ANALELE UNIVERSITĂȚII
"EFTIMIE MURGU" REȘIȚA
ANUL XX, NR. 1, 2013, ISSN 1453 - 7397

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# Study of Phosphating Process for Artillery Pipes Subjected to Mechanical Self-shrinkage with Mandrel

*This paper present the results of a study that was made to establish the optimal parameters of phosphating process for artillery pipes. The optimal parameters that were determined after analysis are: the temperature of phosphating solution respectively the holding time in the phosphate bathroom to obtain a maximum thickness of phosphate layer.*

***Keywords**: phosphate, artillery, pipes, self-shrinkage, mandrel*

## 1. Introduction

The mechanical self-shrinkage method was developed after the Second World War and was applied for the first time in U.S.A. and Israel.

To this procedure the elasto-plastic deformation of pipe was realized by passing a mandrel or a sets of mandrels through pipe channel, having diameter bigger than the inner diameter of blank pipe (Figure.1)

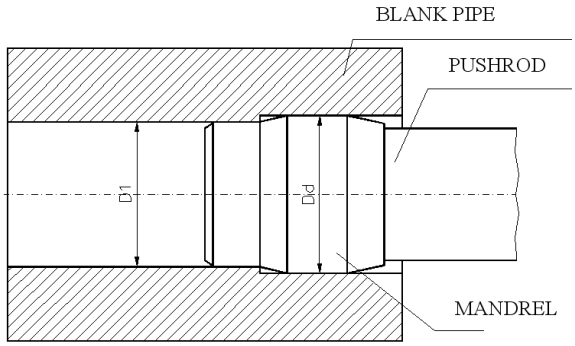


**Figure 1.** The principle of mechanical self-shrinkage

If hydrostatic method the process where controlled using the self-shrinkage pressure, in this case the self-shrinkage are conditioned by the tightening between blank pipe and mandrel. To achieve movement of mandrel is necessary a force to overcome the friction forces between mandrel and inner surface of blank subject to self- shrinkage. The mathematical relation used to determine the necessary force for mandrel movement is:

$$F = \pi \cdot D_d \cdot l \cdot \mu \cdot p\,, \tag{1}$$

where:

- $\mu$ - frictional coefficient at sliding;
- p – the contact pressure, equivalent with necessary self-shrinkage pressure;

To reduce resistance force, by reducing the coefficient of friction at sliding, was used the phosphatating procedure of inner pipe surface. In this way can be observed that while reducing sliding coefficient of friction are obtained also a reduce of self-shrinkage force. It is necessary to mention that the self-shrinkage was made after phosphatation when the blank pipe was still warm.

Actually, the purpose of the present study was to establish the optimal parameters of phosphatation process. By optimal parameters are understand the temperature of phosphating solution and the maintaining time in the phosphatating bathroom in order to provide a maximum thickness of phosphate layer.

## 2. Analysis

For analysis were used specimens made by the same material and having the same degree of finish like the one of pieces that will be phosphated later (OHN3MFA).

The specimens were passing to all fazes of phosphateting process in accordance with technology specified in Table 1.

Verification of phosphate layer mass was made doing the difference between specimen mass before and after the dissolved process of phosphate layer, corresponding to STAS 10338-85, point 3.5, Table 3.4.

The temperature influence over phosphate layer mass is shown in Figure 2.

The maintaining time of specimens inside phosphatated bath was by 30 minutes.

The influence of maintaining time in phosphatated bath is presented in Figure 3.

The temperature of phosphatated bath was by 60º C.

The phosphatating process was made on a plant designed and made in U.M. Resita exactly for to performance the surface covering of inner pipes that will be subject to self-shrikage (Figure 4).

The temperatures for galvanic baths number 1, 2 and 5 were controlled by means of some thermometers located inside bathrooms.

The temperature for galvanic bath number 4 was controlled using a thermo-couple and an electronic controller.

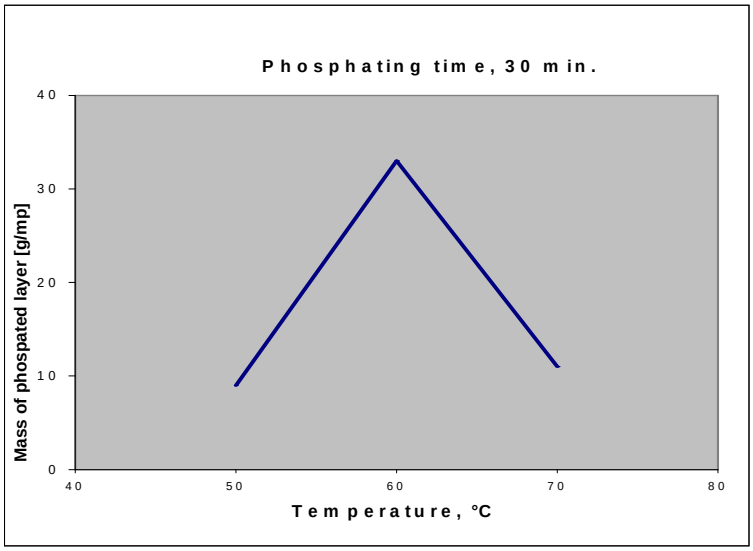


**Figure 2.** The temperature influence over phosphate layer mass g/mp

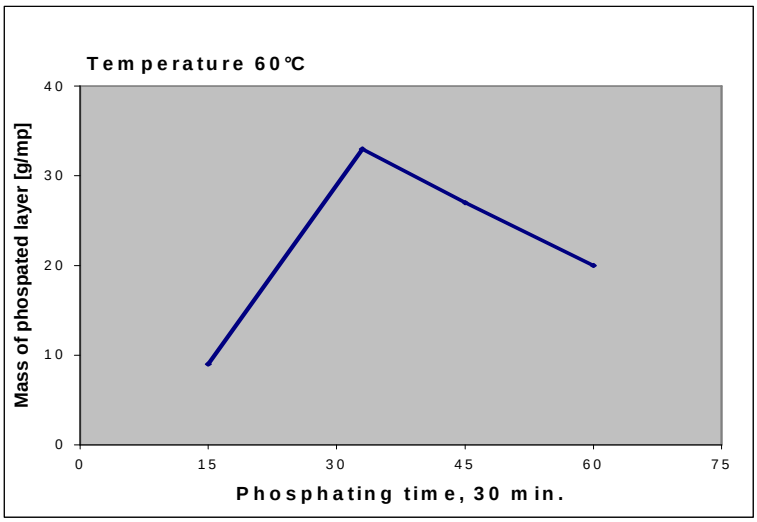


**Figure 3.** The maintaining time influence over phosphate layer mass g/m

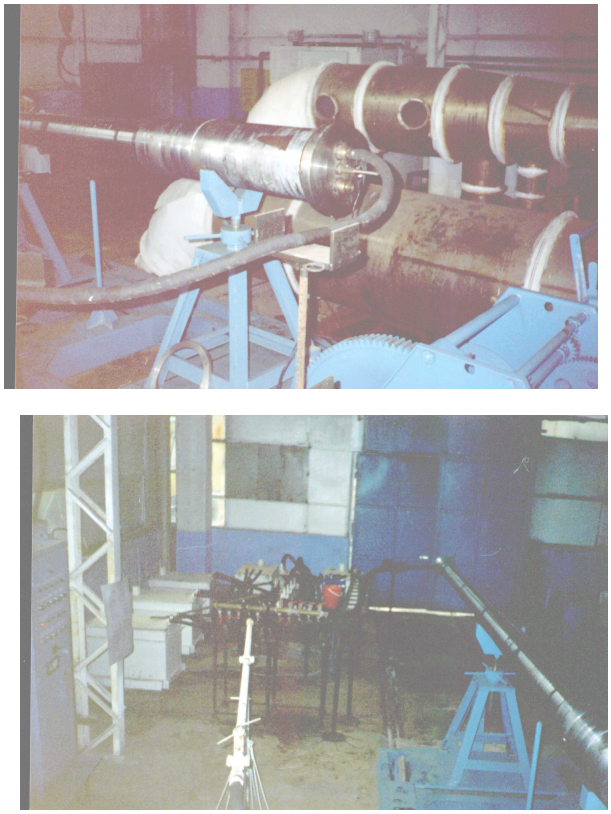

**Figure 4.** Elements of phosphating plant designed and made in U.M.R.

**Table 1.**

| **Phase name** | **Bath composition** | **Solution temperature [$^0$C]** | **Maintaining time [minute]** | **No. of galvanic bath** | **Obs.** |
|---|---|---|---|---|---|
| **DEGREASING** | - sodium hydroxide 10 – 70 g/l<br>- soda 20 – 40 g/l<br>- trisodium phosphate 15 – 20 g/l<br>- sodium silicate 3 – 5 g/l | 80 – 90 | 10 – 20 | 1 | |
| **WASH 1** | - apă | 50 - 85 | 5 | 2 | |

| | | | | | |
|---|---|---|---|---|---|
| **PICKLING** | - hydrochloric acid 100 ÷180 g/l | 10 - 20 | 2 - 5 | 3 | |
| **WASH 2** | - water | 50 - 85 | 5 | 2 | |
| **PHOSPHATE** | - fosfatol type III 90 – 100 $cm^3$<br>- zinc nitrate 140 – 160 g/l<br>- free acidity 5 – 10 points<br>- total acidity 70 points | 54 – 60 | 20 – 30 | 4 | |
| **WASH 3** | - water | 50 - 85 | 5 | 5 | |
| **OILING** | - oil type U.P.7 | 10 - 20 | - | - | Manual |

## 3. Conclusion

After experimental test two important conclusions were revealed:

- To a constant maintaining time, phosphate coating mass increasing, for the temperature range 50º÷60º C; after that, when temperature grows to 70º the phosphate coating mass recorded a decrease. This thinks means that to a increasing temperature over 60º C appears a dissolution of phosphate layer previously formed;
- To a constant temperature by 60º C was obtained a increasing of phosphate coating mass in the same time with the increasing of maintaining time from 15 minutes to 30 minutes. If the maintaining continues longer than 30 minutes the phosphate coating mass recorded a decrease.

Finally can be concluded that to obtain a maximum phosphate coating mass must be working in the following conditions:

- Temperature: 60º C;
- Maintaining time: 30 minutes.

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