11TH INTERNATIONAL SCIENTIFIC CONFERENCE
ON DEFENSIVE TECHNOLOGIES
OTEH 2024
Serbia, Tara, 9-11 October 2024

ALTERNATIVES TO CADMIUM PROTECTION IN DEFENSE AND AEROSPACE INDUSTRY

KONSTANTIN KOMATINA
Vlatacom Institute, Belgrade, konstantin.komatina@vlatacom.com

MILAN IGNJATOVIĆ
Vlatacom Institute, Belgrade, milan.ignjatovic@vlatacom.com

STEFAN TOMIĆ
Vlatacom Institute, Belgrade, stefan.tomic@vlatacom.com

DUNJA CRNOGORAC
Vlatacom Institute, Belgrade, dunja.crnogorac@vlatacom.com

Abstract: *This paper presents results that were achieved during solt fog testing in order to determine the possibility of replacing cadmium surface protection treatmant with plasma or ion nitriding. Additional oxidisation processes were implemented. Solt fog tests were conducted in accordance with relevant MIL-STD 810 test standard. Paper will focus on the experimental procedure and results, theoretical background will be mentioned in short terms. There is no numerical analisys, or complex interpretation of the test results. Conclusion will describe next course of action.*

Keywords: *plasma nitriding, cadmium, defence industry*

1. INTRODUCTION

Domestic defence and aerospace industry has long relied on cadmium surface treatments to achieve high degree of surface protection. Additional passivisation processes were usually required after main cadmium protection. Such processes were reserved for highly stressed parts and components that were expected to reliably operate in most agressive of environments. Technological parameters of cadmium protection proceesses are defined by domestic defence standards

According to regulations[1] that were set by EU governing bodies, cadmium surface coating is banned. Cadmium coatings present a health and safety hazard due to toxicity and carcinogenic properties, thus, it is neccessary to produce a protection treatment that will be safe for its operators, but also be effective as or nearly as cadmium.

2. TEST PARAMETERS

There is a wide array of scientfic papers[1] and studies available[2], however, rarely are stringent military test procedures applied or referenced. Usually authors will reference commercial applications in both automotive or aerospace industry.

Throughout the duration of the test, following conditions inside the chamber were met and maintained[3].

a) Spray duration : 48 hours

b) Test chamber temperature between 32 and 36 degrees C

c) Relative air humidity 84 %

d) Solution NaCl 5%, ph value around 6,5

e) Solt fog concentration 138 cm^3/48 h

f) Dry temperature from 43 ^{0}C to 49 ^{0}C in duration of 24 hours

It bears mentioning that between the „wet“phase and the drying phase, no additional cleaning processes were perfermed. Main goal is to allow the salt build up to remain on the surface. Such salt deposits, on poorly protected components and parts, will inevitably lead to base material corrosion and in case of systems that have moving parts, will clog or disable the operation of such parts. MIL-STD 810 also envisions electrical tests to determine adverse effects on electrical properties after the salt fog, however, this is beyond the scope of this paper.

[1]REACH regulations

[2]Domestic designation is Č 5432, VP additional

[3]Data retrieved from sij group web site “steelselector.sij.sl” “SIQUAL 6580 Steel”

Corresponding author: K. Komatina;
E-mail: , konstantin.komatina@vlatacom.com
DOI: 10.5937/OTEH24099K

3. MATERIAL CONSIDERATIONS

In order to perform a salt fog test, three test samples were prepared. Samples were made from 1.6580 steel bars.

30CrNiMo8[2] steel is videly used in aerospace and defence, as it combines excellent mechanical properties with good machinability. This steel belongs to group of steels intended for heat treatment and can be easily heat treated to achieve high surface hardness, making it ideal for highly stressed shafts, cranks, bolts etc.

Major drawback however is its tendency to easily corrode, even with the main alloying element being chrome. Steel components made from 1.6580 will show signs of surface corrosion even at room temperature conditions, especially if they are kept in humid environments.

Table 1: Mechanical properties[3]

Bar diameter	0,2% proof stress	Tensile strength	Elongation
[mm]	[N/mm$^{2]}$	N/mm$^{2]}$	%
40 to 100	900	1100 -1300	10

Chemical composition is stated in table bellow

Table 2: Chemical composition

C	Si	Mn	Cr	Mo	Ni
[%]	[%]	[%]	[%]	[%]	[%]
0,30	0,40 max	0,45	2,0	0,40	1,9

4. TEST SAMPLES

As mentioned previously, test samples are three steel cylinders measuring as 60mm in diameter and 120mm in length. They are marked numerically from 1 to 3.

On all three cylinders, holes are drilled in order to provide mounting points for installation inside the chamber.

Test samples are oriented in three distinct positions:

1) Vertical
2) Horizontal
3) Slanted at 45 degrees

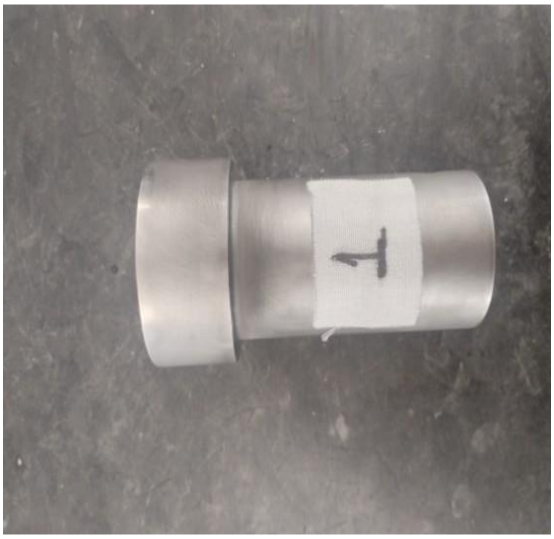

Figure 1: Test sample 1

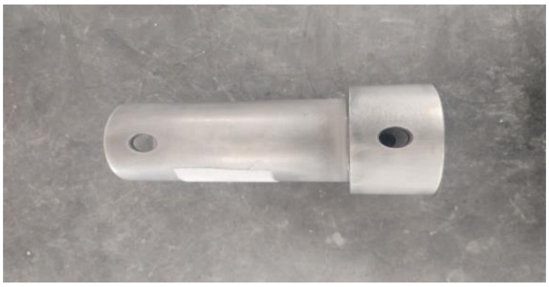

Figure 2: Test sample 1 side position

Figure 3: Test sample 3 – side position

5. SURFACE PROTECTION PARAMETERS

Three samples in question were subjected to following conditions in order to create a hard nitriding surface layer. Thickness of said layer is of several micrometers. Table bellow gives the overview of protection parameters.

Table 3: Process parameters

Sample no.	Protection process	Duration [h]	Coating thickness [µm]
1	Nitriding	15	5
2	Nitriding + Oxidation	20	5
3	Nitriding	20	5

All three test samples were nitrated, in varying duration of the process itself. However, sample number two is the only one that was subjected to oxidization process. Thus we have varied only two parameters, duration of the process and post process itself.

6. RESULTS AND DISCUSSIONS

After the aforementioned salt fog process was completed, test samples were taken for evaluation.

Photos of the samples are given bellow

Figure 5: Test sample number two

Figure 6: Test sample number 1

Figure 7: Test sample number 3

As can be seen from the supplied photographs, all three samples have base material corrosion and thus have failed the test.

However, sample number two has by far performed the best. Reason as to why lies in the added oxidization process. On two sides of sample number two there are observable spilages of salt corrosion that affected the sample, on the other two sides there are not.

7. FUTURE WORK AND ADDITIONAL INFORMATION

On the previous page, a perculiar phenomenom regarding the sample number two was mentioned. One possible solution is to continue with the nitriding and oxidization processes and to optimize the process in order to achieve a sufficient protection.

This avenue lends itself to continuos study of effects nitriding layers in domain of surface protection. Possible downside of course is that no degree of optimization can solve for adverse conditions perscribed in MIL-STD-810 509.5

In recent years, in the automotive industry there has been a discussion about the possible use of a zinc- nickel galvanizing method that could effectively replace cadmium.

This potential solution should be explored and future work will focus on zinc-nickel treatments.

References

[1] : J.C Diaz-Guillen; J.S Zamarripa-Pina; E.E Granda Gutierrez; M.A Gonzales-Albarran; J.A Diaz-Guillen; S.I Perez-Aguilar; J.Candeles-Ramirez, “Increase of Salt Fog Corrosion Resistance of Plasma Nitrided Steel by Pulsed Plasma Post Oxidation”, 2013

[2] : P Wach; J Michalski; K Burdynski; A Ciski, Anticorrosion nitrided layers on unalloyed and alloyed steels, 2017

[3] : Department of Defense, “Environmental engineering considerations and laboratory tests, 2008”