Metallographic examination of 16th century cannon material from the collection of Lviv History Museum

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Abstract – ***The article presents a detailed description of a16th century cannon from the collection of Lviv History Museum. It briefly looks at metallographic analysis techniques of cannon material. It describes metallographic examination of the 16th century cannon from the collection of Lviv History Museum. It makes a conclusion concerning a micro- and macrostructure of the 16th century cannon material from the collection of Lviv History Museum.***

Key words: the 16th century cannon, metallographic examination. iron, micro-, macrostructure, Lviv History Museum

Historical Weapon Study is an interdisciplinary science. It is closely connected with Military and War History, History of Vehicles and Equipment and Art History. Weapon Study also borders on Ballistics and Tactics in issues of artillery research. Modern scientific tendencies take Weapon Study to a whole new level by making Materials Science its constituent. What can better tell us about secrets of a cannon if not its metal?

Nowadays, the collection of Lviv History Museum (further read LHM) comprises iron beaten 16th century cannon [1;2]. The item joined the collection of the museum in 1940 after having left the collection of Taras Shevchenko Scientific Society Museum which was dissolved as a result of museum reform in Lviv. The inventory of Taras Shevchenko Scientific Society Museum mentions that the cannon was given to the museum by a dean Fr. Iliarion Gela in 1934[1].

The cannon gets the registration number № 3-2880 [LHM] in the inventory of LHM. The specifications are as following:

Total length of barrel 675 mm
Length of barrel bore 630 mm
Diameter of barrel bore 27 mm
Diameter of muzzle end 48 mm

The body of the cannon is octagon. The breech end is broken. The inner side of the breech end has got 6 intervals of screw thread for breech screw clamping. As a result of an explosion the screw is lost. Firing tube is of conical shape (getting narrower depth ward) with diameter of 17 mm and located at the distance of 170 mm from the breech end.

Character of destruction can testify that the cannon was made of three plates of packet iron welded by hammer-welding method. Reasons of barrel explosion can be clarified with help of metallographic examination.

It is worth mentioning that metallographic examination first took place in archeological and historical researches in the first part of the 20th century. Files of archeological excavations “The Trails of Ancient Cultures. Ancient Rus” (1951) contain publication by A. B. Kolchyn “Mastership of Ancient Rus Blacksmiths” in which the author applies metallographic analysis to examine relics of cold steel arms [4]. In the recent years there appeared a number of researches applying cannon metallographic analysis carried out by Polish scientists. An outstanding modern professional in the sphere of archeological metallography is Ann Feuerbach (New York, the USA). This tendency is shown in the works of Denys Toyichkin dedicated to cold steel arms study. Researches in the artillery sphere haven’t been presented yet.

This research is the first attempt to make the analysis of the 16th century cannon from Lviv History Museum.

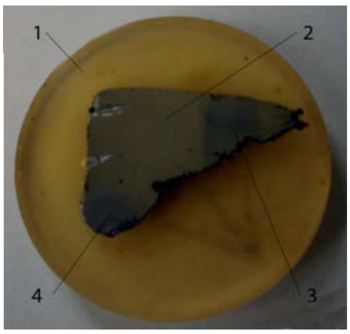
a

b

Picture 1. Specimen selection for microstructural analysis: a – blank for the specimen; b – destructed breeching part of the destructed cannon

The specimen for the microstructure analysis (picture 1a) was cut out with a jab saw to omit overheating of metal from the most ruined part of the cannon. (picture 1b)

The microstructure was examined with metallographic microscope MMT-14C magnifying the sample 100 and 500 times. The microstructure was recorded with an eye lens camera LCMOS14000KPA. Specimens for micro-analysis were fastened to frames with self-curing base rasin «Duracryl ® Plus» (picture 2). The surfice of the specimen was ground with abrasive paper and then polished with diamond pastes. [8].



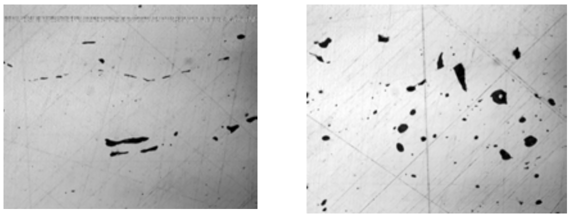
Picture 2. Specimen for microstructure analysis : 1– self-curing base rasin «Duracryl ® Plus»; 2 – microsection; 3 – acid etched surface towards barrel bore; 4 – acid etched surface of the thread

In the course of polishing diamond pastes were changed in the following order:

$$ACM40/28 \rightarrow ACM14/10 \rightarrow ACM7/5 \rightarrow$$
$$\rightarrow ACM5/3 \rightarrow ACM3/2 \rightarrow ACM2/1$$

Aiming to detect phase and structural state, the polished surface of the microsection was chemically contrasted with Nital etching reagent (a 4 % solution of nitric acid $HNO_3$and ethanol C_2H_5OH) [3;9]

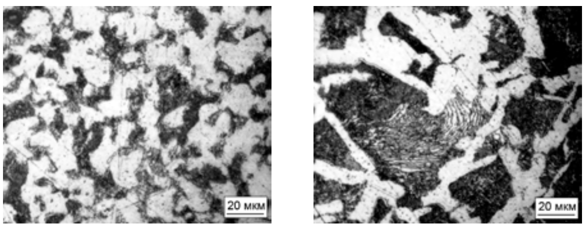
Line arrangement of slag inclusions were detected in the unetched microsection (picture 3a). They go parallel to the barrel long axis. Distance between the lines of slag inclusions is 600 …700 µm and it is almost equal along the whole barrel width. Close to the front edge consistent order of slag inclusions is disturbed (picture 3b) which could relate to metal deformation peculiarities in the course of the item production by open die forging method. Unetched microsections do not show any disruptions of metal integrity in the form of cracks, exfoliation and other defects which could have considerably changed mechanical and exploitation properties of the cannon material.



a b

Picture 3. Slag inclusions

After chemical contrasting of microsection surface with Nital etching reagent, it was detected that metal structure of the cannon is peculiar for carbon steel that is it consists of ferrite and perlite (picture 4 a,b)



a b

Picture 4. Metal structure

Moreover, slightly deeper from the outer surface (approximately 600 µm) there was detected negligible decarbonization which could have been caused by long-lasting holding of the aready produced item at the temperatures of above 900 °C during the final stage of the production operation. Under the decarbonized layer there is an equiaxed ferrite and perlite structure (picture 4a). Equiaxed grains testify about full completion of recrystallization processes after hot shaping of forging. Perlite of grain structure more often locates on the ferrite grain junction lines. Correlation between ferrite and perlite in the structure of this section is estimated according to standard state scales ГОСТ 8233–56 and equals to $\frac{35}{65}$ that corresponds to the quantity of carbon approximately 0,28 %.

At the depth of nearly 5.3 mm from the surface, under equilibrium structure there was detected a 3mm layer with defected Widmannstatten structure (picture 4b). This structure results from the disruption of heating and cooling regimes of blanks by hot-forming method (forging). The structure is characterized by abnormal acicular structure of ferrite grains which grow through perlite grains [2;7]. As a result of this structure, mechanical properties catastrophically deteriorate and this concerns impact value in particular.

This defective structure must have substantially slackened hardness of one of the three plates which were used for barrel cannon production by the forging method. This might have ruined the breeching part of the examined cannon.

Conclusion

1. It was detected that the cannon was produced with help of three plates by the hammer-welding method.
2. Microstructural analysis ascertained that structure of the examined plate is characteristic for malleablized (carbonized) packet iron.
3. The microstructure contained considerably thick segments of Widmannstatten structure which significantly slackened hardness and impact value of material and could be the possible reason for cannon ruining.

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