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Monitoring of deep core drilling operational parameters

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Abstract. The deep core drilling has currently wide application - construction drills, geological exploration, drills for measuring pendulums in dams etc. It is useful to know the drilling process parameters precisely. The most important parameters for the optimal drilling process are torque, pressure force and rotation speed. These parameters depend on the strength of the drilled material (drilling capacity) and of course on the drilled diameter and applied pressure force. In-time identification of the drilling parameters enables the optimization of the drilling process directly during the drilling process. This contribution deals with the design of the new sensor for in-time identification of above mentioned core drilling operational parameters and its testing. The sensor is based on the strain gauge measurement and Hall probe. The measured data are also stored and could be post-processed in longer time context to obtain also the drilling capacity of the drilled materials. First results from the terrain measurement are also presented.

Introduction

The deep core drilling has currently wide application - construction drills, geological exploration, drills for measuring pendulums in dams etc. It is useful to know the drilling process parameters precisely. The most important parameters for the optimal drilling process are torque, pressure force and rotation speed. These parameters depend on the strength of the drilled material (drilling capacity) and of course on the drilled diameter and applied pressure force. In-time identification of the drilling parameters enables the optimization of the drilling process directly during the drilling process, [1]. This contribution deals with the design of the new sensor for in-time identification of above mentioned core drilling operational parameters and its testing, [2], [3]. The sensor is based on the strain gauge measurement and Hall probe. The measured data are also stored and could be post-processed in longer time context to obtain also the drilling capacity of the drilled materials. First results from the terrain measurement are also presented. The schema of whole system can be seen in Fig. 1.

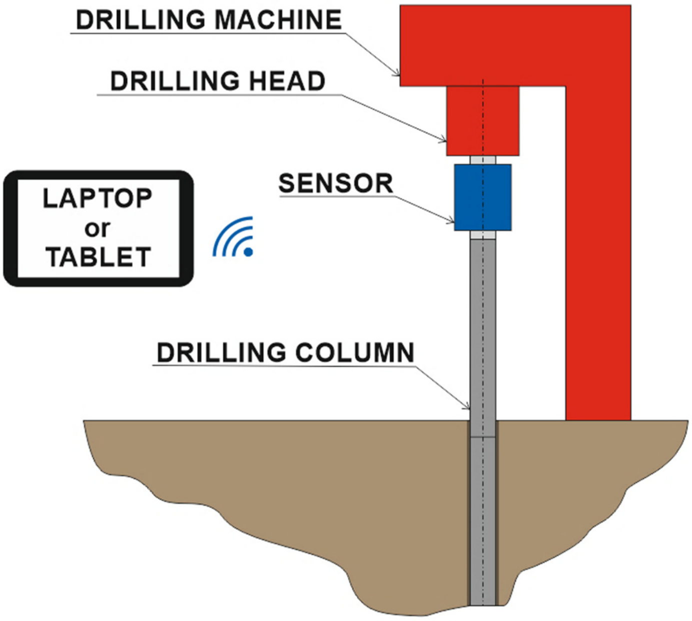

Fig. 1: Scheme of the measurement, sensor installed on the drilling machine

Sensor design

Sensor design is based on the common drilling rod with hexagonal couplings, which is used in short version as a deformation member. Thus, it can be easily connected to the various drilling machines. Above mentioned operational parameters are identified by means of strain gauges (torque and axial force) and Hall probe (rotational speed). For measuring both torque and pressure force, full bridge arrangement with compensation of temperature and other loads is used. Torque is identified by means of strain gauge rosettes HBM 1-XY21-6/120, the pressure load is identified by means of strain gauge rosettes HBM 1-XY91-6/120. The rosettes installed on the deformation member can be seen in Fig. 2.

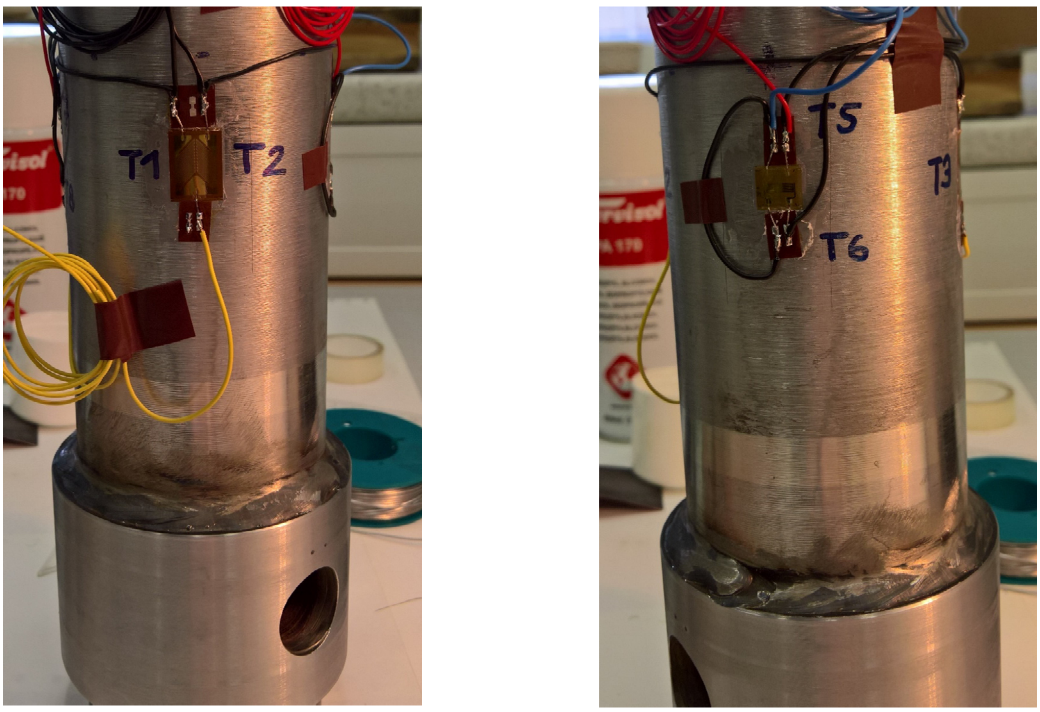

Fig. 2: Strain gauge rosettes installed in the deformation member

Hall probe is used in combination with neodymium magnet placed on the steel console. This console has to be designed for each drilling machine separately because of the drilling head differences. Sensor body is formed by the FDM 3D printed cover, which serves both like a protection and a storage for electronics. During the development of the sensor, two body designs arose. They are illustrated in Fig. 3, in the right there is the final version. It enables much better access to the batteries and micro SD memory card. It consists of the main body, flange and two doors – one is used just for the assemblage and the second one is used for the common access to the batteries and micro SD memory card. The doors with installed batteries and electronics during the testing with the tablet can be seen in Fig. 4. For the energy saving there is furthermore the power switch mounted into the flange.

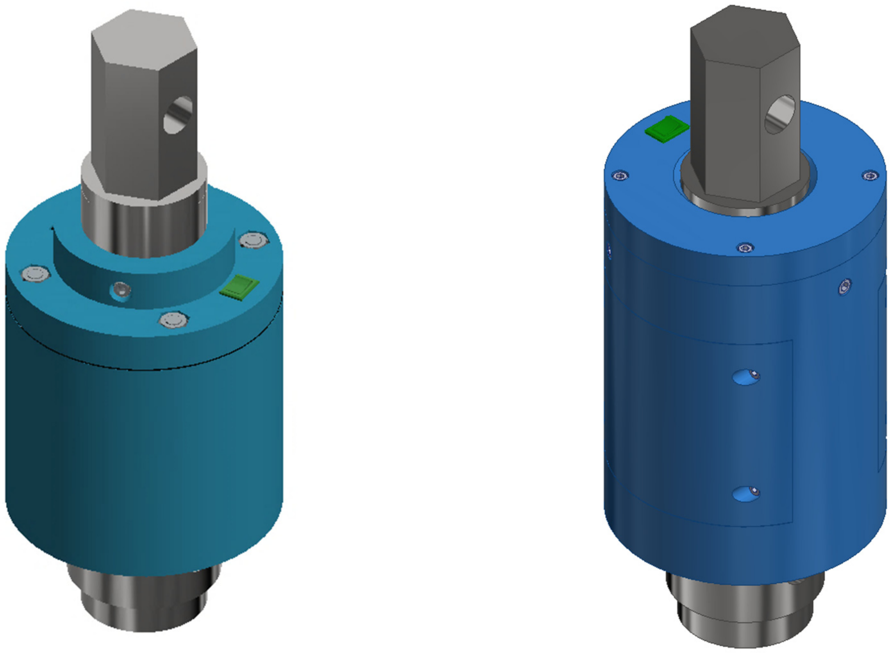

Fig. 3: Prototypes of the sensor body

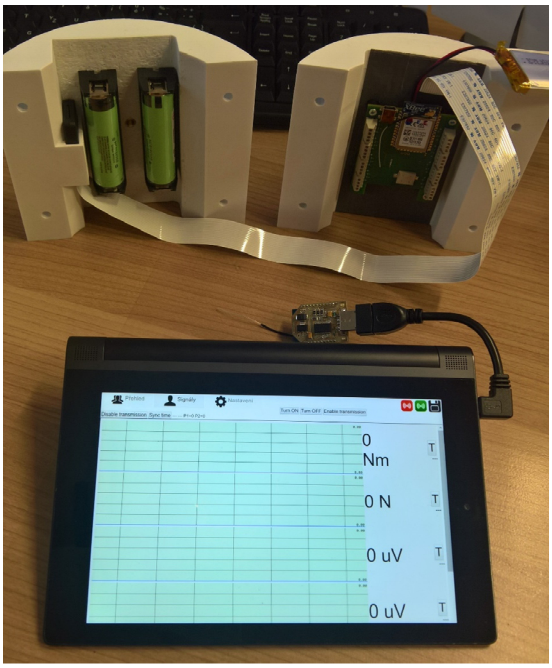

Fig. 4: Sensor doors with installed batteries and electronics during the testing with tablet

Data acquisition and telemetry

Data from the strain gauge Wheatstone bridges and Hall probe are acquired by means of the special datalogger LPDR with 24bit A/D converter and Cortex M3 processor, see Fig. 5 (left). Now it is set to the three-channel acquisition with sampling frequency 500 Hz per channel. The telemetry is realized by the Digi XBee 2.4 GHz transmission. The size of the LPDR is 70 x 55 x 25 mm with weight approximately 165 g. Measured data are processed, transmitted and also stored on the micro SD memory card. The power supply is provided by two Li-ion batteries of type 18650. This datalogger was developed in cooperation with Faculty of Biomedical Engineering.

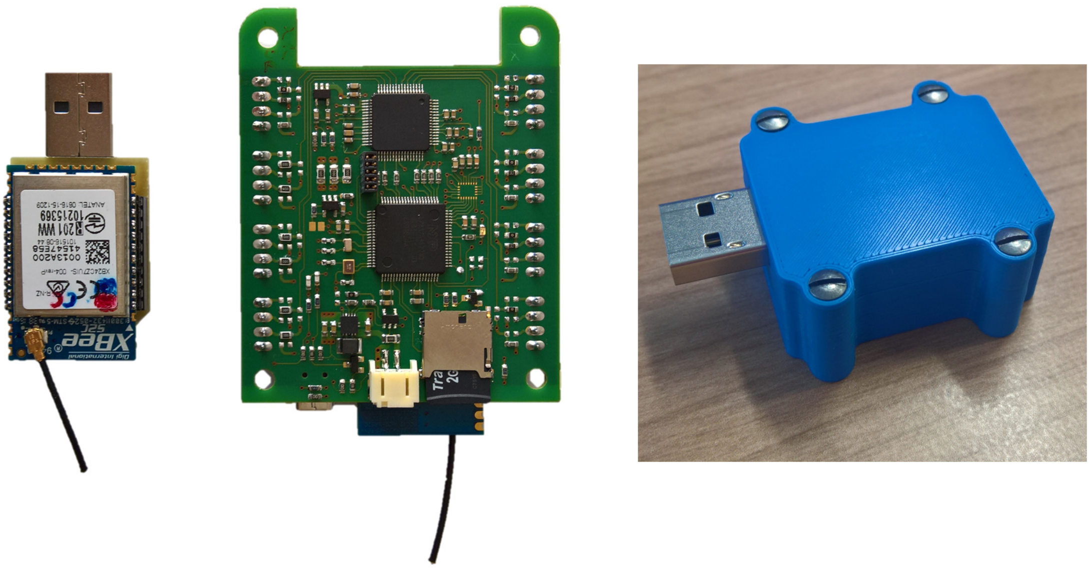

Fig. 5: Datalogger LPDR with Digi XBee receiver (left), cover for the receiver (right)

Laboratory and terrain testing

Designed sensor was laboratory tested to verify the accuracy of the measurement. First results of laboratory testing were introduced in [1]. During this testing the correct functioning was proved. Further tests were carried out on the test polygon in the area of company Chemcomex, a.s. in Prague – Zbraslav and the area in not closely specified company in Prague - Zizkov. Various drilling machines were used during these measurements so that also the versatility of the sensor was tested. From the measurements, the time courses of torque, pressure force and rotational speed were acquired and post-processed.

In the first destination, Prague – Zbraslav, the RDBS drilling machine was used. It is the machine with tracked chassis and maximum rated torque 15000 Nm. The drilling sensor mounted under the drilling head of the drilling machine can be seen in Fig. 6 (left). There were used the drilling tools with diameter 220 mm and 190 mm. The geological profile of this drill can be seen in Fig. 6 (right). The most of the drill consists of the backfill (approx. 6 m) the rest is the sand (approx. 1.5 m). The measured data are presented in Fig. 7. There can be seen the time course of the torque, pressure force and rotation speed. The data will be correlated with the dept of the drill and with the description of the activity.

Fig. 6: Drilling in Zbraslav – drilling machine RDBS (left), 7.5 m drilled core (right)

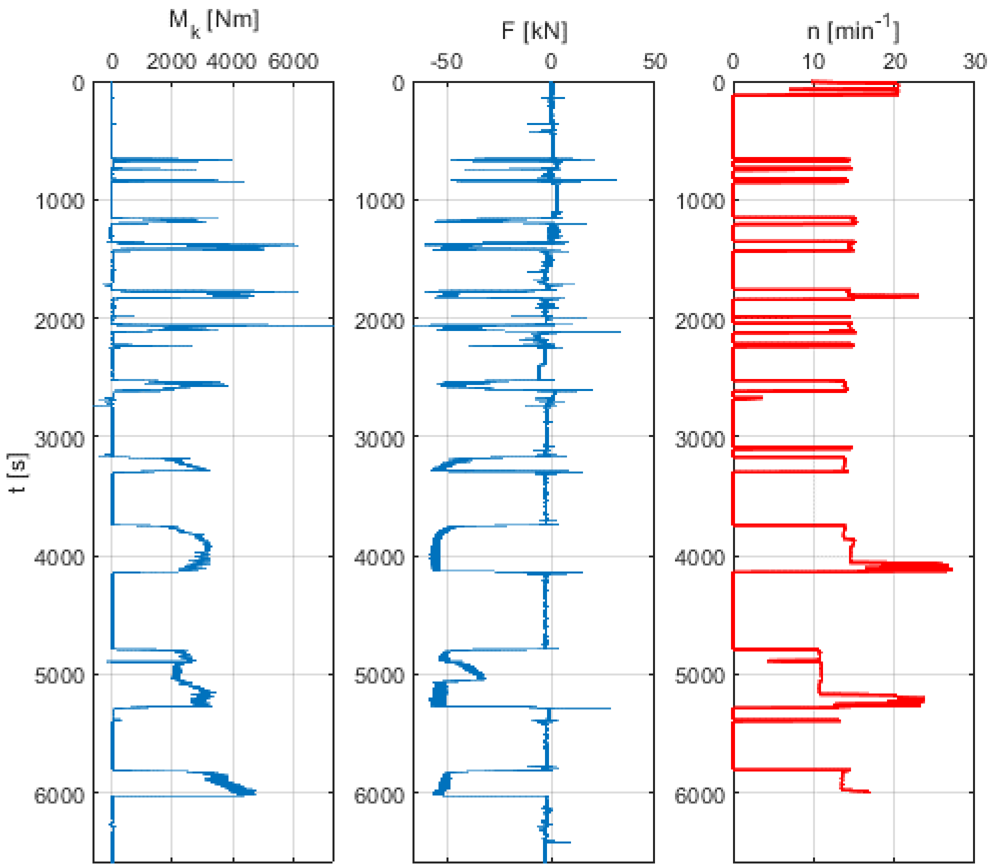

Fig. 7: Drilling in Zbraslav – measured time courses of torque, pressure force and rotation speed

In the second destination, Prague – Zizkov, the SGBO drilling machine was used. It is the drilling machine embedded on the track chassis. The maximum torque of this drilling machine is 10200 Nm. The drilling sensor mounted under the drilling head of the drilling machine can be seen in Fig. 8. There were used the drilling tools with diameter 220 mm and 190 mm. The geological profile of this drill can be seen in Fig. 9. Brief geological profile description follows in Table 1. The water level was approximately in the dept 6.5 m.

Fig. 8: Drilling in Zizkov – drilling machine SGBO

Fig. 9: Drilled core

Table 1: Drilled core brief description

Dept [m]	Material description
0.0 – 0.2	Bitumen
0.2 – 1.1	Backfill
1.1 – 1.7	Clay
1.7 – 3.9	Sandy clay
3.9 – 10.1	Sand
10.1 – 12.0	Slate

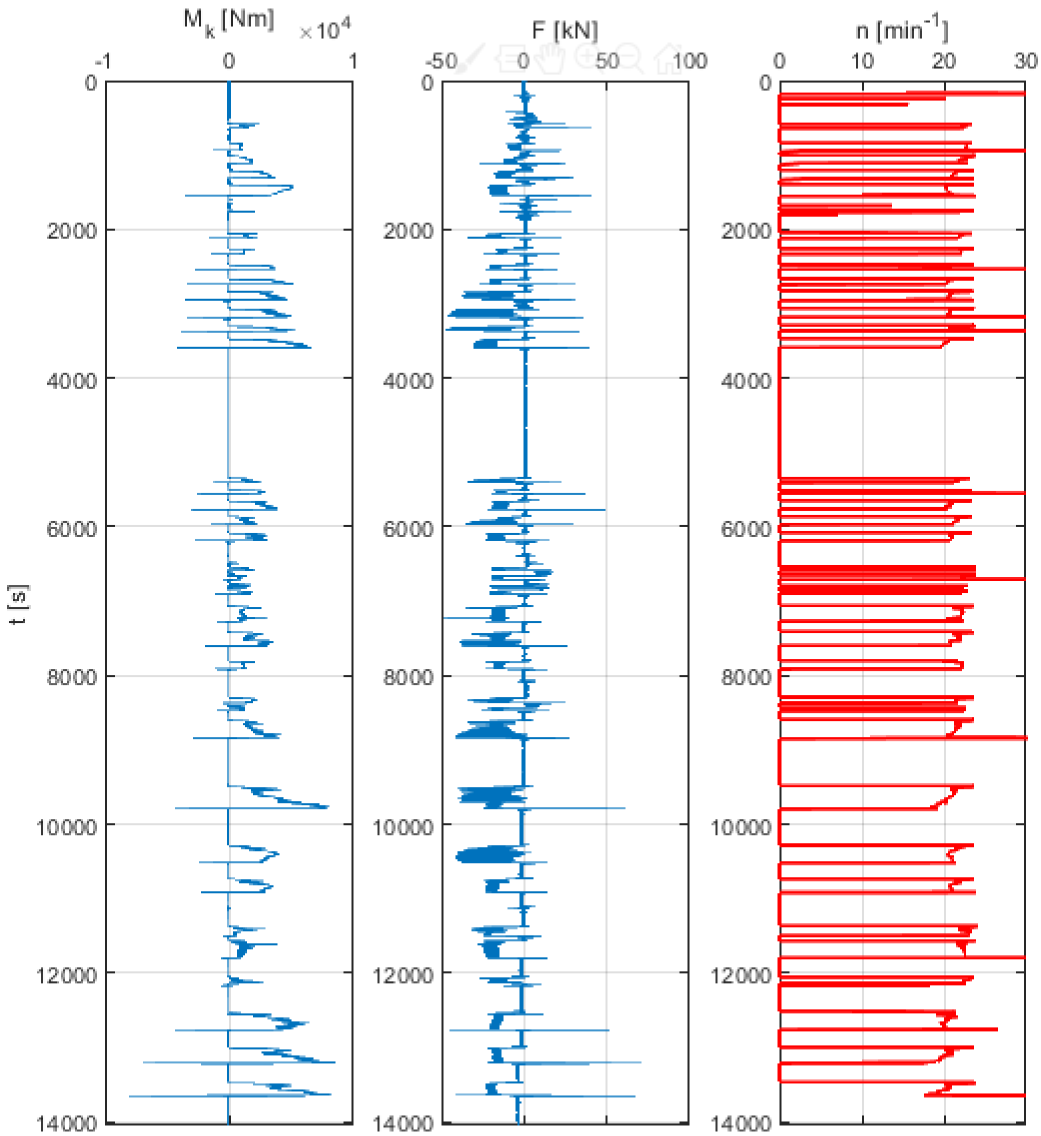

Fig. 10: Drilling in Zizkov – measured time courses of torque, pressure force and rotation speed

Acquired and processed data are presented in Fig. 10. There can be seen again the time course of the torque, pressure force and rotation speed. The data will be correlated with the dept of the drill, geological profile and with the description of the activity. Detailed view on the acquired data can be seen in Fig. 11. The maximal value of the torque reaches approximately 5 kNm, the pressure force is approximately constant 16.5 kN and the rotation speed is also approximately constant 20 rev/min. At the end of the drilling process, there is the significant jump in the torque due to the quick reversation. This is done to enable easier dismounting of the hexagonal rods. There is also significant increase of the axial force. This force is necessary to get the drill bit out of the drill.

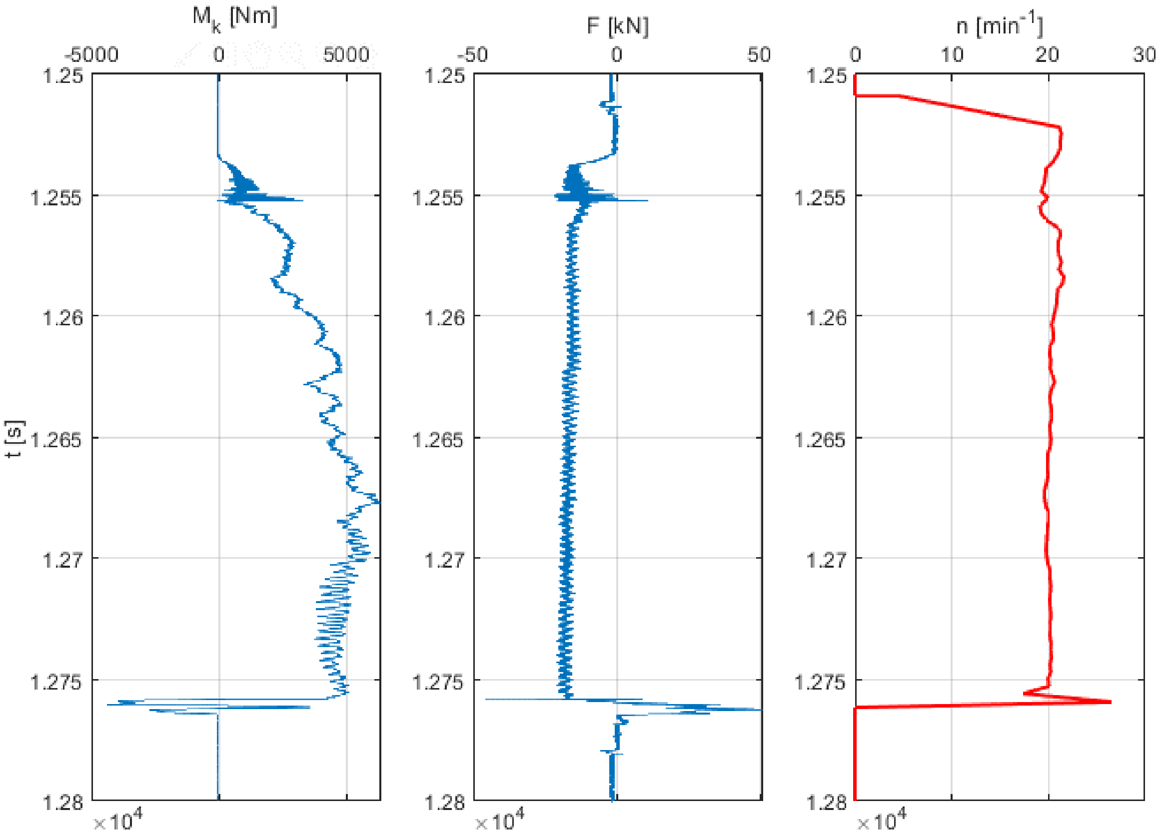

Fig. 11: Drilling in Zizkov – detailed view – drilling of a slate

Conclusions

The sensor for monitoring of deep core drilling operational parameters was introduced in this contribution. It enables acquisition of valuable information about the drilling capacity and also about own drilling process. The sensor is tested both in laboratory and terrain conditions. Special cover for the sensor was manufactured by the FDM 3D printing and will be further improved.

Acknowledgement

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References

[1] M. Dub and V. Dynybyl, Sensor for In-time Identification of Deep Core Drilling Parameters, in: The 59th International Conference of Machine Design Departments, 2018.

[2] P. Bauer, J. Kalivoda, System of axle-box force measurement for experimental railway bogie, in: Experimental Stress Analysis - 56th International Scientific Conference, EAN 2018 - Conference Proceedings, pp. 9-16, 2018.

[3] F. Lopot, M. Dub, M. Janda, O. Berka, Use of notches in the shafts loaded by torque for improvement in accuracy of strain gauge measurements, in: Experimental Stress Analysis - 56th International Scientific Conference, EAN 2018 - Conference Proceedings, pp. 9-16, 2018.