Development of the Testing Device for Simulation of Contact Between Plasmabit's Locking System and the Surface of the Geothermal Well

J. Bucala, J. Mudrák and M. Žarnay

Abstract This article is focused on design of innovative systems for locking mechanisms used for geothermal wells up to 10 km deep. The article contains design of the testing device, which will be constructed in order to confirm proper function of the locking system. The testing device is currently under development at Department of Design and Mechanical Elements of University of Žilina.

Keywords Plasmabit · Locking system · Testing device

1 Introduction

The Plasmabit is unique device which should be able to work under extreme conditions up to 10 km beneath Earth surface effectively. It is an autonomous system for drilling able to move on its own and withstand temperatures up to 400 °C and pressure of 100 MPa. There are not any known manufacturers of such devices or any other similar systems already working anywhere around the world. The device consists of many subsystems, such as systems for motion, rock disintegration, control systems, cooling systems and backup systems.

The locking system is currently under development, but so far we are able to state that the idea of the locking system itself is possible to design. Locking to the surface of the geothermal well is possible because of two horizontally mounted linear hydromotors orientated against each other. Locking to the surface of the

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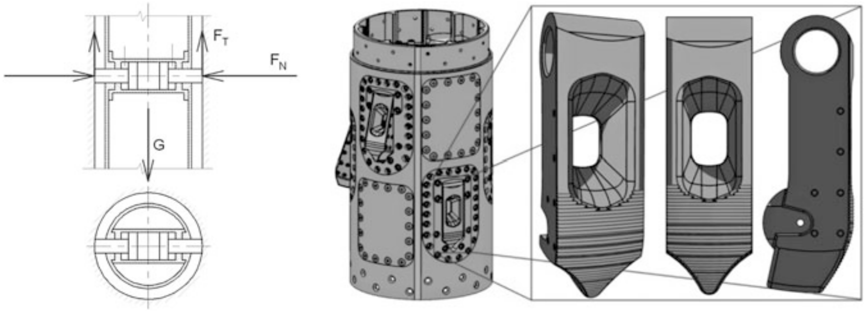


Fig. 1 The principle of the locking system, part of the locking subsystem and detail view on the locking element

geothermal well is accomplished by pushing out locking elements towards the surface of geothermal well and by generating normal force $\boldsymbol{F_N}$ high enough for safe lock. In this case, vertical force which needs to be locked has magnitude according to Eq. (1).

$$\mathbf{G} = 2.F_T = 2.F_N.f \tag{1}$$

where **G** is the force of gravity of the plasmabit, F_T is the friction force between locking elements and the surface of the geothermal well, F_N is generated normal force on the surface of the geothermal well f is the friction factor (Fig. 1).

After one of plasmabit's locking subsystems is fixed, another part can move in vertical direction. Vertical motion is similar to one of the earthworm and it is allowed by the linear hydmomotor which is oriented vertically.

It is possible to minimize dimensions and mass of whole device by next development, research and optimisation of the locking system or whole device at once. That's why it is necessary to have geothermal well surface data measured and verified for further development of the locking system. The key goal is to know real contact conditions between the locking element and the surface of the geothermal well. In order to solve this task, the testing device is being developed. The device will simulate normal force and tangential motion of locking element on the rock specimen (Medvecký et al. 2012).

Measurements will take place in a laboratory of Faculty of Mechanical Engineering of University of Žilina. It is required to use materials and technologies available directly at the university.

2 The Testing Device

It is device designed to simulate contact between locking elements and the surface of the geothermal well. The device is designed to simulate real load of whole device with two locking elements in simultaneous contact with the surface of the

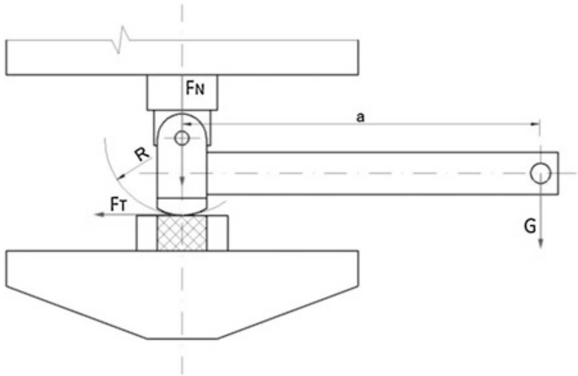


Fig. 2 Variant with one friction surface

geothermal well. Main reason of developing the testing device is to verify system's ability to carry out required functions. Main goal to be achieved is to find out whether it comes to movement of locked locking elements or not under given load and normal forces. In other words, what will the friction factor value for different materials of friction coupling be. The measurement of normal forces is planned in order to verify proper function of the locking system.

The testing device consists of a hydraulic press, which is available in one laboratory of Faculty of Mechanical Engineering. The hydraulic press is suitable for given task because it can generate adequate force and this force can be measured and recorded. However there is only one hydraulic press available. That means one force has to be generated by any other way. Devices such as levers, pulleys and motion screws were taken into an account. Some variants are described in following text.

We took into an account solution with one friction surface as well as solution with two friction surfaces (which represents real load more accurately) while creating new variants. Variant with one friction surface is shown in Fig. 2. Normal force F_N is drawn by the hydraulic press and friction force F_T is drawn by the lever mechanism. The locking elements are located at the very end of lever, the rock specimen is hatched.

Variant with two friction surfaces and the lever mechanism is shown in Fig. 3. Normal force is drawn by the hydraulic press and friction force by the lever mechanism.

Variant with two friction surfaces is designed to draw normal force by hydraulic press and mass of Plasmabit by the motion screw. Plasmabit's mass represents force which is able to move the device, especially the locking elements, vertically. Device is shown in Fig. 4.

Variant, which is shown in Fig. 5, uses extra weight to simulate Plasmabit's mass. Weight is attached to tightened rope through the pulley. The force inside the rope is axial with rest of the device. Weight can be added or removed according to current demands.

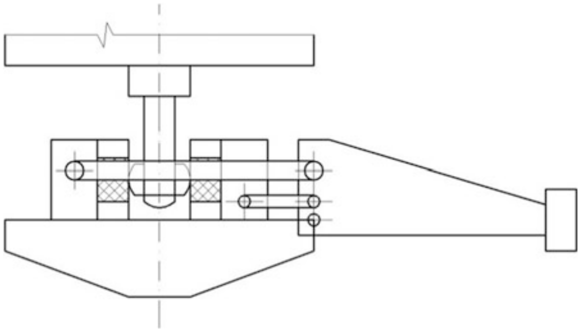


Fig. 3 Variant with two friction surfaces and lever mechanism

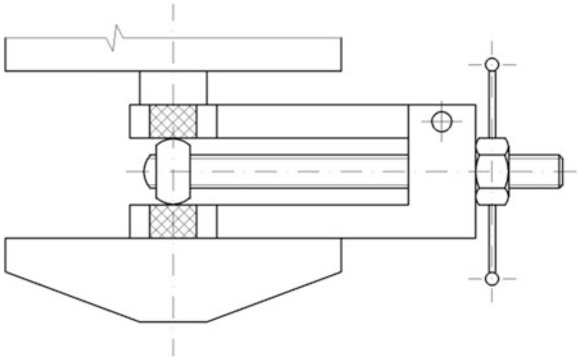


Fig. 4 Variant with two friction surfaces and motion screw

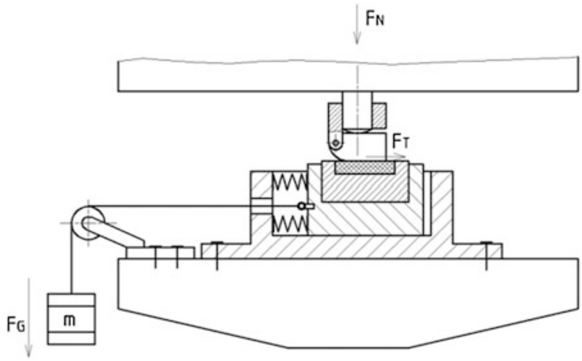


Fig. 5 Simulation of Plasmabit's mass with extra weight and the pulley

The reel is used to generate adequate axial force inside the rope and simulates Plasmabit's mass this way, as is shown in Fig. 6.

Another variant, which is shown in Fig. 7, uses short stroke, manually operated hydromotor to simulate Plasmabit's mass.

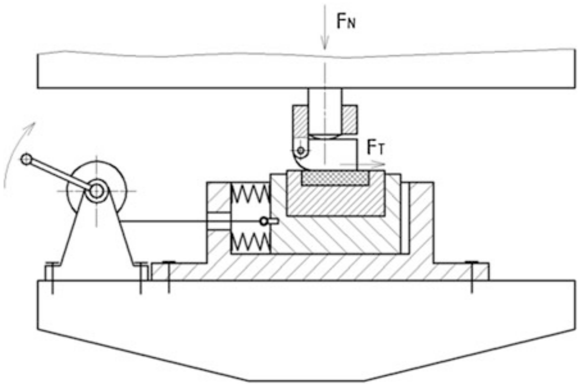


Fig. 6 Simulation of Plasmabit's mass with the reel

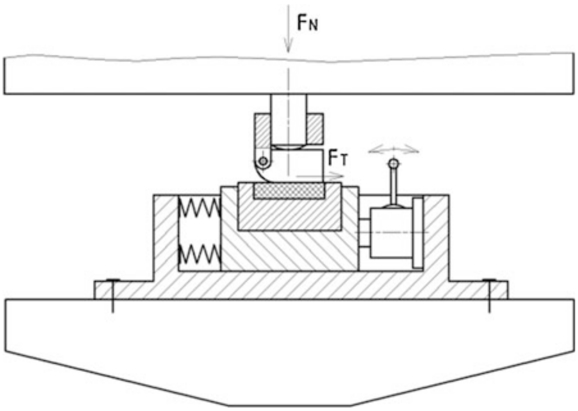


Fig. 7 Simulation of Plasmabit's mass with manually operated hydromotor

Plasmabit's mass is simulated by piston ejection of the linear hydromotor as is shown on Fig. 8. The normal force towards the surface of the geothermal well is simulated by turning the motion screw with a trapezoidal thread. Whole system is attached to the hydraulic press. The locking element has two operational surfaces and is pressed towards two rock specimens.

All variants (including those not mentioned in this article) were compared to each other by many criteria: similarity of force conditions with reality, possibility to apply motion sensors and load cells, compatibility of dimensions with the hydraulic press, manufacturability of whole testing device and manufacture cost. The most suitable system for our purpose is one shown in Fig. 8. All experiments will take place on this variant.

Selected variant of the testing device is currently under development and early stage 3D model can be seen in Fig. 9. (Žarnay et al. 2013)

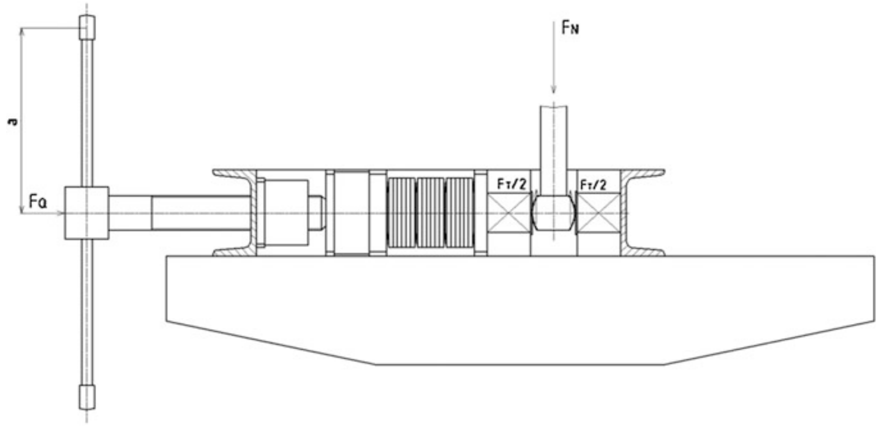
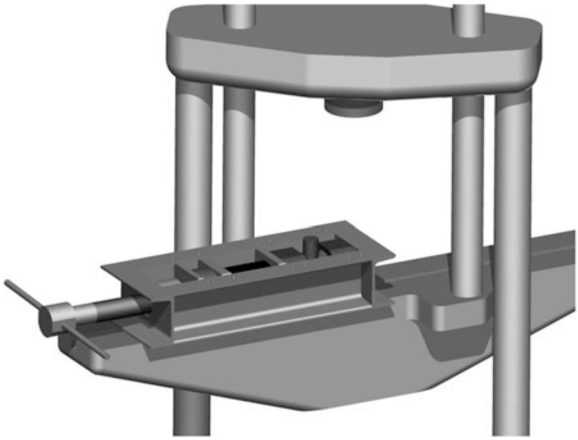


Fig. 8 The force of gravity is drawn by the hydraulic press and the normal force on the locking elements is drawn by the motion screw through the load cell and system of disc springs

Fig. 9 Early stage 3D model of the testing device



3 Conclusions

The data measured during the simulation can be used directly for project "Autonómne robustné mechatronické systémy pre ultrahlboké geotermálne vrty". There are other subjects to be verified during the tests, such as properties of rocks under high contact pressure, experimental verification of the friction factor on selected surfaces and measurement of wear of locking elements. Measured data will be preliminary only because simulation in the real conditions (very high pressure and temperature) would be very expensive and difficult solution.

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