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Process of explosive compaction of internally oxidized powders; Cu-0.15%BeO

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The explosive compaction for processing of electrode material was realized based on axisymmetric loading scheme. The compression of internally oxidized fraction of the alloy Cu-0.15%BeO alloy did not provide a considerable strengthening effect; average microhardness varied from 130 to 150Mpa. The tensile strength comes to 30Mpa. However this method can be applicable to obtain a dense briquette for further extrusion of electrode.

Keywords : Explosive compaction, Internal oxidation, alloy Cu-0.15%BeO, Electrode.

1. INTRODUCTION

For the majority of welded metals, in particular for light alloys, the most preferred material for electrodes are internally oxidized copper alloys. Cu-BeO is one of the best choice in the aspect of higher strength with low volume contents of hardening phase. And the size of the oxide particles of hardening alloys depends on both temperature and concentration of oxidizing agent. To set up the optimum process conditions of production of Cu-BeO electrodes, some investigations are made on dynamic/quasi dynamic compression method with annealing temperature, porosity, and mechanical/ metallurgical analysis.

2. TREATMENT OF ALLOY POWDER

Treatments were made for characterization of the cuttings structure of the alloy Cu-0.15%BeO internally oxidized at 950℃ for an hour and reduced in hydrogen atmosphere at 800℃ for half hour. On treating, the flake structure is heterogeneous. There is a shaped core wherein the internal oxidation does not occur. This is evident from Figs.1a,b,c which present the structure at different depth of flakes produced with decrease in its thickness while polishing. The oxidation front is shown with an arrow. Some different values of hardness for internally oxidized and unoxidized sections are seen from impressions of an indenter. However, owing to a scale factor, the true value of hardness cannot be determined by these impressions.

The working part of an electrode shown in Fig. 2 is produced from an internally oxidized porous mass. For this purpose a method of static and dynamic compaction is used.

3. STATIC COMPACTION METHOD

3.1 Production of a cake

A cake is compacted using a press-hammer at a pressure P dependent on a cake size. On compaction, the cake is sintered in an electro-vacuum furnace at 950℃. After this operation, the cake porosity ranges from 15 to 20%.

The second compaction is performed after sintering. The porosity is reduced to 5-10%.

3.2 Squeezing-out a rod

Prior to squeezing-out, a rod is heated at 1000℃. Squeezing-out is conducted up to the ratio So/S=(5-7) where So and S are cross-sectional areas of the of the cake and rod, respectively. In Fig. 2 is shown the external view of the rod (a) and the electrode (b) made from it.

3.3 Structure and properties of the rod

The rod structure is investigated at cross and longitudinal sections. Microsections are cut out of the rod center. A "band-shaped" structure (Fig. 3a) found in the longitudinal microsection is determined by the method of producing of the rod. The cross-sectional structure is presented in Fig. 3b. The given structures indicate that the rod production is followed by active recrystallization. The microhardness Hv is measured with P = 50g and its values for two rods at different sections are listed in Tables 1 and 2 (where N is the number of a sample cut out of the N rod; the numeration accords with test data log).

Table 1. Alloy Cu-BeO, squeezable, of longitudinal section.

	Rod N3			Rod N4
Hv	3_1	3_2	3_3	3_4
Mean	121.4	132.8	148.7	113
Max	175	180	196	191
Min	69.5	80	93	60

Table 2. Alloy Cu-BeO, squeezable, of cross section.

	Rod N3			Rod N4		
Hv	3_1	3_2	3_3	4_1	4_2	4_3
Mean	122.7	148.7	145.3	125.5	125.4	128
Max	185	191	171	191	171	191
Min	68	90	121	61	64	62

As to samples whose length direction coincides with that of the rod axis, the mean value of tensile strength amounts to 250 Mpa.

4. METHOD OF DYNAMIC COMPACTION

For compaction, a plane loading scheme is used (Fig. 4). The powder is poured into a container. The container is loaded by virtue of the energy released on detonation of an explosive located at its surface (Fig. 4).

The compact structures obtained after explosive loading are shown in Fig. 5a. The compact materials are annealed in the temperature range from 400-800℃. The character of structural changes on annealing is presented in Figs 6b,c,d,e. All the values of microhardness after explosive compaction and annealing are given in Table 3.

Table 3. Sample made of cuttings of the alloy Cu-BeO, compacted by explosion.

Hv	start.	400℃	500℃	600℃	700℃	800℃
Mean	143	104.8	132.3	128.9	94	101.2
Max	231	162	236	202	185	175
Min	106	56	58	62	64	48

Notice that, on explosion, the values of Hv are larger than those after annealing in the given temperature range. It is evident from Table 3 that the hardening is basically produced by deforming the fraction center which is unaffected by internal oxidation (Hvmin). The finite value of Hvmean is determined by the volume of the fraction. It is not difficult to see that in the sections adjacent to its surface the value of Hvmax is unaffected by essential changes due to their heat treatment (see Tables 1,2,3) and principally determined by the presence of hardening phase, its size and distribution.

5. PRODUCTION OF ON EXPERIMENTAL SAMPLE OF ELECTRODE

The electrode consists of two parts : a base-1, and a working part-2 (see Fig. 2). Technical-grade copper or chrome bronze is used as a base of the electrode, which depends on its subsequent use (a view of welded materials). The working part is internally oxidized copper forming a rod part obtained under static compression or a compact part on explosive compaction and annealing. The working part of electrode is welded into the base by explosion (Fig. 8). The structure of joint boundary between the working part and the base is shown in Fig. 9. One can see from Fig. 9 that a good physical contact is formed. Noteworthy also are the advantages of the static method for producing the working part of the electrode. This method governs the more homogeneous structure and a good joint quality by contacts of the fraction particles owing to the highly plastic deformation defined by the producing rod method.

6. PEFERENCES

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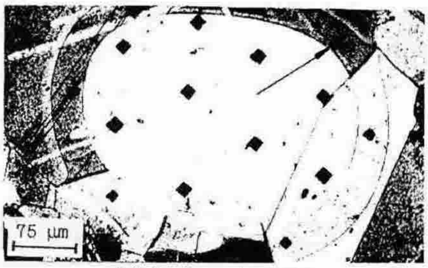
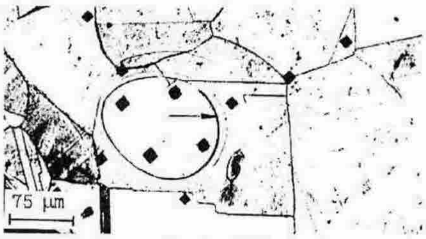
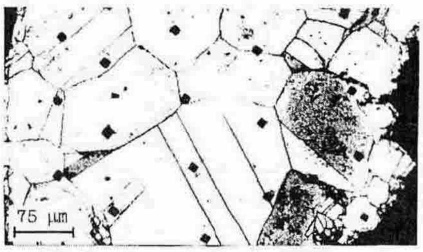


(a) Surface structure

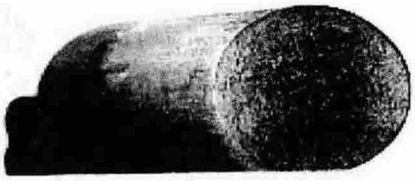


(b) Structure at a depth of 50 μm from a surface.

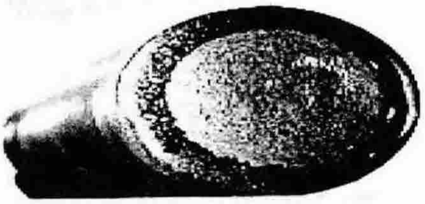


(c) Structure at a depth of 100 μm.

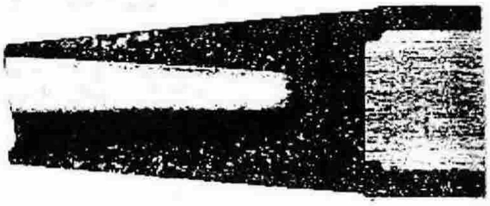
Fig. 1 Flake structures of the internally oxidized alloy Cu-15% BeO, h=200μm:



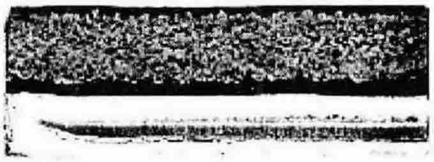
(a) Rod produced from the internally oxidized alloy by staticsqueezing out



(b) Electrode with a working part made of the rod.

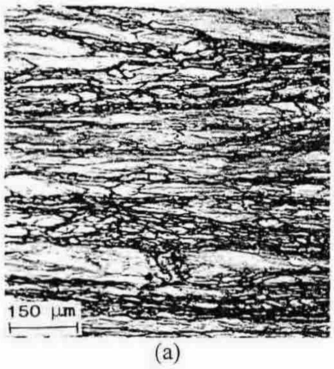


(c) Section of the working part of the electrode.



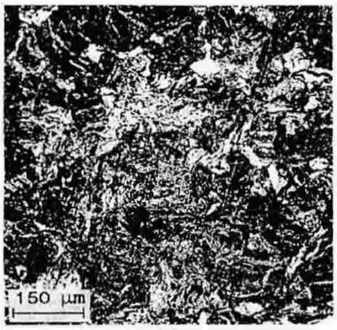
(d) Blank for the electrode working part produced by explosive compaction.

Fig. 2 external view of the rod

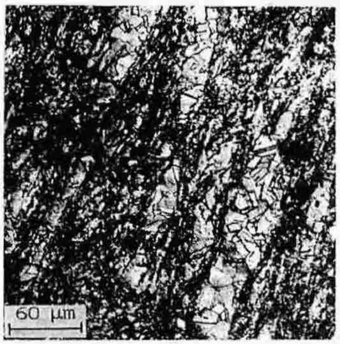


(a)

(b)



(c)



(d)

Fig. 3 Rod structure produced by the static method
a. Longitudinal section.
b. Cross section.

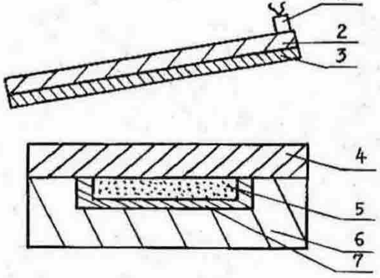
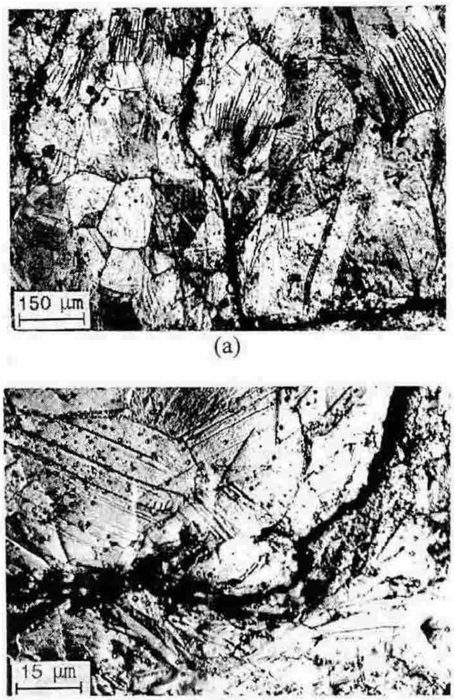


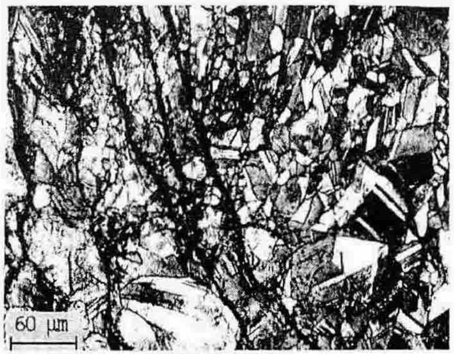
Fig. 4 Diagram of compacting the internally oxidized alloy fraction.
1. Detonator, 2. Explosive, 3. Plate,
4. Explosive, 5. Powder, 6. Catridge clip.
7. Container.



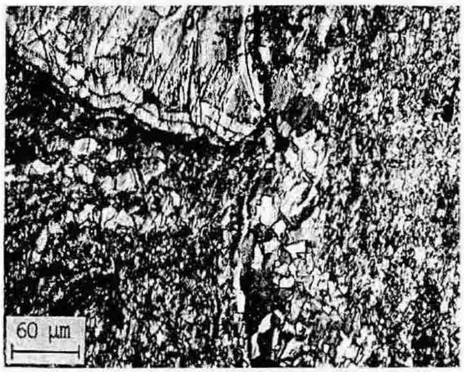
(a)

(b)

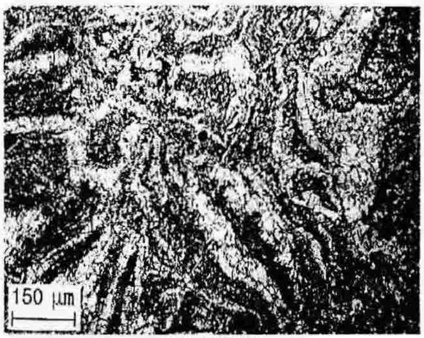
Fig. 5 Structure of compact materials produced by the dynamic method.



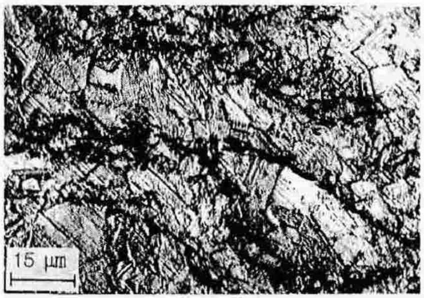
(a) 400 °C



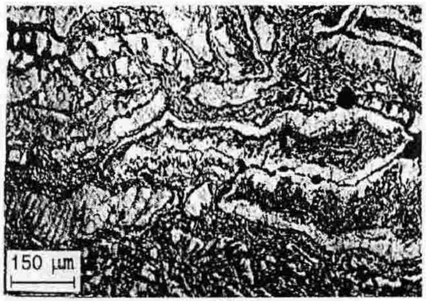
(b) 500°C



(c) 600°C



(d) 700°C



(e) 800°C

Fig. 6 Structure of compact materials produced by explosion on annealing.

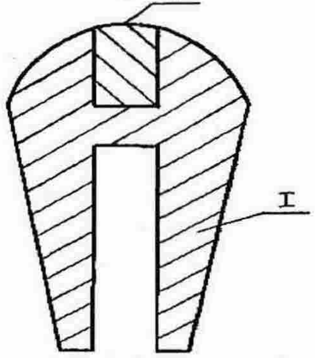


Fig. 7 Diagram of the pilot electrode structure.

1. Electrode base.
2. Working part of electrode.

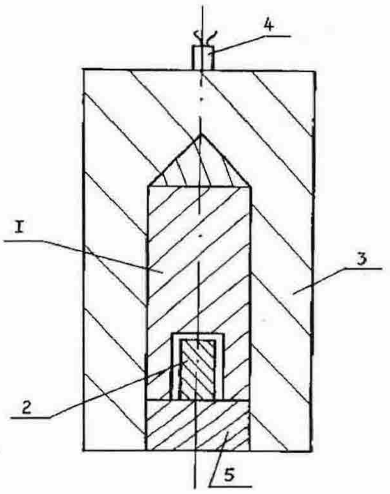


Fig. 8 Diagram of joining the working part of electrode to its base.

1. Electrode base.
2. Working part of electrode.
3. Explosive.
4. Detonator.
5. Split-off element.

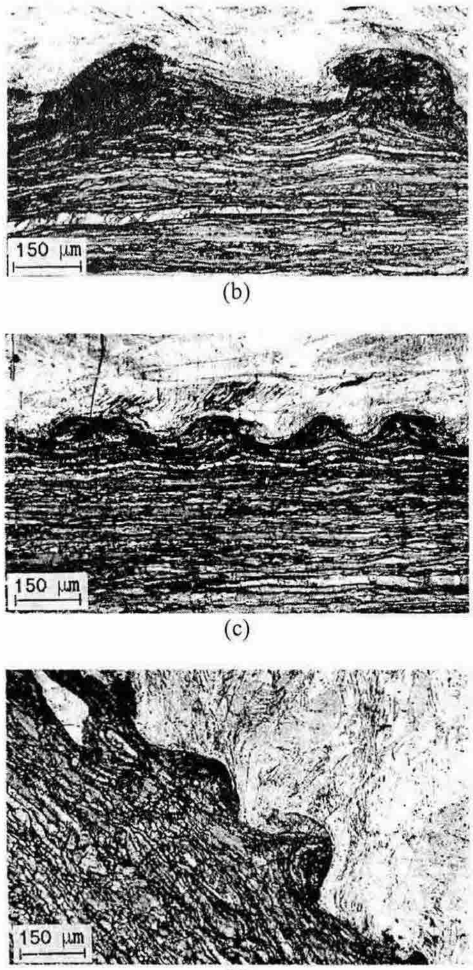


Fig. 9. Structure of the joint boundary.