COMPLEX TESTING OF DIFFERENT TYPES OF EXCAVATORS IN THE MOST BASIN CONDITION

KOMPLEKSOWE TESTOWANIE RÓŻNYCH TYPÓW WIELONACZYNIOWYCH KOPAREK KOŁOWYCH PRACUJĄCYCH W ZAGŁĘBIU WĘGLOWYM MOST

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The Brown Coal Research Institute is the participant of the European Commission - Research Fund for Coal and Steel project "Bucket wheel excavators operating under difficult mining conditions including unmineable inclusions and geological structures with excessive mining resistance". The main research problem of VUHU is complex testing of different types of excavators. The article briefly summarises the results of complex testing of SchRs 1550-4x30/K109, KU 800.7 and KK 1300 excavators.

Keywords: excavator, testing, measurement system

Brown Coal Research Institute jest uczestnikiem projektu realizowanego w ramach Funduszu Badawczego Węgla i Stali „ Praca koparek kołowych w warunkach występowania w urabianym ośrodku utworów o nadmiernych oporach urabiania jak i wtrąceń nieurabialnych". Głównym problemem badawczym podnajmowanym przez VUHU jest kompleksowe testowanie różnych typów koparek. W artykule podsumowano wyniki badań koparek SchRs 1550-4x30/K109, KU 800.7 i KK 1300.

Słowa kluczowe: koparka, testowanie, system pomiarowy

INTRODUCTION

The main aim of the project is to develop solutions aiming at as large as possible decrease of bucket wheel excavator failure frequency during operation in difficult mining conditions, including unmineable inclusions and geological structures with excessive mining resistance. It is planned that developed solutions will refer not only to operating bucket wheel excavators but also to newly constructed excavators. It is necessary to elaborate new solutions because currently applying rules and regulations referring to excavator construction do not include sufficiently mining conditions occurring during exploitation of such structures.

Brown Coal Research Institute (VÚHU a. s.) finished first step of research in 2015. It was summarisation of geological situation of the Most Basin, locating of the Most Basin hard rocks, characteristic of the main parameters of the Most Basin hard rocks and summarisation of the first experience with the survey methodology.

The second step of research started in 2016. Brown Coal Research Institute made a new acquisition according to the project programme. The main task of the year 2016 was realisation of three long term measurements in the Libous Mine. The target of these measurements was verification of working parameters of the SchRs 1550-4x30/K109 excavator during the relocation from the first overburden cut to the second overburden cut with worse mining conditions [4].

The third step of research started in 2017. It consists of 2 complex tests of different types of excavators. The main research problem was application of complex measurement system in the KK 1300 excavator (realisation 11/2017 – 12/2017). The second research problem was strength analysis of KU 800.7 bucket wheel body, bucket wheel shaft and bucket (realisation 7/2017 – 9/2017) [5].

The complex testing of different types of excavators was the most important part of the Brown Coal Research Institute research. We selected the SchRs 1550-4x30/K109 excavator research parameters as a typical example for this article.

TARGET OF RESEARCH

The main task of the year 2016 was the realisation of the three long term measurements in the Libous Mine. The target of these measurements was verification of working parameters of the SchRs 1550-4x30/K109 excavator during the relocation from the first overburden cut of the Libouš mine to the second overburden cut of the Libouš mine with worse mining conditions.

COMPLEX TESTING OF THE EXCAVATOR SchRs 1550-4X30/K109

We realised survey and evaluation of geological situation of three excavator positions and mechanical and electrical excavator parameters.

Geological situation and hard rocks occurrence

The research was realised in one position in the first overburden cut and in two positions in the second overburden cut. Geodesic survey of these positions occurred before the start of

Fig. 1. Position 1 – the first overburden cut of the Libouš Mine
Rys. 1. Pozycja 1 – pierwsze piętro nadkładowe w kopalni Libouš

the research. The survey of the geological situation of these positions was the first step of the research.

The first position was situated in the first overburden cut. The geological situation was quite complicated. The overburden cut consists of three different horizons – Quarternary loams, Tertiary brown clays and tertiary grey clays. The situation of the first position is shown in the figure 1, the results of the laboratory analyses are shown in the table 1. The main minerals are the quartz, montmorillonite, illite and kaolinite (and calcite in the case of the loess loam). The content of siderite was about 1%. We did not discover any hard rock structure. We took three samples.

The second position was situated in the second overburden cut. The geological situation was quite simple. The overburden cut consists of one horizon – Tertiary brown clays. The situation of the second position is shown in the figure 2, the results of the laboratory analyses are shown in the table 2. The main minerals are the quartz, montmorillonite, illite and kaolinite. The content of siderite was about 2%. We discovered one hard rock structure (thickness about 0.1m, calcite). We took three samples.

The third position was situated in the lowest part of the second overburden cut. The geological situation was quite simple. The overburden cut consists of one horizon – Tertiary brown clays. The situation of the third position is shown in the figure 3, the results of the laboratory analyses are shown in the table 3. The main minerals are the quartz, montmorillonite, illite and kaolinite. The content of siderite was about 3-4%. We did not discover any hard rock structure. We took two samples.

Geological survey of three measure positions was very important part of complex testing.

The first measurement stand was situated in the first overburden cut. The main overburden rocks were loess loams, plastic brown clays and grey claystone. We did not discover hard rocks. We analysed 3 samples.

Comprehensive strength of loess loam: 0.1-0.3 Mpa
Comprehensive strength of brown clay: 0.2-0.4 Mpa
Comprehensive strength of grey claystone: 0.8-1.2 MPa
Mining conditions in this position are very good.

The second measurement stand was situated in the second overburden cut. The main overburden rock was grey claystone. We discovered one hard stratum (calcite, 0.1 m thickness). We analysed 3 samples.

Comprehensive strength of grey claystone: 1-1.3 Mpa
Comprehensive strength of calcite hard rock: 14.8 Mpa
Mining conditions in this position are very good.

The third measurement stand was situated in the lower part of the second overburden cut. The main overburden rock was grey claystone. We did not discover hard rocks. We analysed 2 samples.

Comprehensive strength of grey claystone: 1.8-2.1 MPa
Mining conditions in this position are good.

The situation of the first overburden cut is shown the figure 1.

Long term complex testing of mechanical parameters

Brown Coal Research Institute made a new acquisition according to the project programme before the beginning of the long term complex testing. The modern measurement system consists of three modular components and evaluation computer. Three measure switchboards are equipped by 20 tensiometric channels, 12 vibration channels, 20 analogue input ports, 16 digital input ports and indication of measurement from rotate shaft.

The realisation of the long term complex testing of the SchRs 1550-4x30/K109 excavator parameters passed off according to programme of the excavator transport.

I. Complex measurement
started on 10. 5. 2016 at 12:35 a. m. SchRs1550 excavator started mining in the first position (1. overburden cut).

Fig. 2. General view of the SchRs 1550-4x30/K109 excavator
Rys. 2. Widok koparki wielonaczyniowej kołowej SchRs 1550-4x30/K109

II. Complex measurement
started on 1. 7. 2016 at 10:00 a. m. SchRs1550 excavator started mining in the second position (2. overburden cut).
III. Complex measurement
started on 10. 5. 2016 at 12:35 a. m. SchRs1550 excavator started mining in the third position (2. overburden cut – lower part).

General view of the SchRs 1550-4x30/K109 excavator is shown in the following figure 2.

- Measurement of selected parts load
Bucket wheel drive
Drive of slewing gear of the upper part of the excavator
Drive of bucket wheel stroke
Suspension cables – change of tension force during mining operations
Working cables – change of tension force during mining operations
Construction of bucket wheel boom – change of tension force in lower belt of bucket wheel boom during mining operations
Construction of front brace rod - change of tension force in lower belt of front brace rod during mining operations

- Measurement of required quantities
Lateral force
Digging – peripheral force
Impacts to the cockpit of driver
Vibration exposition of the man on the seat of driver
Capacity
Digging resistance – We realised the measuring of the following quantities because of evaluation of digging resistance:
Bucket wheel drive input
Height of mining bench
Width of slice
Speed of bucket wheel
Peripheral force
Capacity
Travel to advance
Strength parameters of the rock
Motion of the excavator during mining.

Tab. 1. Information about measured quantities - recording of deformation of lower belt conveyor of bucket wheel boom
Tab. 1. Zestawienie informacji o mierzonych wartościach - rejestracja odkształcenia dolnego przenośnika taśmowego na wysięgniku z kołem urabiającym

Place	Quantity	Unit	Orientation	No of sensor	Cable	Measure channel	Sensitivity Mv/m.s^{-2}
Left belt	acceleration	m.s^{-2}	**Y**	**25832**	**2**	**ACC2-G30-S0-Ch4-YL**	**3.5384**
Left belt	acceleration	m.s^{-2}	**Z**	**25831**	**3**	**ACC2-G30-S0-Ch3-ZL**	**3.4262**
Right belt	acceleration	**m.s^{-2}**	**X**	**-**	**-**	**-**	**-**
Right belt	acceleration	m.s^{-2}	**Y**	**25823**	**8**	**ACC2-G30-S0-Ch2-YP**	**3.4364**
Right belt	acceleration	m.s^{-2}	**Z**	**25824**	**9**	**ACC2-G30-S0-Ch1-ZP**	**3.5282**

Tab. 2. Information about measured quantities - connecting of tensiometric sensors and amplifier DS NET ACC2
Tab. 2. Zestawienie informacji o mierzonych wartościach - podłączenie czujników tensometrycznych i wzmacniacza DS NET ACC2

Place	Quantity	Unit	Cross section /mm²/	K of tensiometric sensor	Measure Channel	Density Mv/v
Left pillar	proportional lengthening	μm.m⁻¹	36400	2	ACC2-G28-S0-Ch0	769.23
Right pillar	proportional lengthening	μm.m⁻¹	36400	2	ACC2-G28-S0-Ch1	769.23

Tab. 3. Information about measured quantities - tensiometric sensors of axial force in cable hanging of bucket wheel boom
Tab. 3. Zestawienie informacji o mierzonych wartościach - tensometryczne czujniki siły osiowej w zawieszeniu kablowym na wysięgniku z kołem urabiającym

Place	Quantity	Unit	Cross section /mm²/	K of tensiometric sensor	Measure Channel	Density Mv/v
Left cable hanging	proportional lengthening	μm.m⁻¹	72000	2	BR4-G29-S2-Ch0	769.23
Right cable hanging	proportional lengthening	μm.m⁻¹	72000	2	BR4-G29-S2-Ch1	769.23

Tab. 4. Information about measured quantities- vibrations of hanger of drivers' cockpit frame
Tab. 4. Zestawienie informacji o mierzonych wartościach – wibracje zawieszenia ramy kabiny operatora

Place	Quantity	Unit	Orientation	No of sensor	Cable	Measure channel	Density Mv/m.s-²
frame	acceleration	m.s⁻²	x		2	ACC2-G29-S0-Ch0	19.29124
frame	acceleration	m.s⁻²	Y		2	ACC2-G29-S0-Ch1	19.46245
frame	acceleration	**m.s⁻²**	z		2	ACC2-G29-S1-Ch0	19.18944

Tab. 5. Information about measured quantities - peripheral force of bucket wheel
Tab. 5. Zestawienie informacji o mierzonych wartościach - siła obwodowa koła czerpaka

Place	Quantity	Unit	Orientation	No of sensor	Cable	Measure channel	Sensitivity Mv/m.s⁻²
bucket wheel	force	kN	x	ČASO 24	2	ACC2-G29-S1-Ch1	153.888

Results of the main parameters measurement are shown in following tables.

The situation of tensometric sensors of the measure unit No 29 - R1- R4 is shown in the figure 3.

Long term testing of electrical quantities measurement

The measurement of the electrical quantities in electric motors of the SchRs 1550-4x30/K109 excavator drives was realised by analysers ENA 550, ENA 500 Multi 4 and ENA 500.22. Measurement and data registration were realised continuously during complex testing interval.

Measurement of bucket wheel drive

The bucket wheel input (nominal input 1000 kW) was detected in switchboard of SchRs 1550 switching station with application of analysers ENA 500.22, IT 6kV, 6000/100V, 150/5A.

Drive and gearbox of upper part slewing gear

The input of upper part slewing gear (nominal input 2x45 kW) was detected in slewing gear R13.1 and R13.2 of excavator NN slewing gear box with application of VÚHU a.s. equipment; 400V, TNC-S.

Fig. 3. Situation of tensiometric sensors R1- R4
Rys. 3. Lokalizacja czujników tensometrycznych R1-R4

Drive of bucket wheel boom stroke

The input of drive of bucket wheel boom stroke (nominal input 2x132 kW) was detected in slewing gear R13.3 and R13.5 of excavator NN slewing gear box with application of VÚHU a.s. equipment; 400V, TNC-S

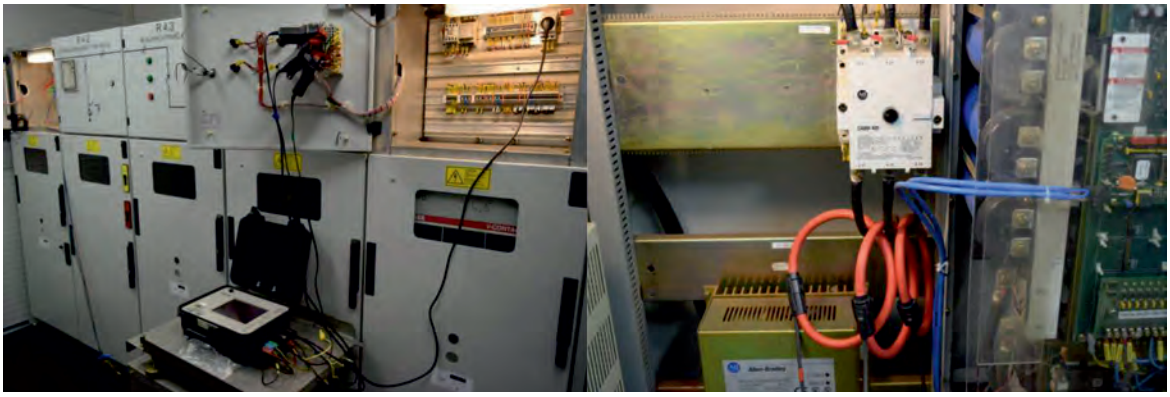

Fig. 4. Measurement of bucket wheel drive
Fig. 4. Pomiar napędu koła czerpakowego

CONCLUSION

The Brown Coal Research Institute team realised tree long term measurement of tree different types of excavators working in the Most Coal Basin from 2016 to 2017. We selected long term testing of the SchRs 1550-4x30/K109 excavator parameters as a typical example for this article. Data of all realised measurement are summarised in the expert reports No 1 and No 2 [4], [5].

The main result of three long term tests realisation is the large information database about parameters of the excavator during the mining in different mining conditions. The main parameters are summarised in the conclusion of this article.

• The survey proved differences in mining conditions in three positions of the excavator. Comprehensive strength of rocks increased from 0.08 MPa (first position) to 2.05 MPa (third position), content of siderite from 0.2% to 6%.

• The main geomechanical boundary is lower part of the second overburden cut. The category of rocks diggability changes from B to C.

• Load of the bucked wheel by peripheral force in harder rocks increased 1.35 times, dynamics 2 times.

• Load of cable suspension increased in harder rocks increased 1.6 times, dynamics 0.82 times.

• Load of front brace rod in harder rocks increased 1.1 time, dynamics 1.1 time

• Load of lower belt of bucket wheel boom in harder rocks increased 3.7 times, dynamics 15 times (vibrating movement, not axial force).

•Vibration exposition of the cockpit of driver did not get worse. It is different - vibration exposition of the seat of driver gets worse.

• Input of bucket wheel in harder rocks dropped 1.9 times, dynamics 1.68 times.

• Input of the drive of slewing gear of upper part of the excavator increased in harder rocks 1.4 times, dynamics 1.2 times.

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