COETZER OPTICAL SYSTEMS (Pty) Ltd

Fiber Optic Temperature Sensor Geology

Overview

A review of fiber optic sensing in geomechanical applications at. Fiber optic sensing (FOS) offers a promising alternative due to its scalability, durabi.

Key Takeaways

Fiber-optic distributed temperature sensing (FO-DTS) enables continuous, high-resolution monitoring of subsurface and surface temperatures, providing critical insights into geological and hydrological processes.Principles of FO-DTS

FO-DTS systems measure temperature along optical fibers by sending pulses of laser light through the fiber and analyzing the Raman backscatter. The ratio of temperature-dependent anti-Stokes to temperature-independent Stokes photons allows precise temperature determination at specific locations along the fiber, with spatial resolutions typically ranging from 0.25 to 2 meters over several kilometers of cable . Measurement precision can be adjusted by the user, improving from about 0.2°C to 0.01°C depending on integration length and measurement duration . This enables continuous monitoring of dynamic processes in both time and space.

Applications in Geology and Hydrogeology

FO-DTS is widely used in geological and hydrogeological studies to monitor temperature variations that indicate subsurface processes:

• Groundwater-Surface Water Interactions: FO-DTS can identify zones where groundwater discharges into streams or aquifers by detecting thermal anomalies along riverbeds or boreholes .

• Fracture and Borehole Characterization: In bedrock, FO-DTS helps locate transmissive fractures and preferential flow paths by mapping temperature variations along boreholes .

• Geothermal Monitoring: Low-temperature geothermal fields can be monitored for thermal performance and heat transport using fiber-optic arrays .

• Geotechnical Engineering: FO-DTS arrays measure strain, stress, and vibrations in hard rock mines, alluvial formations, and civil infrastructure, providing data for subsurface imaging and structural monitoring .

Advantages for Geological Studies

• Continuous, Long-Distance Monitoring: FO-DTS allows measurements over kilometers of fiber, providing a continuous temperature profile rather than discrete point measurements .

• High Temporal Resolution: Data can be collected at intervals from seconds to hours, capturing dynamic processes in real time .

• Integration with Other Data: FO-DTS results can be combined with chemical, hydrologic, or geophysical data to improve interpretation of subsurface processes .

• Non-Invasive Deployment: Fibers can be deployed in water columns, sediments, or boreholes without significantly disturbing the environment .

Challenges and Considerations

• Spatial Resolution Limitations: While FO-DTS provides high-resolution data, reported temperatures are influenced by light dispersion and instrument response, requiring careful interpretation .

• Data Processing: Large datasets from kilometers of fiber require specialized software, such as DTSGUI, for visualization and analysis .

• Environmental Factors: Temperature readings can be affected by external conditions, necessitating calibration and careful deployment planning . FO-DTS technology has revolutionized geological and hydrogeological monitoring by providing high-resolution, continuous temperature data that reveal subsurface processes, groundwater flow, and geotechnical behavior, making it an essential tool in modern geological engineering and environmental studies .

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In-Depth Overview of Fiber Optic Temperature Sensors

A fiber optic temperature sensor is a temperature measurement device that uses optical fibers as the sensing medium. Unlike

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2. FOS principles FOS is based on the analysis of returned light that is initally sent into the optical fiber and allows

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