# RESEARCH NEWS

**Renewable energies**

## Micro drilling turbine improves efficiency of geothermal systems

**Geothermal systems are becoming an increasingly important source of clean and, above all, baseload-capable energy. But the geothermal wells, which can be several thousand meters deep, are risky, and things can sometimes go wrong. Fraunhofer scientists have now developed an innovative tool that enables additional branches to be drilled off of the main well. This decreases the risk of dry boreholes and improves the output.**

Geothermal energy is an inexhaustible energy source. Hot water from reservoirs, fissures and cracks can be found deep in the earth's crust, which is about 30 kilometers thick. The water at a depth of 5000 meters is already 200 °C hot. In geothermal applications, it is pumped up using a production well. This water can then be used to power steam turbines to generate electricity or to heat buildings via heat pump systems. The cooled water flows back into the earth's crust via a second well — the injection well — where it is heated up again in the hot rock. It is a complete cycle. This renewable energy can play a significant role in the fight against climate change.

But the wells, which reach several thousand meters deep, entail both significant costs and risks at the same time. The risk of being wrong and finding nothing (what experts call the exploration risk) is about 30 percent. That is what the experts at the Fraunhofer Research Institution for Energy Infrastructures and Geothermal Systems IEG in Bochum want to change. Their idea is to use a mini-drill to perforate the area around the borehole in a radius of 50 meters and hydraulically connect the surrounding water-filled cracks and fractures to the borehole. This opens the way for the water to flow into the production well from where it can be pumped up.

### Secondary drilling explores the surrounding area

The micro turbine drilling (MTD) technology was developed by Niklas Geißler, who performs research at the Fraunhofer IEG in Bochum and the Fraunhofer-Chalmers Research Center for Industrial Mathematics FCC in Sweden. “Wells that reach several kilometers into the earth's crust cost millions of euros. Additional branches from the main well using MTD increase the catchment area for hot water and the exploration risk significantly decreases,” explains Geißler.

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The key to MTD is a compact micro drilling turbine which is equipped with a special drill bit. It is very small, measuring just 3.6 centimeters in diameter and 10 centimeters in length. The micro turbine is attached to a high-pressure hose, through which it is powered by up to 200 liters of water per minute at an inlet pressure of about 100 bar, which makes the bit rotate. The bit consists of a tungsten carbide matrix with incorporated diamond grains and grinds into the rock at up to 80,000 rotations per minute. Therefore, it is especially suited for hard, crystalline rocks like granite. Furthermore, it is also capable of drilling steel. That is important because wells are usually lined with steel casing for better stability. Without changing the drilling tool, the MTD can first drill the steel casing and then the rock in a single step. "We can drill two to three meters in one hour. The water that powers the micro turbine serves as both a coolant, so the drill doesn't get too hot, and also flushes the hole to remove the drill cuttings," Geißler says. There have been similar technologies using pressurized water in the past, such as radial jet drilling. However, until now only soft rock could be drilled using those technologies. For geothermal energy in particular a method is needed to drill through the hard rock in which geothermal reservoirs are often found.

One of the challenges in the process is to deflect the micro drilling turbine out of the main well and drive it into the surrounding rock at a relatively large working angle. That is why the IEG researchers have developed a special deflection device. Using this "deflector shoe," the compact tool can be guided out of the main well at an angle of about 45 degrees. Thus, the drilling tool opens up new cracks and fissures with hot water around the main well. Using hydraulic pressure means that when the water is pumped up, the water flows out of the cracks and fissures and into the main well.

"During the last months, we successfully demonstrated the technology in a proof of concept at the Bedretto Underground Laboratory (BUL) in Switzerland, near the Gotthard tunnel. The process is already very stable and reliable," Geißler enthused.

## Audio recordings of the drilling noises

The importance of the issue has also been noticed by politicians. Since March 2021, the German Federal Ministry for Economic Affairs and Energy has funded the project with over 430,000 euros. Meanwhile, Fraunhofer IEG researchers have been pushing ahead with the project. The next step is to record the drilling noises. The sound of the micro drilling turbine, whose blades emit a characteristic pulse pattern during rotation, can also serve as an acoustic reference for the analysis. By analyzing the audio recordings, it is possible to determine whether the drill is rotating at the right speed, is stuck or is even running dry. The noise is transmitted as structure-borne sound to the steel pipes and recorded on the surface.

The technology is not only useful for geothermal applications. "In general, the MTD can be used in any deep drilling where it is important to explore the surrounding area

of a well with potentially heterogeneous rock types, such as for the oil and gas industry. In the geotechnology or tunnel construction fields, for example, this micro drilling technology can be used to drill anchor holes in hard to reach areas where the amount of available space precludes the usage of conventional equipment," explains Geißler.

However, one main application of the technology, for which a patent application was filed in 2020, is certainly the extraction of geothermal energy. Experts estimate that the number of geothermal power plants in Europe will double over the next five to eight years. Micro turbine drilling from the Fraunhofer IEG can play a significant role in making production wells less risky, less costly and even more efficient.

**Fig. 1 The micro drilling turbine with a diamond drill bit is only 10 centimeters long and has a diameter of 3.6 centimeters. When drilling, it rotates at up to 80,000 revolutions per minute.**

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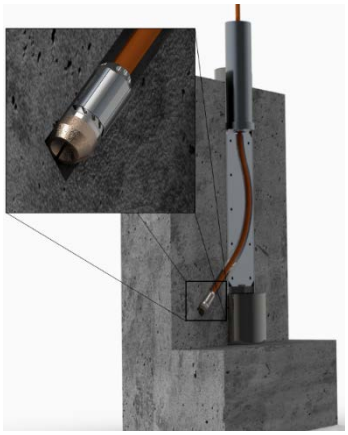

**Fig. 2 Simple and reliable: the sheet steel deflection shoe guides the drilling tool outward at an angle of 45 degrees.**

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**Fig. 3 View of a freshly drilled side arm at 346 meters. The micro drilling turbine milled out the granite rock cleanly.**

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