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OBTAINING MULTILAYER COPPER STRIPS BY ARB (ACCUMULATIVE ROLL BONDING) ROLLING PROCESS

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Abstract

In this paper, the production of multilayer samples, by joining copper strips, by the rolling process at temperatures below the recrystallization temperature is presented.The newly obtained multilayer samples were then subjected to tensile testing and hardness measurement in order to determine their properties.The obtained results show that with increasing degree of reduction, the tensile strength and hardness of the samples increase.Up to the degree of reduction of 66.5%, the tensile strength and hardness of the samples increase slightly, while at a higher degree of reduction of 66.5%, the growth is much more pronounced.

Keywords:*Multilayer copper strips, ARB Roll Bonding, hardness, tensile strength.*

1. INTRODUCTION

The initial idea for this work was based on the knowledge about the application of ARB (Accumulative Roll Bonding) method for rolling sheets and strips (Figure 1) [1].This method achieves the required metal reduction with minimal stresses, by cutting the rolled sheets, joining and re-rolling, whereby this procedure can be repeated an unlimited number of times [2].There is a joining of metals by hot and cold rolling.Making the joint by hot rolling is a more efficient and widely used production method of rolled multilayer semi-finished products.The joint is made by hot rolling from pre-prepared strips packed and joined, and then heated to the temperature required for hot rolling.The application of hot rolling has its basic meaning in the setting to obtain products of smaller thickness than the initial large pieces without intermediate annealing and to facilitate joining, and the joint is achieved at a lower degree of deformation.Cold rolling technology, especially strips rolling, has a disadvantage in terms of the use of expensive equipment for both preparation and rolling.The requirements for large reduction in one pass impose the use of specialized rolling machines with large roller diameters, small rolling width and low rolling speed, as well as a preparation line within the rolling machine.In addition, solving the disadvantages of hot and cold rolling is done by combining procedures, in such a way that the joining is done by some other process, such as explosive joining, and by further hot or cold rolling pieces of the final dimensions are produced[3,4].

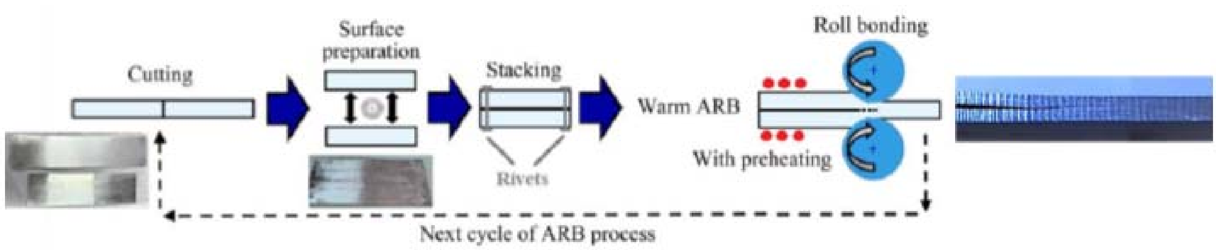

Figure 1. Schematic view of ARB (Accumulative Roll Bonding) rolling process

2. EXPERIMENTAL

As a starting material, dip-forming wire in the form of a strip with dimensions 100 x 7 x 1 mm was used, which was rolled on a quarto rolling machine with smooth rollers, diameter D =180 mm.

Rolling was done by cutting 200 strips 100 mm long, 7 mm wide and 1 mm thick.For degreasing, they were boiled in detergent for about 30 minutes, and then washed with a solution of nitric acid (1: 1 solution), distilled water and finally alcohol.After drying, two strips were joined together, whereby the joining was done by placing copper foil on the ends of the sample. Thus, two-layer samples (2 mm thick) were formed, ready for annealing.The samples were annealed at 400 ° C for 10 minutes to reduce the oxidation level of the sample surface.Annealing was performed by inserting the samples into a metal box filled with charcoal.After annealing, rolling was started on a quarto-rolling machine, whereby the obtained samples had a degree of reduction of ε_1 = 40%.Such samples were immediately deposited in a charcoal box, annealed at 400 ° C for about 10 minutes and re-rolled, with a reduction degree of ε_2 = 44.1%.The obtained sample consisted of two layers with a total reduction of ε_{uk} = 66.5%.After that, two two-layer samples were joined, of course, before their joining, the sample was washed and cleaned again, in order to remove impurities.Joining of these samples was done with copper foil at the ends of the sample. The samples were then annealed for 10 minutes at 400 ° C and then rolled. The degree of reduction after rolling is ε_3 = 48.5%.The obtained samples had four layers.The obtained samples were washed again for degreasing and cleaning, joined in pairs, annealed and rolled, however the process of joining these samples and obtaining eight layers in the sample was not successful.As a final result, a sample with four layers was obtained. The total degree of reduction in relation to the initial sample is ε_{uk} = 83%.The flow of the whole experiment is schematically shown in Figure 2.

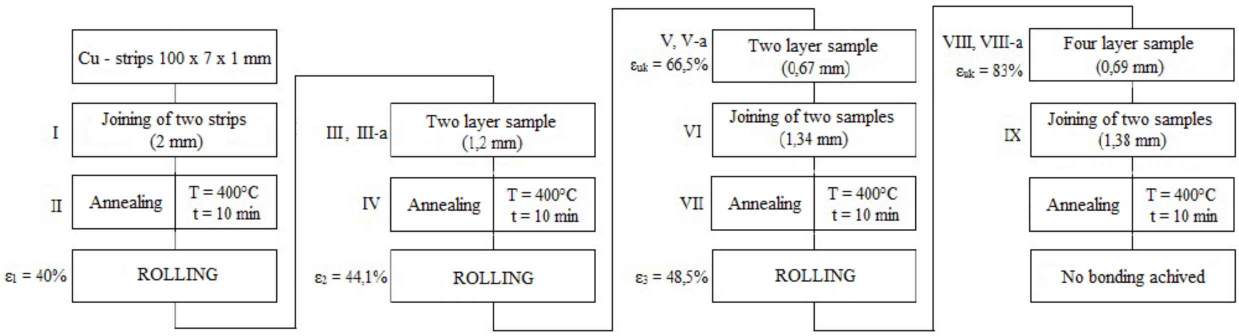

Figure2. Schematic view of the experiment flow

3. RESULTS AND DISCUSSION

Visual inspection of the samples has shown that quality bimetallic strips of small thickness below 0.7 mm can be obtained by rolling.

Flaking was not observed in any of the examined samples. The strips have smooth surfaces, even widths along the length, even thicknesses along the length, and the edges are smooth without cracks.

The results of the change in tensile strength and hardness of the samples depending on the degree of reduction are presented in Table 1 and Figures 3 and 4.

Table 1. Hardness and tensile strength values depending on the degree of reduction

Sample	Degree of reduction ε (%)	Medium hardness value (HV)	Tensile strength R_m (N/mm^2)
III	40	103	46,221
III - a	40	102	44,345
V	66,5	109	55,336
V - a	66,5	108	47,826
VIII	83	116	116,422
VIII - a	83	110	84,559

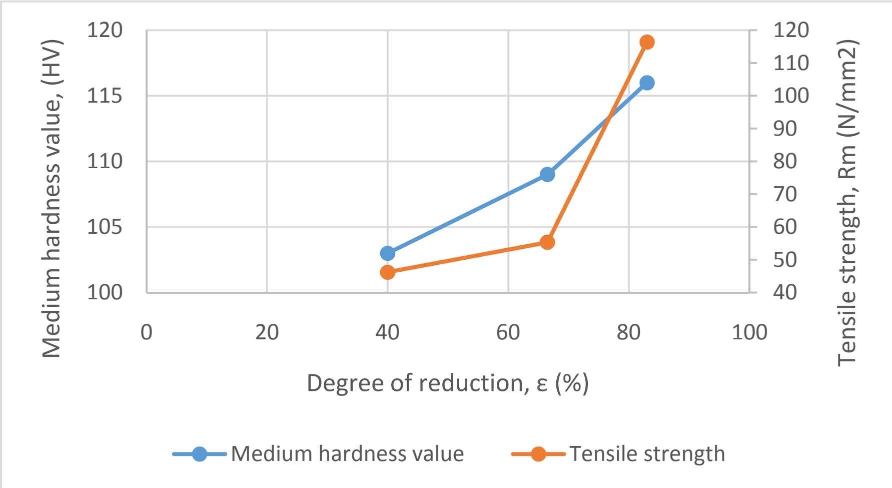

Figure3. Dependence of hardness and tensile strength of samples on the degree of reduction for the I series of samples

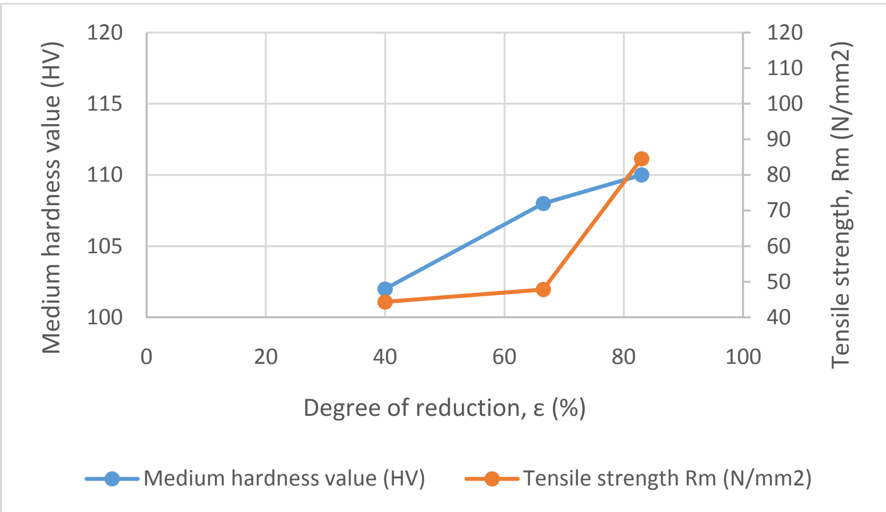

Figure4. Dependence of hardness and tensile strength of samples on the degree of reduction for the II series of samples

The diagrams show that as the total reduction increases, both the hardness and the tensile strength increase.

In the first series of samples, higher values of hardness and tensile strength were observed compared to the second series of samples.

The minimum hardness values, 102 HV and 103 HV, were obtained for samples deformed with a reduction degree of 40%, while the maximum values, 110 HV and 116 HV, were obtained at a reduction degree of 83%.Tensile strength has values of 44 (N/mm^2) and 46 (N/mm^2) to a maximum of 116 (N/mm^2) and 84.5 (N/mm^2).

The measured values of hardness and tensile strength for the first series of samples are higher than the measured values of hardness and tensile strength for the second series of samples at given degrees of reduction.

4. CONCLUSION

Based on the obtained results, the following conclusions can be drawn:

- By rolling copper strips, samples less than 0.7 mm thick can be obtained, without flaking, the strips have smooth surfaces, uniform widths along the length, uniform thicknesses along the length, and the edges are smooth and without cracks.
- With increasing degree of reduction, the tensile strength and hardness of the samples increase. Up to the degree of deformation of 66.5%, the tensile strength and hardness of the samples increase slightly, while at a higher degree of reduction than 66.5%, the growth is much more pronounced.
- The measured values of hardness and tensile strength for the first series of samples are higher than the measured values of hardness and tensile strength for the second series of samples at given degrees of reduction.
- Higher values of hardness and tensile strength for samples rolled in the first series compared to the hardness and tensile strength of samples rolled in the second series, are probably due to either slightly shorter heating of samples in the furnace or longer retention of samples in the charcoal box after removal from the furnace and a longer time of transferring samples from the box to the rolling machine.

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