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JOINING OF CARBON FIBRE - COPPER COMPOSITE TO METALS

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Fibre reinforced composites belongs to the group of composites with programmable properties, which are meant to be the most attractive kind of advanced materials. Carbon fibre-copper composites are used e.g. for electric contacts, dilatation bases for power semiconductive elements and also for brazes with enhanced mechanical strength.
The important problem is joining of these composites to metal-technical alloys.
This paper contains the results of investigations on bonding carbon fibre-copper to molybdenum and carbon fibre-Ag-Cu alloy to FeNi42 alloy.
The presented paper includes the results of structural investigations (microstructure, linear elements distributions and X-ray diffraction patterns).

INTRODUCTION

Fibre-reinforced composites belong to the group of materials of programmable properties, the ones considered most promising among advanced materials.

One of this group is a composite carbon fibre-copper matrix. This type of composite manifests a number of advantages originating from the properties of the component materials - like thermal and electric conductivity,

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which make it suitable for e.g. resistance welding electrodes, electric contacts or dilatation bases in semiconductor power elements. In order to make full use of the advantages, of this material, it is necessary to join it to ceramics and to metals and alloys used in engineering. The technology of joining should be selected to ensure that a interface formed during bonding will be of an appropriate structure - to secure good mechanical properties and resistance to thermal shocks [1].

This paper presents the results of research concerning bonding of the carbon fibre-copper composite to molybdenum and to FeNi42 alloy. The two materials have been selected in view of potential future application of the resulting joints in electronic industry, namely for power diodes and thyristors (joints involving Mo) and for electric contact pieces (joints involving Fe-Ni42).

EXPERIMENTAL PROCEDURE

Materials

The following materials were used in the experiments:

- volumetric composite, carbon fibre (uncoated)-copper matrix,
- volumetric composite, carbon fibre 1μm copper coated-copper matrix,
- volumetric composite, carbon fibre 1μm nickel coated-copper matrix,
- laminar composite of uncoated carbon fibre-AgCuInTi alloy containing 15% (volume) fibres,
- laminar composite as above, but containing 25% fibres by volume,
- laminar composite: 1μm Ni coated carbon fibre-AgCuInTi alloy with 20% volume content of fibres,
- molybdenym,
- FeNi42 alloy.

Carbon fibres SAFD67/a 12000 WW2, produced by the Institute of Carbon Fibres were employed in those composites. Table 1 below lists their basic properties. The fibres were 1-2mm long.

Table 1. Properties of carbon fibres.

Nominal quantity	12 000
Filament cross-section	circular
Filament diameter	7μm
Breaking strength	3,6GPa
Young modulus	215GPa
Elongation	1,67%
Density	1,73g/cm^3

The AgCuInTi alloy was of the following composition (by weight): 72.5% Ag, 19.5% Cu, 5% In, 3% Ti. The volumetric composites were produced by volumetric bonding, under the following conditions: temperature about 1000°C, time 30min., pressure about 60MPa, vacuum 2.66x10^{-4}Pa [2,3].

The laminar composites were produced using infiltration method and the following conditions, approximately: temperature 870°C, time 15min., pressure 0.6MPa, vacuum 2.66x10^{-4}Pa [3].

The pieces of all materials tested for bonding - composites, molybdenym and FeNi42, were of the shape of pills 10mm in diameter and 8mm thick.

Bonding of composites to Mo and FeNi42

The joints were made using diffusion bonding method, in a diffusion bonding instrument. In bonding of volumetric composites: carbon fibre-copper to Mo, the following process parameters were used: temperature 950°C, time 30min, pressure 50MPa, vacuum 2.66x10^{-4}Pa.

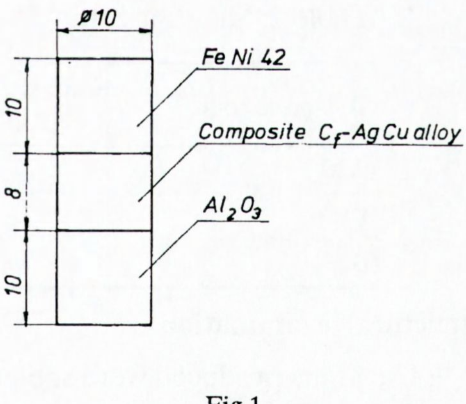

Fig.1
Scheme of the joint.

The laminar composites carbon fibre - AgCuInTi alloy were bonded to FeNi42 alloy and to Al_2O_3 ceramics using: temperature 850°C, pressure 0.6MPa, time 5min and vacuum 2.66x10^{-4}Pa.

RESULTS AND DISCUSSION

The joints produced were tested to determine their mechanical strength and examined for structural properties.

Mechanical strength tests

The strength of the laminar composite: carbon fibre-AgCuInTi alloy was determined by shearing strength testing. The test pieces used were of dimensions according to Fig.1, while the load application scheme was as shown in Fig.2

The results have been given in Table 2.

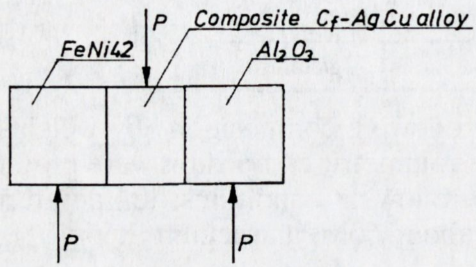

Fig.2
Load application scheme
in shear strength testing.

Table 2. Shearing Strength of Joints.

Test-piece code	Carbon fibre content by volume	Shearing strength of joint [MPa]
A20	20	80
B15	15	56
B25	25	68

Structural examination

The joints produced were subjected to examination including microscopy, RXA and the electronic probe in order to determine the linear distribution of elements.

The microstructure of a typical joint of the carbon fibre - AgCu alloy composite and FeNi42 alloy is shown in Fig.3. The X-ray diffraction patterns were recorded using a Phillips PW-1840 X-ray diffractor equipped with a solid state detector and an APD 1877 automated computer identification system. X-ray diffraction patterns were recorded in the range 20 from 3-60°, using filtered K_α radiation, a tube voltage of 40kV, filament current of 45mA and time constant of 1s.

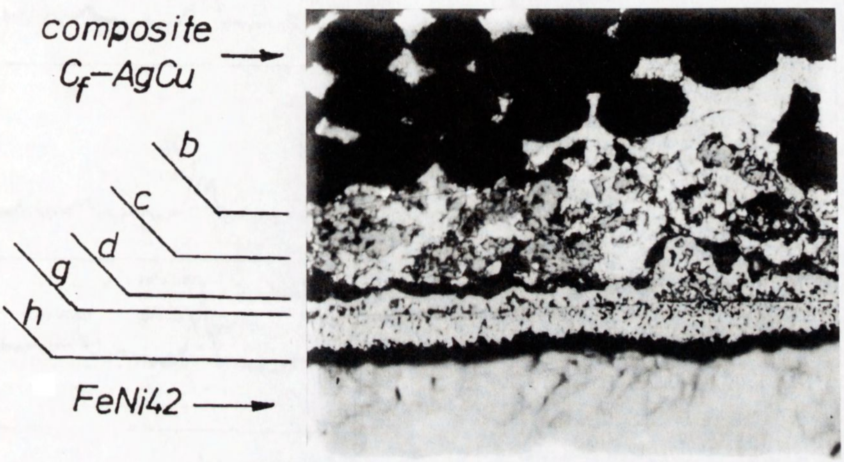

Fig.3
Microstructure of a typical joint. 1000x. See Fig.4 and 5.

The RXA examination was performed on the joint: uncoated carbon fibre-AgCuInTi alloy composite to FeNi42 alloy. A scheme of a test-piece cross-section, including the planes (b,c,d,g,h) in which the X-ray diffraction patterns were taken, is shown in Fig.4.

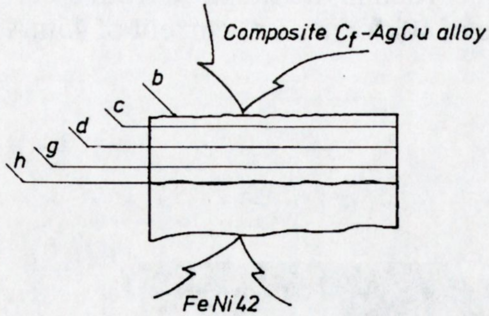

Fig.4
A scheme of a test-piece cross-section, including the planes (b,c,d,g,h) in which the X-ray diffraction patterns.

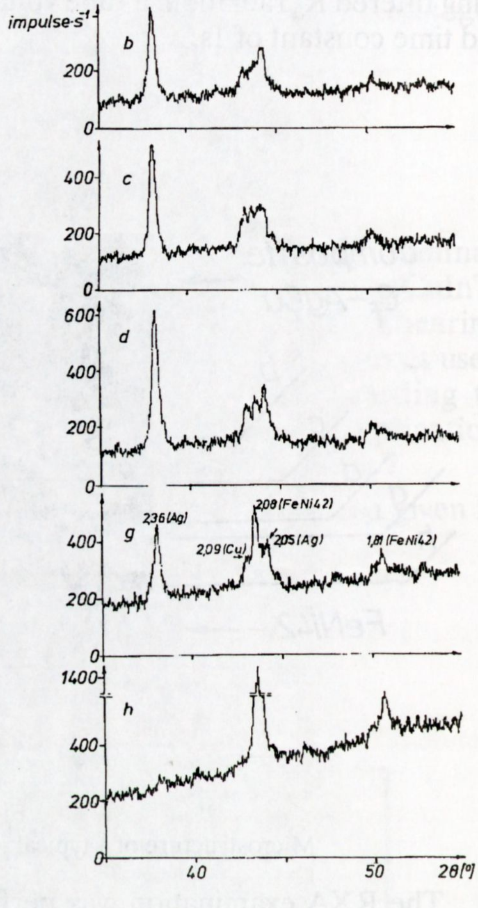

Fig.5
X-ray diffractometer of test-piece B25.

Fig.5 illustrates the diffraction patterns of test-piece B25. The diffraction lines visible are due to the composite component materials (AgCu) and FeNi42 alloy. The values od d corresponding to the peaks of the pattern are given in A°.

The scanning electron microscopy, together with electron microprobe analysis, allowed to reveal the distribution of elements in the joints.

The graphs of the linear distribution of elements in the joint are presented in Fig.6.

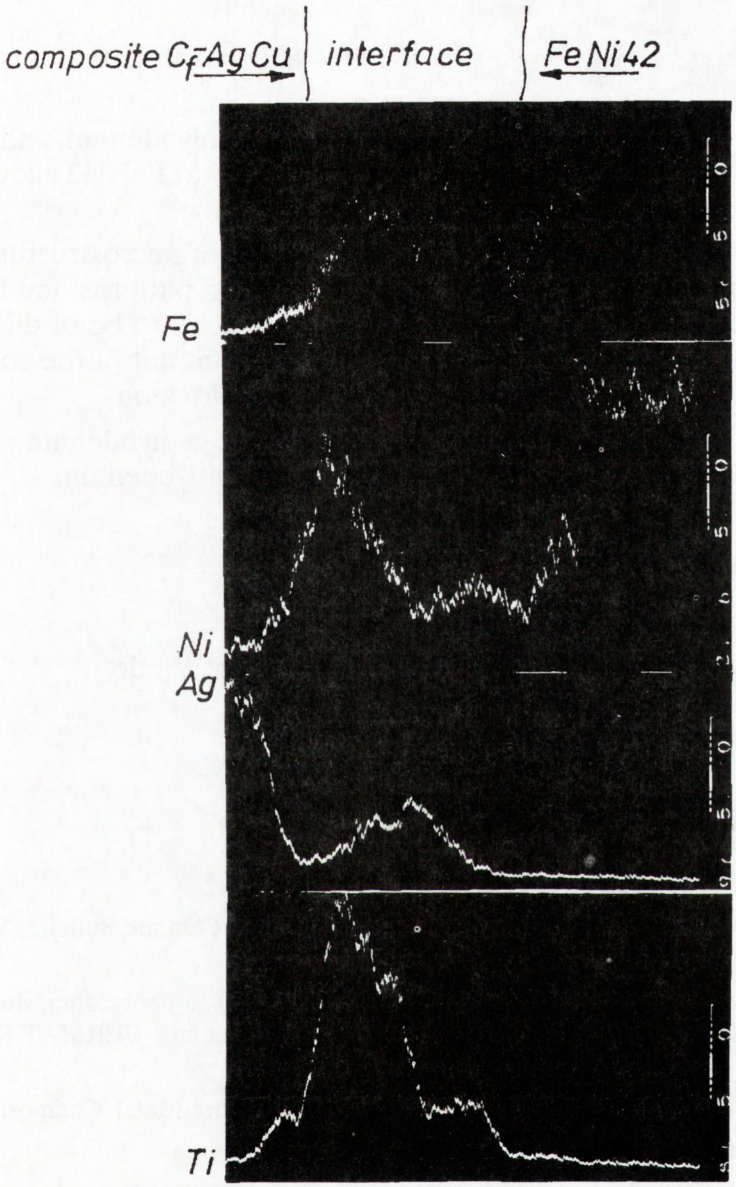

Fig.6.
Linear distribution of elements in the C_f-AgCu composite to FeNi42 joint (5000x).

CONCLUSIONS

The experiments already completed allow to state that it is possible to produce the joints:

- of carbon fibre-copper composites to molybdenum, and
- of composites: carbon fibre+AgCu alloy to FeNi42 alloy, displaying good strength properties.

As may be inferred from the examination of microstructure, of linear distribution of elements and of X-ray diffraction patterns, the bond of the composite C_f+AgCu alloy to molybdenum is likely to be of diffusion type, and it results from diffusion of silver and titanium out of the composite, as well as from diffusion of Fe and Ni in opposite direction.

In case of the composite C_f-Cu bonding to molybdenum - the joint is formed mainly as an effect of Ni diffusion into molybdenum.

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