ISSN 0543-5846
METABK 43 (1) 49-53 (2004)
UDC - UDK 669.35´5:621.778.011:620.172=111

PHENOMENA OF DUCTILITY MINIMUM OF CuZn28 BRASS BARS WHICH ARE PLANNED FOR DEEP DRAWING

Received - Primljeno: 2002-09-24
Accepted - Prihvaćeno: 2003-04-25
Preliminary Note - Prethodno priopćenje

Effect of ductility minimum is common properties from most metals and alloys. Research which is presents in this work is in connection with occurrence of ductility minimum during the strain test of brass after rolling and then drawing at room and elevated temperatures. The occurrence of ductility minimum is connected to determined temperature and determined type of fracture which appears exclusive at that temperature. This conditions required to avoid this area for plastic deformation and chapping [1]. The tests of ductility on brass CuZn28 were done because that alloy has the highest ductility in a area comparing to other brasses [2]. Besides this, those tests were done because of problems which involve cold plastically deformation of rolled bars of brass CuZn28 (DIN 17660/84) which are planned for deep drawing. The problems were presented in the beginning of surface and under surface defect in the shape of vertical cracks on rolled and then on past drawn bars which were produced in semi-industrial factories of Metallurgical institute in Zenica.

Key words: *brass, ductility minimum, intergranular fracture, transgranular fracture, temperature ductility minimum*

Pojava minimuma sposobnosti kovanja pri mjedi CuZn28 u šipkama namijenjenim za duboko izvlačenje. Učinak minimuma sposobnosti kovanja je zajednička osobina više metala i legura. Istraživanje prikazano u ovom radu vezano je za pojavu minimuma sposobnosti kovanja pri ispitivanju zatezanjem na sobnim i povišenim temperaturama uzoraka mjedi poslije valjanja a zatim vučenja. Pojava minimuma sposobnosti kovanja je vezana za određenu temperaturu i određeni tip loma koji se pojavljuje isključivo na toj temperaturi. Ovo zahtjeva izbjegavanje tog područja za plastičnu deformaciju i oblikovanje [1]. Ispitivanja sposobnosti kovanja provedena su za mjed CuZn28 (DIN 17660/84) pošto ta legura ima najveću sposobnost kovanja u odnosu na druge mjedi [2]. Pored toga, istraživanja su provedena i radi problema vezanih za hladnu plastičnu deformaciju valjanih šipki mjedi CuZn28 namjenjenih za duboko izvlačenje. Problemi su u pojavi površinskih i podpovršinskih grešaka u obliku uzdužnih pukotina na valjanim, a zatim vučenim šipkama proizvedenim na poluindustrijskim postrojenjima Metalurškog instituta u Zenici.

Ključne riječi: *mjed, minimum sposobnosti kovanja, interkristalni lom, transkristalni lom, temperatura minimuma sposobnosti kovanja*

INTRODUCTION

Brass CuZn28 is the most important alloy in the group of brasses because of very high ductility in α area. Therefore, during the production of cold drawn bars for deep drawing, existing the problem of bad deformability appears as well as surface defects on the bars itself [3].

This fact was directed flow of examination, because of analysis of chemical composition, conditions and temperature of hot and cold mechanical treatment, mechanical and metallographycal examinations did not carried adequate answers. During this examination, stress was on discovering of causes of beginning of surface and under surface defect in connection with grain size, mechanical working technology as well as on examination of influence of temperature on mechanical properties and ductility of brass during strain testing.

Also, a study of microscopic structural changes at the temperature of ductility minimum was done. According to knowledge from the technical literature, a change in mechanical fracture - which appeared at the temperature of ductility minimum, was researched too.

M. Oruč, Metallurgical institute ”Kemal Kapetanović” Zenica, Zenica, Bosnia and Herzegovina, R. Hadžalić, Faculty for Metallurgy and Materials Science, Zenica, Bosnia and Herzegovina

APPEARANCE OF DUCTILITY MINIMUM ON ROLLED AND DRAWN BRASS CuZn28

Rolled bars with diameter ∅ 16 mm and cold drawn till diameter of ∅ 14.2 mm then there are tensile tested on room temperature (environmental temperature) and on higher temperatures (200 °C, 300 °C, 400 °C, 510 °C, 550 °C).

Temperatures of testing have been chosen on the base owner's seeing, i.e. high change mechanical properties tensile test on the one definite temperature.

Nine experimental melts were made because of testing which are separated in three groups. For producing the melt from the first group pure cuprum and zink and 50 % of waste brass of CuZn28 were used; for the melt from the second group pure cuprum and zink and 20 % of waste brass were used and for the melt from the third group only pure cuprum and zink were used.

The waste brass appears during the cutting of brass bars CuZn28 and it is a part which can substitute pure cuprum and zink while producing mentioned brass. At the same time the influence of this addition to the brass features was tested. Chemical analysis of brass shown in the Table 1.

Table 1. **Chemical analysis of brass**
Tablica 1. **Kemijska analiza mjedi**

M* m. 94..	Chemical analysis [%]								
	P	Fe	Pb	Bi	Ag	S	As	Sb	Cu
91	0.007	0.012	0.004	0.010	0.0013	0.000	0.00	0.00	71.7
92	0.006	0.007	0.005	0.009	0.0011	0.000	0.00	0.00	72.7
93	0.005	0.005	0.004	0.010	0.0011	0.000	0.00	0.00	71.8
96	0.006	0.001	0.004	0.009	0.0011	0.000	0.00	0.00	71.4
97	0.005	0.003	0.004	0.009	0.0011	0.000	0.00	0.00	71.9
98	0.005	0.002	0.004	0.010	0.0011	0.000	0.00	0.00	71.5
94	0.006	0.000	0.003	0.009	0.0006	0.000	0.00	0.00	72.1
95	0.005	0.003	0.004	0.009	0.0007	0.000	0.00	0.00	73.5
99	0.007	0.000	0.004	0.009	0.0010	0.000	0.00	0.00	71.1

Mark* melt	Note	Mark* melt	Note	Mark* melt	Note
9491	50 % wasted brass	9496	20 % wasted brass	9494	Pure Cu and Zn
9492		9497		9495	
9493		9498		9499	

After the plastical processing rolling and then drawing the samples of bars were tested by strain test at universal hidraulic mashine - type Amsler 200 kN, its maximal speed of stress is 10 N/s mm^2.

The strain test at room and elevated temperature was done with standard test tubes which were adapted to diameter of bars.

The results of the strain test were taken from the diagram F - Δl and shows values for convectional yield strength ($R_{p\,0,2}$) and tensile strength (R_m) in accordance with expected values, with temperature increase taken for samples decrease.

Deformation characteristics, i.e. extension (A) and contraction (Z) at both sample groups decrease down to temperature nearly 300 °C and they have the lowest values on that temperature and just above that temperature values begin to increase (Figure 1. and Figure 2.).

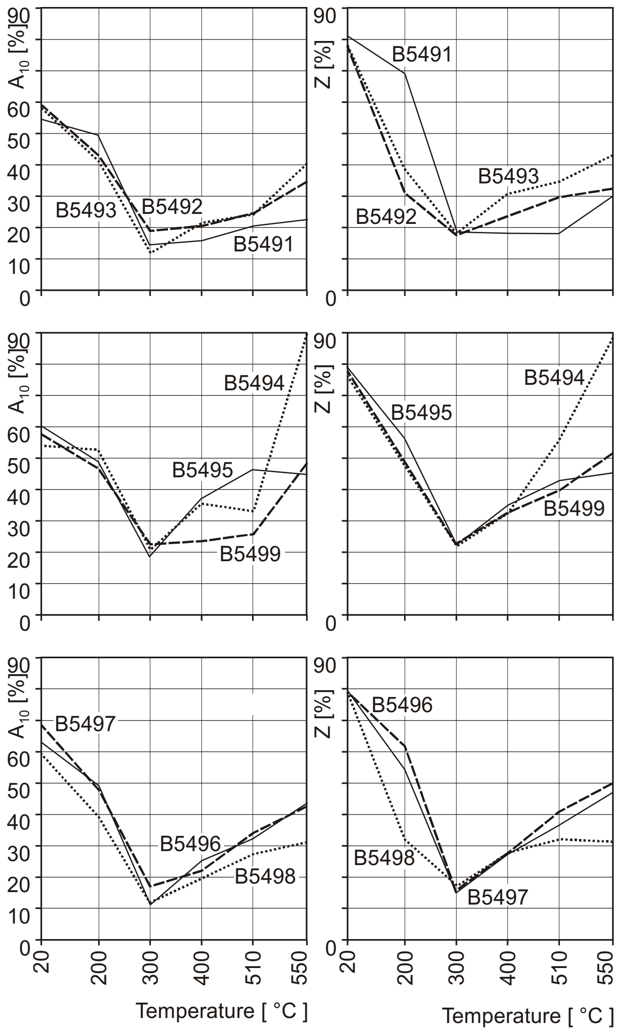

Figure 1. **Diagrammatic review of haw does the elongations and reductions depend on the temperature-rolling samples**
Slika 1. **Dijagramski prikaz ovisnosti izduženja i suženja od temperature - valjani uzorci**

That means that appear ductility minimum, i.e. fall of value extension and contraction, on just exact temperature at all samples. Above that temperature begin increase of value of mentioned characteristics.

After rolling and drawing, a metalographical testing of samples was done and average grain size for mentioned groups of melts were determined - Table 2.

Fracture of examined samples on room and higher temperatures after tensile tests have been observed on optical stereo microscope and scanning electron microscope (SEM).

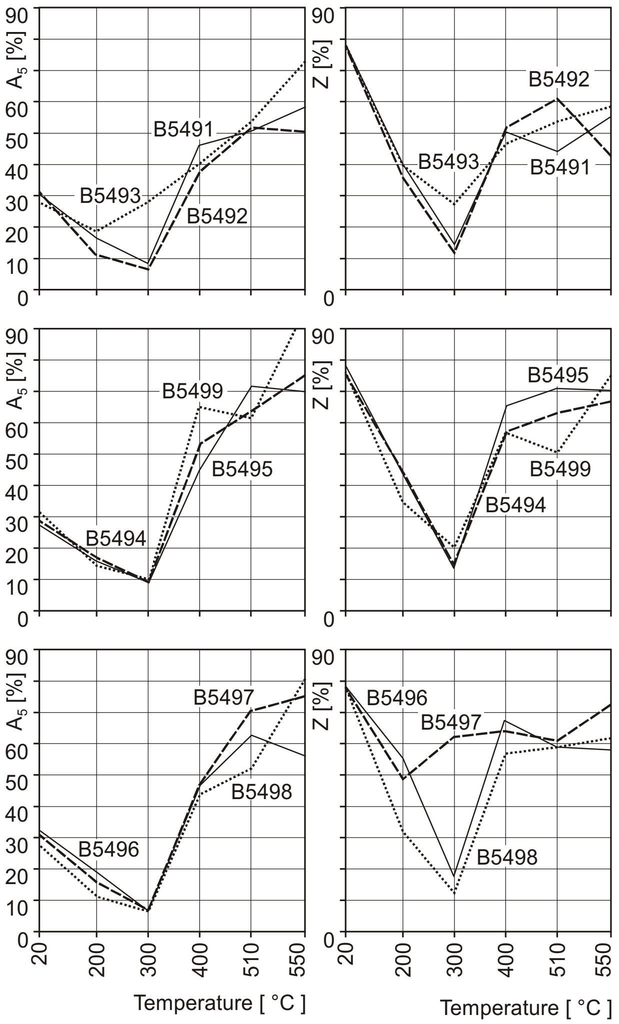

Figure 2. **Diagrammatic review of haw does the elongations and reductions depend on the temperature-drawing samples**
Slika 2. **Dijagramski prikaz ovisnosti izduženja i suženja od temperature - vučeni uzorci**

More complete and more important parameters are obtained on the base of SEM examination. These results are, dependently of temperatures, different.

Table 2. **Average grain size**
Tablica 2. **Prosječna veličina zrna**

Mark melt	Grain size average [mm]	Mark melt	Grain size average [mm]
A9491		B9491	
A9492	0.056	B9492	0.025
A9493		B9493	
A9494		B9494	
A9495	0.053	B9495	0.030
A9499		B9499	
A9496		B9496	
A9497	0.052	B9497	0.052
A9498		B9498	
Mark A is for rolling samples		Mark B is for drawing samples	

Surfaces of fractures are shown: Picture 3. - optical stereo microscope; Picture 4. - SEM (scanning stereo microscope).

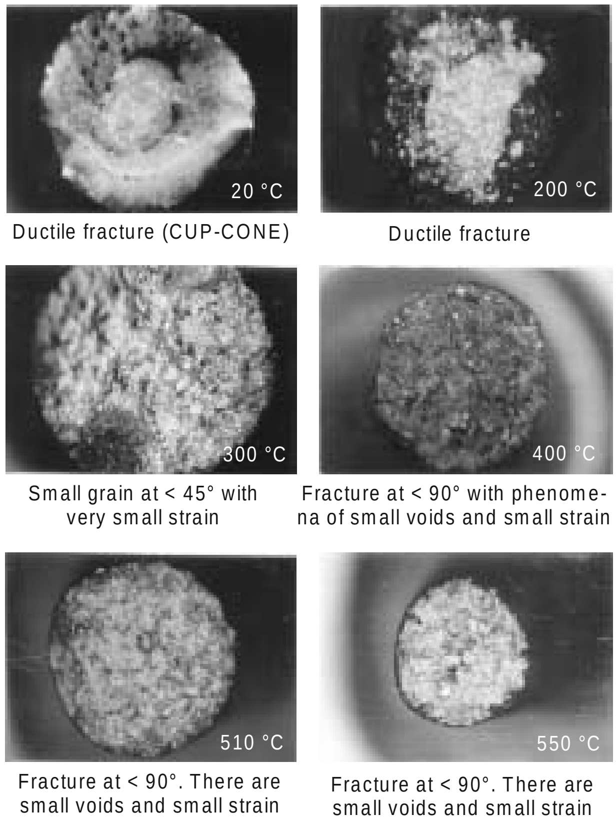

Figure 3. **The looks of fractures surface for tensile testing at room and elevated temperatures - optical stereo microscope. Drawing samples, increase 16x**
Slika 3. **Izgled prelomnih površina pri ispitivanju zatezanjem na sobnoj i povišenim temperaturama - optički stereo - mikroskop. Vučeni uzorci, povećanje 16x**

By using the optical stereo microscope only general conclusions can be made.

By using SEM concrete and detailed conclusion can be made.

Figure 4.a) - room temperature - Orientation of the grains is in direction of the applied stress. The fracture is transgranular and fallowing a well - defined crystallographic plane. This plane would be different in different grains.

Figure 4.b) - temperature 200 °C - Fracture at this temperature shows an array of couplets and each couples corresponds to a pore. The fracture mechanism has changed and there is evidence intercrystalline fracture.

Figure 4.c) - temperature 300 °C - The grains are elongated and rounded and one can observe a complex pattern of voids and hills. This is an indication of intergranular fracture with numerous micro voids.

Figure 4.d), e) and f) - temperature 400 - 550 °C - A reappearance of the river - patterns and chaotic texture, i.e. transgranular fracture mechanism secondly, each surface

shows features of recrystallisation and new crystals tending to block the micro fissures that had been formed at the lower temperature. It shows that the increase in ductility after 300 °C has some relationship with this recrystallisation.

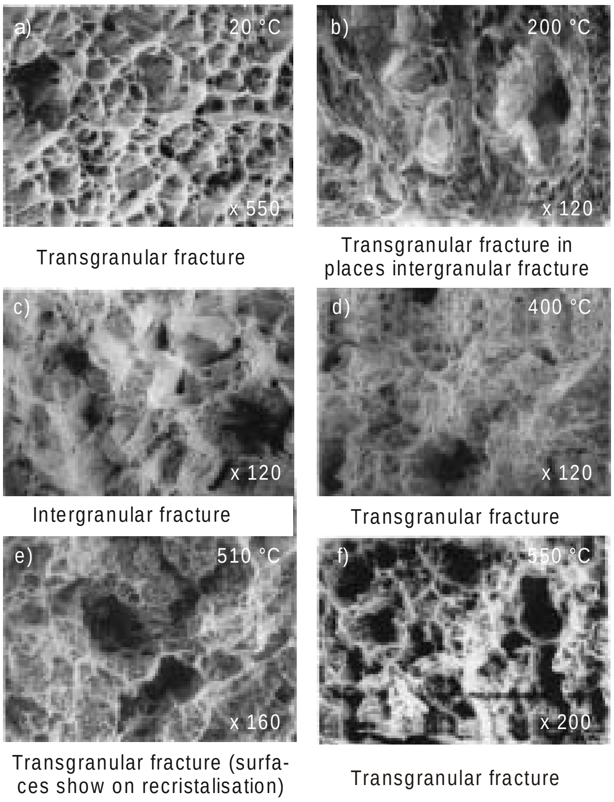

Figure 4. **The looks of fractures surface for tensile testing at room and elevated temperatures - drawing samples - SEM**
Slika 4. **Izgled površina preloma pri ispitivanju zatezanjem na sobnoj i povišenim temperaturama - vučeni uzorci - SEM**

As it is known that fracture of polycrystalline metals appears at tension with continuous velocity because of growth and coalescent of small voids on the grain boundaries. Nucleation of these voids probably appears by concentration strain at non-metallic inclusions or at tripartite and quadripartite knots of grains and segregation formations of atoms or mixtures [4].

At lower temperatures pores nucleation is larger, but growth velocity is smaller, while with increasing temperature is obvious increase of voids size with decrease of nucleation velocity. At the certain (middle) temperature fracture velocity is proportional to nucleation velocity of pores growth.

Moment of appearance of micro voids at brittle is difficult to fix. Formation of micro voids there is under suitable circumstances only in some micro volumes and they are consequences of sliding, local press, winding of strips, grain boundaries, twinning of layer and so on.

During the examination of the micro voids using the optical microscope it was notice increase of the 180 times under the temperature 200 °C (Figure 5.), therefore on the temperature of 300 °C it is visible their fusion which will make fracture under that temperature.

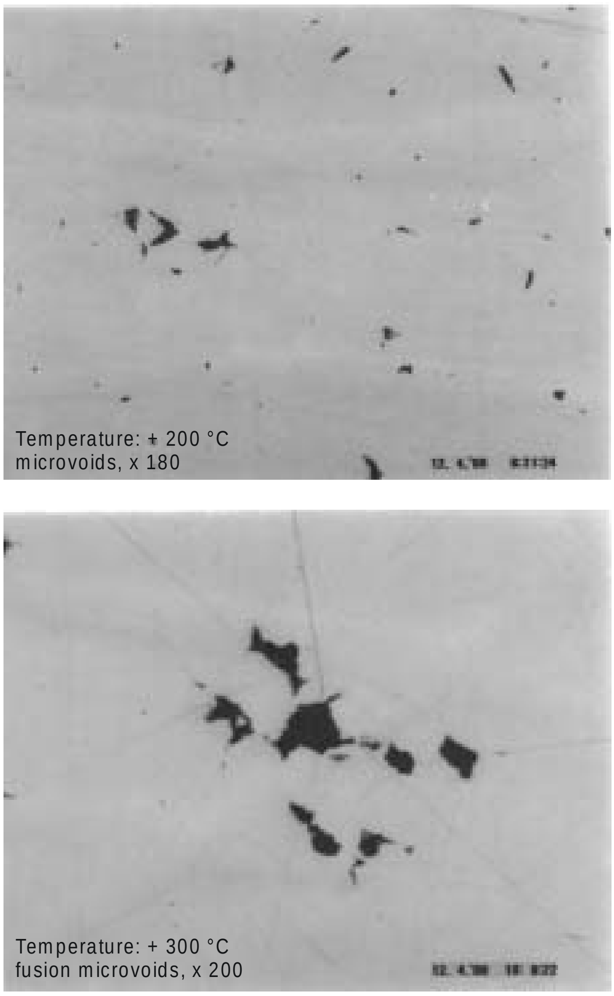

Figure 5. **The phenomena of microvoids around the temperature of ductility minimum (Optical stereo microscope)**
Slika 5. **Pojava mikropukotina (pora) oko temperature duktilnog minimuma (optički stereo mikroskop)**

The examination is conformed phenomena of the ductility minimum on the temperature of 300 °C and way of the appearance by itself.

DISCUSSION

Examination of ductility properties (extension and contraction) on different temperatures, at tensile testing with continuous velocity witch determined by type of factory, it occurred at temperatures field between room temperature and 550 °C. The least values of extension and contraction are on temperature 300 °C. With temperature increase over 300 °C at tensile test ductility (controlled by *A* and *Z*) increase again, and that is conditioned with other mechanism (another fracture type, recrystallysation, etc.).

Chemical analyze of all melts is approximate the same and addition of waste brass has not influence on chemical compound or waste of mechanical properties, what is economical good in aspect of forming.

Experimentally it is confirmed that under conditions static loading tension for brass CuZn28, with defined grain size (0.025 - 0.056 mm), the technology of mechanical working (rolling and drawing) that is occurring of ductility minimum at 300 °C, resulting the transformation of one type of fracture into another, i.e. transgranular fracture into intergranular on the temperature of ductility minimum. Grain size at rolled and drawn samples did not have effect on temperature of ductility minimum.

By analysis of fracture types at tensile loading at room temperature as well as at higher temperatures, it is started that under temperature of ductility minimum fracture is transgranular, and on temperatures of ductility minimum fracture is intergranular, and over temperatures of ductility minimum fractures is again transgranular. It means that ductility drop on temperature of ductility minimum is strait connected with fracture types.

An appearance of ductility minimum on lower temperatures (300 °C for experimental melts) is not expectable. Because of voids nucleation and their fusion appears still on lower temperatures (200 °C), so it is necessary suggest a deformation with urgent controlled high speed, retaining grain size under the specifically chemical contents for this alloys.

Temperature field between 200 °C to 400 °C have to be avoiding for possible plastic deformation or stress. There is no data appearance of ductility minimum for a brass under production condition, i.e. condition manufacturing by plastic deformation, therefore it was not possible to predict additional influence factors which are opposite of the previous exempts astute ductile minimum under the considerably higher temperature. Referring the literature value mentioned above, ductility minimum is moved to the lower temperature, so any kind of over heating during the manufacturing can more harmful effects.

REFERENCES

[1] S. Tomašević i dr.: Od kapljice do granice, Univerzitet u Sarajevu, Fakultet za metalurgiju i materijale Zenica, (2002), 176-177

[2] S. Tomašević: Dizajniranje tehničkih materijala, APEX / Nauka i industrija, Zenica, (1999), 44-49

[3] Z. Pašalić i dr.: Regeneracija otpadne trake i osvajanje proizvodnje hladno vučene šipke ∅ 14,2 mm, Metalurški institut, Zenica, (1995), 6-20

[4] A. S. Wagh i dr.: The intermediate temperature ductility minimum in 70 % Cu and 30 % Zn a brass, Scripta metallurgica, 18 (1984), 933-938

[5] W. Y. Yeung: A transmission of microstructure in heavily cold rolled 70:30 brass, Scripta metallurgica, 23 (1989), 617