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SHAFT LINING STRUCTURE MADE FROM ANTICORROSIVE ALLOYS - ITS SCHEME AND DYNAMIC DESIGN

Abstract. Shaft lining, its calculations, construction and projection are given in the mine regulations BP 12/82 and technical standards ON 445595-97 and ON 445591-94. It is thus a complete basis from which individual elements of the shaft lining may be dimensioned. However, introducing gradually the scientific and technical revolution and scientific research into practice, we may state, that the technical bases given above do not fully meet the newest requirement to shaft lining. Particularly the mine regulations BP 12/82 solve a lining the elements of which are made from timbre or steel.

Because of the aggressive underground waters treating in shafts, the previous research dealing with anticorrosive precautions led to the conclusions that there are special coats including those using metal spraying for steel parts of shaft lining, which are most suitably used to protect against corrosion. In this connection we must state that the problems of surface protection, especially of shaft steel guides has not been sufficiently solved first of all for upcast shafts as well as for underground environments in which underground waters containing NaCl, iodine, and bromine occur. Particularly the shafts in the northern part of the Ostrava-Karviná Coal District can be mentioned, namely the shaft of Mines Darkov, ČSM, and 9. květen.

The upcast shafts of ČSM-Mine, Concern Enterprise in Stonava show the highest aggressivity of underground waters and air against the steel elements of a shaft lining.

For these shafts a new profile 6011 was designed, which is made from light alloys with anticorresive resistance to "sea water". As both the material and installation of this profile in an upcat shaft is atypical, some extra calculations must be dane both according to the BP 12/82 and especially utilizing the newest knowledge of mathematical modelong and the dynamics of the set conveyance - shaft lining.

1. INTRODUCTION

The quality and nominal wall thickness of a shaft lining structure made from steel components decreases gradually owing to underground water, air and abrasion with conveyances, and generally with respect to the corrossive aggressivity a successive renewal must be done once in 7 to 15 years.

2. SHAFT LINING

Not only applications of scientific and technical revolution to practice but also technological changes tend to be generalized. To such innovation tendencies also the problems with steel shaft lining corrosion belong. This was solved at the University of Mining and Metallurgy of Ostrava in cooperation with the Ostrava-Karviná Coal Basin, Mine ČSM in Stonava and Non-Ferrous Metal Works Děčín which resulted in shaft lining construction from light alloys.

Great attention was paid to the questions of corrosion resistance of steel shaft lining structure in many extensive research papers dealing predominantly with surface protection of steel mine equipments. As the results showed, there are three types of protective coatings te be considered to protect the mine equipment:

- organic coatings - solvent or powdered,
- metal - metallizing with zinc or aluminium, or deep zinc coating respectively
- combined coatings - metallizing with zinc + polymerate, metallizing with Al + epoxy tar, or combined metallizing with Zn + Al completely with epoxy varnish.

It is the aluminium coating which shows unambiguously the best corrosion resistance. Positive results were obtained also with deep zinc coating, which was done especially in the German Federal Republic. However, in our conditions the production of deeply zinccoated shaft lining would be rather difficult and expensive. Also producing shaft lining metallized surface is not simple - both from technical and economical points of view, especially because of the extensive operations to prepare and carry out the metallizing process. All these reasons led us to the decision to produce the shaft lining components from light and highly corrosive resistant alloys and with corresponding mechanical properties. Also the economical aspect as well as the very important fact were considered that the installation of such shaft lining will be much more simple because of its mass which is three times smaller than that of steel. The very technical solutions which were proceeded by long-lasting successive testing of various light alloys in the particular conditions in the environment with aggressive waters were carried out awaring fully the fact that we certainly come across with a number of problems concerning the possible application of light alloys in underground shafts. These problems may be subdivided into three basic groups:

1. Mechanical properties and the resulting condition for the equipment to satisfy the stress analysis to limit states given by the Mine Regulations BP 12/82, Supplement 2.

2. Safety of operations - using light alloys the formation of warm spark must be unconditionally taken into account.

3. Economical relations

ad 1. At first a guide profile was designed corresponding practically to the steel profile, the guide sets being welded to square profile. The material being proposed respecting the Czechoslovak State Standard (ČSN) possessed mechanical properties given in Tab. 1 (ČSN 42 4400); here also these properties are compared with those of the material being presently used for steel guides (ČSN 42 0074).

Tab. 1

Mechanical properties of shaft linings made from light alloy and steel

Material	Re [MPa]	Rm [MPa]	σ_{st} [MPa]			ρ [kg.m^{-3}]
			static	repeated	alternating	
ČSN 42 4400	195	270	Czechoslovak State Standard is not given			2710
ČSN 42 00 74	200÷240	350÷450	100 ÷ 140	85 ÷ 120	65 ÷ 90	[illegible]

ČSN • Czechoslovak State Standard

Tab. 2

Chemical analysis of waters from the upcast shaft in Mine ČSM in Stonava

pH	6,5	—
conductivity	50,16	mS.cm^{-1}
total hardness	106,51	mval.1298^{-1}
salinity	1262,02	mval.l^{-1}
vaporization/105°C	40403	mg.l^{-1}
vaporization/180°C	36873	mg.l^{-1}

cations	mg.l^{-1}	mval.l^{-1}	concen v %	anions	mg.l^{-1}	mval.l^{-1}	concen v %
calcium	1395,8	69,65	5,52	chlorides			
magnesium	448,2	36,86	2,92	bromides	22338	630,0	49,92
sodium				iodides			
	12588	524,50	41,56	sulphates	0	0	0
potassium				bicarbonates	61,0	1,01	0,08
sum of cations	14432	631,01	50,00	sum of anions	22399	631,01	50,00

total alkali	1,01	mval.l^{-1}
apparent alkali	0	mval.l^{-1}
acidity	0,40	mval.l^{-1}
bonded CO_2	44,4	mg.l^{-1}
free CO_2	17,6	mg.l^{-1}
total CO_2	62,0	mg.l^{-1}

From the standpoint of stress the shaft lining BP 12/82 proved to be sufficient and was therefore installed in the upcast shaft in the Mine ČSM. The underground water composition is given in Tab. 2 and it is evidently seen that the environment is very aggressive. After three years of operation, the corrosion losses on the light alloy shaft lining were practically zero. Certain losses because of abrasion when solid guides came into contact with shaft lining were observed, however, this is a specific phenomena of solely technical character which is independent of the corrosion resistance of the particular material.

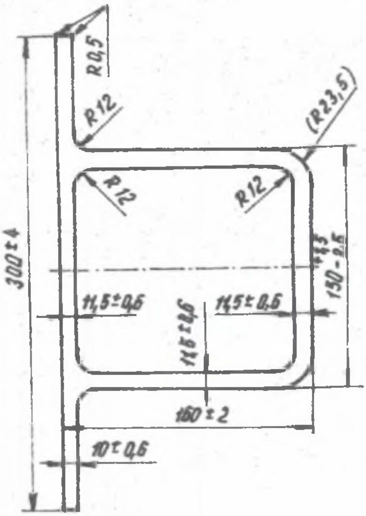

Fig. 1. Profile shaft lining "winge type"

The welded type of shaft lining was abandoned and a new, the so called "wing" profile was designed, see fig. 1, the real length of which may reach 8 m and its mass being only 160 kg, while the mass a steel quide amounted to 500 kg. Mechanical properties as well as analysis to limit states are fully agreeable.

ad. 2. It was the State Testing Laboratory No 214 which was submitted this type of shaft lining to judge it from the standpoint of the safety of operations. This decided to use the light alloy shaft lining in an upcast shaft providing the CH_4 concentration will not exceed 1,5 per cent and CH_4 is measured continually using two mutually independent apparatus. The CH_4 measurements are carried out using the "IREX I M", which is a highly sensitive and to the whole mining public sufficiantly known aparatus. The measured CH_4 concentrations are recorded in 20 sec. intervals using point recorder Z 61. By means of longdistance power transmission a permanent control on an indicator is possible, the scala of which is divided into 0,1 CH_4 per cent by volume concentration.

ad 3. To appreciate economical advantages already today would be premature. A detailed economical evaluation will be necessary containing investment costs compared with maintenance costs. At present the informative price relations are the following:

1 kg metallized guide ...	cca 19,- crowns
1 kg light alloy guide (in dependence on the quantity of alloying elements) ...	32,- to 40,- crowns

3. CALCULATIONS

Calculating the shaft lining, first of all Supplement 2, BP 12/82 must be respected. The calculation is based on determining material parameters inclusive lining deflection. Carrying out calculations according to Supplement 2, BP 12/82, requirements given by mine inspection are practically fulfilled. However, this is not enough in case of a light alloy shaft lining. Other calculations must be done respecting worldwide experiences, it means hoisting experiences from underground mines in the GFR, USSR, and Poland. Also experiences obtained when solving the government-sponsored research programme "Deep Hoisting" enable us to apply computers for dimensioning lining nodes and elements with respect to the dynamic stability or lenght of life and reliability. First calculations of this type were done in Czechoslovakia for mining equipments in an upcast shaft of Mine ČSM-South, Ostrava-Karviná Coal District, for which the project was done replacing stage by stage the corroded steel shaft lining by anticorrosive, i.e. based on ligh metal alloy lining.

4. CONCLUSIONS

In the end we may state that lining calculations respecting dynamic effects are being developed at present and penetrate thus into technical practice.

Recenzent: Doc. dr inż. Taduesz Zmysłowski

KONSTRUKCJA OBUDOWY SZYBU WYKONANA ZE STOPÓW ANTYKOROZYJNYCH

S t r e s z c z e n i e

Obudowa szybu, jej obliczenia, konstrukcja i projektowanie są określone w przepisach kopalniancyh BP 12/82 i normach technicznych ON-445595-87 i ON-445591/84. Jest to więc kompletna podstawa wymiarowania poszczególnych elementów obudowy szybu. Jednakże wprowadzając stopniowo naukową i techniczną rewolucję oraz badania naukowe do praktyki możemy stwierdzić, że wspomniana wyżej techniczna baza nie spełnia najnowszych wymagań stawianych obudowie szybu. W szczególności przepisy kopalniane BP 12/82 przewidują zastososanie elementów obudowy wykonanych z drewna lub stali.

Z uwagi na agresywne działania wód gruntowych w szybach, wcześniejsze badania dotyczące zabezpieczeń antykorozyjnych doprowadziły do wniosku, że istnieją specjalne powłoki, w tym nanoszone natryskowo warstwy metaliczne na stalowe cześci obudowy szybu, które są najbardziej odpowiednie

do ochrony przed korozją. W tym kontekście musimy stwierdzić, że problem ochrony powierzchniowej, w szczególności stalowych prowadnic szybów nie został zadowalająco rozwiązany, szczególnie dla szybów wylotowych, jak również dla podziemnego środowiska, w którym występują wody gruntowe zawierające NaCl, jod i brom. Należy tu wymienić szyby w północnej części Ostrawsko-Karwinskiego Okręgu Węglowego, a w szczególności szyby kopalń Darkov, CSM i 9 Maja.

Szyby wylotowe w kopalni CSM, Przedsiębiorstwo Koncernowe w Stonowie wykazują najwyższą agresywność wód gruntowych i powietrza względem stalowych elementów wyłożenia szybu.

Dla tych szybów zaprojektowano nowy profil 6011, wykonany z lekkich stopów z odpornością antykorozyjną na działanie "wody morskiej". Ponieważ zarówno materiał, jak i instalacja tego profilu są nietypowe, muszą zostać wykonane dodatkowe obliczenia, zarówno według BP 12/82, jak i z wykorzystaniem najnowszej wiedzy z dziedziny matematycznego modelowania i dynamiki układu pojemnik przewożący - obudowa szybu.

КОНСТРУКЦИЯ КРЕПЛЕНИЯ ШАХТНОГО СТВОЛА СДЕЛАННАЯ ИЗ АНТИКОРРОЗИОННЫХ СПЛАВОВ

Р е з ю м е

Крепление шахтного ствола, его расчет, конструкция и проектирование определены в правилах горно-добывающей промышленности ВР 12/82 и технических стандартах (нормах) О N - 445595-87 и ОN -445591-84. Это является комплектным основанием на основании которого отдельные элементы крепления шахтного ствола могут быть размерены. Однако, при постепенном введении научно-технической революции и научных исследований в практику, можно сказать, что вышеупомянутая техническая база не полностью отвечает современным требованиям для крепления шахтного ствола. Особенно, шахтные (горно-рудные) правила ВР 12/82 предвидят применение элементов крпеления из стали или дерева.
Из-за агрессивного воздействия грунтовых вод, более ранние исследования антикоррозионной защиты позволили прийти к выводу, что существуют специальные пленки, в то наноимые распылением на стальные части крепления, которые наиболее соответствуют для защиты от коррозии. В этом аспекте можно сказать, что проблемы поверхностной защиты, особенно стальных направлющих стволов не были достаточно решены, особенно для выходных стволов, как и для подземно среды в которой выступают грунтовые воды , содержащие NaCl

иод и бром. Тут надо назвать стволы в северной части Остравско-Карвинского угольного бассейна, а особенно стволы шахт Дарлов, ЧСМ и 9-го мая.

Выходные стволы шахты ЧСМ, Предприятие-Концерн в Станове, отливаются наибольшей арессивностью грунтовых вод и воздуха по отношению к стальным элементам выкладки ствола.
Для этих стволов запроектировано новый профиль 6011 из легких сплавов с антикоррозионной стойкостью на воздействие"морской воды". Так как материал и инсталяция этого профиля не типичны, должны были быть проведены дополнительные расчеты как по ВР 12/82, так и при использовании современных достижений науки в области математического моделирования и динамики системы превозной контейнер- крепление ствола.