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Henry J. Ramey, Jr. and Paul Kruger, Editors
William E. Brigham, Ian G. Donaldson, Roland N. Horne,
and Frank G. Miller, Co-Principal Investigators
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APPLICATION OF A DOWNHOLE FLOWMETER TO DETECTING CASING BREAKS IN A GEOTHERMAL WELL

Margot C. Syms
Geophysics Division, D.S.I.R.,
Wairakei, New Zealand

Peter H. Syms and, Paul F. Bixley,
Ministry of Works & Development,
Wairakei, New Zealand.

The downhole flowmeter logging system for high temperature geothermal wells developed at Wairakei, New Zealand, is proving to be an invaluable tool for use during workovers to repair or reinstate problem wells. This contribution describes a straightforward example of identifying breaks in plain casing near the top of a productive well.

THE DOWNHOLE FLOWMETER

The flowmeter (described in Syms, 1980) contains an impeller, or spinner, which is rotated by water flowing through the tool. The flowmeter is operated while it is travelling up or down a well and the frequency of spinner rotation is recorded at the surface. The frequency is made up of two components: one due to the movement of the tool and the other due to water flowing in the well. These components either reinforce each other or tend to cancel depending on their relative directions; and the magnitude of each depends on the cross-sectional area of the well at the depth of the flowmeter. The sign convection adopted is that flow incident on the tool from above is positive, for example when the tool is moving upwards in stagnant water. The spinner frequency is given a sign to conform with this.

THE REPAIR OF WELL WAIRAKEI 216

This well has been supplying steam to the Wairakei power station since 1961. During a routine inspection in 1978, several large pieces of casing were found in the wellhead equipment. Two breaks in the casing and a pulled coupling were identified by a casing caliper survey in 1979. When the well was shut or on bleed, the measured internal pressure exceeded the calculated formation pressure at the level of the shallowest break, indicating potential blowout conditions. It was therefore decided to repair the casing and this was commenced in February 1980.

Just after the well had been quenched the injection pressure suddenly built up and no further water could be pumped, even at a pressure of 60 bg. The well was found to be blocked at 19 m, and a major casing collapse was suspected. Subsequent events showed that once the well had been quenched, pressure at the level of the breaks was reduced and the loose, water saturated, pumice breccia formation flowed into the well through the casing break(s). This material was then drilled out to 149 m depth. Several obstructions were found in the $8\frac{5}{8}$ inch casing, even with a $4\frac{1}{2}$ inch drill bit, so the casing was realigned with a roller tool.

At this stage there were at least seven sites of possible casing damage above 149 m and it was desirable to know which of these possible breaks would accept fluid from the well so that cement could be placed at the appropriate levels. The purpose of this cementing operation was to hold the $8\frac{5}{8}$ inch casing in the properly aligned position so that a smaller casing could be run and cemented inside it.

Investigations were carried out with the spinner flowmeter while injecting 6 litres/second of cool water from the surface at 10 bg wellhead pressure. Figure 1 shows three logs of spinner frequency against depth, two made with the tool moving upwards in the well and one with the tool moving downwards. Since the measurements were made inside plain casing (i.e. the well area is uniform) and the logging speed for each run was constant, in any one log the frequency should only change when water enters or leaves the well. Regular cycles of small amplitude on these logs are caused by fluctuating delivery rate of the piston pump. Logs made in wells which are not under pressure during injection do not have these regular variations, but do have a small amount of noise.

In the upper part of the well (above 107 m) the injected water flow is causing the spinner to rotate faster than it would if operated in a stagnant well for the up runs and slower for the down run. The tool is overtaking the flow on the down run so the spinner frequency is negative (water entering the tool from below). Five logging runs were made altogether and all logs show distinct changes in frequency at 107 m and 127 m depth. Water flow is leaving the well at both these depths since the frequency magnitude decreases on the up run logs and increases on the down run logs.

Relative flow quantities are shown by the relationship of logging speed to average spinner frequency, Figure 2. The interpolated spinner frequency corresponding to zero logging speed is proportional to volumetric flow. About 25% of the injected flow is lost at 107 m and most of the remainder at 127 m depth. The small remaining flow (7% of injected) that is indicated below 127 m is within the error limits of the measurements, so there may be no flow there.

The spinner flowmeter revealed that only at 107 m and 127 m depth were there any significant breaks in the casing. These breaks were grouted, taking 450 and 730 litres of grout respectively. Plain casing of smaller diameter (7 inch) was then cemented inside the repaired $8\frac{5}{8}$ inch casing and the well is now back on production.

REFERENCE

Syms, M.C. 1980: Interpretation of Flowmeter and Temperature Logs from Geothermal Wells. Geophysics Division Report No. 168. D.S.I.R., Wellington, New Zealand.

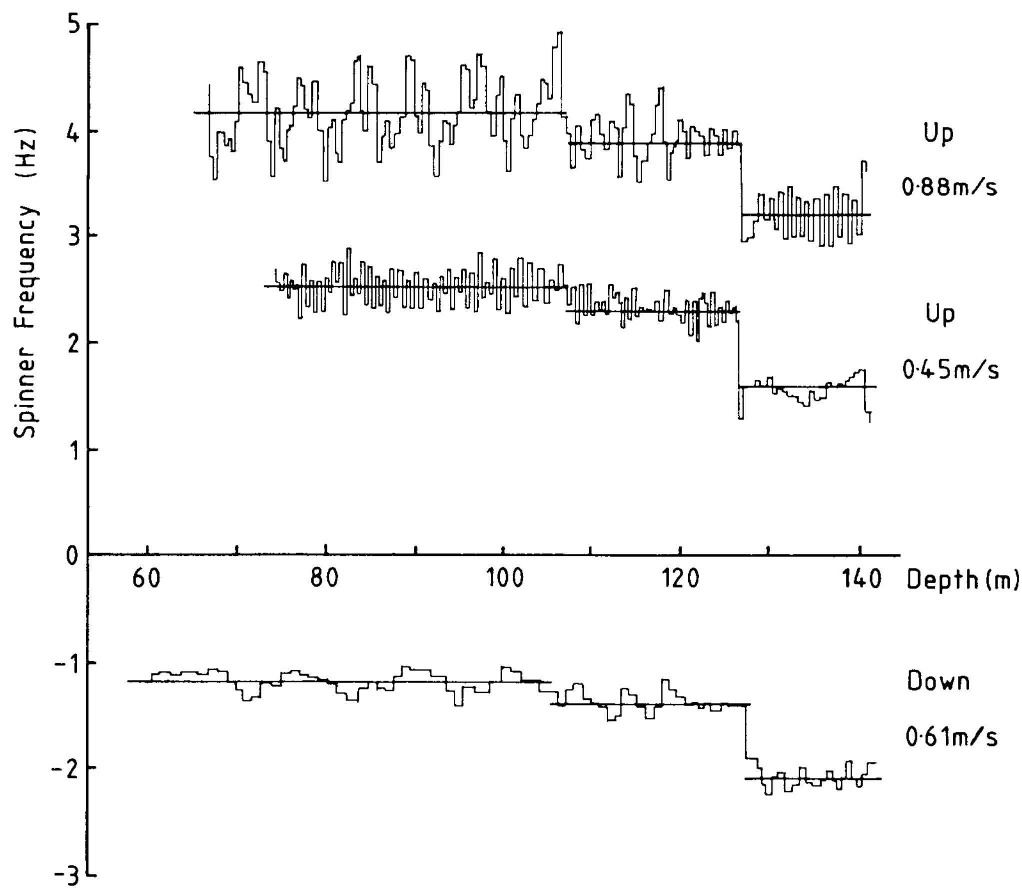

Figure 1: Three flowmeter logs made in well Wairakei 216 with 6 l/s being injected from the surface. The logging direction and speed are shown beside each record. Average values of spinner frequency have been drawn to remove cyclic variations caused by the piston pump.

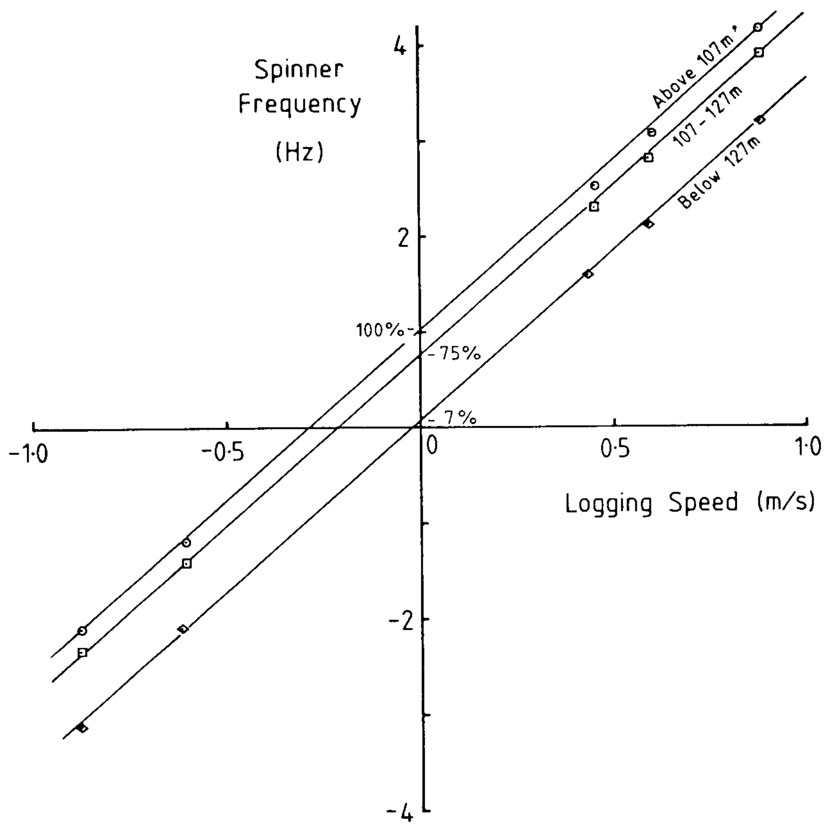

Figure 2: A plot of average spinner frequency against logging speed for the three constant-flow regions in the upper 149 m of Wairakei 216. Intercepts with the frequency axis indicate the relative amounts of flow in each region.