4.4.2 The Development and Demonstration of an Electric Submersible Pump at High Temperatures - High-temperature Motor Windings for Down-hole Pumps Used in Geothermal Energy Production

Presentation Number: 016
Investigator: Hooker, Matthew (Composite Technology Development, Inc.)
Objectives: To develop and demonstrate electric submersible pump (ESP) motor windings that utilize inorganic electrical insulation systems for high-temperature use.
Average Overall Score: 3.0/4.0

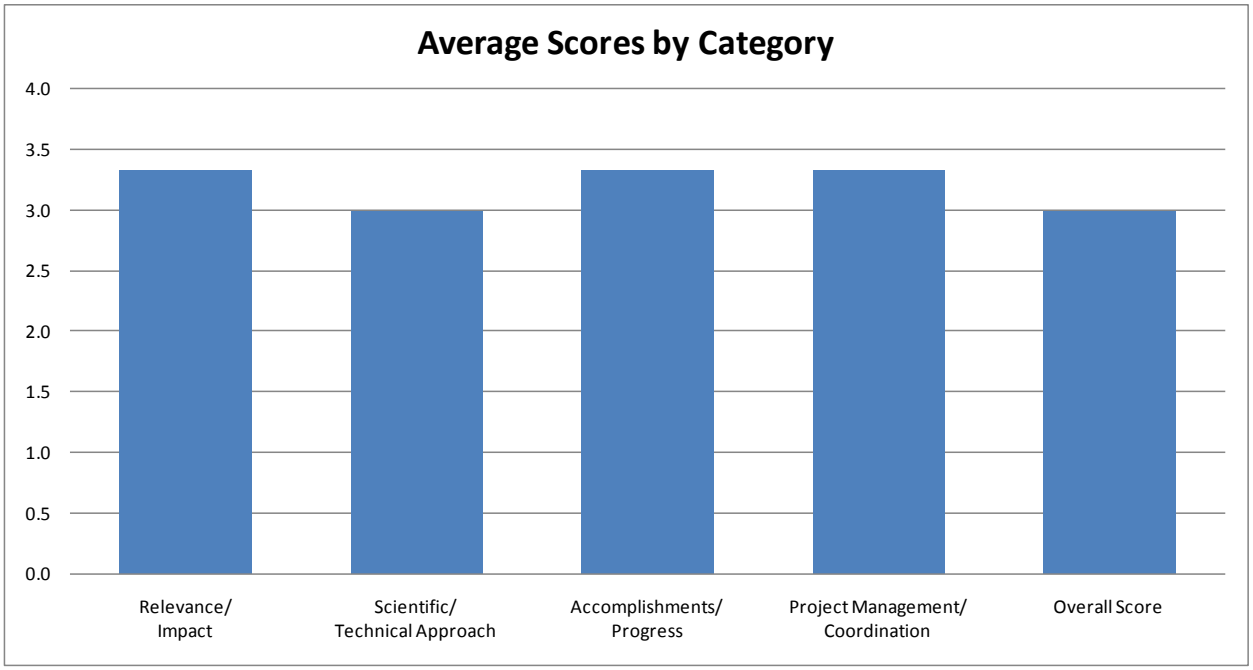

Figure 23: The Development and Demonstration of an Electric Submersible Pump at High Temperatures – High-temperature Motor Windings for Down-hole Pumps Used in Geothermal Energy Production

4.4.2.1 Relevance/Impact of the Research

Ratings of Three-member Reviewer Panel: Good (3), Good (3), Outstanding (4)

Supporting comments:

- Electric Submersible Pumps are an essential component of many geothermal systems (except those in which there is a natural flow of steam to the surface). The author notes that of the causes of failure in ESP systems, pump motor failure is (just) the largest single contributor, at 32 %. However, not all motor failures are due to failure of the insulation on the wires, and so, while important, work to improve the insulation will solve only one of a number of causes of failure.

- We absolutely need pumps that can operate at higher temperatures for EGS to be successful.

- An ultimate objective of Enhanced Geothermal Systems research is a down-hole electric pump capable of moving 300 °C geothermal fluids at high rates through boreholes several inches in diameter from depths of up to 10 km to the ground surface. Present down-hole pumps used by the oil industry are designed for much smaller diameters and lower temperatures.

  While scaling up the diameter, length and power of down-hole pumps for EGS service appears to be possible with an extension of present technology, survivability at high temperatures is not. A major weakness is the breakdown of insulation on the copper motor windings. This project's objective is to develop and prove new materials that will provide the necessary electric insulation at temperatures of 250 °C for long periods of time, as in years. A second aim is to assure that the new insulation can be applied to the motor windings in manufacture.

  Improving the high temperature of other down-hole pump components will doubtless be important, but the motor winding insulation is critical and absolutely essential.

4.4.2.2 Scientific/Technical Approach

Ratings of Three-member Reviewer Panel: Good (3), Good (3), Good (3)

Supporting comments:

- The scientific approach and the proposed improved insulation material appear to provide very significant improvements over the current PEEK material, and there seems to be a high probability of success. The development of testing procedures (first laminate then as coatings to wires) is logical and appears successful. Incorporating glass fiber braid looks like giving superior mechanical properties as well as creep resistance.

- The approach of the research team is focused on increasing the temperature capability of the pump by increasing the temperature capability of the electrical resistance material.

- The investigation of inorganic materials for electrical insulation at high temperatures is an appropriate course of action. Early coordination with a wire manufacturer is important. Testing of candidate materials is the correct first step. This leads to making scaled down motor windings with the qualified materials, in collaboration with the wire maker. However, the first tests confirm temperature resistance only at 250 °C.

  The sample "statorettes" are constructed with the new wire in coordination with a down-hole motor manufacturer. The resulting assemblies are to be subjected to electrical tests at 250 °C temperatures .

4.4.2.3 Accomplishments, Expected Outcomes and Progress

Ratings of Three-member Reviewer Panel: Good (3), Outstanding (4), Good (3)

Supporting comments:

- The project is proceeding as planned, with good progress. I like the steady progression from laminate to single wire to "statorette" testing. I also like the fact that the new insulation is

strong and flexible enough that wire so insulated can be used to build motor windings using conventional techniques.

- The team has tested in the lab a material with 300 °C capability. It looks promising.

- Appropriate materials have been identified and applied effectively by a wire manufacturer. Then the wire has been fabricated by a down-hole motor manufacturer into the statorettes, which then will be tested at high temperatures. The project therefore is about where it should be at this stage, and appears to be on track toward achieving its objective at 250 °C.

4.4.2.4 Project Management/Coordination

Ratings of Three-member Reviewer Panel: Good (3), Good (3), Outstanding (4)

Supporting comments:

- The research teams appear competent, and the collaboration between experts in the different domains (Wood Group, New England Wire and CTD) is logical and valuable.

- There are two partners working on this project and they appear to be working well together.

- The coordination with the wire maker and motor manufacturer seems to have been accomplished almost seamlessly, resulting in the project being on track.

4.4.2.5 Overall

Ratings of Three-member Reviewer Panel: Good (3), Good (3), Good (3)

Supporting comments:

- The project is going well, and looks as if it will deliver as proposed. My only reservation is that the solution will address only one of the reasons for the failure of EGS projects, (pump motor failure) and within the domain of pump motor failure, only one of the possible reasons for motor failure.

- Testing a specimen in a lab environment and testing in a well are very different. This project has a long way to go, but it does promise to significantly raise the temperature rating of electrical insulation.

- Successful completion of this project is likely to lead to the desired down-hole pump motor technology, able to function at temperatures up to 250 °C, significantly better than other present technologies. It should be noted that the pump motor may get hotter than the fluid being pumped, and future design and testing should account for this if the pump is to function in a 250 °C environment for long periods of time. Future research will be necessary to develop motor winding insulation that will survive at 300 °C.

4.4.2.6 PI Response

No response.