Petroleum engineers develop technology to simulate mechanical properties of subterranean rock

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A test facility simulating rock positions was developed in Samara Polytech. It allows carrying out many experiments with the core material under conditions close to rock positions at different depths.

The original facility developed at Samara Polytech will help to explore the Earth's interior. Under laboratory conditions, the mechanism recreates the physical parameters (for example, pressure and temperature) of a deposit located at multiple depths. The technology makes it possible to accurately determine the mechanical properties of a rock such as hardness, elasticity and plasticity. Its technical characteristics are described in detail in an article published in the journal *Construction of Oil and Gas Wells On Land and Sea*.

"The development of the facility that we call the 'Monster Machine' was inspired by the invention of the Academician of the Russian Academy of Sciences, the founder of oil and gas geomechanics in the USSR, Sergey Alexeevich Khristianovich," says Alexey Podyachev, the project manager, an associate professor of the Oil and Gas Well Drilling Department, Candidate of Technical Sciences. "Unfortunately, we did not see the 'live' installation of the legendary scientist, we were content only with photographs on the internet. But we knew the main principles of its work that formed the basis of our project."

Alexey Podyachev, together with the senior lecturer of the department Pavel Bukin, calculated the rigidity of the machine body, which was modeled and manufactured by engineers of a plant in St. Petersburg. When the body was delivered to Samara, the Polytech workers began to manufacture the inner part of the mechanism, where the rock sample directly interacts with the hydraulic cylinder rods (metal rods that transmit the force from the piston).

"The uniqueness of the machine is that the investigated core fragment is loaded independently from three sides. To do this, in the inner block, we designed rather complex kinematics of a decreasing cube with 100% overlap of the edges," explains Alexey. "As a rule, a cylinder with a diameter of 30 and a height of 30 (or 60) millimeters is considered the reference shape of the core being examined. However, it is impossible to

provide a full-fledged orthogonal load along three axes on such a sample. Therefore, we decided to replace the cylinder with a cube. We cut a cube-shaped sample from a full-size cylindrical core and place it on a special pedestal inside the machine, where pressure plates press it from three sides. All the faces of the sample are completely covered, that is, there is no free areas. This means that it is loaded evenly over the entire face plane and has no "unloading" sections."

So, you can simulate, for example, the pressure inside the well. For this, the sample is uniformly loaded, and then one of the sides is being gradually released. Thus, engineers calculate at what pressure and at what loads plastic deformations of the rock appear, and its subsequent destruction.

With this technology, it is possible to carry out unique research into the influence of drilling fluid on the mechanical properties of the rock. For this, the sample is saturated with liquid and installed in the machine. An elastic wave is passed through the sample at a predetermined interval. All occurring deformations are monitored using special pressure and deformation sensors.

Since the rigidity of the casing of the Polytech installation allows creating large loads without reducing the accuracy of the results, a number of tests not related to drilling can be carried out on it, for example, the study of the strength of cement, metal and other materials.

More information: Pavel Nikolaevich Bukin, et al. About some elements of natural gas thermodynamics in deep wells, *Construction of Oil and Gas Wells on Land and Sea* (2021). DOI: 10.33285/0130-3872-2021-1(337)-10-17