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Modernization of gob shield of longwall powered roof support

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Abstract:

Longwall powered roof supports have been used to protect mine workings for over 70 years. Their design and especially technological parameters, have evolved significantly. These changes were dictated, on the one hand, by the need to meet the growing functional requirements and, on the other hand, by the increasingly difficult natural operating conditions. Conditions of interaction of the roof support with the surrounding rocks, which determine not only operational safety, also impact of the structural form of the roof support and its assemblies. Powered roof support is an important part of the longwall system, not only separating the working area of the longwall panel from the rocks forming the roof and the caving, but also ensuring the advance of the longwall system as the longwall advances and realization of each operation of the technological cycle. The need to meet these functional requirements means that technical factors such as: the method of managing the roof of the working, height of the wall, its inclination, the method of mining and the planned advancement of the wall significantly impacts the structural form and technical parameters of the roof support. The main purpose of this article is to present the method of modernization of a gob shield which is a part a powered longwall roof support.

Keywords: powered roof supports, gob shield, modernization, technical control

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1. Introduction

Due to the need to optimally select mining equipment for constantly deteriorating geological and mining conditions in Polish mines, it is often necessary to adapt the equipment owned by mines to other, stringent requirements in the new workings. It becomes justified to use devices with operating parameters dedicated to the current conditions.

The above is the reason why designers of mining equipment are often looking for modernization methods that would give users the certainty of achieving the planned production rates while ensuring the safety of the crew and equipment during operation in changing geological and mining conditions. Durability is also an important element. Durability is one of the basic issues of functionality of technical objects, in particular mining machines and equipment. This applies especially to devices where it is important to meet the criterion of required durability of the device operating under extreme loads and exceptional operational demands. Such conditions are met in hard coal mining.

Powered roof support is a device exposed to extreme and changing conditions during operation. Practice shows that the powered roof support is the most frequently modernized device.

The gob shield is a part of the powered roof support that separates the mine working from goafs and absorbs the pressure of the caved rubble. Determining the pressure of the rocks falling on the gob shield is a very important problem, both in terms of determining the roof support load bearing capacity in the conditions of a given longwall, as well as determining the external pressure of the goaf, which should be taken into account at the designing stage of this component. The present form of the powered roof support is the result of many years of research work, analyses, observations and operational experiences, as well as designing work of many research centres around the world.

The main purpose of this article is to present the method of modernization of a gob shield which is a part of a longwall powered roof support.

2. Materials and Methods

2.1. Powered roof support

The powered roof support should meet the occupational safety requirements, as well as detailed criteria of European and global mining standards and regulations. The powered roof support are designed taking into account the individual requirements of each customer, using the 3D prototype modelling tools and FEM strength analysis. Correctness of the design is always confirmed by tests in accredited laboratories and by conformity certificate [1, 2, 3].

Characteristic features of the roof support:

- individual kinematic form selected for current geological and mining conditions and customer requirements,
- full compatibility with the machines operating in the longwall,
- operating range from 0.6 to 6.0 m,
- two- or four-leg configuration, with one-, two- or three-telescopic legs,
- load-bearing capacity up to 1.5 MN/m^2,
- application of a system for the "no step back" or "with step back" roof supports,
- equipped with rigid, extended or articulating-extended canopies adapted to the current geological and mining conditions,
- use of single catamaran or divided bases,
- adapted to operate with longitudinal inclinations up to 45° and transverse inclinations up to 20°,
- equipped with electro-hydraulic control with full pressure monitoring with longwall automation functions or pilot control with a wireless pressure monitoring system in legs,

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– made of high-strength steel, protected against corrosion using the latest available technologies (especially coatings used in power hydraulics: stainless steel welded coatings or "Durachrom" type coatings and others).

Longwall powered roof supports are designed to guide and support a roof in horizontal and inclined coal seams (Fig. 1).

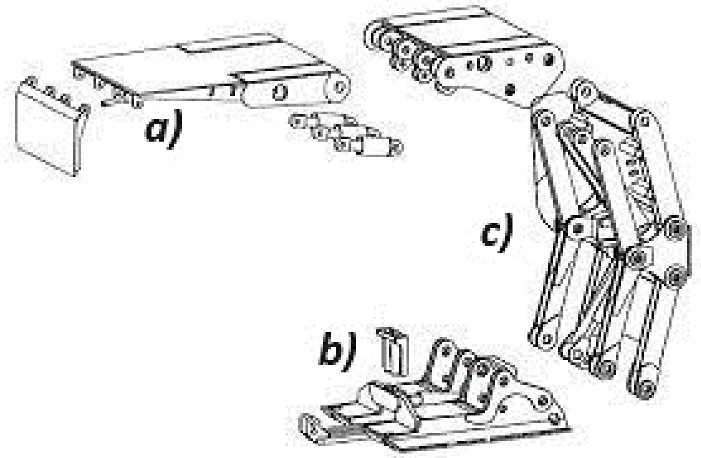

Fig. 1. Powered roof support:
a) canopy, b) base, c) gob shield [4]

The roof support design has two legs with a lemniscate canopy system and enables mechanization of the following operations:

– setting to load the roof support between the floor and the roof with initial load-bearing capacity,
– supporting the roof with constant operating load-bearing capacity,
– securing the newly opened roofs,
– withdrawal the roof support,
– supporting the caved rubble,
– moving the roof support towards the longwall face.

In the longwall complex, roof supports of each type of are adapted to cooperate with AFC and the mining machine (shearer, coal plow) of any operating height.

The same type of powered roof supports are used in the longwall. It is allowed to use different types of powered supports in one longwall, provided that a positive opinion is obtained from an expert, taking into account both the technical parameters of the supports and the geological and mining conditions of a given longwall panel.

2.2. Gob shield

The gob shield is a part of the powered roof support that separates the mine working from goafs and absorbs the pressure of the caved rubble.

Determining the pressure of the rocks falling on the gob shield is a very important problem, both in terms of determining the roof support load bearing capacity in the conditions of a given longwall, as well as determining the external pressure of the goaf, which should be taken into account at the designing stage of this component. Determining the load acting on the caving shield from the goaf side requires determining the volume of rock debris that affects the powered roof support. This volume depends on the geological and mining conditions, for which a specific shape of the rock mass acting on the roof support is assumed.

The gob shield also has side shields designed, as in the canopy, to seal the space between the sets and are also used to correct the roof support.

In backfill longwalls, it can also function as a final backfill dam.

Shielding supports commonly used in longwall panels with block caving are basically composed of lemniscate supports. These supports can take on the load on the canopy, but also on the gob shield when the roof rocks collapse at the end of the canopy and the rubble of the roof rocks covers the gob shield [5, 6].

This phenomenon, depending on the properties of the rocks surrounding the workings, may occur in every support cycle or few support cycles. The gob shield may be covered with rock debris to different degrees. It depends on the characteristics of the caved rubble and the working inclination, but above all on the extent of the roof collapse.

In this design there were least changes compared to the design from years ago. Now, improved methods of side shields operation and the components sealing the caving area are often used. In end supports, there is also an increased range of movement of the side shields, which allows for changing the support pitch [7, 8].

2.3. Modernization of the gob shield

Repair processes are an integral part of the life cycle of a roof support. After the longwall panel is completed, all roof supports are thoroughly inspected to identify any damage and then implement the required repair process. Aim of these processes is to restore roof supports to their original technical parameters so that they can be reused in a new mine working. Special computer programs support repair processes and also indicate the places that require strengthening or, in special cases, restructuring [8, 9, 10].

Modernization of the ZPR 12/35/Poz gob shield was realized in accordance with the scope of work specified by the orderer. During the modernization, the gob shield covering was partially replaced and additional ribs were introduced to increase its stiffness. Fig. 2 shows the replaced gob shield covering (marked in red).

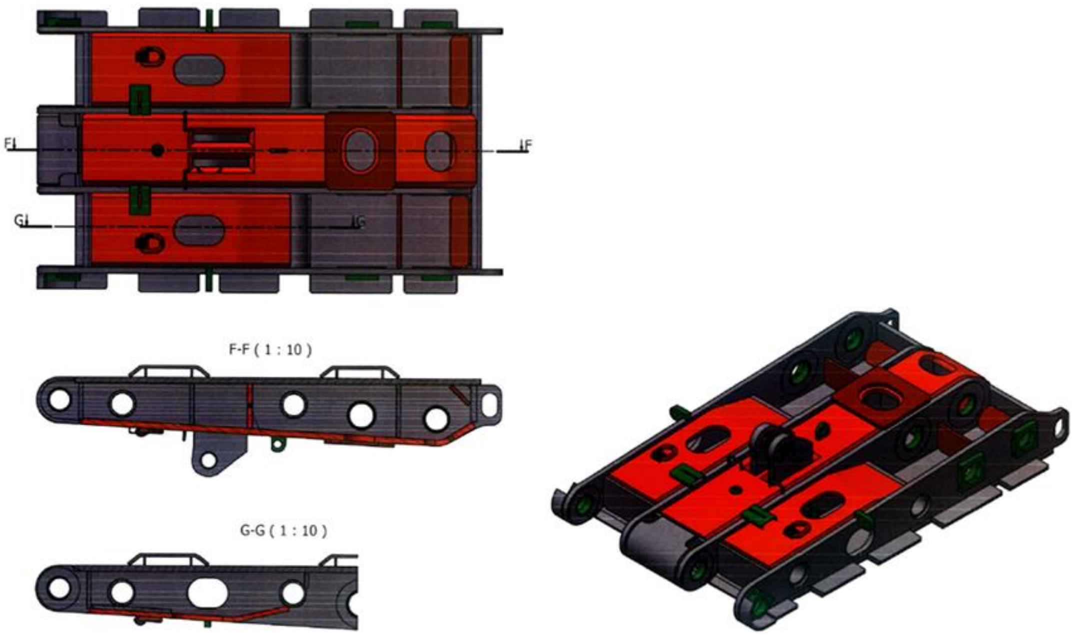

Fig. 2. Replaced parts of the gob shield (marked in red)

2.4. Stages of modernization

Modernization was performed in ten stages:

Stage I – Preparation for work, ordering the materials in accordance with the documentation provided by the orderer.

Stage II – Cutting out parts to be replaced in the gob shield with an acetylene torch (Fig. 3).

Fig. 3. View of the gob shield after burning out the details

Stage III – Abrasive blast cleaning.

Stage IV – Inspecting the shield after shot blasting – checking for additional damage. Preparing the shield for further operations (Fig. 4).

Fig. 4. The gob shield after shot blasting

Stage V – Regeneration of openings by welding (Fig. 5).

Fig. 5. Welding the openings

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Stage VI – Installation and welding the previously removed parts (Fig. 6).

Fig. 6. Welding the details

Stage VII – Inspecting the welds using the following methods: NDT, UT, VT and MT.

Stage VIII – Machining of welded openings.

Stage IX – Assembly and welding of so-called "accessories".

Stage X – Painting and shipping (Fig. 7).

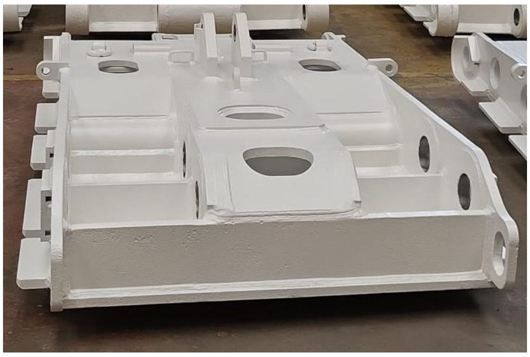

Fig. 7. The gob shield after modernization

Assembly of the shield structure was performed in stages due to the need to weld details in the appropriate sequence so that all internal welds could be made, e.g. before covering the structure with sheathing sheets, it was possible to make welds connecting the braces (main sheets) to the bottom sheet or to place welds in hard to access places. During the modernization of the gob shield, preliminary and main stages were distinguished, the number of which depended on the size of the shield structure and its complexity. Preliminary stages usually include assembling and welding reinforcing pads to the main braces, straightening after welding, and assembling and welding smaller components of the shield structure.

2.5. Technical control of the process

2.5.1. Welding

Welding of the gob shield components was performed strictly in accordance with the general and detailed Welding Technology Cards (Welding Plans) and the Welding Technology Instructions - WPS, strictly observing the welding parameters contained therein [11]. The manual specifies type of joint, grade of base material, welding method and position, welding parameters and type of additional materials – an electrode wire and a protecting gas

Veriforce 500A automatic welding machine was used for welding (Fig. 8). A mixture of argon and CO_2 was used as the shielding gas, in the proportion: 82% argon + 18% CO_2 [12].

Fig. 8. Veriforce 500A automatic welding machine

S355J2 material was welded using the gas-shielded wire ϕ1,2 NiMoCr (certificate, Fig. 9) manufactured by Multimet.

Multimet®
Inżynieria spawalnicza
Świadectwo odbioru nr 2024/0581
Inspection certificate / Abnahmeprufzeugnis
PN-EN 10204:2006 - 3.1.

CE
0036
12
0036-CPR-S 057
EN 13479 + EN ISO 16834-A

Odbiorca:
Customer / Kunde

Wyrób: Product / Produkt — **Drut elektrodowy** Wire electrode / Drahtelektrode

Oznaczenie: Trade name / Fabrik Marke — **IMT NIMOCR**

Średnica: Diameter / Durchmesser — **1,2 mm**

Ilość: Quantity / Menge — **192 kg**

Klasyfikacja: Classification / Klassification — EN ISO 16834-A: G 69 4 M21 Mn3Ni1CrMo; AWS A5.28 : ER 100S-G

Skład chemiczny [%]
Chemical composition / Chemische Zusammensetzung

Wytop/Heat /Schmelzen	C	Si	Mn	P	S	Cr	Ni	Cu	Al	Mo	V	Ti+Zr
T28075	0,09	0,56	1,65	0,012	0,004	0,31	1,43	0,02	0,003	0,266	0,068	0,0051

Własności mechaniczne EN 10204 - 2.2

DOPUSZCZENIA: Approvals / Zulassungen — **TUV,DB**

KONTROLA JAKOŚCI
Quality control / Qualitätskontrolle

Fig. 9. Certificate – welding wire NiMoCr

The material was preheated to 120°C with a propane burner. Temperature was checked approximately every 30 minutes using a pyrometer. Full penetration welds were made - all welds were tested (UT).

Openings ϕ100, ϕ120, ϕ110 and ϕ72 were surfaced with SG3 wire, also with preheating to 120°C. SG3 wire was also used for welding the details (certificate, Fig. 10).

Material	Średnica	Typ szpuli	Nr. wytopu	Ilość[kg]	Data
SG3	1.2	K300	5430492	15	13.02.2024

Skład chemiczny:

wytop	C	Mn	Si	P	S	Cr	Ni	Cu	Mo	V	Al	Ti+Zr
Wymagania wg.normy PN-EN-ISO 14341-A	0,06-0,14	1,60 -1,90	0,80-1,20	max 0,025	max 0,025	max 0,15	max 0,15	max 0,35	max 0,15	max 0,03	max 0,02	max 0,15
5430492	0,08	1,68	0,96	0,010	0,010	0,020	0,02	0,21	0,013	0,013	0,009	0,09

Własności mechaniczne spoiwa:

Klasyfikacja/wytop	Re [MPa]	Rm[MPa]	A5 %	Praca łamania KV [J] temp. -40°C	GAS
Wymagania wg.normy PN-EN-ISO 14341-A	min 420	500-640	min 22	min 47	
5430492	458	545	27	101	C1
5430492	476	545	28	101	M21

CE

0036
18
Nr ref. ROBO 091989

Dopuszczenie:
TUV Kennblatt Nr 19843.00
DB Zul.Nr. 42.202.02

Kontrola Jakości

Fig. 10. Certificate – SG3 welding wire

2.5.2. Control of welded joints

Weld inspection is based on the weld inspection card, which specifies the welds that must be checked in accordance with the requirements of PN-EN ISO 14175:2009 [13] and the types of non-destructive testing PN-EN ISO 17635:2017-02 [14], which should be used for weld testing. All welds were 100% visually inspected (VT). Welds that should be examined using other methods are specified on the weld inspection card. These tests include the following:

1. volumetric testing (NDT) – non-destructive testing,
2. magnetic-particle testing (MT) - this method tests fillet welds,
3. ultrasonic testing (UT) – for testing butt welds,

Visual inspection of welded joints enables checking for cracks, pits, surface pores, undercuts, missing joints and other imperfections in the weld. The visual inspection uses tools such as a microscope, magnifying glass or mirror.

Ultrasonic testing is one of the NDT volumetric testing techniques (non-destructive testing), which means that it enables to detect defects in the entire volume of the tested material. Depending on the ultrasonic waves used during the inspection, it is possible to detect internal defects and surface and subsurface discontinuities. Ultrasonic tests can be manual, semi-automatic or fully automatic (e.g. automated quality control systems on production lines).

Magnetic Testing, (MT) is a method that allows detecting discontinuities on the surface of the tested object or directly beneath it (surface method) and indirectly assessing their nature and size by assessing the resulting indication of discontinuities.

Ultrasonic testing (UT) is based on the observation of recorded impulses received from material discontinuities and reflections from the bottom of the tested part or at the boundaries of media with different wave propagation speeds.

In the discussed case, welded joints were inspected using the following methods: NDT, UT, VT and MT. The test results were entered in the weld inspection card and are archived.

2.5.3. Control of dimensions

Before painting, the shields were finally inspected by a technical inspection employee. The technical inspection consists in checking the correctness of the gob shield modernization, in accordance with the submitted documentation (Fig. 11).

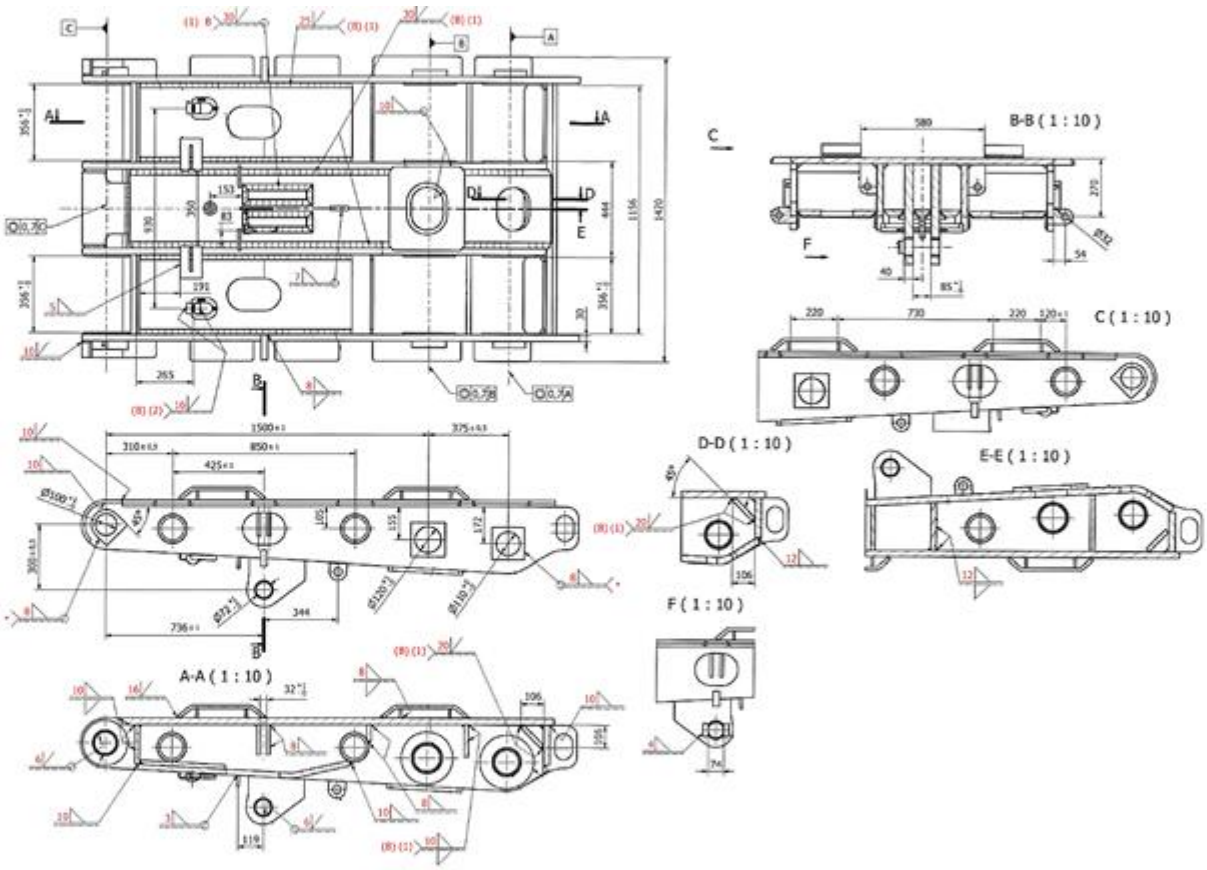

Fig. 11. Dimensions of the modernized gob shield

Dimensions of diameters and spacing of the main openings as well as the functionality of the connection of the shield with other components of the roof support (with the canopy and legs) are checked using gauges and control templates. The measurement results are entered into the measurement card and archived.

3. Conclusions

Welding processes in the plant, due to their special nature, should be carried out by competent and qualified welding personnel. A plant carrying out welding processes of important components should have sufficient and competent staff to plan, perform and supervise welding. It should have qualified staff in non-destructive tests or cooperate with the organizations accredited in this field.

Manufacturing rules, acceptance criteria, etc. contained in standards and documents related to the product facilitate the development of documents describing standard operational conditions that should be provided by the manufacturer.

The manufacturing process of welded structures in the plant must be in accordance with the guidelines and quality procedures implemented in the plant.

As a result of the modernization of the gob shield, it became more rigid a durable due to additional ribs and increased thickness of the replaced the shield covering metal sheets.

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The proper design and strength of the gob shield is very important both in terms of determining the roof support load-bearing capacity in the conditions of a given longwall, as well as determining the external load to the gob shield, which should be taken into account at the stage of designing or modernizing this component.

An equally important task of the roof support is to simultaneously ensure the safety of the crew and machines in the place where operations take place.

References

[1] Słania J., Marcinkiewicz H., Kiełbik M.: Plan spawania elementu obudowy kopalnianej – osłony odzawałowej. Przegląd Spawalnictwa 2012, nr 2, pp. 6-16

[2] Słania J., Marcinkiewicz H., Kiełbik M.: Technologia wykonania konstrukcji osłony odzawałowej obudowy kopalnianej – montaż i spawanie elementów oraz kontrola osłony odzawałowej. Przegląd Spawalnictwa Vol. 88 11/2016

[3] Szweda S.: „Obciążenia osłon podpierających zawał obudów podporowo-osłonowych," VIII Zimowa Szkoła Mechaniki Górotworu – Teoria projektowania obudów i zaciskania wyrobisk, Prace Naukowe Instytutu Geotechniki Politechniki Wrocławskiej, seria Konferencje, nr 31/12, Wrocław, 1980

[4] Trojan. A., Zabierowski S.: Pierwsza bezlemniskatowa obudowa ścianowa Glinik-13/29-Pz, Wiadomości Górnicze 1996, nr 4, pp.163-165

[5] Szyguła M.: Rozwój konstrukcji sekcji obudowy zmechanizowanej w górnictwie węgla kamiennego w Polsce. Maszyny Górnicze 2013 Volume 31, issue 2, pp. 30-38

[6] Labus J., Markowicz J., Szweda S.: Uszkodzenia połączeń spawanych w osłonie odzawałowej a bezpieczeństwo użytkowania sekcji obudowy zmechanizowanej. Maszyny Górnicze 2009. Volume 27, issue 4. pp. 19-24

[7] Losiak S., Ptak J.: Wpływ gruzowiska zawałowego na osłonę odzawałową i zachowanie się sekcji lemniskatowej obudowy ścianowej. MiAG 2010. Vol. 3(469) pp. 35-41

[8] Wiadomości Górnicze Numer specjalny: Obudowy zmechanizowane, Katowice 2006

[9] Szweda S., Szyguła M., Mazurek K.: Czynniki wpływające na postać konstrukcyjną i parametry techniczne sekcji ścianowej obudowy zmechanizowanej. Monografia. Wydawnictwo ITG KOMAG Gliwice 2016, p. 162

[10] Zajic D., Gil J.: Komputerowe wspomagania projektowe w procesie produkcji, modernizacji i remontów obudów zmechanizowanych Polskiej Grupie Górniczej S.A. Oddział Zakład Remontowo-Produkcyjny. Szkoła Eksploatacji Podziemnej, Materiały Konferencyjne SEP 2021, pp. 1244-1283

[11] Pawlikowski A.: Symulacja wpływu obciążenia osłony odzawałowej na podporność sekcji obudowy zmechanizowanej. Systemy Wspomagania w Inżynierii Produkcji. 2017, vol. 6, nr 2, pp. 247-256

[12] Słania J.: Istota planów spawania. Przegląd Spawalnictwa 2011, nr 2, pp. 3-9

[13] PN-EN ISO 14175 Welding consumables - Gases and gas mixtures for fusion welding and allied processes (ISO 14175:2008)

[14] PN-EN ISO 17635:2017-02 Non-destructive testing of welds - General rules for metallic materials (ISO 17635:2016)

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