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INFLUENCE OF COLD ROLLING AND ANNEALING ON HARDNESS OF BIMETALLIC STRIP Cu– Al

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Abstract

Samples of bimetallic strip Cu-Al were cold rolled with different reduction degrees, and the ones deformed with the highest reduction degrees were annealed afterwards at different temperatures for a period of one hour. The values of the hardness of the layers of the bimetallic strip were obtained as a function of the degree of deformation, and the annealing temperature. Global flow of curves hardness - total deformation, increases, where the increase in the hardness of aluminum with increasing degree of deformation is approximately linear. A decrease in hardness was observed with an increase in the annealing temperature, in both the aluminum layer and the copper layer.

Keywords: *bimetallic strip, hardness, deformation degree, annealing temperature*

1. INTRODUCTION

Thanks to combination of different properties in one material, bimetals are widely used in industry, because of saving expensive scarce metals, and for their specific properties which separate metals-components doesn't have.

In a bimetal, expensive metals and alloys are used as plating materials, with thickness of up to 25% of the bimetal's thickness. Thanks to that it is possible to get relatively cheap materials with required properties where performing layer keeps the properties it's got before joining into bimetal, while cheaper, basic material acts as carrying material that provides required mechanical properties.

Corrosion-proof bimetals with cooper as a plating layer are used more and more.

Cold rolling of a plated strip is a final operation in plastic processing in all cases when enhanced strength and deformation resistance are required [1, 2, 3, 4, 5].

2. EXPERIMENTAL

The samples cut from trilayer sheet Cu - Al – Cu, 10,4 mm thick, obtained by plating by explosion, were used for examination. One Cu layer was removed, so bimetal strips, 8,4 mm thick, were obtained. The initial thickness of Al, in those strips, were 6,4 mm, and2 mm for Cu.

Prior to rolling of the bimetal strip, the gap between the working rolls was set to 8,4 mm, and then the strip was let between for a few times till the total deformation of 10% was reached.

In order to simplify it, it was accepted that the deformation for a single pass was 2,5%. After the deformation of 10% the total thickness and layers thicknesses were measured on various spots.

The same procedure was repeated for the total deformations of 20%, 30%, 40%, 50%, 60%, 70%, and 80%.

The samples deformed with maximum deformation degree, ε_{max}=80%, were subjected to annealing.

The annealing was done in a protective atmosphere of nitrogen, for a period of one hour, at temperatures of 200, 250, 300, and 400 °C.

Hardness measurements were performed after all degrees of deformation and after the annealing.

The experimental flow is shown schematically in figure 1.

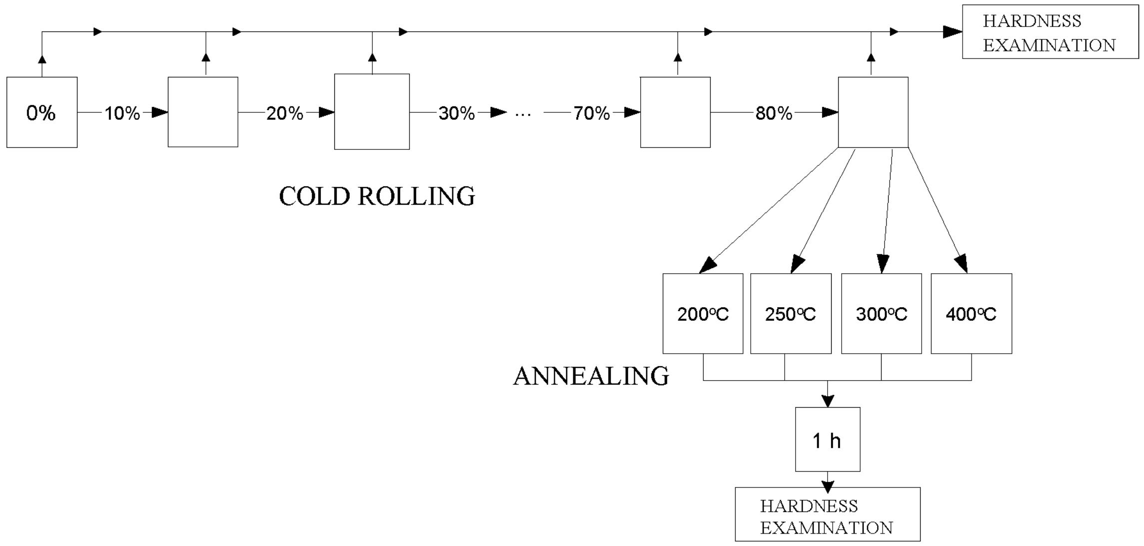

Figure 1. Schematic diagram of the experimental flow

3.RESULTS AND DISCUSSION

The obtained data for the hardness measurements, depending on the total deformation degree are given in Table 1. and Figure 2.

Table1. Dependence of the hardness of bimetallic strip layers on the degree of deformation

ε (%)	HV (daN/mm^2)	
	Al	Cu
0	43.83	106.00
10	44.20	115.75
20	46.33	117.00
30	47.27	120.40
40	48.04	121.67
50	48.44	125.50
60	49.20	131.80
70	49.80	136.00
80	51.05	146.75

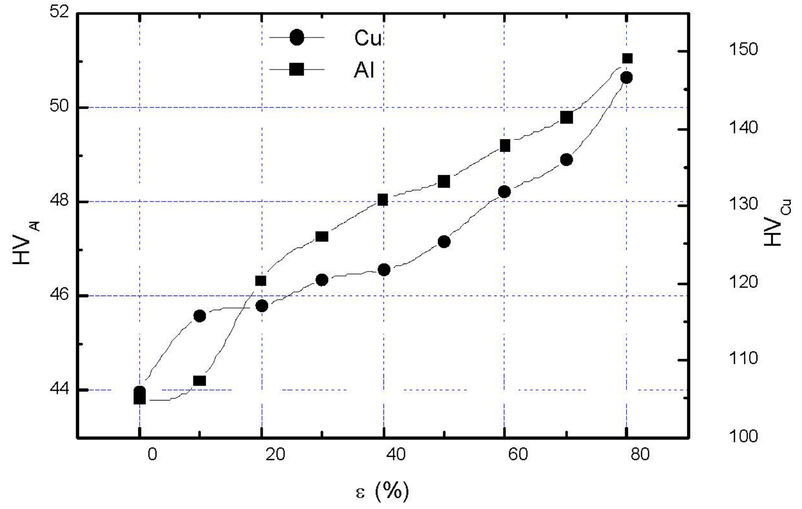

Figure 2.Diagram of the dependence of the hardness of the bimetallic strip layers on the degree of deformation

Global flow of curves hardness - total deformation, increases, where the increase in the hardness of aluminum with increasing degree of deformation is approximately linear.

The curve that represents dependence of the hardness of the copper layer on the degree of deformation, can be divided into three parts.In the first part of the curve, up to a deformation of 10%, the hardness of the copper layer increases sharply, in the second part of the curve, up to a deformation of 50%, slightly, and then increases rapidly again to a maximum value of 146.75 daN/mm^2, at a total deformation of the bimetallic strip of 80%.

The obtained test results, dependence of hardness (HV) from the annealing temperature are shown in Table 2 and the diagram in Figure 3.

Table2. Dependence of the hardness of bimetallic strip layers on the annealing temperature

t(°C)	HV (daN/mm^2)	
	Al	Cu
200	42.30	137.00
250	40.12	130.50
300	28.86	63.52
400	25.57	55.72

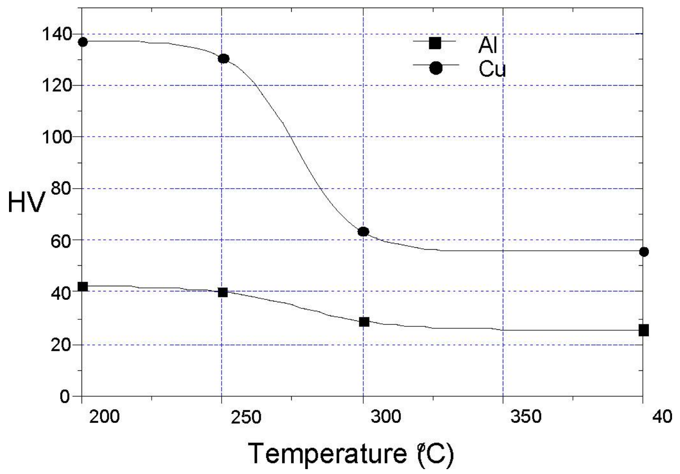

Figure 3. Diagram of the dependence of the hardness of the bimetallic strip layers on the annealing temperature

A decrease in hardness is observed with an increase in the annealing temperature, both in the aluminum layer and in the copper layer.

The hardness decreases slightly to T = 250 °C, and then decreases sharply in both layers in the temperature range of 250 - 300 °C, when recrystallization of both layers occurs.

Further increase of the annealing temperature, up to 400 °C, does not significantly affect the reduction of the hardness values of the layers.

4. CONCLUSION

The maximum hardness values characterize the samples obtained with the maximum single reductions.

Global flow of curves hardness - total deformation, increases, where the hardness curve for aluminum is approximately linear and is always lower than the hardness curve for copper, whose flow can be divided into three parts.

As the annealing temperature of the cold deformed bimetal strip (ε = 80%) increases, the hardness decreases in both the aluminum layer and the copper layer, slightly up to 250°C, and then sharply in the interval from 250 °C to 300 °C, when both layers recrystallize.

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REFERENCES

[1] Grinberg. B. G., Knišev Y. B., Mnogoslojnijemetally v tehnike, Znanije, Moskva 1969.
[2] Vaccori J. A., The Manu Roles of clad Metals Design Engineering, January (1980) 55.
[3] Wright J. C., New Materials For sheet Metal working – Part 3. Sheet Metalindustries, March (1976) 126.
[4] Kubeta A., Present and Future of Explosive Clading, Chemical Economy and Engineering Review, 7, dec. (1975) 1.
[5] Konon A., Redorov V. H., Pervulin L. B., Bikov A. A., Korrozionostojkij bimetal – Mašinostroenie, Moskva, (1984)