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C3Or3B-02: Cryogenics in the drilling of deep, multi kilometer geothermal wells

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The potential of geothermal resources is currently limited by existing drilling technology. To address this issue, the DeepU project is investigating the use of laser and cryogenic gas to drill deep wells (>4 km) to create a U-shaped closed-loop geothermal heat exchanger. This technology includes a high-power laser source and optics, a drill string, a drill head, a flushing system and some ancillary systems required for successful rock penetration. Supercritical nitrogen is transferred down the borehole, then after isenthalpic expansion of the gas, vitrifies the rock and flushes the rock debris to the surface. A complex mathematical model of nitrogen flow during the laser drilling was developed. Pneumatic transport modeling provided preliminary information on the required supply of supercritical nitrogen to provide the necessary cooling power and pneumatic transport of cuttings to the surface.

Vacuum insulation was selected for the supercritical nitrogen transfer pipe. No commercially available cryogenic transfer line couplings suitable for the DeepU operating parameters were found, so a custom coupling system was designed to ensure tightness, robustness and ease of assembly. Potential failure modes of the proposed system were identified and mitigation steps were proposed. The study demonstrates the feasibility of delivering supercritical nitrogen to a borehole several kilometers deep. The test campaign of selected process phenomena and design solutions is ongoing.

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