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# Chapter 1

## Introduction

### 1.1. Genral Introduction

An important process in petroleum industry is the zonal isolation; cement slurry must be designed carefully to avoid cementing problems. A lot of problems happened while cementing one of these is the cement micro-cracks or tinny channels in cement sheath. This research is evaluating the cement micro-cracks by using the mesquite wood powder.

Chapter 1 is a general introduction about cementing and objectives of research also problem statements. Chapter 2 defines the cement micro-cracks, its associated problems and mesquite information's. Chapter 3 presents the methodology of preparing cement samples and the evolution methods. Chapter 4 shows the results and a dissection chapter 5 conclude with the conclusions and recommendations.

### 1.2. Introduction to cementing

Cementing is the process of mixing and pumping cement slurry down to fill the annular space behind the pipe. When setting, the cement will establish a bond between the pipe and the formation. Unlike oil and gas wells, the casings in wells are usually fully cemented back to the surface. Portland cement is the most commonly used cement (Bett, 2010)

The American Petroleum Institute (API) Classifies cement into eight types depending on required properties. Slurry is made by mixing cement with water and additives. Chemical additives are mixed into the cement slurry to alter the properties of both the slurry and the hardened cement. The success and long life of well cementation requires the utilization of high-grade steel casing strings with special threaded couplings and temperature-stabilized cementing compositions. A hydraulic seal must be established between the cement and the casing and between the cement and the formation.

This requirement makes the primary cementing operation important for the performance of the well. Geothermal wells are drilled in areas with hot water or steam and because of the hostile conditions, special planning is necessary to ensure the integrity of the well. When primary cementing is not well executed due to poor planning, despite using the right methods and materials, remedial cementing may have to be done in order to restore a well's operation.

In general, there are five steps in designing a successful cement placement:

- i. Analyzing the well conditions: reviewing objectives for the well before designing placement techniques and cement slurry to meet the needs for the life of the well.
- ii. Determining slurry composition and laboratory tests.
- iii. Determining slurry volume to be pumped, using the necessary equipment to blend, mix and pump slurry into the annulus, establishing backup and contingency procedures.
- iv. Monitoring the cement placement in real time: comparison is made with the first step and changes implemented where necessary.
- v. Post-job evaluation of results. Cementing operation is a continuous process as shown in Figure (1.1), (Bett, 2010).

### **1.3. Cement definition**

Cement is made from calcareous and argillaceous rocks such as limestone, clay and shale and any other material containing a high percentage of calcium carbonate. The dry materials finely ground and mixed thoroughly in the correct proportions. The chemical compositions determined and adjusted if necessary. This mix is called the kiln feed; the kiln feed is then heated to temperatures of around 2600-2800° F (1427-1538 C). The resulting material is called clinker. The clinker is then cooled, ground and mixed with controlled amount of gypsum and other products to form a new product called Portland cement. Gypsum ( $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$ ) is added to control the setting and hardening properties of the cement slurry and to prevent the flash setting cement (Rabia, 2002).

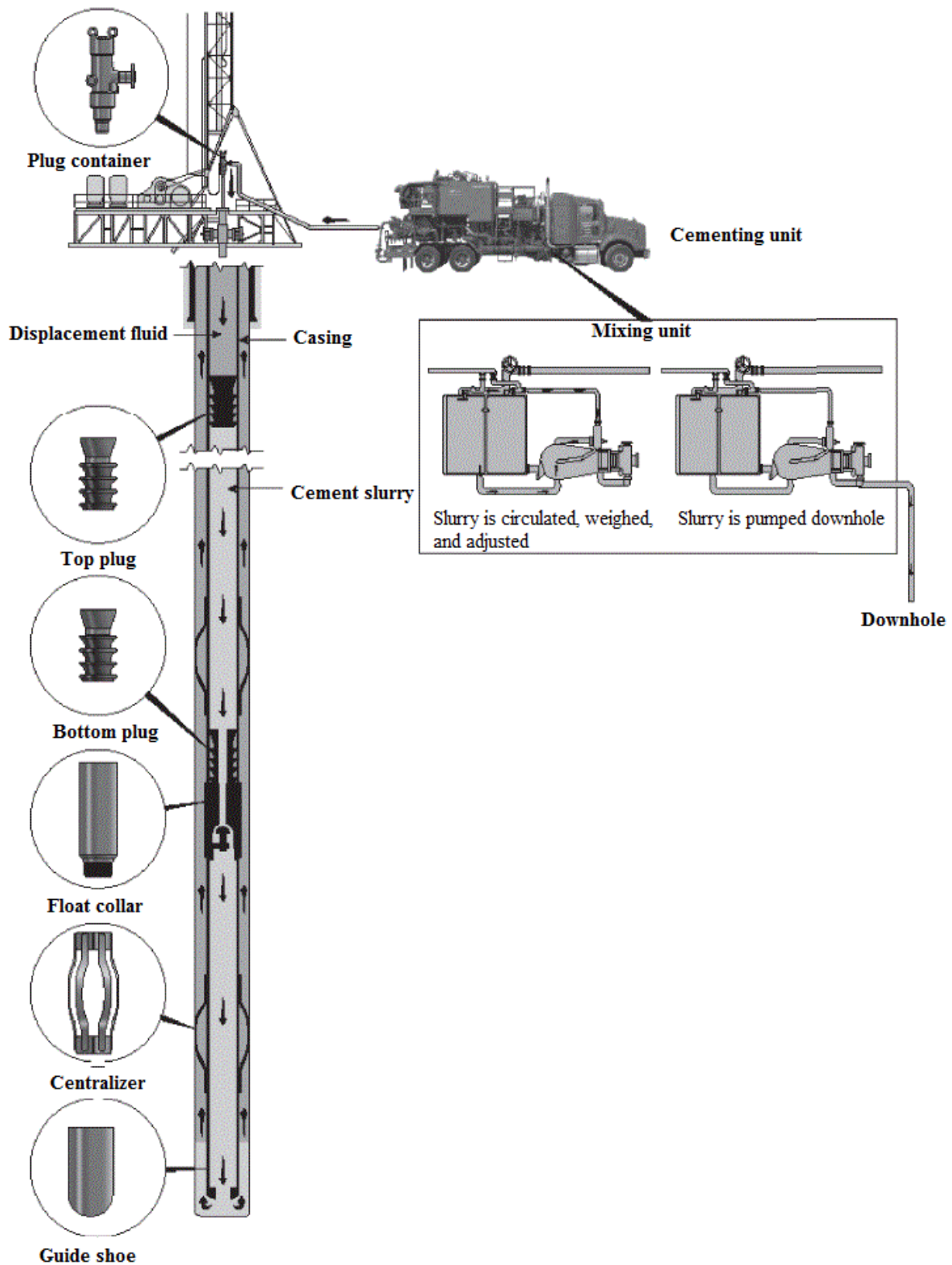


Figure (1.1): Typical cementing process (Bett, 2010)

The cements classified according to:

**I. American Society Testing of Materials (ASTM):**

1. Ordinary cement (O)
2. Moderate sulfate resistant (MSR)
3. High sulfate resistant (HSR)

**II. American Petroleum Institute (API):**

1. **CLASS A:** Intended for use from surface to a depth of 6,000 ft (1,830 m), when special Properties are not required. Similar to ASTM (American Society for Testing Materials) Type I Cement.
2. **CLASS B:** Intended for use from surface to a depth of 6,000 ft (1,830 m). Moderate to high sulphate resistance. Similar to ASTM Type II, and has a lower C3A content than Class A.
3. **CLASS C:** Intended for use from surface to a depth of 6,000 ft (1,830 m) when conditions require early strength. Available in all three degrees of sulphate resistance, and is roughly Equivalent to ASTM Type III. To achieve high early strength, the C3S content and the surface Area is relatively high.
4. **CLASS D:** Intended for use from 6,000 ft (1,830 m) to 10,000 ft (3,050 m) under conditions of moderately high temperatures and pressures. It is available in MSR (moderate sulfate resistance) And HSR (high sulfate resistance) types.
5. **CLASS E:** Intended for use from 10,000 ft (3,050 m) to 14,000 ft (4,270 m) under conditions of high temperatures and pressures. It is available in MSR and HSR types.
6. **CLASS F:** Intended for use from 10,000 ft (3,050 m) to 16,000 ft (4,880 m) depth under conditions of extremely high temperatures and pressures. It is available in MSR and HSR types.
7. **CLASS G + CLASS H:** Intended for use as a basic well cement from surface to 8,000 ft (2,440m) as manufactured, or can be used with accelerators and retarders to cover a wide range of well depths and temperatures. No additions other than calcium sulfate or water, or both, shall be
8. Underground or blended with the clinker during manufacture of Class G and H well cements. They are available in both MSR and HSR types (Rabia, 2002).

## 1.4. Cement additives

Additional chemicals are used to control slurry density, rheology, and fluid loss, or to provide more specialized slurry properties. Additives modify the behavior of the cement slurry allowing cement placement under wide range of down hole conditions. There are many additives available for cement and these can be classified under one of the following categories:

### 1.4.1. Accelerators:

Chemicals which reduce the thickening time of a slurry and increase the rate of early strength development. They are usually use in conductor and surface casing to reduce waiting on cement time (WOC). Calcium chloride ( $\text{CaCl}_2$ ), sodium chloride ( $\text{NaCl}$ ) and seawater are commonly used as accelerators.

### 1.4.2. Retarders:

Chemicals which retard the setting time (extend the thickening) of slurry to aid cement placement before it hardens. These additives are usually added to counter the effects of high temperature. They are used in cement slurries for intermediate and production casings, squeeze and cement plugs and high temperature wells. Typical retarders include: sugar; lignosulphonates, hydroxyl carboxylic acids, inorganic compounds and cellulose derivatives. Retarders work mainly by adsorption on the cement surface to inhibit contact with water and elongate the hydration process; although there are other chemical mechanisms involved.

### 1.4.3. Extenders:

Materials which lower the slurry density and increase the yield to allow weak formations to be cemented without being fractured by the cement column .Examples of extenders include: water, bentonite, sodium silicates, pozzlans, Gilsonite, expanded perlite, nitrogen and ceramic microspheres.

### 1.4.4. Weighting Agents:

Materials which increase slurry density including barite and hematite.

### 1.4.5. Dispersants:

Chemicals which lower the slurry viscosity and may also increase free water by dispersing the solids in the cement slurry. Dispersants are solutions of negatively charged polymer molecules that attach themselves to the positively charges sites of

the hydrating cement grains. The result is an increased negative on the hydrating cement grains resulting in greater repulsive forces and particle dispersion.

#### **1.4.6. Fluid-Loss Additives:**

Excessive fluid losses from the cement slurry to the formation can affect the correct setting of cement. Fluid loss additives are used to prevent slurry dehydration and reduce fluid loss to the formation. Examples include: cationic polymer, nonionic synthetic polymer, anionic synthetic polymer and cellulose derivative.

#### **1.4.7. Lost Circulation Control Agents:**

Materials which control the loss of cement slurry to weak or fractured formations.

#### **1.4.8. Strength Retrogression:**

At temperatures above 230 F, normal cement develop high permeability and reduction in strength. The addition of 30-40% BWOC (by weight of cement) silica flour prevents both strength reduction and development of permeability at high temperatures.

#### **1.4.9. Miscellaneous Agents:**

E.g. Anti-foam agents, fibers, latex (Adam, et al., 1998).

### **1.5. Problem statement**

The reason of placing cement in the wellbore is to fill or partially fill the space between a full string of casing and the wellbore. The cement sheath which settled in annular may contains a lot of micro-cracks if the design and setting presses are bad. These micro-cracks for long time increase cement permeability and make the formation fluids reach to the casing (water or gas migration). In this research we studied this problem and its effects and we used the mesquite wood powder as additives to reduce micro-cracks.

## **1.5. Research objectives**

The main objective of the research is to evaluate the effect of mesquite wood powder as an additive to stop cement micro – cracks or decrease it. Other sub-objectives are:

1. General Knowladagment about well cementing and design.
2. Reduce the cost by using mesquite floor at cementing job operations rather than imported one.
3. Reduce the damage causes by mesquite trees in our country Sudan; by use them as an additive.
4. Produce local products that can compete internationally.