Freitag, 1. März 2024, 09.50 Uhr
Baden Arena Kongress 1 – Tiefe Geothermie

Friday, 1 March 2024, 09.50 am
Baden Arena Congress 1 – Deep Geothermal Energy

Realistic automated scenario drilling through implementation and validation of physical and machine learning models using a real-time drilling simulator

Realistische automatisierte Bohrszenarien durch Implementierung und Validierung von physikalischen und maschinellen Lernmodellen mit einem Echtzeit-Bohrsimulator

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Scenario drilling is a method that creates realistic drilling environments to simulate and execute complex drilling processes in real-time. Its application also includes pre-drilling or re-drilling a complete well or critical sections of the well. This is done in order to analyze the process and understand or investigate particular drilling and downhole phenomena. By obtaining and analyzing the data from the simulation, it is possible to improve the drilling performance (for instance in deep geothermal wells) by adjusting the operating or wellbore parameters.

The software simulator (DrillSIM:600) available at the Drilling Simulator Celle is designed and manufactured by Drilling Systems, UK. The simulator emulates a real-time life drilling environment, including a land rig and its surface and downhole equipment. The simulator combines a 3D surface and downhole graphics with realistic rig equipment sounds, allowing the user to have real-life learning experience.

Another function of the DrillSIM:600 is the ability to create different drilling scenarios by designing formation conditions, such as formation layers, formation properties, etc., and setting up drilling parameters like rig, drillstring, BHA, trajectory, etc. There is also the option to include potential drilling problems, for example loss circulation, kick, pipe sticking, drillstring vibration. The combination of all the mentioned factors creates a complex drilling operation which can be simulated in real-time or with accelerated simulation speed.

An Application Programming Interface (API) is used to establish the communication with the DrillSim:600. The API allows the user to improve existing models and implement externally developed physical and machine learning models to calculate drilling and downhole parameters, such as rate of penetration, bottom hole pressure, wellbore temperature. The newly developed models shall provide a more realistic drilling simulation compared to the built-in simple models.

In this paper, both physical and machine learning models will be included such as ellipsoid of uncertainty, bit walk tendency, rate of penetration, weight on bit, and equivalent circulation density.

The process of scenario drilling has been automated by the use of a specifically designed automation algorithms, which consists of related parameters regarding multiple drilling phenomena.
The improved and implemented models are validated by analyzing their behavior and comparing them to the already available models and the historical data of the drilled wells. This comparison allows the user to observe, analyze and optimize the effects and behavior of different parameters and multiple drilling operations included in scenario drilling.