A WIRELINE-DEPLOYED TOOL FOR MONITORING FLUID FLOW WITHIN AN EGS BOREHOLE

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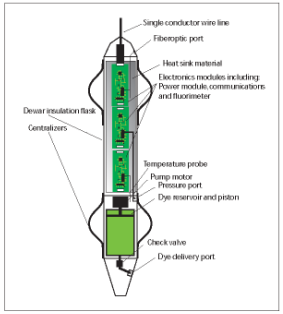
Objective: to design, fabricate, demonstrate and market a borehole flowmeter for measuring flow within geothermal and petroleum wellbores

The need for a better borehole flowmeter:

- Geothermal spinner tools are notoriously ineffective and unreliable:
  - Bearings fail and propellers are destroyed through contact with rock fragments flowing through the wellbore.
  - The pitch of the propeller blades must be changed frequently to account for the range of flow rates.
  - Spinner tools measure axial (not volumetric) flow rates and therefore fail in washed-out zones.
- Spinner tools also fail in conventional-petroleum waterfloods:
  - At very low (laminar) flow rates, spinners fail to turn
  - Current radioactive-iodide methods are non-quantitative, time-consuming and unreliable

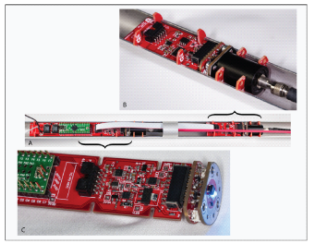


Approach: This tool is based upon the well-established tracer-dilution method that has become the standard for accurately measuring single- and two-phase flow in surface pipes (Hirtz et al, 2001). In applying the tracer-dilution method to our application, tracer is injected at one end of the tool at a constant known flow rate and concentration. The tracer then mixes evenly within the wellbore as the brine flows up and around the tool to its opposite end where its diluted concentration is measured. From these tracer-flow and concentration parameters, a simple calculation (performed using software within the tool) then determines the volumetric flow rate of brine within the wellbore:

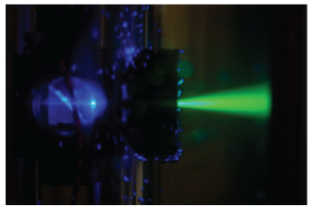
$$C_p * Q_p = C_w * Q_w$$

where C_P is the concentration of the tracer coming from a tracer-delivery pump and into the wellbore, Q_P is the flowrate of that tracer solution from the pump, C_W is the measured concentration of the thoroughly mixed tracer a few feet away from the tracer delivery point and Q_W is the flow rate of fluid within the wellbore. Both C_P and Q_P are known, C_W is measured, leaving only Q_W to be calculated from the equation. As the tool is made to ascend or descend along the wellbore, the flow is measured as a function of depth and a flow log is created.

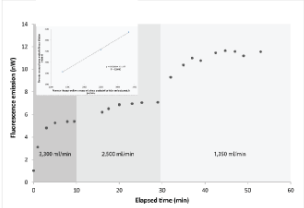
Phase 1 results:



The prototype LED source and photodiode detector.



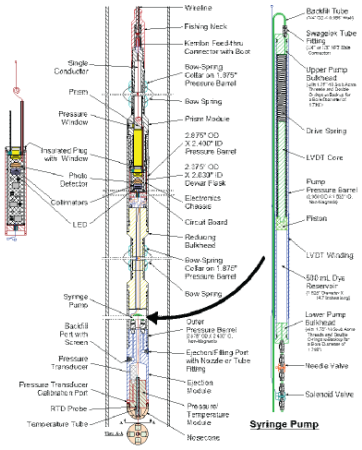
The blue LED light source shining into the laboratory wellbore test fixture and the backscattered green fluorescein emission.



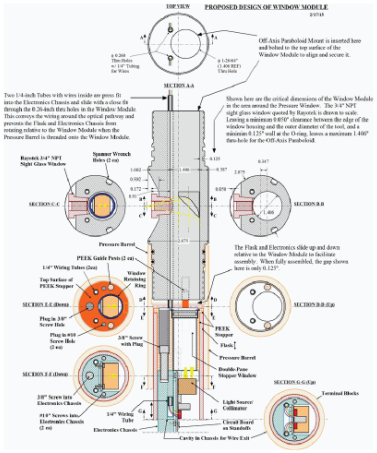
Data from the testing of the laboratory flowmeter at very low (sub-gpm) flow rates.

Phase 2 (Year 1) results:

- High-temperature (250°C) FluorFlow™ prototype design completed, including a novel spring-driven syringe pump
- Award of borehole fluorimeter/flowmeter patent, U.S. Patent # 8,952,319
- All components currently being fabricated/machined
- The prototype to be tested in a laboratory 'wellbore'



The fully assembled tool (not to scale).



The window module showing electronics and photonics within flask.

The syringe pump.

Phase 2 (Year 2) plans:

- Demonstrate FluorFlow™ prototype in a high temperature geothermal wellbore
- Make needed modifications, fabricate and demonstrate a second FluorFlow™ tool
- Launch the geothermal flow profiling service
- Conduct a market survey to identify waterflood flow-profiling customers in the petroleum industry
- Design, fabricate and test a prototype FluorWaterfloodFlow™ tool based on FluorFlow™ concepts
- Fabricate and test a second FluorWaterfloodFlow™ tool
- License FluorWaterfloodFlow™ to a petroleum service company for waterflood injection-well profiling
- Launch a petroleum waterflood flow profiling service and/or identify a petroleum-company licensee

Hirtz, P. N., Kunzman, R. J., Broaddus, M. L., and Barbitta, J. A. (2001) Developments in tracer flow testing for geothermal production engineering, *Geothermics*, **30(6)**, pp. 727-45