CORROSION BEHAVIOUR OF SINTERED Cu-Ni COMPACTS

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ABSTRACT: The authors present the research on corrosion behaviour of various compositions of Cu-Ni alloys sintered in hydrogen atmosphere. The resistance to corrosion has been determined electrochemically and polarization curves have been drawn for each material, in acid (1N H_2SO_4) and salt (3% NaCl) solutions. The 1N H_2SO_4 solution is a medium more aggressive in comparison with 3% NaCl solution. The corrosion voltage moves towards more positive values with a nobler copper. The relative order of their resistance to corrosion: Cu100<Cu80Ni20<Cu50Ni50<Cu20Ni80<Ni100, was established. The resistance to corrosion also does not depend on density in the case of sintered materials ranging from 7.0 g/cm^3 (Ni100) to 7.4 g/cm^3 (Cu100).

KEYWORDS: copper alloys, corrosion, sintering, compacts

1 INTRODUCTION

The Cu-Ni alloys are known as nickel-bronze mixtures. Copper and nickel are isomorphous (CFC) materials with very similar atomic radii which form a continuous solid solutions series as they are able to form alloys in any mixing proportion.

In all these alloying proportions the homogenous solid solutions can be cold worked and plastically deformed, even if cross sections are largely diminished and no in-between annealling is carried out. They can be easily rolled and formed/extruded; while hot treated they can be forged and cast so that sheets, bands, pipes can be readily obtained.

Besides these features, their high resistance to corrosion in aggressive chemical enviromments such as: brine, organic acids, water vapours etc. is their main property. All these characteristics make these alloys proper for ship helices, submarine tubing, condensation tabes, coins, medical equipment, fine mechanics parts, chemical industry components, household appliances, combustion chambers, spaceships and so on. The Cu-Ni alloys are difficult to cast when the nickel amount exceeds 80% in the compositions and the cast temperature is high, due to high level gas absorption, slag-inclusions and shrink hole, low fluidity etc. [5].

One way of removing these inconveniences is that of using powder metallurgy procedures which help the process of obtaining homogeneous, segregation free, inclusion free and shrink hole free parts in which the materials are used in high proportions.

The mechanical properties are poorer with the alloys made by powder metallurgy processes (where compactness lowers to 90-95%), but they can be improved in compactness or in other properties by wire-drawing, sheet-rolling or other compacting means.

2 EXPERIMENTAL METHOD

2.1 Cu-Ni COMPACTS FORMING AND SINTERING

The Cu-Ni compacts were obtained with powder metallurgy processes.

The copper powder used in the experiments is obtained electrolitically, the particles having a dendritic shape the grain distribution - between 40-90 μm at a purity of about 99.95%. The nickel powder (carbonyl) had grains ranging from 5 to 25 μm at a 99.99% purity.

Five batches of powder mixtures with various copper and nickel concentrations were prepared, Table 1.

Table 1. Composition and name of alloys

Powder [%]	Alloy name				
	Cu20Ni80	Cu50Ni50	Cu80Ni20	Cu100	Ni100
Cu	20	50	80	100	-
Ni	80	50	20	-	100

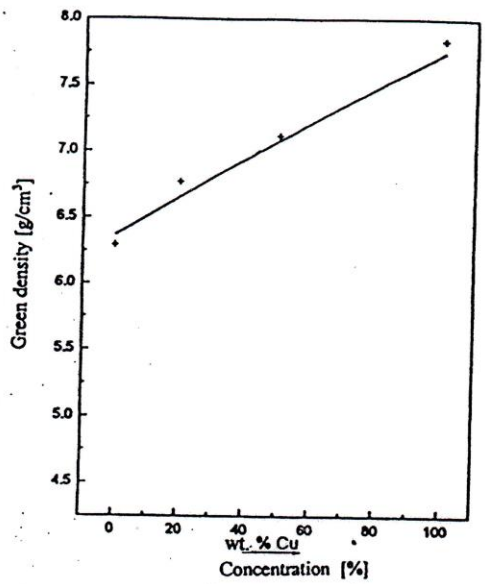

Fig.1. Green density vs. copper concentration.

The powders were homogenized in a spacial TURBULA type device for 10 minutes (each batch), the 0.8% zinc stearate being the lubrifier.

The powders with various compositions were bilaterally pressed at 600 MPa compacting pressure and a height of h=10 mm.

The densities before sintering as function of concentrations in Table 1 are presented in Figure 1.

A better behaviour during pressing at increased copper content can be explained by the fact that the copper powder can be better plastically deformed as compared to nickel powder and the dendritic copper powder fills the spacess among grains better than the nickel one.

A hydrogen reduction atmosphere was used to sinter the alloys at an output of 280 l/h with the dew point at 0°C.

After about 1 hr of preheating, the mixture was kept in the sintering process for 1.5 hrs and cooled for 1 hr.

The after sintering density varied from 7.4 g/cm^3 with pure copper, to 7.0 g/cm^3 with the 100% Ni sample.

2.2 THE RESISTANCE TO CORROSION.

The behaviour to corrosion was studied in the frame presented in Figure 2 [2, 4]. The potentiochemical polarization curves for each alloy were measured in both 1N H_2SO_4 and 3% NaCl solutions.

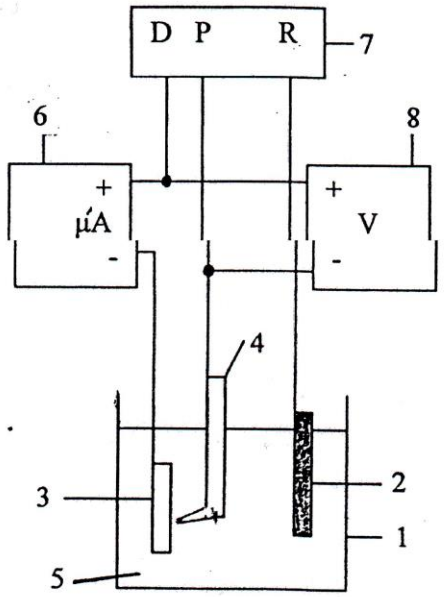

Fig.2. The experimental assembly.

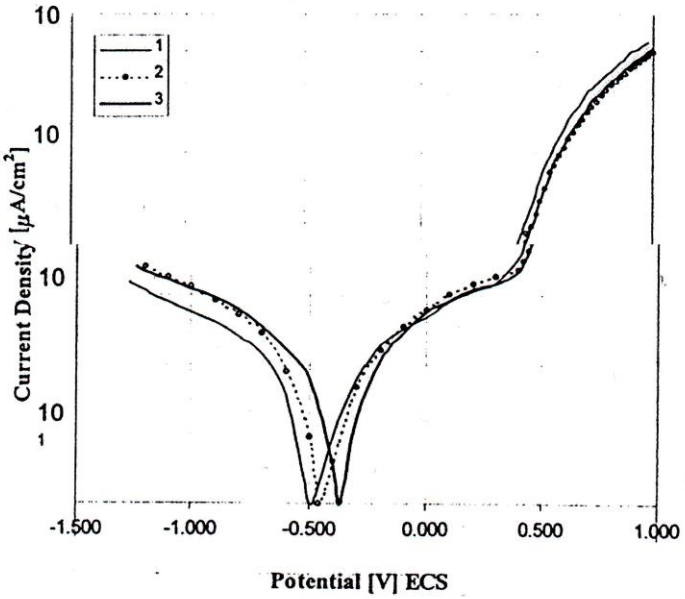

Fig 3. Corrosion potentiodynamic curves in 3% NaCl: 1-Cu100, 2-Cu50Ni50, 3-Ni100.

The experimental assembly, Fig.2, consist of: 1 - working cell; 2 - counterelectrode (Pt); 3- working electrode (sample); 4- reference electrode; 5- solution, 6- microampermetrer; 7- potentiometer; 8- voltmeter. The working cell (1) consists of the three electrodes, the sample (2), the reference electrode (4) and a platinum counterelectrode (2).

The standard calomel electrode (ECS) was placed in the Luggin-Haber capillary to measure the corrosion locally.

The samples were polished with abrasive paper (SiC 240), washed in distilled water and immersed in solution one hour before the experiment. Their surface was of 1 cm^2. The solutions were changed when the determinations began.

The 3-4 electrodes voltage continuously varied from -1.2V to +1.2V, at a speed of 6V/h (from the active to the noble) electrode. The representative curves obtained in 3% NaCl solutions for the Cu100, Ni100 and Cu50Ni50 compositions are shown in Figure 3.

Figure 3 points out that hydrogen ions begin to be reduced at negative voltage larger than -1.0V when the working electrode operates as a cathode.

When the potential reaches the value of 0.V the electrodes operate as anodes a shallow anodic dissolution reaction occurs.

$$Me - 2e^- \rightarrow Me^{2+}$$

The copper or nickel metal ions are diminished by the Cl^- ions in the $[MeCl_4]^{2-}$ solution, according to some kinetic and thermodynamic processes (aspects) [1, 3].

At a potential of 0.5V , the corrosion (anodic dissolution) becomes stronger.

Comparing the curves (1), (2) and (3) one can see the hydrogen ions reduction voltage tends to wards more positive values can concommitantly with the copper becoming nobler.

The corrosion voltage also moves towards more positive values with a nobler copper.

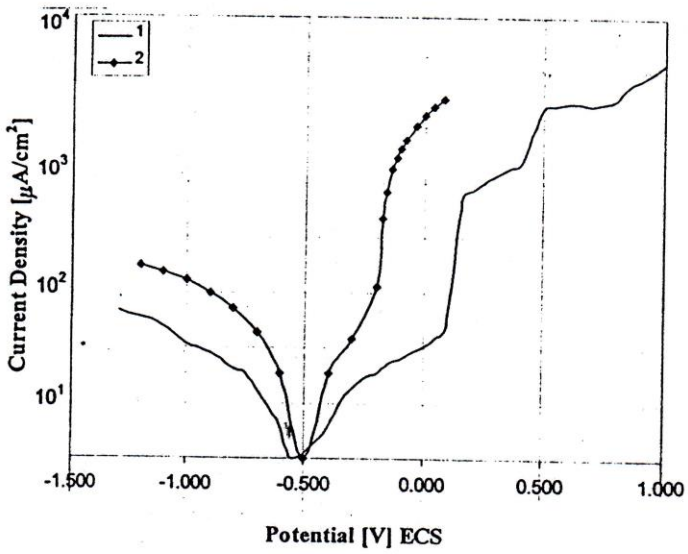

Fig 4. Corrosion potentiodynamic curves in 1N H_2SO_4: 1-with inhibitor, 2-without inhibitor

Figure 4 presents the representative curves for the Cu80Ni20 alloy compositions in 1N H_2SO_4, with and without corrosion inhibitor the ammonium phtalic.

It is obvious that the sulphur acid environment is more aggressive, the metals are dissolved before the anode range voltage is reached. If the ammonium phtalic is used as an inhibitor, in the case of the Cu80Ni20 alloy the curve assumes a shape similar to those for 3%NaCl solutions.

4 CONCLUSIONS

The materials subjected to experiments exhibit an active corrosion voltage in the 1N H_2SO_4 and 3% NaCl solutions and the relative order of their resistance to corrosion being: Cu100<Cu80Ni20<Cu50Ni50<Cu20Ni80<Ni100.

The 1N H_2SO_4 solution is a medium more aggressive in comparison with 3% NaCl solution. The corrosion voltage moves towards more positive values with a nobler copper.

The resistance to corrosion does not depend on density in the case of sintered materials ranging from 7.0 g/cm^3 (Ni100) to 7.4 g/cm^3 (Cu100). It also seems that porosity is inactive during corrosion; the lack of sensitivity to corrosion (implicitly porosity) indicates general corrosion, which diminishes with the material becoming nobler.

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