Evaluating the cement condition of cased wells in the presence of hard rocks

Lucio N. Tello*, and Edwin K. Roberts
Computalog Research Division

Current methods of evaluating the cement condition of cased wells will produce erroneous measurements in the presence of hard rocks or "fast" formations. The traditional CBL method measures the amplitude of the first or second arrival of the compressional wave that travels through the casing and compares it to the amplitude of the arrival in known free pipe. A problem arises when the borehole formation is hard and there is a good cement bond in the annular space between the casing and formation. The velocity of the sound in this type of formation is faster than the velocity of the sound in the casing or pipe. Under this condition the sound arrival through the pipe is distorted by arrivals traveling through the formation and very often produces a combined arrival with a large amplitude which would indicate poor bond or an absence of cement. Solutions proposed which add a receiver at a small distance from the transmitter are ineffective in large diameter casings (>7 inches) and /or when the cement layer is relatively thin (< 1 inch thick). In large diameter casings, the direct fluid wave arrives at the receiver earlier than the casing arrival, while in thin cement layers the formation arrival outruns the casing arrival. The net result in both cases is a distorted pipe arrival. Ultrasonic methods also fail when wells drilled in hard rock have a diameter in gauge with the drill bit resulting in a thin cement layer. In this case formation reflections appear in the casing measuring resonance window indicating low acoustic impedance, which is interpreted as poor or an absence of cement.

This paper presents a method for measuring the cement condition of cased wells in the presence of hard or "fast" formations. The method uses a traditional sonic tool, such as the Sector Bond Tool™, with a 3-ft and/or 5-ft spaced monopole transmitter-receiver, but it can be applied to other sonic tools with different transmitter-receiver spacings. The new method uses a full wave power frequency spectrum from either one of the receivers. By taking the Fourier transform of at least 500 microseconds (preferable 1,000 microseconds) of signal the casing arrival can be separated in the frequency-domain from other arrivals. A broadband transmitter with a sharp or short duration acoustic pulse and a wide-band receiver enhance the frequency separation of the pipe from other frequency components such as formation and fluid. A digital gate is positioned within the pipe frequency and its energy is calculated by numerical integration. A free pipe frequency energy is typically between 3 to 6 times the energy of a bonded pipe. Waveform examples from logs show the time-domain and the frequency-domain power spectrum of both a free pipe and a well-cemented pipe in fast and slow formations. The frequency of the pipe is separated and its power amplitude measured while in free pipe. Then this frequency energy is compared to the frequency energy in bonded pipe regardless of whether a fast formation is present or not. It was also found in observations of the frequency spectrum that the pipe frequency exhibits a larger quality factor "Q" in free pipe than in well cemented pipe (Q being defined as the ratio of its maximum or center frequency to the difference of the two frequencies with amplitudes 50% of the amplitude of the center frequency). Log examples illustrating the results of this method are presented containing free pipe sections and well-bonded sections of the same wells.

(1998) Geo-triad '98: Abstracts: Plenary, Oral, Posters, Core Workshop