FACTORS INFLUENCING THE CORROSION OF INFANTRY WEAPONS' BARRELS

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Abstract: *The condition of the inner surface of the barrels greatly influences the stability of the bullet and the accuracy of firing with infantry weapons. Therefore, it is of particular importance to keep the inside of the barrels in perfect condition and to protect them against corrosion.*

For this reason, the article aims to highlight the possible degradation of the inside of the barrels in operation and the main factors influencing their corrosion, in order to counteract their effect. The whole issue is addressed both to the personnel specialized in the design and construction of infantry weapons systems and to the personnel that uses them.

Keywords: surface condition, corrosion, potassium chloride, tombac, nitrogen oxides, hydrogen sulphide, reducing gases, neutral gases, gases

1. Degradation of the interior of the barrels

The condition of the inner surface of the barrels greatly influences the stability of the bullet and the accuracy of firing. If the inner surface of the barrel is smooth, straight, without cavities, hanks, cracks or other defects, the bullet is guided uniformly in the grooves, and the grooves give it a correct axial rotation movement. During the firing with such barrels, the spread of bullets is very low.

If the inside of the barrel has surface defects, the bullet suffers excessive friction in the barrel in its various sections due to which the scattering of bullets becomes appreciable, worsening the accuracy of the weapon.

Therefore, it is of particular importance to keep the interior of the infantry weapons barrels in perfect condition and to protect them against corrosion.

Examining the inside of a barrel which is

not chrome-plated, the following damage (degradation) can be observed: rust, traces of rust, rust stains, puncture corrosion (pinching) and metal deposits of the bullet's cover [3].

Rust appears as a thin layer of dark color or in the form of dark conglomerates; it often occurs in the part from the muzzle, because this is where the most intense wetting (steaming) occurs due to the difference between the temperature of the barrel and that of the environment.

Rust stains are appreciable grooves in the metal inside the barrel; they usually have irregular shapes with sharp edges and are often filled with corrosion products or gas burns.

Corrosion in the shape of points is the initial stage of rust inside the barrel and is in the form of very small cavities [2]. If the inside of the barrel is viewed in light, these corrosion signs look like small dots, arranged in various parts of the inside of the

barrel or along its entire length, especially in the middle of the fillings of the grooves. Tombac residues are presented as thin layers or deposits on the inner surface of the barrel, especially in the middle of the rifled part and along the fillings of the grooves. Sometimes the tombac on the bullet begins to deposit with great intensity in a single place inside the barrel, where a small bump or an annular strangulation of the inside of the barrel is formed.

In addition to these types of degradation, the inside of the barrel may also have: line-shaped scratches with the edge sometimes appreciably high; hollows, which are more or less pronounced grooves and in which the metal is sometimes also bumped at the edge; rounding of the grooves' fillings, a phenomenon that is observed especially on the attack side of the fillings; the ring pattern of the tube, i.e. the formation of a continuous or interrupted dark colored cross ring.

All these types of defects of the inside of the barrel are not due to the corrosive destruction of the metal, but later they can favor the initiation of a strong corrosion process in the respective places.

2. Influence of the cap's composition combustion products on the barrel's inside corrosion

Due to the firing phenomenon, gas burns arise in the pipe, consisting of products left after the combustion of the composition of the cap and the throwing load and of small metal particles detached from the bullet or torn by the powder gases on the surface of the cartridge tube and entrained by the gas stream. The higher the amount of gas burns deposited inside the barrel, the higher the number of shots fired with the respective weapon and the more degraded the condition of the inside of the barrel. If there is a pinch inside the barrel, even a small one, the amount of gas burns deposited in the barrel after a certain number of blows is doubled compared to the amount deposited in a barrel without pinches. If the barrel also has rust signs inside, the amount of

deposited gas burns is several times higher than in a barrel without signs of rust.

The composition of the ignition cap consists of several components, each of which fulfills a specific function.

These compositions are based on mercury fulminate, because their main starting substance is mercury fulminate. Potassium chlorate (KClO_3) contained in this composition serves as an oxidant, and antimony trisulfide (Sb_2S_3) is introduced to increase the temperature of the cap's flame. Since the antimony trisulfide being made of sharp-edged crystals, it increases the percussion sensitivity of the cap's composition. It is found that the proportion in which the various components are contained in the percussion composition varies depending on the destination of the cap, but basically the components are the same. During ignition, the composition with mercury fulminate and potassium chlorate decomposes after the following reactions [7]:

The gaseous products of the reaction - carbon dioxide CO_2 and nitrogen N_2 - do not influence the corrosion of the inside of the barrel because they are completely eliminated together with the powder's gases. On the other hand, the powder gases do not completely contain mercury (Hg) or antimony oxide (Sb_2O_3). In addition to these substances, potassium chloride (KCl) and potassium sulphite (K_2SO_3) remain inside the barrel, which arises from the side reaction [7]:

The gaseous hydrochloric acid that arises during this reaction is removed together with the gaseous powder. Instead, potassium chloride (KCl) and potassium sulfite (K_2SO_3) remain inside the barrel, absorb water (present in atmospheric moisture) and dissolve, forming an

electrolyte that triggers the corrosion process [6].

In addition to the chemical action, the solid products from the combustion of the cap composition also exert a dynamic action on the metal inside the barrel: the solid particles of mercury fulminate, being driven from the cap at high speed, collide with the incandescent metal surface, causing small cracks. The higher the percentage of mercury fulminate in the cap's composition, the stronger the dynamic effect of mercury fulminate on the inside of the barrel.

So, by burning the composition of the cap, gas and solid products are born: after the decomposition of potassium chlorate (KClO_3) oxygen and potassium chloride (KCl) are formed, and after the burning of antimony trisulfide sulfur dioxide (SO_2) and oxides of antimony (Sb_2O_3 , Sb_2O_4 , și Sb_2O_5). At high temperature, sulfur dioxide reacts with potassium chloride and gives rise to potassium sulphate (K_2SO_4) and potassium sulphite (K_2SO_3). In addition, the gases sometimes contain SbCl_3 antimony trichloride. As a result of these reactions, the combustion of the powder results in salts of which the most harmful in terms of corrosion is potassium chloride. During firing, due to the high temperature, the potassium chloride evaporates, being distributed, in gaseous state, among the powder gases. Coming in contact with the relatively colder walls of the barrel, the vapors of potassium chloride and those of other salts condense in the form of small drops of molten salt or in the form of small crystals. During the subsequent firing, the inner surface of the barrel is strongly heated, the crystals and drops of potassium chloride adhere to the steel surface, forming a very resistant layer on it. This extremely thin layer consists mainly of potassium chloride. Potassium chloride condenses not only on the visible, exposed surfaces of the inside of the barrel, but also in all cracks, grooves and pores of the material.

A greater amount of potassium chloride will be deposited in cracks and pores, because here the temperature is lower than on the visible surface of the inside of the barrel, and on the other hand, from these places the deposited salt particles are not driven by the powder gases.

Not only do the salts deposit on the steel surface, but they also absorb the rest of the gas burns in solid form, transforming from a spongy (brittle) layer. In this way, potassium chloride acts as a binder, as it binds together the particles of the spongy gas burns and "sticks" them to the inner surface of the barrel.

The rest of the gas burns, namely the insoluble part, consists of ash and metals; copper, zinc, lead, tin and iron. The ash consists of silicon dioxide, aluminum oxide and iron compounds. Copper, brass and zinc come off the bullet casing and are driven inside the barrel when the brass cartridge tube partially melts to the surface. In bullets in which the steel coating is covered with a thin layer of tombac (brass and zinc), when the bullet passes through the barrel, the metal on its surface is deformed, remaining partially in the barrel as deposits on the fillings of the grooves. The higher the amount of tombac left in the barrel, the greater the degradation on the inner surface of the barrel in the form of pinches, cuts or indentations and the lower the surface quality.

Gas burns deposited on the inner surface of a barrel with corrosive degradation contain almost 50% copper and zinc, and gas burns on the inner surface of a new barrel contain about 30% of these metals.

The lead contained in the gas burns comes from the bottom of the bullet and is entrained by the hot gases of the powder. The tin inside the barrel comes from the tin foil that covers the composition of the cap in its glass. The iron contained in the gas burns may be of different origin; incandescent dust gases "wash" the surface of the inside of the barrel and release small iron particles, which are partially retained

in the barrel and incorporated into the gas burns.

3. The influence of powder gases on barrel corrosion

The composition of the powder gases, which arise during the firing of smokeless powder, is very varied, depending on the composition of the throwing powder and the conditions in which it burns. In addition, the composition determined by the analysis of the cooled gases does not always correspond to the composition of these gases inside the barrel, during firing, at high temperatures. By total combustion of the throwing powder inside the barrel occur: reducing gases - hydrogen, carbon monoxide and small amounts of methane; neutral gases - especially nitrogen; oxidizing gases - carbon dioxide and water vapor.

In case of incomplete combustion of the throwing powder, nitrogen oxides can also be formed, which is of particular importance for the study of corrosion inside the barrel. Also, the sulfur dioxide resulting from the burning of the cap composition can be reduced by hydrogen, thus giving rise to a certain amount of hydrogen sulfide.

At high temperature, hydrogen, carbon monoxide, methane, nitrogen, carbon dioxide and water vapor, being completely removed from the inside of the barrel, after firing, do not intensify at all the process of corrosion of the metal of the barrel. Instead, nitrogen oxides and hydrogen sulfide greatly amplify the corrosion caused by the combustion products of the cap's composition [1].

The ash left after burning the smokeless powders consists of silicon dioxide and oxides of aluminium and iron; even if it has adhered strongly to the inner surface of the barrel, it only decreases the corrosion resistance of the steel to a very insignificant extent.

4. The influence of metal residues on barrel corrosion

Copper, tombac and brass favor the evolution of steel corrosion, because in the presence of salt solutions, they form a galvanic element with iron. In this case, the mentioned non-ferrous metals are not destroyed, but the steel with which they come into contact; steel oxidizes intensely, the phenomenon being accompanied by the appearance of deep deposits on the surface of the metal [5].

In a solution of potassium chloride the electrode potential of copper is positive and that of steel is negative; by bringing these two metals into contact, copper will promote the oxidation of the steel, without dissolving itself. The greater the difference between the electrode potential of copper and that of steel, the faster the steel will be destroyed. Inside the barrel, after firing and washing the inside, a solution of chloride and potassium sulfate arises. It is found that in potassium chloride solutions, the potential differences are the largest; the difference between the potential of steel and that of copper, respectively of the tombac, differs only slightly, therefore in these conditions the tombac and the copper possess practically identical corrosive properties.

5. Conclusion

An important aspect that contributes to increasing the life of barrels is the protection of their interior and exterior surfaces, necessary to increase the resistance to mechanical, chemical and thermodynamic wear of the interior, as well as to reduce the corrosion effect of the outside, generated by atmospheric agents [4].

Destruction of barrels due to corrosion and erosion is the consequence of the action of gases resulting from the combustion of the ignition composition and the throwing load and their movement at very high speed after the bullet is fired. By burning the powder charge and the ignition composition, the main and secondary chemical reactions take

place, as a result of which compounds are formed which act negatively on the inside of the barrels. As the material of the barrels is also mechanically required, the corrosion due to the gases is amplified, the phenomena of pressure cracking corrosion and weariness corrosion occurring.

The unprotected barrels inside suffer a faster degradation due to the galvanic element that occurs between steel, electrolyte and deposited non-ferrous metal. If the inside of the barrel is hard chrome-plated, the resistance to wear and, in particular, to corrosion and erosion increases considerably, but exfoliation of the chromium layer can occur in these

barrels because it is electrochemically deposited.

The article is intended to be a corollary of the main factors that influence the corrosion of the interior of the infantry weapons barrels and detail their influence on the phenomenon itself.

Knowing these aspects, it is possible to establish and apply measures to counteract the phenomenon, in relation to the type of factors involved. In this way the most appropriate measures will be used to maintain in operation some infantry barrels capable of ensuring the necessary accuracy in firing.

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