

Development and construction of BHA and drill string for field scale bench testing of a novel laser-assisted drilling process

Dennis Schwarz, Shahin Jamali, Volker Wittig, Rolf Bracke

International Geothermal Centre (GZB) / University of Applied Science Bochum

dennis.schwarz@hs-bochum.de

Abstract

Interest in geothermal energy resources has increased substantially in Europe and worldwide over the recent years. It represents a large enough renewable resource that can be used to supply the high energy demand especially for district heating while having minimal environmental impacts. However, many geothermal resources tend to be found in deep and hard rock formations within the earth.

The current deep drilling industry has been undergoing several incremental improvements in various aspects. However, it still performs poorly especially in hard formations and no groundbreaking improvement has been introduced to address the exponentially increasing technical challenges. Problems mainly include very low rate of penetration, high tool and bit wear-rates and consequently time-consuming tripping resulting in economic unfeasibility.

Laser-based thermal drilling technologies could be the vital change to improve the hard rock drilling process and eventually overcome various problems associated with it. GZB in Bochum is investigating Laser Jet Drilling (LJD) based on thermal spallation and rock weakening. Subsequently, as part of the research project there was a requirement to implement the developed thermal drilling process into a full-scale drill rig in form of a combined laser-mechanical drilling process. However, in order to implement the process, a novel fit for purpose drill string and bottom hole assembly (BHA) needed to be developed to fulfill the requirements of both mechanical and laser-based drilling methods, which has been the main topic of the thesis.

In the course of this study, the pertinent components required to facilitate a functional combined thermo-mechanical drilling into a full-scale drill rig have been engineered. The fluid distribution system including a quadruple pipe system and swivel was designed to meet the requirements of HP-water, air and drill mud and protect the central fiber optic cable. The bottom hole assembly including a modular drill bit have been designed to act as a housing for the delicate laser-head and bring the required mechanical assistance into the process. Its modular design enabled the possibility to incorporate necessary changes and optimizations in each step of the research project. As the last step, a special fluid nozzle system has been implemented into the drill bit module to enable and optimize the creation of a downhole vortex under submerged drilling conditions. Finally, a new model has been proposed to better understand and assess the parameters effecting the generation and maintenance of a downhole vortex.