Real Time Flow Measurement For Two-phase and Other Flows

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Introduction

Two new sensor technologies have been developed that provide **real-time measurement** of fluids inside steam field or other field piping. The sensors can provide information on **water content**, **dryness fraction** and **flow velocity** on a real time basis in two-phase and other geothermal fluids, thereby providing the necessary information to calculate **total mass flow** and **Enthalp**y in a considerably more timely manner than techniques currently in use. The sensor techniques do not require pressure drops or similar disruption to the flow and allow for cost effective full deployment throughout a steam field to provide information on well performance from multiple wells simultaneously.

The two sensor techniques are the load cell version and the RF (radio frequency) version. The load cell version has been tested in field trials, showing that the sensor can accurately track changes in the contents of the pipe and flow rate of the water. The RF sensor version has also been tested with promising results, but in a non-flowing laboratory environment, without the use of pressurized high temperature fluids.
The load cell field trials showed that the sensor could provide data to calculate changes to dryness fraction, total mass flow, and overall Enthalpy. The results show that the same sensor can provide information on flow regime, minute-by-minute changes to well output, and onset of events worth tracking such-as development of slug flow or other dangerous conditions. These capabilities are all possible from the same sensor, allowing much more information to be available for steam field operation.
The RF version laboratory testing allowed for development and modification of antenna designs, resulting in effective antenna plans that are more robust while also showing an increase in performance. The RF version is potentially more useful than the load cell version as it is able to provide the same wide range of capabilities while allowing for deployment in more complex piping structures.
Producers could deploy either or both of these sensor technologies at individual wells, or multiple wells simultaneously, allowing for continuous sensor results from the entire resource. This is information not currently available to production operations, and may lead to production strategies that improve the efficiency of electrical generation immediately, while also allowing for better understanding of how the resource could be managed for the long term.
For the load cells, the device can be mounted at the same location as pipe supports, using a suitable stand to hold the load cell and allow the weight of the pipe to be carried by the cell. The sliding pipe support and its guides remain responsible for pipe alignment.
For the RF version, antennas are introduced into the pipe through standard tap ports such as the ports used for chemical sampling or Tracer Flow Tests. Results of laboratory tests indicate that successful data can be obtained in a small section of pipe, possibly only a few meters in length.

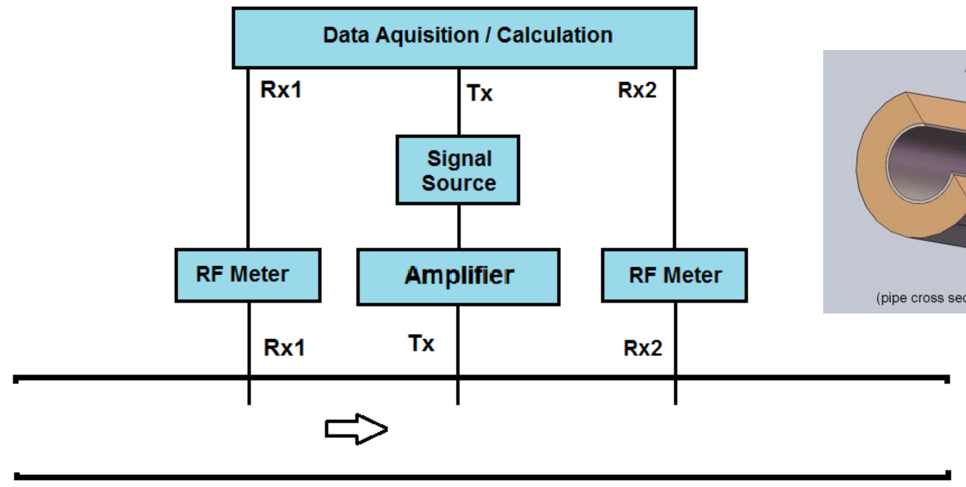
Methods

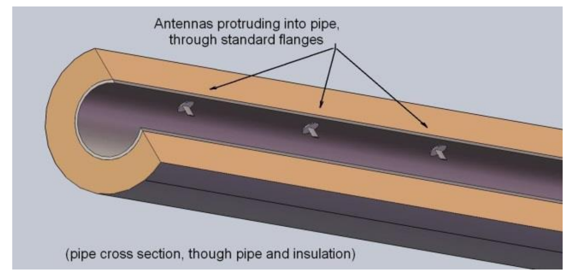
Load Cell Method: This method relies on determining the contents of the pipe by weighing the overall structure. Piping in geothermal fields is often held above ground on pipe supports that are designed to accommodate thermal expansion/contraction. This aspect of steam field design is used to allow for a measurement of pipe and fluid weight by monitoring the overall weight seen at one or more of these sliding pipe supports.



Load cells installed on two in-line supports allow the ability to measure the velocity of the water flow, which can be used to calculate the overall Mass flow Rate. A single load cell is sufficient to determine changes to dryness fraction (x), and changes to flow regime or detection of dangerous flows such as slug flow.

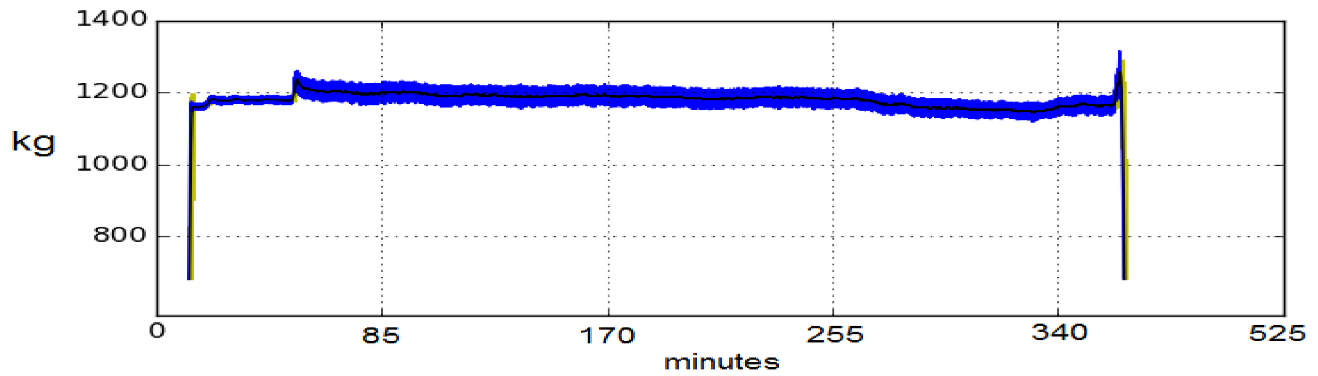
RF Method: The sensor measures the fluid contents of a pipe by attenuation of RF signals. A transmit antenna and a receive antenna are installed into the pipe, and an RF signal is sent from one to the other. Measurement of response provides the necessary data to determine pipe content. The sensors can be placed in relatively close proximity. Initial tests used a distance of one meter for the space between transmit and receive locations, but closer spacing may be possible. A useful configuration would be the use of three antennas, equally spaced approximately ½ to 1 meter apart. The center antenna is used for transmit, and the two outer antennas are used for reception, allowing for determination of pipe flow similar to the use of two load cells as discussed above.



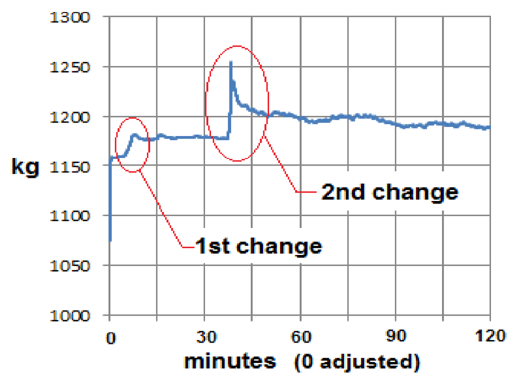


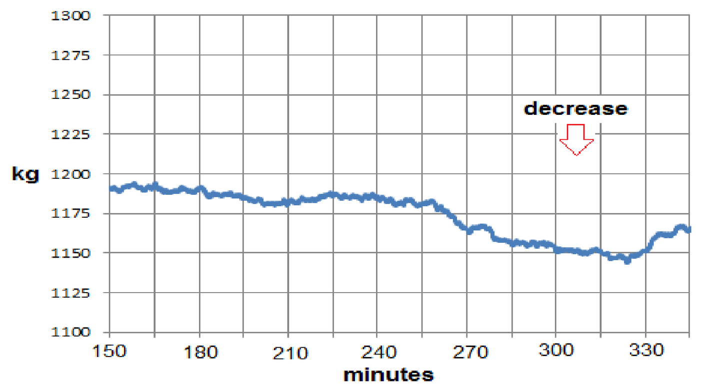
Results

Below is a typical view of raw data received from the **load cell sensor**. The blue is the full data output, The black line seen within the blue is a processed trendline, based on a specific weighted running average:



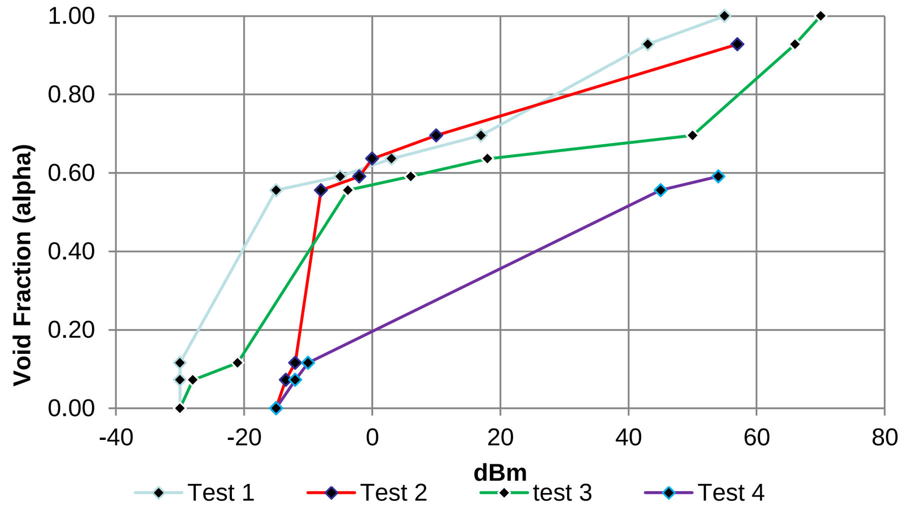
By viewing the processed data we can see well changes in extreme detail:



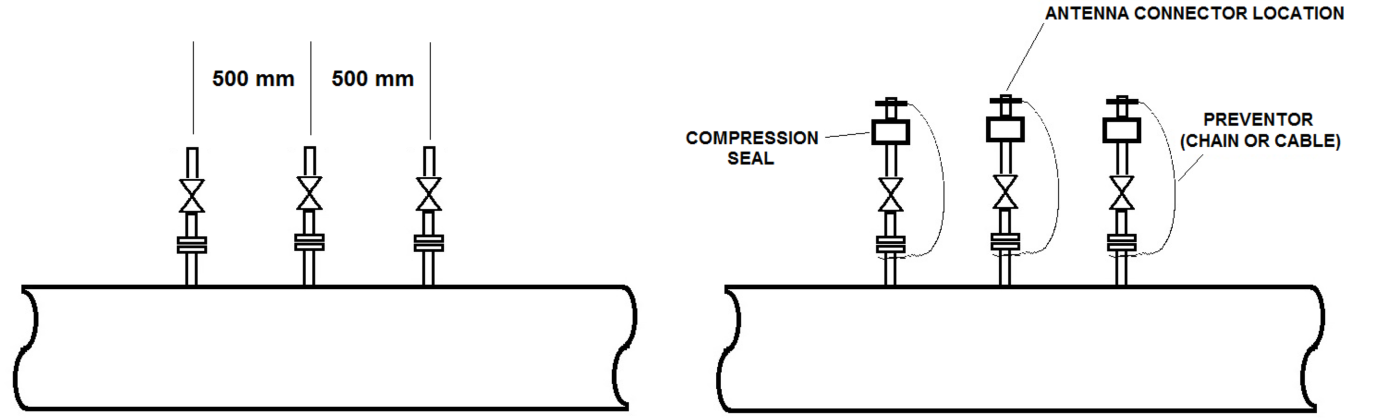


The '1st change' and '2nd change' area mark times when the well valve was closed slightly, choking the well and increasing the overall measured weight. This directly relates to a change in dryness fraction (x). The sensor can track changes in x of less than 1%. Note the 'decrease' seen late in the test. This is an effect that occurred from the well itself, and shows that the sensor can notify us immediately about changes occurring naturally in the well.

RF Sensor: Tests show the accuracy of the RF sensor may be able to be better than that of the load cell. And with signal processing it is expected that accurate velocity data can be obtained with antennas mounted in only a few meters of pipe length. Test 4 seen below shows the improvement in performance possible with modification to the antenna design, showing that the new antenna plan allows for more than 3 times the accuracy.



The antennas can be introduced into the pipe through standard tap ports, allowing access for maintenance and support without disruption to the flow in service. They can be inserted and removed while the flow is under pressure with the use of a compression seal. A standard tap such as that used for testing and sampling could be used for the antenna insertion, and has the advantage of already having been designed to meet most piping agency approvals.



Conclusions

These two sensor methods are new techniques, unheard-of and unknown in the industry. Both sensor methods can readily detect changes in flow regime, and act as a protection device or alarm for dangerous flows such as slug flow while continuing to provide real-time data on pipe content and flow velocity. Used as a method to provide data about well Enthalpy and overall Mass Flow Rate, the devices can provide producers information on a much finer time scale than previously obtained. Once these sensors have been proven, a full deployment would lead to a greater understanding of the reservoir while also providing real-time information on well performance and interaction that could be used to immediately improve energy production.

We are actively seeking additional opportunities to test these sensors in field locations, and improve and show their capabilities while also providing users with useful real-time data. We welcome all inquiries, and hope to further this development and evaluate reservoir performance by testing multiple wells simultaneously. Suitable testing can also be performed during drilling operations. If you are interested in seeing these sensors in action on wells in your facilities, please contact: Jsisler@cruzio.com Thank You.

References

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