The Handling of the Finite Element System in the Determination of Cartridge Cases

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Abstract: During artillery activities cases suffer stress which can cause internal stress in cases. The stress, the gas of gunpowder and the time of storage are enough to generate the process of stress corrosion crack. I examined how to change the internal stress in the cases during the shelling. I used the Finite Element System to determine the value of internal stress. I determined the limit of internal stress of brass. I want to prove whit these experiments that. With these experiments I want to prove that cases suffer stresses during the artillery activities. The laboratory experiments explored the reasons of crack and advised solution how to prevent of crack rising.

Keywords: The handling of the Finite Element System

1 Display the Flaw of Artillery Cartridge Cases

Representatives of Hungarian Defence Forces have found cracks on a part of renewed artillery brass cases after a short storage time, and our Department was requested to make experiments on given artillery cartridge cases, and provide advice for prevention of rising of cracks. Reloaded cracked brass cases are dangerous for the crew and the weapon would be demaged temporarily.

Detected main characteristics of faults were the following:

- cracks rose around the slot,
- forwarded in the axis of the body of cases.

The results of observation were the same on factory renewed brass cases in a limited storage time, some months or years later inspite of the preselection and testing before renewal. Cracks started from the internal surface of the body in every case and only turned into observable when the total cross-section had been penetrated.

Our conception was that these symptoms were caused by stress corrosion process. First we wanted it to be proved, then, as a result of the experiments, provide a renewing technology of cases.

2 Results of Experiments Made on 85 mm Brass Cases

Experiments were made on numbered (from 1 to 85) cases provided by the base responsible for renewal. All of them were spent then renewed, disassembled, giving opportunity to test them. 50-60 mm long cracks were found on the neck, and 1-2 mm wide cracks on the mouth of a certain percent of 54 cases, some year stored sample cases. These cases had been stored after renewal and assembly. On the basis of symbols in my country of cases it was confirmed that they belonged to the group of non-silicon brass cases.

Microscopical test was executed on three crack suffered cases and found 45-49 mm long cracks on neck part of all of them. Testing of their metallurgical specimen it was verifiable that they had intercrystalline feature which can be seen on the following slides.

Figure 1
Amplification=250x; Etched in 10% ammonium persulphate

Having these intercrystalline characterisctics, it came out that they refered to effects of stress corrosion. The purpose of the next tests are to verify that the renewed, assembled and stored cases have internal stress. Cases were separated into two parts, purposing execution of stress corrosion and control test.

3 Execution of Stress Corrosion Test

Using 3% mercury nitrate (Hg/NO3/2) seemed the best way to indicate the existence of internal stress. Before testing, surface of cases were cleared by sand blaster. Every tested cartridge case was immersed into the solution as far as 150 mm from the neck of cases. Etching took 15 min, the solution was changed after every 3 cases. During the 15 min stress corrosion test cracks arose at 34% of cases, having intercrystalline characteristics on their metallurgical specimens.

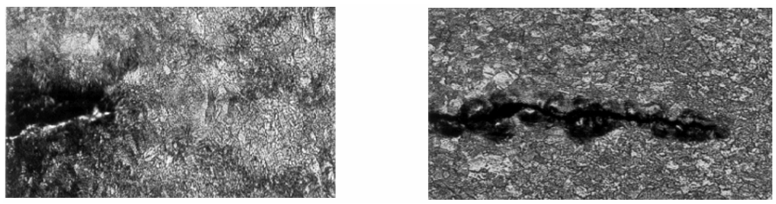

Figure 2
Amplification=250x; Etched in 10% ammonium persulfate

Laboratory detection proved that among examined cases which had no cracks, some had internal stress after 14 years of storage.

4 Control Test

Remaining cases were heat treated at low temperature salt tempering bath to decrease the internal stress of cases to a certain level, so as not to support the stress corrosion process. After the heat treatment 3% mercury nitrate test was conducted on every case according to the previous experiment. In conclusion, there were no cracks inspite of the large quantity of heat treated cases.

5 Summarized Conclusions of Crack Reasons that Occured During Storage and Using

During artillery activities cases suffer (3000 bar stress)shooting that can generate internal stress in cases. The stress, the gas of gunpowder, and the time of storage are enough to generate the process of stress corrosion crack. I examined how the internal stress in the cases had changed during the shelling. I used the Finite Element System to determine the value and limit of internal stress of brass cases. With these experiments I wanted to prove that cases suffer stresses during the artillery activities.

6 The Finite Element System to Determine the Value of Internal Stress

6.1 Internal Ballistic Counting

Date: Cannon: 85mm anti-aircraft gun

Gunpowder: HATVAN-U NDT-3 18/1

Composition of gunpowder:

Nitrocellulose	56.00%	Dibutyl phtalate	4.00%
Nitroglycerine	26.00%	Centralit	3.00%
Dinitrotoluene	9.00%	Vaseline	1.00%
Shot:	85mm-es		

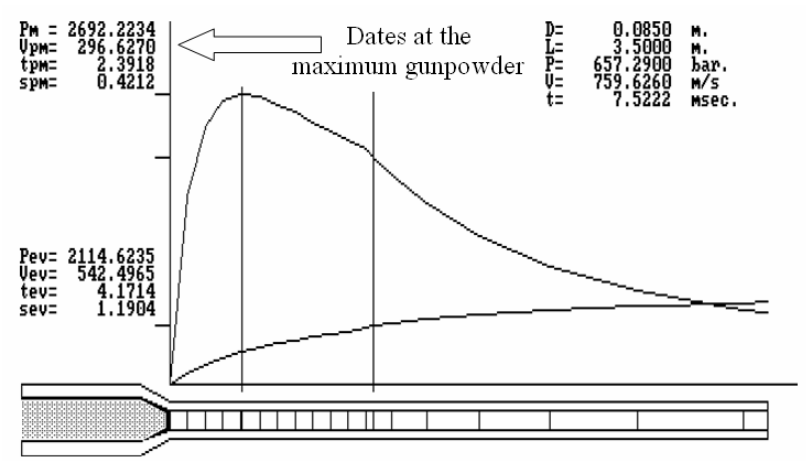

Figure 3

I accomplished the internal ballistic counting with the formula of H. Reasal [1] using a computer program in order to determine the data internal ballistic for the Finite Element System.

Next, I checked the value of internal stress of 85mm cartridge cases with the counted data. The examination was executed at Pmax and 0.1 Pmax pressure. I considered the shapering of artillery cartridge cases was linear during the explosion. Which partially chenged the results. Examination were to be continued.

6.2 Examination in the Part of Bottom of a Case with the Finite Element System

Load: 2692 bar

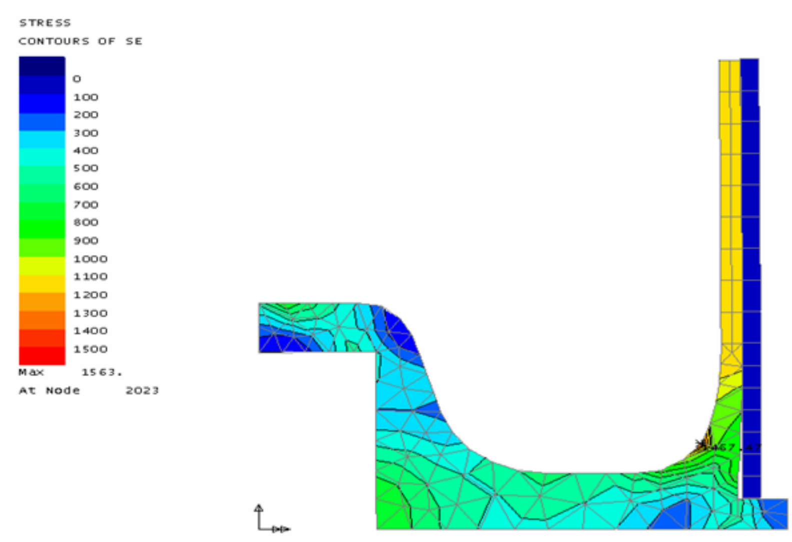

Figure 4

I proved with the Finite Element System, that 0.1 Pmax pressure can cause internal stress in cases. This stress is high enough to generate the process of stress corrosion crack in cartridge cases. The figures (Figs. 4-6) show the segments of bottom of brass artillery cartridge cases at Pmax and 0.1 Pmax. Figures present the stress status of cases. All part of examined cases underwent plastic change that can be studied by these slides.

Load: 269.2 bar

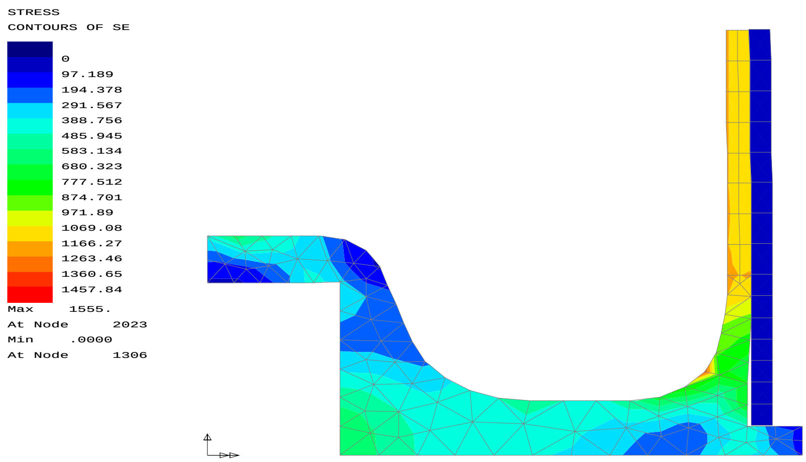

Figure 5

6.2.1 Examination the Neck

Load: 2692 bar

Figure 6

Conclusion coming from the Finite Element Examination

I succeeded to prove during artillery activities cases suffer stress which can cause internal stress in cases. The internal stress was so high that all parts of the examined cases underwent plastic change. The remaimind internal stress can generate the process of stress corrosion crack. The next question was if the combustion heat of gunpowder caused the recrystallized state in cases or not?

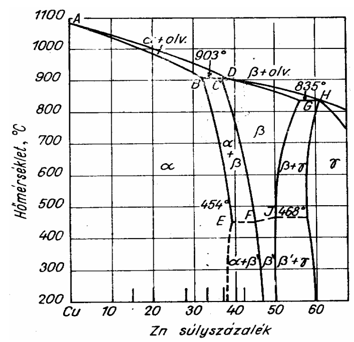

Figure 7

During artillery activities the temperature is about 3000-4000 K°. [2] The combustion heat of gunpowder was 2626 C° on the examined gunpowder (HATVAN U NDT-3 18/1). The temperature of recrystallisation is 0.4 x melting temperature [3]. This temperature is 0.4 homolog temperature. It is 290 C° on the brass artillery cartridge cases (CUZn30) (Fig. 7) [4]. The combustion heat of gunpowder is larger than 0.4 homolog temperature, the recrystallisation process still did not start in the cases. Why? Because the period of shelling is short, it is 7.5222 msec. Cases do not have enough time to get warm after the 0.4 homolog temperature. I examined the temperature of the cases immediately after shelling. I got the following data. The temperature of all the cases was between 90 C°- 140 C°. They were at lower heat than the 0.4 homolog temperature of brass. After this examination I could state that the cases suffered cold shaping during the shelling. Thus the internal stress stayed in cases after using, and it was enough to generate the process of stress corrosion crack.

References

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