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Presentation title:
Real-Time Sensors for Multi-Phase measurement of pipe flows in steam and gathering lines.
Laboratory and field trial results

Prefer poster or oral presentation.

Real-Time Sensors for Multi-Phase measurement of pipe flows in steam and gathering lines.
Laboratory and field trial results

Laboratory and field trial results of testing of two new sensor techniques for measuring parameters of two-phase or multi-phase flows are presented. The sensor techniques are specifically developed for ease of deployment in geothermal piping, with the intent of providing affordable sensor technology that could be deployed on a per-well basis throughout a production steamfield.

Laboratory results suggest that the use of both sensors working together may be able to determine multi-phase information about oil/gas flows in gathering lines.

The sensor techniques are introduced, as well as results of laboratory and field trial data gathering.

Real Time Flow Measurement For Two-phase and Other Flows

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Introduction

Geothermal energy producers need to know their well performance. Current monitoring techniques cannot provide data continuously.

Well response is measured quarterly, or in extreme cases monthly, which is still no more than one data point per month.

Much time passes before you can know the effects of a change made to a well, whether done to improve day-day operations or develop long-term plans for the reservoir, and the opportunity for improvement is delayed.

Real-time sensors allow time to react **before the opportunity is lost.**

Two Sensor Types

Two new sensor technologies have been developed that provide **real-time measurement** of fluids inside steam field or other field piping.

LC Sensor: Measures pipe content by evaluation of Weight.
RF Sensor: Measures pipe content by evaluation of Internal Pipe Impedance.

Both measure water content inside the pipe.
Both offer data in real-time (per minute) intervals with +/- 2% accuracy.

The two sensors use very different means to measure the pipe content, but can use similar software for data analysis.

LC Sensor installs at pipe supports, with no contact to geothermal fluid.

RC Sensor Installs through standard pipe tap ports, and is not affected by pipe stresses or environmental effects.

LC Sensor

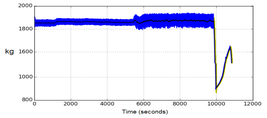
RF Sensor

Field Trials

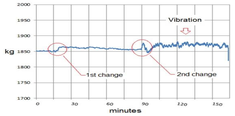
The two sensors take measurements multiple times per second. A onboard computer handles all calculations and allows for full connection to wired or wireless data networks. The system can also perform stand alone data logging, with battery power.

Data is analyzed and used for:

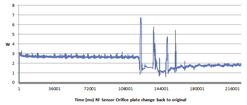
Tracking of well performance - Tracking of water flow rates - Water build-up
Changes in flow regime - Monitoring of unsafe conditions - Well interactions



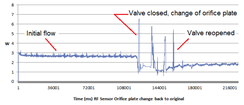
Raw Data (LC Sensor)



Averaged Data (LC Sensor)



Raw Data (RF Sensor)



Field Trial Events (RF Sensor)

Data Analysis

Sensors measure water content.

Onboard computer uses pipe ID and distance between supports to calculate void fraction.

Additional trends are found in the data by:

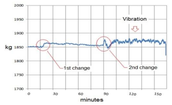
- Statistical evaluation such as Standard deviation
- Frequency analysis with Fourier transform
- Pattern recognition and time correlation

Historical analysis can also be performed, to provide comparison of current performance to past trends.

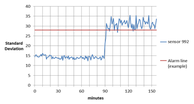
Results

Standard Deviation

More can be learned than changes in water content. Changes in flow regime can be found by tracking changes in Standard Deviation of the data.



Averaged Data

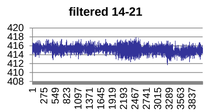


Standard Deviation

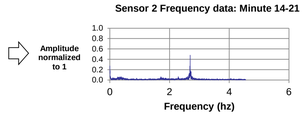
Note that Standard Deviation remains fairly constant from time 0 to time 90 minutes, but jumps rapidly to a new value after that time, corresponding to a change (choking) of the well.

Fourier Transform

Normal well flows are chaotic, without specific continual patterns. Datasets with a perfect harmonic resonance may indicate something other than just the flow in the pipe.



Raw Data

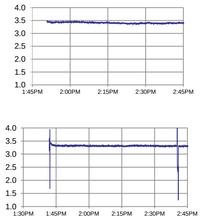


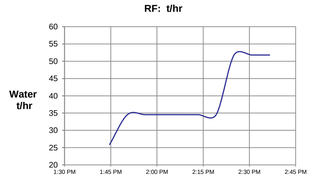
Frequency Spectrum

The strong harmonic seen in frequency analysis indicates a pipe vibration.

Time Correlation

When two sensors are placed on the same pipe a distance apart, the patterns within their data can be compared.





Time Correlation between the two datasets is used to find water velocity, and in turn mass flow rate.

Conclusions

Trends in the well flow can be found immediately with these real time sensors. Overall system response of a field of wells can be understood to a much finer degree in a much faster time, allowing for planning of operations such as day-day or day-night load balancing and variable power output for grid stabilization.

The same data allows for additional functions that may help overall field reliability and safety.

The following uses have been discussed:

- Immediate viewing of trends in the well flow, and calculation of void fraction
- Tracking of changes to flow regime, including water build-up in gas lines
- Alarm systems for major (dangerous)r changes in flow, such as slug flow
- Monitoring of pipe vibration, maybe even valve vibration
- Longterm monitoring of piping to track scale buildup

And if two sensors are used:

- Calculation of flow velocity, and in turn water mass flow rate

Future work

Upcoming geothermal field trial: May/June 2018. Includes multi-well testing for evaluation of well interaction.

Steamfield Sensors is actively seeking opportunities for further field trials, in geothermal fields and gas or oil gatherng lines. All datasets from real-world fields are extremely helpful to software development.

Please contact us, thank you:
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References

MEASUREMENT OF TWO PHASE FLOWS IN GEOTHERMAL PIPELINES USING LOAD-CELLS: FIELD TRIAL RESULTS
John R. SISLER, Sadiq J. ZARROUK, Alex URGEL, Yoong Wei LIM, Richard ADAMS and Steven MARTIN