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COMPARISON AND ASSESSMENT OF THE CUZN30 BRASS STRUCTURE IN THE PRODUCTION OF THE 9X19 LUGER CARTRIDGE CASE

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Abstract:

In the process of small-caliber ammunition production, the quality of the setting of the deep drawing technology of CuZn30 brass and its subsequent recrystallization is essential. The quality of the setting of this technological process is also very important for the final quality of the whole ammunition, as the cartridge case, or even the projectile, is produced by the technology of deep drawing. In deep drawing technology in cartridge case manufacturing, when CuZn30 brass already reaches the value required for recrystallization, the brass structure changes the grain size of the structure. And at the same time, makes it difficult to achieve a uniform grain size in the entire cartridge case cross-section after recrystallization or after some steps of the technological process.

1 Introduction

At present, which desires for the development of defense technologies, as well as the efficiency of ammunition production, the constant goal is to optimize production as much as possible with respect to the time and economy within the highest or required quality of the final product. In this work, I will compare and assess the structures in the semi-finished product for the production of cartridge cases in places, where the greatest transformation of the material is. Semi-finished products and inner products for the production of cartridge cases are from single-drawing technology of cartridge case production. This technology is older, it has been used since the beginning of ammunition manufacturing. It is less demanding on the stability of the input material, but it is less efficient for high production. Ideally, the metallographic structure of the cartridge case cross-section should be as regular as possible, without significant differences in the grain size of the structure, which could also ensure the multiple use of the cartridge case. Ensuring a uniform structure over the entire cross-section of the cartridge case is problematic and the differences in the structure of the material are according to different deformations in different parts of the material.

2 Description of the work methodology

2.1 Composition of the brass for the production of cartridge case

Cartridge case brass means brass intended for the manufacture of cartridge cases in the ammunition industry. The chemical composition of cartridge case brass is 70% Cu and 30% Zn. Cartridge case brass is binary brass. The newer designation of the cartridge case brass is CuZn30, the older designation that is still in use, is Ms70. In the past, CuZn28 brass (former designation Ms72) was also used to make cartridge cases. This brass has a higher content of copper. Copper is a more expensive raw material than zinc, so that´s why this type of brass has

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mostly ceased to be used. Only some ammunition uses CuZn28 brass to make cartridge cases so far.

Table 1 Chemical composition of cartridge case brass according to DIN 17660 (wt.%)

Cu	69-71
Al. max.	0.02
Fe max.	0.05
Ni max.	0.2
Pb max.	0.05
Sn max.	0.05
other max.	0.1
Zn	rest

The integration of cartridge case brass into the Cu-Zn equilibrium binary diagram is observable in Fig. 1. The equilibrium binary diagram Cu-Zn consists of five simple peritectic diagrams.

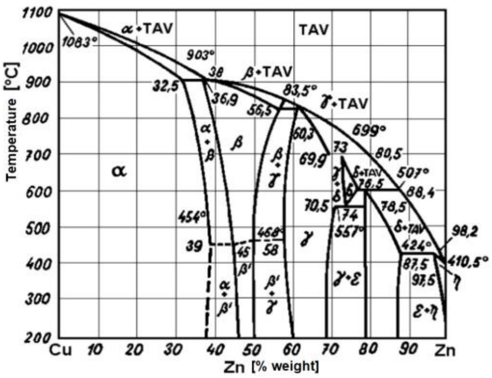

Fig. 1 Equilibrium binary diagram Cu-Zn [1]

In the case of cartridge case brass, the alpha phase is interesting, thus the phase rich in copper – more than 61-62% of copper in the alloy. Whereas the alpha phase is rich in copper, it also has a lattice like copper, a cubic lattice centered. The alpha phase is a solid solution of the substitution type, where some copper atoms have replaced zinc atoms.

2.2 Production procedure of 9x19 Luger cartridge case

Fig. 2 9x19 Luger cartridge case manufacturing process

Fig. 2 shows the sequential steps in a single-drawing (single-operation) technology for the production of a 9x19 Luger cartridge case from a semi-finished product cup (shown in Fig. 2 by the number 1). In this work, I will deal with the comparison of the structure in the cross-section of the semi-finished product after the second drawing (shown in Fig. 2 in Fig. 3). Further steps in production technology (steps 4-9 in Fig. 2) do not affect the change of material structure as much as steps 2,3. In step 5, a change in structure is visible when a primer hole is formed, but not as much as in steps 1,2,3.

2.3 Recrystallization annealing of brass

When forming or deforming a cartridge case brass, the grains in the microstructure elongate and break up. This creates their orientation. The orientation of the grains is in the direction of deformation. If the degree of deformation is large enough, the brass acquires a fibrous or fragmented structure, as seen in Fig. 3. Cartridge case brass acquires greater strength by forming, but the possibility of further forming is also exhausted. If we want to shape this material further, we need to include the recrystallization annealing operation among the forming.

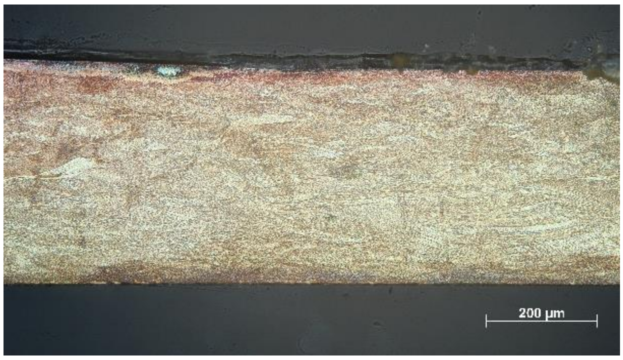

Fig. 3 Structure of CuZn30 brass after deformation

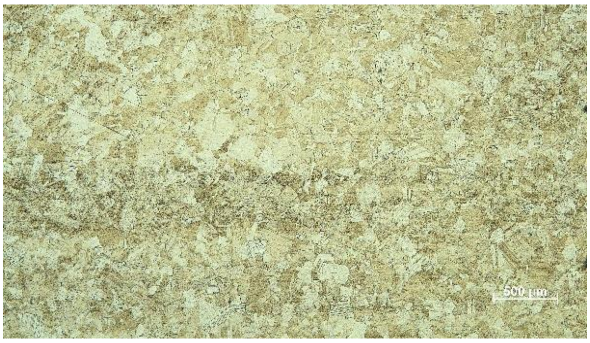

Fig. 4 Structure of CuZn30 brass after recrystallization

Recrystallization annealing removes the consequences of the previous cold forming (deformation strengthening), the malleable property of the material is restored Fig. 4. The conditions of recrystallization annealing are determined by the degree of transformation and the required properties of the annealed material. The standard annealing temperature for the production of CuZn30 cartridge cases is usually in the range from 500 to 650 °C, depending on the technology settings. In some manufacturing, they also use a different temperature range according to the degree of deformation of the material in the individual steps, and according to the time endurance at the temperature. The recommended grain size of the CuZn30 brass structure after recrystallization is in the range of 0.045-0.090 mm.

Hardness measurement and determination of the average grain size of CuZn30 brass after the second drawing in the production of a 9x19 Luger cartridge case

I will use a comparative method using the ČSN 42 0462 standard to assess the grain size. To assess the size of the deformation, I will use data from the work of Georg Vander Voort [7], the values of the deformation which are dependent on the measured hardness are in Table 2.

Table 2 Dependence on cold forming on CuZn30 hardness of George Vander Voort

Reduced CuZn30	Hardness
Without Reduced	57.9 ± 4.8 HV
Cold Reduced 15%	126 ± 11.3 HV
Cold Reduced 30%	159.8 ± 10.4 HV
Cold Reduced 40%	185.5 ± 6.2 HV
Cold Reduced 50%	194 ± 2.1 HV
Cold Reduced 60%	199.6 ± 5.2 HV
Cold Reduced 70%	231.9 ± 7.9 HV

Measurement and assessment were realized on the following five types of samples:

1. 4.5 grams cup for the production of a 9x19 Luger cartridge case
2. 4.5 grams cup after recrystallization
3. after the first drawing
4. after the first drawing and recrystallization
5. after the second drawing.

On these samples, I measured in places where the greatest deformation of the material is after deep forming in the technology of production of the 9x19 Luger cartridge case. In Fig. 5 are shown the locations on the cross-sections of the samples where the measurement was performed.

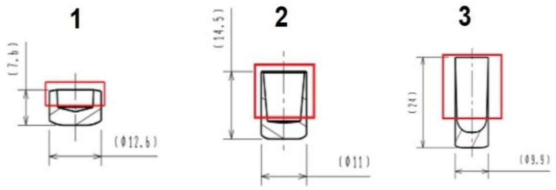

Fig. 5 Picture of samples for measuring with locations of the biggest transformation, number 1. Entry semi-finished product cup, number 2. After first drawing, number 3. After second drawing (from left to right)

3 Discussion of results

Recrystallization was performed on an entry semi-finished product cup and an after first drawing at a temperature of 520 °C in a continuous recrystallization furnace.

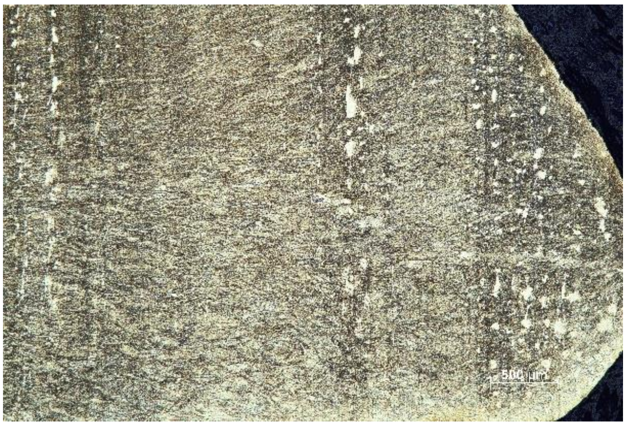

Fig. 6. Structure of entry semi-finished product cup

Fig. 7 Structure of entry semi-finished product cup after recrystallization

Fig. 8 Structure after first drawing

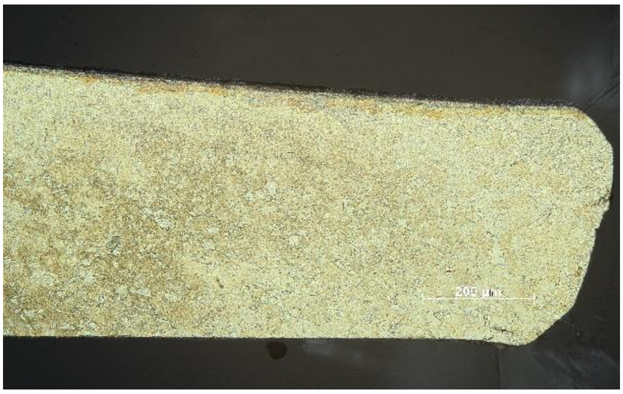

Fig. 9 Structure after first drawing and recrystallization

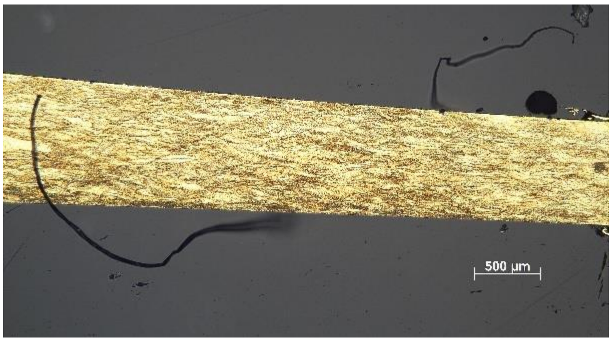

Fig. 10 Structure after second drawing

In Fig. 6, the structure of the CuZn30 brass is in place of the largest deformation on the cup as the semi-finished product of cartridge case. The cup is cut and drawn, so most of it has a narrowly shattered grain. In Fig. 7, there is a cup after recrystallization, so the structure of the CuZn30 brass can be seen in place of the largest transformation. In Fig. 8, there is the structure of the most deformed part after the first drawing, the structure is deformed and the grains are small and fragmented. In Fig. 9, there is the structure after the first drawing, but also after recrystallization, where we can see the renewed grains of the structure. In Fig. 10, the structure of the material is after the second drawing.

Table 3 Measured and calculated data at the most transformed locations during deep drawing and recrystallization

Place of the biggest transformation	Entry semi-finished cup	Entry semi-finished cup after recrystallization	After first drawing	After first drawing and recrystallization	After second drawing
	Hardness	Hardness	Hardness	Hardness	Hardness
Measurement 1	197 HV	96.8 HV	221 HV	91.2 HV	214 HV
Measurement 2	250 HV	98.9 HV	150 HV	69.3 HV	206 HV
Measurement 3	239 HV	91.8 HV	221 HV	76.1 HV	203 HV
Measurement 4	242 HV	96 HV	224 HV	-	-
Measurement 5	252 HV	-	213 HV	-	-
Average hardness	236 HV	95.88 HV	210 HV	78.87 HV	207.67 HV
Cold reduced	70%	less than 15%	less than 70%	less than 15%	less than 70%
Size of grain	-	0.088 mm	-	0.125 mm	-

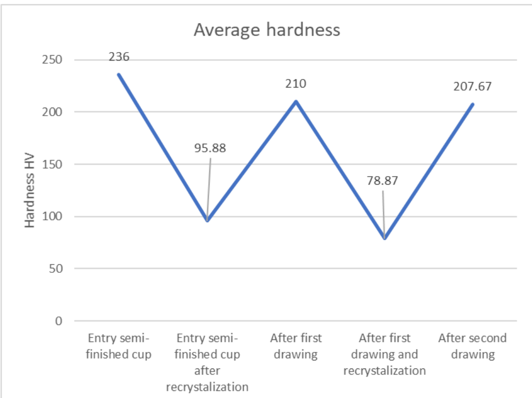

Fig. 11 Average hardness of the biggest transformation locations

From the measured and calculated data in Table 3 and in the graph (Fig. 11), it is clear how the structure of CuZn30 brass is fragmented after the drawing technology, the grain size is smaller or elongated. The hardness increases after this operation. The strength of brass also increases with increased hardness. Based on hardness, the percentage of cold reduced increases. After the recrystallization operation, the brass structure is restored, also grain growth and structure restoration can be seen. Of course, the hardness of the structure and its strength are smaller. Based on hardness, the percentage of "cold reduced" decreases, so the restored structure of CuZn30 brass is ready for transformation again.

Entry semi-finished product cup is a semi-finished product made of CuZn30 material, which most of smaller ammunition buys as a basis for the production of a 9x19 Luger cartridge case. The structure of this product can be seen in Fig. 6. Larger ammunition is making these semi-finished products from sheet metal separately. This requires single-purpose technologies for cutting and deep drawing of this CuZn30 sheet metal. The standard weight of this semi-finished product is 4.5 g. After cutting and deep drawing, the entry semi-finished product cup has the exhausted possibility of structure for further forming. The structure has small dimensions or very stretched grains in the most deformed part. The average measured hardness is 236HV. This means that the rate of cold reduced is 70%. In order to further usage of this semi-finished product in the technological process of forming, the entry semi-finished product cup structure must be recrystallized.

Entry semi-finished product cup after recrystallization. The structure of this product can be seen in Fig. 7. The inner structure of the material was restored after recrystallization of the entry semi-finished product cup. The average hardness decreased from 236 HV to 95.88 HV in the place of largest deformation of the structure. This means that the cold reduced rate has been reduced from 70% below 15%. The measured value of the structure grain size is 0.088 mm. As shown in Table 4, this value is 0.0205 mm higher than the mean recommended value of the CuZn30 material after recrystallization, which is reported by Malov [5] in the publication Ammunition Manufacturing. This difference is a deviation of 30.37% from the ideal mean value after recrystallization. But it is still within the maximum recommended value after recrystallization, which is set at 0.090 mm.

Table 4 Grain size values after recrystallizations

	Entry semi-finished cup after recrystalization	After first drawing and recrystalization
Average hardness [HV]	95.88	78.87
Size of grain [mm]	0.088	0.125
Deviation from ideal value after recrystallization mean deviation 0.0675 mm	0.0205	0.0575
Deviation from ideal value after recrystallization mean deviation [%]	30.37	85.19
Deviation of the maximum recommended value after recrystallization mean deviation 0.090 mm	-0,002	0.035

After the first drawing, the inner structure of the material changed again in the place of the largest deformation. The inner structure and grain are elongated and shattered, as we can see in Fig. 8, also in the table of values 3. The fact that the structure changed resulted in an increase in hardness from an average value of 95.88 HV to a value of 210 HV.

This means that the cold reduced rate has increased from below 15% to value below 70%. This increased hardness means an increase in the strength value of the brass, as well as the exhaustion of the possibility of further reshaping without previous recrystallization of the structure.

We can see the structure after first drawing and recrystallization in Fig. 9. In comparison with the Fig. 8, the structure is restored. The restored grains of the structure are visible in the place of the greatest deformation after the previous forming. The average hardness of the material decreased from 210HV to 78.87 HV. This means that the cold reduced rate decreased from 70% below 15%. The measured value of the structure grain size is 0.125 mm. As shown in Table 4, this value is 0.0575 mm higher than the mean recommended value of CuZn30 after recrystallization, which is also reported by Malov [5] in publication Ammunition Manufacturing. This difference is a deviation of 85.19% from the ideal mean value after recrystallization. This value is 0.035 mm higher than the maximum recommended value after recrystallization, which is set at 0.090 mm.

After second drawing, the inner structure of the material changed again in the place of the greatest deformation. The inner structure and grain are elongated and shattered, as we can see in Fig. 10, also in the table of values 3. By changing the structure, it resulted in an increase in hardness from an average value of 78.87 HV to 207.67 HV. This means that the cold reduced rate increased from below 15% to value below 70%. This increased hardness means an increase in the strength value of the brass, as well as the exhaustion of the possibility of further bigger deformation.

3 Conclusion

According to the assumptions, the increase in hardness of the material is the highest in places where is the maximum value of deformation in the production of the 9x19 Luger cartridge case. Since the grains of the structure are stretching at first, the value of hardness increases as the structure changes after deformation. Later, the grains break up, so the value of the structure grain size decreases. This causes the increase of the transformation degree of cold reduced. Gradually, the possibilities of further transformation of the material are exhausted if we do not include the recrystallization of the structure in the process. In our results we have maximum average values of hardness after forming from 207.67HV to 236 HV. Interesting thing is the lowest value of the average value after the second drawing, in which case after this operation until the end of production of the 9x19 Luger cartridge case, there are no other larger values of deformation. The other largest value of the deformation outside the production of the cup, the first and the second drawing, is in the calibration before turning. But this deformation is much smaller than in the first or second drawing, because this deformation is without changing the wall thickness. Practically, the hardness of the material does not change or just very slightly. The samples were from single-drawing technology, where is bigger area for slight changes in the quality of the input products stability, as I have already mentioned. This can also be seen in the resulting hardness after the second drawing, where the hardness is 207.67 HV. If we compare this with the results of hardness in the same area of the cartridge case (in the muzzle of the cartridge case, where the bullet is inserted, wall thickness approximately 0.3 mm) in multi-drawing technology, where hardnesses reach 230-250HV, there is still a reserve of transformation possibility in this part of the final cartridge case. This lower hardness can practically ensure a longer usage of the cartridge case for multiple reloading. Of course, multiple reloading is dependent on the size of the powder charge, the amount of crimping force required to pull the projectile out of the cartridge case, and the dimensional tolerance of the cartridge chamber from which the ammunition will be fired. From my experiences I will state entry semi-finished product cup after recrystallization, which I did let go through the entire production process of the 9x19 Luger cartridge case without recrystallization after the first drawing. The result was a standard cartridge case visually. This only served as visual test of the entire production line, without further testing of how this cartridge case would behave during firing. The omission of recrystallization after the first drawing could result in bursting of the cartridge case, which is very undesirable and sometimes dangerous element in shooting. During my measurement, after the first recrystallization of the entry semi-finished product cup, the size of grain structure was 0.088 mm, which is a very good value, even though it is only 0.002 mm below the maximum recommended value after recrystallization. During the second recrystallization, after the first drawing, the size of the structure was 0.125 mm, which is 0.035 mm above the recommended value after recrystallization, but it has no significant effect on the functionality of the technology or the final cartridge case. However, it is necessary to point out a possible problem. If we change the input material (for example within the standard range), recrystallization set up in this way, after the first drawing, could make a problem if this change in the input material accentuated such an extreme value. Therefore, it is good to have the whole technology set up universally and keep the values after recrystallization as close as possible to ideal value after recrystallization – 0.075 mm, which will ensure possible reserves in technology. For example, when changing within the standard or within other imperfect part of technological process.

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