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A study of worn wear plates of fan blades of steel mill fumes suction system

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Abstract: In this paper, examination of a part of worn fan blade of the fan of steel mill fumes suction system are presented. Fan body was made from the CORTEN steel and the working surfaces of the blades are covered by wear plates 4666 CDP (4666 DP 0503) produced by CASTOLIN Co. It was proved that the main reason of very strong wear of the middle part of the fan blades is fumes erosion phenomenon greatly accelerated by water pollution of fumes.

Keywords: Fan blade; Wear plate 4666 CDP; Erosion

1. INTRODUCTION

The subject of the study is a part of worn fan blade of the fan of steel mill fumes suction system, shown in Fig 1. Fan body is made from the CORTEN steel, Table 1, and the working surfaces of the blades are covered by wear plates 4666 CDP (4666 DP 0503) produced by CASTOLIN Co., attached to the blades by spot arc welding, Fig 2 and 3, Table 2. The deposit of 4666 CDP is produced by SSA surfacing process using CASTOLIN TeroMatec 4666 self-shielded wire. Deposit thickness is 3,0 [mm] and its structure is hypereutectic high chromium cast iron alloy containing complex carboborides and carbides, shown in Fig. 3. The base material of 4666 CDP is S235JRG2 carbon steel of thickness 5,0 [mm], Table 1 [1, 2].

During fumes suction operation the fan blades are subjected very strong wear phenomena of erosion corrosion (mechanical erosion degradation augmented by corrosion) which result in very strong wear of the center part of the blade, Fig. 1a. Fumes produced during steel milling process ventilated by the suction system are polluted by water leakage from furnace cooling system. Water presence in fumes as a pollutant is the main source of atmospheric and galvanic corrosion which strongly augments fumes' erosion wear phenomenon. Atmospheric corrosion of fan blades is greatly accelerated by water (moisture) in fumes. The surface of the wear plate is attacked by atmospheric corrosion and as the result products of the corrosion in the form of oxides (rust) and sulphates are constantly produced on the fan blades wear plates surfaces and the surface of CORTEN steel fan body. Products of atmospheric corrosion are not erosion resistant in comparison to high chromium cast iron alloy deposit of the wear plates of blades, so these products are rapidly removed from the deposit surface what strongly accelerates fan blades wear [3, 4].

In the same time galvanic corrosion takes place because of difference in the chemical composition and the structure of deposit and carbon steel base material of 4666 CDP and

CORTEN steel fan body, shown in Fig. 3, Table 1 and 2. Less noble - anodic carbon steel base material of 4666 CDP and CORTEN steel fan body (- 0,6 [V] to – 0,7[V] - standard potential) then cathodic high chromium base cast iron alloy of 4666 CDP deposit (- 0,45 [V] to -0,50 [V]) are attacked to greater degree. As a result the 4666 CDP base material and CORTEN steel of the fan body are strongly dissoluted and form ions which migrate from anodic areas of carbon steels on the surface into the electrolyte. Additionally galvanic corrosion initiates strong crevice corrosion in the area of fusion zone between deposit and base material of 4666 CDP, in the bottom area of the residual stresses cracks of the deposit, shown in Fig 2, which later continues as stress corrosion cracking.

On the other hand due to very complex hypereutectic ledeburite structure of 4666 CDP deposit of ferritic matrix containing carboborides and chromium and niobium carbides of different potential in galvanic series, stress corrosion cracks are initiated as the synergistic interaction between mechanical (welding) stresses in the deposit and a galvanic corrosion on the surface of deposit.

Table 1.
The chemical composition (wt-%) of CORTEN steel and S235JRG2 steel

Elements	C	Mn	Si	Cr	Cu	P	S
CORTNEN	0,10-0,15	0,25-0,55	O,25-0,60	0,5-1,5	0,25-0,50	max. 0,04	max. 0,05
S235JRG2	0,17	1,4	-	-	-	max. 0,045	max. 0,045

Table 2.
Classification, chemical composition and hardness of the deposit of fan blades wear plates - 4666 DP 0503

Surfacing consumable		Thickness - [mm]		Deposit hardness
Classification of cored wire	Chemical composition (wt-%) of the deposit	base metal	deposit	
TeroMatec 4666	Fe + 5,4%C, 0,9%B, 0,3%Mn, 20,5%Cr, 6,7%Nb, 1,5%Si	5,0	3,0	743-847 HV10 62-65 HRC

a) b)

Figure 1. a) - a view of the fan of steel mill fumes suction system. Fan blades are covered by the wear plates 4666 CDP attached to the fan body by arc spot welding, b) - a view of worn center part of thr fan blade

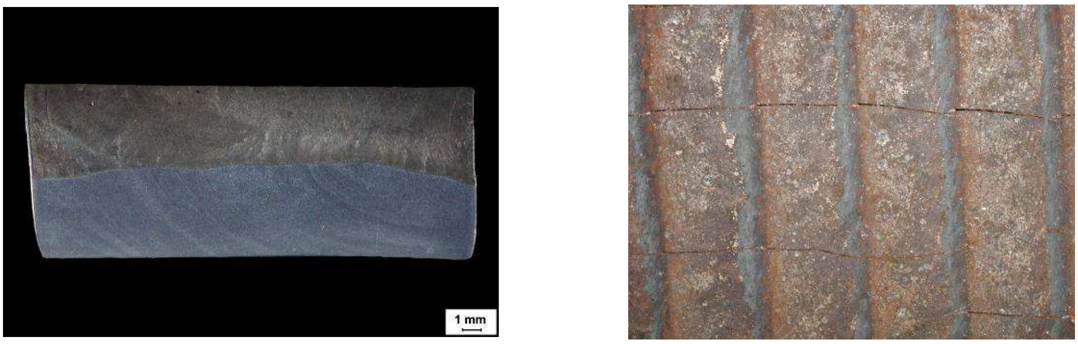
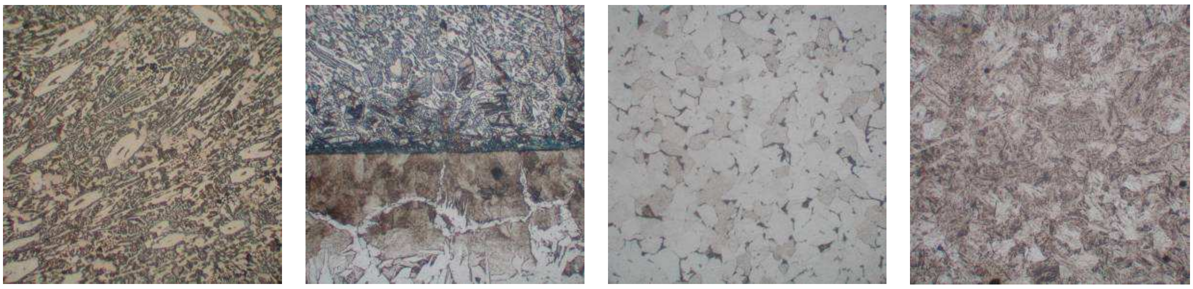


Figure 2. Macrograph and a view of the surface of the wear plate 4666 CDP, visible transverse cracks induced by SSA surfacing residual stresses

The purpose of a study is to determine the chemical composition of basic compounds of corrosion products of the worn surfaces of 4666 CDP deposit and CORTEN steel fan body and visual and metallographic examinations of worn parts of the fan blade.



DEPOSIT FUSION ZONE HAZ S235JRG2 STEEL

Figure 3. Micrograph of deposit, fusion zone, HAZ and base material of 4666 CDP, 200x magnification

2. DETERMINATION OF BASIC COMPOUNDS OF THE WORN FAN BLADE CORROSION PRODUCTS

Samples of the corrosion products of the worn surface of the fan blade wear plate and CORTEN steel fan body were collected from the part of worn fan blade. To determine the basic compounds of corrosion products qualitative X-ray crystallographic examination was applied and all possible compounds have been searched. Basic compounds of corrosion products on the surface of 4666CDP deposits are Mn_3O_4, Fe_2O_3 and Cr_5O_{12} oxides and FeS troilite. Basic compounds of corrosion products on the surface of CORTEN steel fan body are Mn_3O_4, Fe_2O_3 oxides and FeS troilite. Philips X-ray crystallography examination apparatus was used and radiation parameters were: voltage – 40 [kV] and current 20 [μA].

3. VISUAL AND METALLOGRAPHIC EXAMINATIONS OF THE WORN BLADE

Samples for visual and metallographic examinations were cut from different areas of strongly eroded, corroded and cracked worn fan blade. Pictures of eroded and corroded surfaces of the 4666 CDP deposit and CORTEN steel were taken with a digital camera and are shown in Fig. 4. Transverse cross sections of the samples have been examined with LEICA MEF4A metallographic microscope and results of macro and micro metallographic examinations are shown in Fig. 5.

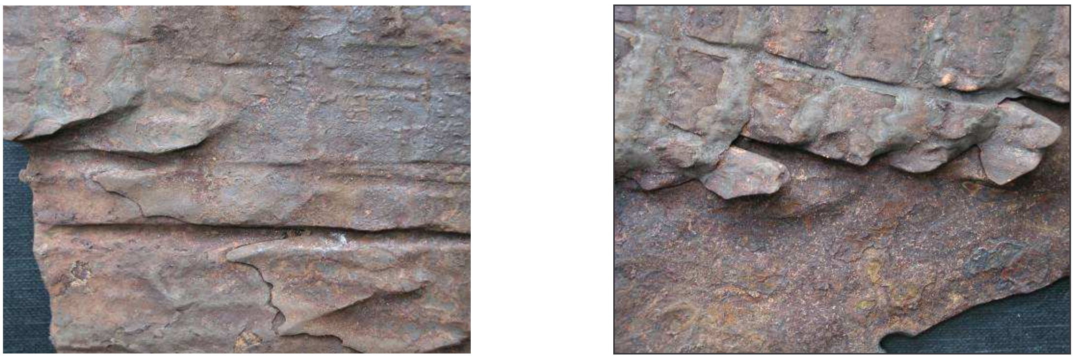
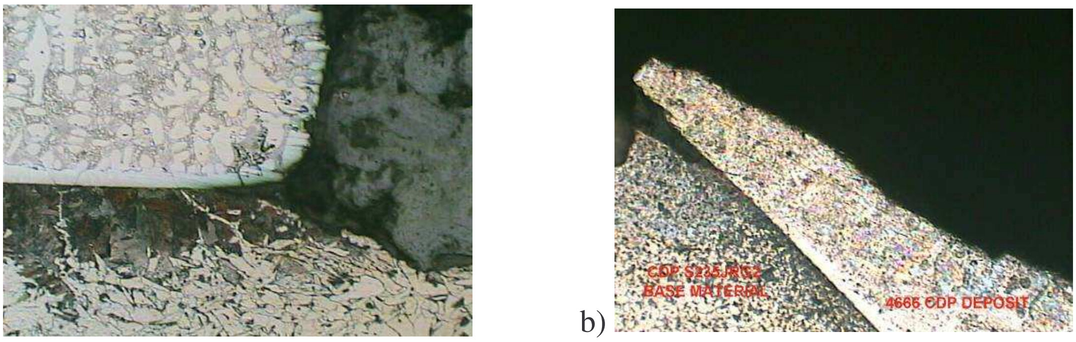


Figure 4. A view of strongly eroded, corroded and cracked surfaces of 4666 CDP deposit and CORTEN steel fan body, 2x magnification



a) b)

Figure 5. Micrograph of cracked and galvanic corrosion area of 4666 CDP deposit, showing galvanic corrosion creative between deposit and base material; magnification: a) 200x, b) 100x

4. CONCLUSIONS

1. Basic compounds of the products of atmospheric corrosion of 4666 CDP deposit are Mn_3O_4, Fe_2O_3 and Cr_5O_{12} oxides and FeS troilite as a result of water pollution of fumes.
2. Basic compounds of the products of atmospheric corrosion of 4666 CDP deposit are Mn_3O_4 and Fe_2O_3 oxides and FeS troilite as a result of water pollution of fumes.
3. Visual and metallographic examination have proved that the main reason of very strong wear of the middle part of the fan blades, Fig. 1b, is fumes erosion phenomenon greatly accelerated by water pollution of fumes. Water pollution is the source of very strong atmospheric corrosion and galvanic corrosion of 4666 CDP and CORTEN steel fan body shown in Fig. 4 and Fig. 5.
4. Galvanic corrosion induced strong crevice corrosion and stress corrosion cracking of the 4666 CDP shown in Fig. 5.

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