THE CHALLENGE:
Optimizing Unconventional Resource Development

THE SOLUTION:
Integrated Sensor Diagnostics (ISD)
Every shale formation is different, to some degree. Optimizing the asset can be a complex undertaking that involves understanding and integrating a vast scope of data to form a unified picture of the asset, from early planning through exploration and development to long-term production.

Pinnacle’s integrated sensor diagnostics (ISD) service delivers subsurface insight to help make financially important decisions related to well spacing, fracture spacing and completion design.

Pinnacle’s integrated sensor diagnostics service provides recommendations to improve well performance and develop overall asset deliverability. Pinnacle’s unique approach combines subsurface insight with far-field and near-wellbore sensors data collected from completion to stimulation to production. This knowledge is integrated with proven fracture and reservoir engineering techniques to address unconventional resource challenges.

**Near Wellbore Sensors**

- **FiberWatch® Distributed Optical Sensing** - FiberWatch® sensing centers around distributed temperature and acoustic sensing results. These data provide real-time results during the fracture treatment to determine cluster efficiency, fluid distribution, and completion effectiveness. These are valuable inputs for the calibrated fracture model.

- **Pressure Gauges** - Downhole pressure sensors are important for understanding fluid movement in a wellbore and fracture fluid movement between wells. Their value to integrated sensor diagnostics is tied to accurate bottom hole pressure results during well production.

- **FracHeightSM Microdeformation Monitoring** - This tool combines the sensitivity of Pinnacle’s patented downhole tiltmeter sensors with downhole microseismic receivers conveyed on a fiber optic wireline. This hybrid tool array provides insight on actual fracture deformation as a function of depth. The focus for fracture geometry is on accurate hydraulic fracture height.

- **FracNetSM Microdeformation Monitoring** - The FracNetSM monitoring solution is a deformation based solution developed to better understand fracture geometry. The patented technology provides clarity around fracture azimuth, orientation, and complexity; all of which are important for integrated sensor diagnostics.

**Far Field Sensors**

- **FracTrac® Downhole Microseismic** - FracTrac® pionered this fracture mapping technology. The results from microseismic determine fracture geometry, azimuth, and fracture complexity. This is crucial to the integrated diagnostic solution as it provides critical inputs for the calibrated hydraulic fracture model.

- **Surface Microseismic Imaging** - Pinnacle offers surface imaging to complement the down hole microseismic solution. The results again provide valuable fracture geometry information used to constrain the hydraulic fracture model. The far field geometry is critical for integrated sensor diagnostics.
Integrated Sensor Diagnostics (ISD) Real-time stimulation diagnostics is a staple within Pinnacle’s core business expertise. Near well-bore fluid distribution and far-field fracture geometry form the framework for integrated sensor diagnostics. Performing calibrated fracture modeling based on the fracture geometry and fluid distribution is the best method to take results indicating fluid placement, and turn that into proppant placement. Pinnacle professionals perform this step to further constrain the calibrated reservoir model and have more confidence in the end result.

Reservoir modeling is performed by Pinnacle’s professionals on the complete project using the results acquired during injection through production. Once all this data is compiled, a final calibrated reservoir model is generated. The final step of integrated sensor diagnostics ties all these pieces together. Pinnacle, along with the operator, can now go back and assess the project objectives and answer those most pressing questions. Pinnacle professionals will deliver engineering-based optimization recommendations built on this complete process.

**Integrated Sensor Diagnostics Workflow**

**PROJECT SETUP**
Understanding the project objectives is the first critical step to successful integrated sensor diagnostic implementation. To meet these objectives, ISD lays out a plan that places the correct sensors in the optimum locations and aligns the results with the correct engineering tactics.

**PRODUCTION ANALYSIS**
Production analysis is the step that makes the critical leap between fracture interpretation and the final reservoir interpretation. This analysis is performed through Pinnacle’s professionals using the distributed fiber-optic data throughout the well life.

**REAL-TIME STIMULATION ANALYSIS**
Real-time stimulation diagnostics is a staple within Pinnacle’s core business expertise. Near well-bore fluid distribution and far-field fracture geometry form the framework for integrated sensor diagnostics.

**CALIBRATED FRACTURE MODELING**
Performing calibrated fracture modeling based on the fracture geometry and fluid distribution is the best method to take results indicating fluid placement, and turn that into proppant placement. Pinnacle professionals perform this step to further constrain the calibrated reservoir model and have more confidence in the end result.

**CALIBRATED RESERVOIR MODELING**
Reservoir modeling is performed by Pinnacle’s professionals on the complete project using the results acquired during injection through production. Once all this data is compiled, a final calibrated reservoir model is generated.

**ASSET OPTIMIZATION**
The final step of integrated sensor diagnostics ties all these pieces together. Pinnacle, along with the operator, can now go back and assess the project objectives and answer those most pressing questions. Pinnacle professionals will deliver engineering-based optimization recommendations built on this complete process.
Stage to Well
Real-time analysis and adjustments can be made on a per stage basis. These lessons can be applied throughout the entire well stimulation process, with the end goal of improving well performance. Integrated sensor diagnostics has a large, focused goal of asset optimization that begins during the very first stage. These include diversion effectiveness and completion effectiveness.

Well to Pad
Significant improvements can be made with each well analyzed using integrated sensor diagnostics. These real-time results are studied and analyzed by Pinnacle professionals and immediate lessons from the well applied to the remainder of pad operations. These include perforation cluster efficiency and stimulation design optimization.

Pad to Field
The end of the stimulation operations for a pad is quickly followed by the acquisition and analysis of production data. These lessons, when tied into the fracture and reservoir modeling results, produce asset optimization recommendations that can be applied throughout the entire field. These include stage spacing and lateral well spacing designs.

North American Focus – ISD Track Record

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