DIFFUSION WELDING OF METALCERAMIC ALLOY TO STEEL

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The investigations are carried out on welded joints of metalceramic alloy to structural steel of ferritic-pearlitic grade.The welding is made with an intermediate nickel layer.The maximum temperature, holding time and pressure are used for controllable variable technological parameters.The main part of the investigations is directed to determination of the influence of holding time on the connection quality.The analyses of the weld microstructure as well as the micro X-ray spectral analysis allow an explanation about the change in the weld properties to be given and rational solutions to be recomended.

INTRODUCTION

The introduction of thermomechanical energy is required for the activation of joining surfaces in diffusion welding. Welding conditions are regulated through pressure (P), temperature (T), temperature holding time (t). Those parameters are very important for the structure and mechanical characteristics of the joint region.

EXPERIMENTAL PROCEDURE

As a result of the experiments carried out in advance, some suitable values of pressure and temperature have been determined. Therefore, the objective of the present work is to study the influence of holding time(t) in vacuum diffusion welding of WC-Co20 cermet alloy to steel (St45). The weldability is determined by the processes which form the structure spectrum in the transition zone and by the field of internal thermal and structural stresses. Weldability improvement is achieved by the use of

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intermediate layer. In this case, the layer represents 0.05mm thick nickel foil. Due to its high plasticity nickel assists in : the reducing of the gradient of internal stresses, caused by the difference between the thermal expansion coefficients of the two materials; the increasing of the active contact surface in the region of joining; the activating the diffusion processes. Very important is the fact that nickel is completely soluble both in iron and cobalt at the welding temperature used.

Specimen welding has been carried out under laboratory conditions by means of vacuum diffusion welding machine under vacuum not less than 10^{-5} Torr. Parameters values are shown in Table 1.

TABLE 1 - Parameters values of diffusion welding conditions, and size of the mass transfer regions.

Specimen N	Holding time t,s	Pressure P,MPa	Temperature T,K	Size of mass transfer regions	
				Fe - Ni,mm	Ni - Co,mm
1	300	10	1330	0.020	0.030
2	600	10	1330	0.028	0.040
3	900	10	1330	0.044	0.052

EXPERIMENTAL RESULTS AND DISCISSION

The results of the mechanical tensile tests (Fig.1) of specimens welded with different holding times show that tensile strenght decreases with holding time increased and fracture area „shifts". When t=300s fracturing occurs through the intermediate layer and very litlle part through the hard alloy; when t=600s fracturing is almost fully through the hard alloy, and when t=900s it is observed only through the hard alloy.

X-ray microanalysis has been carried out of weld joint sections for defining the regions of Fe-Ni and Ni-Co diffusion mass transfer. With different holding times the following processes have been observed and they can serve as an explanation of the fracture line „shifting":

1. Fe-Ni mass transfer region increases with holding time (Fig.3). Wedge-like expansion of the initial grain boundaries in the austenite has been observed at the steel side. Iron diffusion into nickel layer reduces steel plasticity and considerably increases steel strength; nickel layer relaxation capability is reduced.

2. As a result of nickel diffusion into hard alloy matrix a substitution of nickel for cobalt has been observed together with the formation of Ni-Co solid solution (Fig.2). The decrease of cobalt concentration leads to strength reduction in the mass transfer region belonging to the hard alloy. When holding time is above 600s intensive solving of the tungsten carbide grains has been observed in the region adjacent to nickel layer. Tungsten carbide grains visibly become round and smaller. Substitution of nickel for cobalt as a bonding element in the hard alloy and partial solving of tungsten carbide leads to microhardness decrease in the transition zone (1).

When comparing the nickel-steel and nickel-hard alloy zones of diffusion mass transfer it has been established that nickel diffusion in the hard alloy is more intensive. This is caused by the more active mass exchange between nickel and cobalt.

No „non-alloying", inclusions and other defects have been observed in the contact zone of the diffusion welded joints.

Figure 1 shows the residual deformation in the steel portion of the specimens. Holding time increase leads to increase of the barrel-shaped zone of the specimens and residual deformation increase.

Obtained data allow to reach the conclusion that runing diffusion processes have a significant effect on the composition, structure and strength of the dilution zone in weld joints. Strength parameters optimization can be achieved by regulating the nickel diffusion level through rational control of the introduced thermal energy, which is the subject of subsequent investigations.

SYMBOLS USED

T = temperature (K)
P = pressure (MPa)
t = holding time (s)
Rm = tensile strength (MPa)
Δ = residual deformation (%)

REFERENCES

(1) Kazakov N. F. at al., „Study on Hard Alloy-Steel Diffusion Welded Joints of Bimetallic Components in Dies", Diffusion Welded Joints in Vacuum , Collection of Scientific Reports, No6, Moscow, 1973 (in Russian).

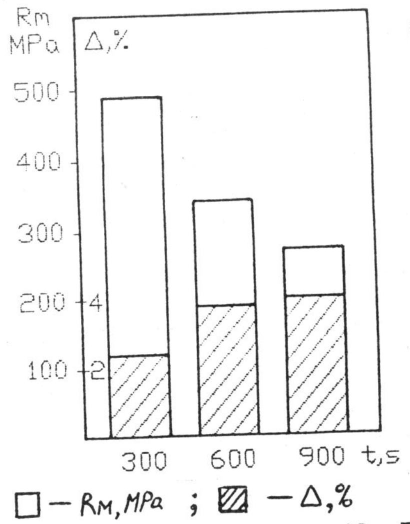

Fig.1 Weld specimen tensile strength and deformation

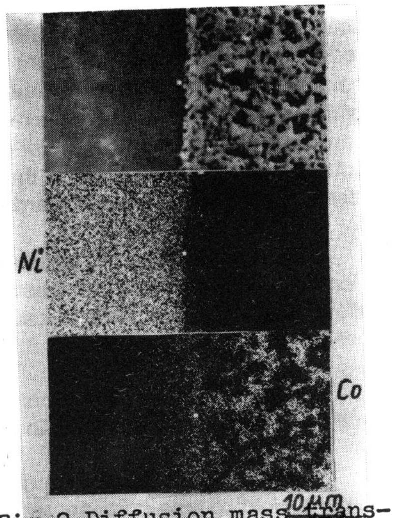

Fig.2 Diffusion mass trans-fer zone, nikel-hard alloy

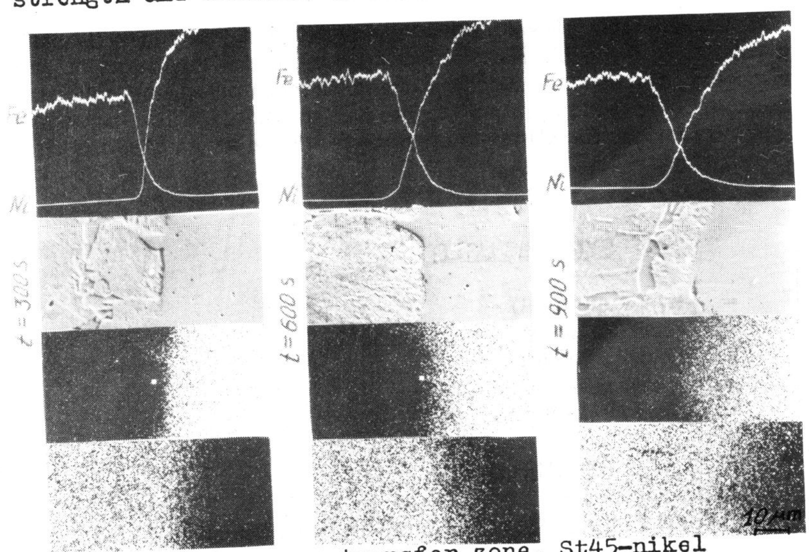

Fig.3 Diffusion mass transfer zone, St45-nikel