is necessary to calculate the internal yield pressure and joint strength unless the casing is cemented to the surface. If the casing is not cemented to the surface, the critical stresses at the squeeze point can be calculated. If squeezing is to be performed through tubing set inside the casing, calculations must be made for the tubing and the casing, allowing for the collapse resistance of the tubing.

9.9 Slurry Design

The following factors should be considered in designing the cement slurry for any squeeze operation.

Temperature and Pressure

In squeezing, as in primary cementing, both temperature and pressure influence the placement and thickening time of a cement slurry. Squeeze pressure also affects the dehydration of the slurry.

Temperatures encountered in squeezing can be higher than those on primary jobs because the well usually has not been circulated by enough fluid to decrease the bottom-hole temperature. Table 7.5 illustrates the time at which the first sack of cement reaches bottom-hole conditions on a squeeze job and the static vs circulating temperatures at various well depths according to normal API testing schedules. Table 9.2 compares the thickening times of a given cement slurry for casing cementing with those for squeezing.

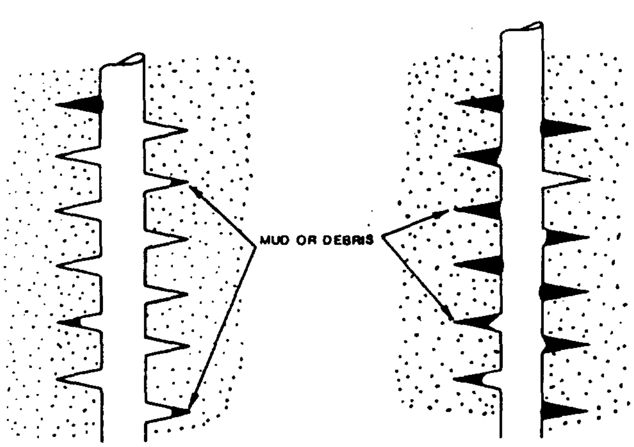

Fig. 9.11 Misconception 2 — All perforations are opened.[11]

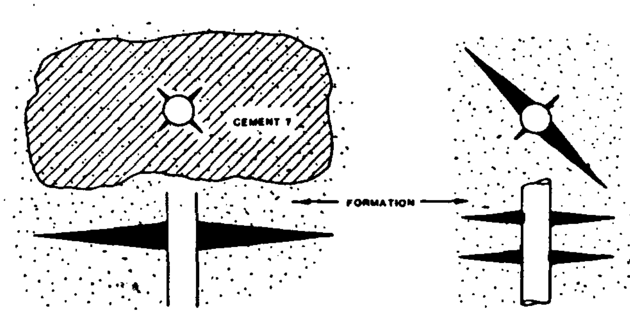

Fig. 9.12 Misconception 3 — Squeezing produces a horizontal pancake of cement.[11]

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