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ABSTRACT
The method of increasing the technical resource of the 152 mm caliber howitzer, model 1981 aims to improve the construction solution of an essential subassembly of this product’s structure, without affecting the functioning of the howitzer and without diminishing its safety and stability in firing. For this reason, the article aims to highlight the essential aspects of the construction of the guiding and sealing piston of the 152 mm caliber, 1981 model howitzer’s recuperator, using a polymer composite material and to present how the chosen technical solution influences the technical resource of the product.

KEYWORDS: technical resource, fibroplast burnas, objective function, diagnostic parameter, critical technical condition

1. General Considerations
The method of increasing the technical resource of the 152 mm caliber howitzer, 1981 model aims to improve the design solution of an essential subassembly of the structure of this product without affecting the functioning of the howitzer and without reducing its safety and firing stability.

The constructive solution consists in the manufacture of the guiding and sealing piston, which is part of the 152 mm cal. howitzer recuperator, 1981 model, made of polymer composite materials and highlighting how this solution influences the technical resource of the product.

The proposed technical option improves the current configuration in terms of ensuring increased sealing of the recuperator both in dynamic operation and during liquid quantity checks. The increased leak-tightness of the recuperator results in the pressure being maintained constant over a longer period of time, which ensures better operational safety, mainly at operating times close to the planned preventive repair deadlines of the howitzer.

2. Presentation of the New Technical Solution, the Tests and Trials to Which the Product Has Been Subjected in Operation, with Evidence of Its Compatibility with the Requirements of Use Imposed

2.1. Compatibility of Polymer Composite Recovery Pistons with the Requirements of Use Imposed By the Technical Conditions of the Muzzles

The polymer composite material chosen for the technical construction solution shown in Figure no. 1 is FIBROPLAST BURNAS STI-20, which, due to its properties of resistance to physical and mechanical stress, is generally intended for the production of parts that require higher exploitation indexes such as:
good mechanical strength, high thermal resistance, stability to oils and acids, etc. (Popescu, 2015; Popescu, Iacobescu & Dascălul, 2004).

Figure no. 1: The 152 mm caliber howitzer recuperator, 1981 model – constructive solution with guiding and sealing piston made of BURNAS STI-20 (Popescu, 2015)

The processing of this material in order to obtain the piston from the recuperator, is done by pressing, in heated moulds.

For the technical solution of the howitzer cal. 152 mm, model 1981, the guide and sealing piston was chosen for experimentation.

Obtaining this piston from STI-20 material (Ispas, 1987) required the design of (Cirillo, 1972; Ionescu-Muscelianu, 1987) and the fabrication of a hot pressing die, Figure no. 2.

Figure no. 2: Hot-pressing mould for guiding and sealing piston of the 152 mm cal. howitzer recuperator, 1981 model using STI-20 composite material (Popescu, 2015)
In order to obtain a good homogeneity of the resulting pieces, it is necessary to pre-cast the material in moulds at a temperature of 150ºC for about 10 minutes (Dascălu, 2005). The material thus pre-cast was placed in the moulds and hot pressed, obtaining the final pieces, shown in Figure no. 3.

Figure no. 3: Guiding and sealing pistons of the 152 mm howitzer recuperator, 1981 model, made of STI-20 material and the original one made of bronze (Popescu, 2015)

At the 152 mm cal. howitzer, 1981 model, the guiding and sealing piston is mainly stressed by static pressures arising during the check of the fluid quantity in the recuperator. The pressure check of the piston in the STI-20 composite configuration is carried out using a manually operated hydraulic pump, the check pressure being 5 to 10% higher than the initial pressure in the recuperator (Dascălu, 2005).

2.2 Tests and Trials of the Guiding and Sealing Piston for the 152 Mm Cal. Howitzer, 1981 Model

The testing of the constructive solution of the guiding and sealing piston was carried out, in a structure specialized in the maintenance of the military technique, on a 152 mm howitzer, 1981 model with level two and three repair needs (RpN2, RpN3). To this end, the quantity of liquid in each recuperator was successively checked after carrying out 8 (eight) artificial recoils with each product. In the original (bronze) construction version, the test was carried out with new guiding pistons.

The new design was tested after replacing the bronze guiding pistons with FIBROPLAST BURNAS STI-20 guiding and sealing pistons.

From the comparative analysis of the values of the liquid quantities in the recuperator, in the two constructive variants - by type of repair, it was observed that in the variant with FIBROPLAST BURNAS STI-20 pistons the liquid quantity remained constant in all the test samples. Therefore, it can be considered that the proposed design solution is viable in comparison with the current version and keeps the liquid quantity and pressure in the recuperator constant for a longer period of time (Constantin & Nuțu, 1996).

3. Evolution of the Standard Objective Function of the 152 Mm Howitzer in the Two Constructive Variants


Due to the variable stresses on the piston’s recuperator at static and dynamic pressures, over time, as the gaskets age,
deformation of the seals occurs. This phenomenon favors the passage of the liquid through the space between the working cylinder and the seals to the filling and venting plug, which causes the quantity of liquid in the recuperator to decrease and consequently the pressure in the recuperator to decrease.

The stresses also affect the sealing elements in the seal box resulting in STEOL-M fluid leakage between them and the piston rod (Popescu & Dascălu, 2002).

According to the new technical solution, only the aspect of leakage through the cylinder filling area was analyzed, as this has significantly higher values and more implications for the operation and verification of the muzzle.

From the data provided during the test it was found that in the design with the FIBROPLAST BURNAS STI-20 guiding and sealing piston, the leakage of liquid through the filling and venting area is very slow, the time of occurrence being much later compared to the design with the bronze guide piston.

The howitzer is considered to be operated at constant temperatures for a certain period of time, and therefore the variation of the liquid quantity can be detected by monitoring the pressure variation. This argument was taken into account when determining the diagnostic parameters of the recuperator in the composition of the elastic bond of the tested product.

3.2. Pressure Variation Mode in the Recuperator in the Version with BURNAS STI-20 Guiding and Sealing Piston Compared to the One with Bronze Guiding Piston

In order to set the graph of the variation over time of the pressure in the recuperator in the construction version with guiding and sealing piston made of BURNAS STI-20 material, experimentation was carried out in a specialized army structure, on a product in service, at time intervals of one and two years, using seals and pistons maintained in STEOL-M over these time periods. The data obtained formed the basis for plotting the time variation graph of the pressure in the recuperator in this design variant, the law of variation of the parameter being the following (Chereches, 2000):

\[
\text{p}_{\text{aram,d}_{12112}}(t) = \frac{5}{96} t^2 - \frac{7}{48} t + 65, \quad t \geq 0. \quad (1.1)
\]

The pressure variation in the recuperator in the two designs is shown comparatively in Figure no. 4 (Ispas, 1987).

![Figure no. 4: The pressure variation in the recuperator in the BURNAS STI-20 piston version compared to the bronze piston version](Popescu, 2015)
Correlation of the variation of scores for the pressure diagnostic parameter, $p_{\text{aram.d}_{12}^{112}}(t)$, is shown in Figure no. 5 (Popescu, 2005):

![Graph showing variation of scores for pressure diagnostic parameter](image)

**Figure no. 5: Variation of the scores given $p_{\text{aram.d}_{12}^{112}}(t)$ to the guiding and sealing piston in the two design variants**

(Popescu, 2015)

### 3.3. Evolution of the Standard Objective Function of the 152 mm cal. Howitzer in the Two Constructive Variants

The computation of the standard objective function and the shaping of its graph are done in successive steps from the subsets to the general set.

Applying the calculation methodology and the way of plotting the standard objective function for a subassembly, one obtains the standard objective function of the recuperator in the new constructive variant.

Comparatively, the evolution of the standard objective function of this subassembly in both constructive variants is shown as in Figure no. 6 (Popescu, 2015).

On the graphical representation, the tinted area represents the increase of technical resource of the recuperator, due to the use of the technical solution with guiding and sealing piston made of FIBROPLAST BURNAS STI-20.

In order to establish the hierarchical level of each assembly and sub-assembly in the organizational structure of the howitzer, it is first necessary to make the product diagnosis tree.

In the sequence of the diagnosis tree, the comparative evolution of the standard objective function of the elastic link has the graphical configuration in Figure no. 7 (Popescu, 2015).
Figure no. 6: Evolution of the standard objective function of the recuperator in the two versions of the guiding and sealing piston (Popescu, 2015)

Figure no. 7: Evolution of the standard objective function of the elastic linkage in the two graphical variants of the recuperator’s guiding and sealing piston (Popescu, 2015)
The area between the two graphs indicates the increase in the technical resource of the elastic connection in the version with guiding and sealing piston made of FIBROPLAST BURNAS STI-20.

The standard objective function of the 152 mm cal. howitzer, 1981 model evolves in relation to how the standard objective functions of the main sub-assemblies evolve.

The BURNAS STI-20 piston construction solution results in a different evolution of the standard objective function of the muzzle compared to the bronze guiding piston variant.

Taking into account the graphical representations in the figures above, this evolution, in the two construction variants of the recuperator piston, is given in Figure no. 8, where the area between the two graphs in the figure means the increase of the technical resource of the howitzer as a result of the new construction solution of the recuperator.

Figure no. 8: The evolution over time of the standard objective function of the 152 mm. cal. howitzer, 1981 model in the two constructive versions of the piston’s recuperator (Popescu, 2015)

4. Conclusions

1. The technical resource of the muzzle can be increased by improving some of the construction solutions for some of the sub-assemblies and component parts, especially those whose share in the system is greater.

2. The technical resource of a component, assembly or product depends directly on the design solution adapted to its manufacture.

3. Improving the design solution for the sub-assemblies and component parts of a muzzle increases the technical resource of these parts and of the product as a whole. The verification of this aspect was done on the 152 mm cal. howitzer, 1981 model and consisted in changing the constructive solution of the assembled piston of the recuperator in which the bronze guiding piston was redesigned and replaced with a guiding and sealing piston made of FIBROPLAST BURNAS STI-20 (Popescu, 2015).
4. The constructive solution adopted in the manufacture of the piston’s recuperator was practically realized in a military structure specialized in the maintenance of military equipment and tested on real products both at static and dynamic stresses. It was found that the bearings made of FIBROPLAST BURNAS STI-20 withstand the stresses occurring at maximum pressure, and their manufacture is much easier, more precise and faster than that of bronze.

5. The more the technical diagnostic parameters improve, the more accurate their influence will be in increasing the technical resource of the muzzle, an influence that will be differentially manifested in the useful evolution cycle of the product. This article highlights the necessity and utility of the use of polymer composite materials in the structure of artillery weapon components and the influence of the design solution on the technical resource of the muzzle.

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