STRUCTURE AND PROPERTIES OF WELDED ALUMINUM—COPPER JOINTS

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It is of practical interest to obtain efficient Al—Cu-joints, for example pipe-lines in a refrigeration unit, made by fusion butt welding and friction welding. With fusion welding a liquid phase forms which is squeezed out during upsetting of the contact zone.

With friction welding there is no liquid phase and friction forces provide thermal activation of the surfaces being joined.

The structure and properties of Al—Cu-joints made by thermomechancial and mechanical welding have been studied. Fusion butt welding and friction welding was performed on pipe 8 mm in diameter with a wall thickness of 1.5 mm made of copper M2 and aluminum AD1.

In Fig. 1a, b the transition zone of joints is presented. With fusion welding its width h = 20-25 μm (average microhardness value 82 H), and with friction welding h = 10-14 μm (68 H).

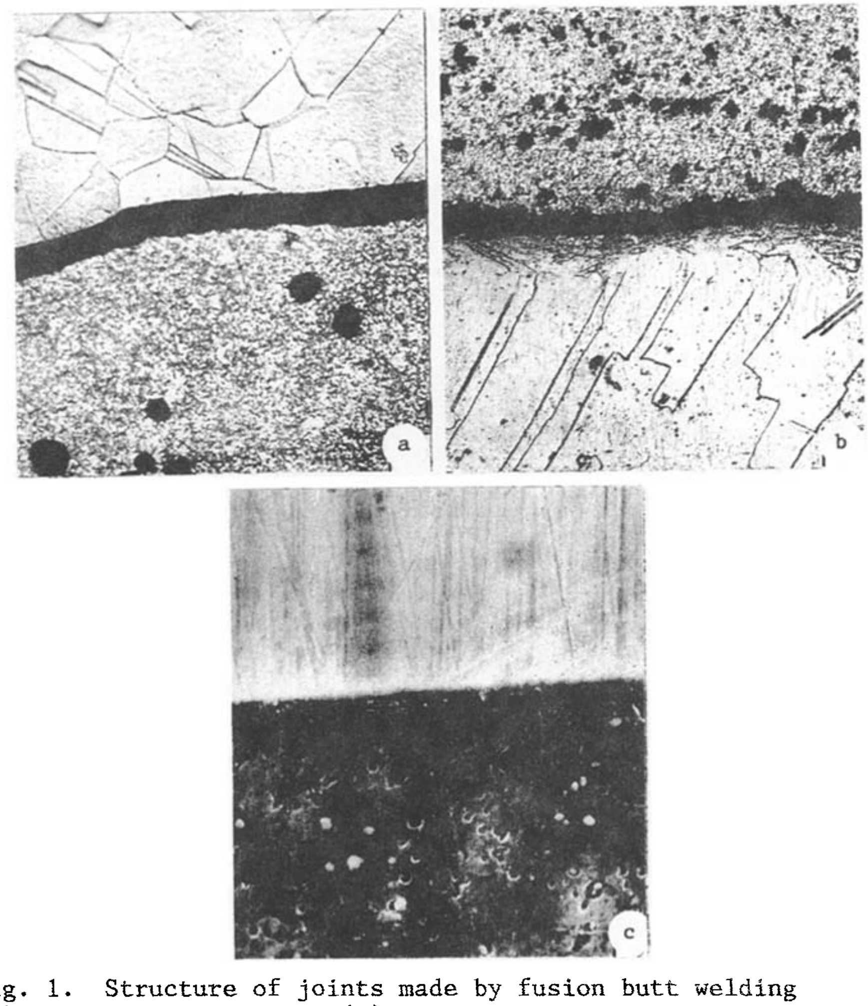

Fig. 1. Structure of joints made by fusion butt welding (a) and friction welding (b), and also the structure of the transition zone of a joint prepared by fusion welding (c): a, b) ×500; c) ×3680.

ZIL Factory Higher Technical School. ZIL Production Association. Translated from Metallovedenie i Termicheskaya Obrabotka Metallov, No. 12, pp. 34, December, 1990.

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Results of microhardness measurements (measured in a PMT-3 instrument with a load of 0.1 N each 5 μm) showed that in the transition zone of all of the test welded joints there are no coarse primary crystals of θ-phase which have a microhardness of 45-56 H [1].

In the transition zone of a joint prepared by fusion butt welding a eutectic probably forms which is indicated by the microhardness of this zone (82 H) close to the microhardness of the aluminum—copper eutectic (80 H) [1]. The presence of a eutectic in the structure of the transition zone is confirmed by the results of studies in a scanning microscope (Fig. 1c). Apparently fine round inclusions of the eutectic correspond to θ-phase. X-ray microanalysis established that in this zone a hypereutectic alloy forms (in atomic fractions) 9.3% Cu and 89.8% Al.

Presence in the transition zone of a solid solution of copper in aluminum and θ-phase in the eutectic is also confirmed by the x-ray structural analysis data given below.

d, nm	I
0,4280/0,2080	0,12/0,94
0,2080/0,1409	1,0/0,13
0,1409/0,1357	0,14/0,21
0,1357/0,1288	0,5/0,34
0,1204/0,1221	0 5/0,57

Note: The numerator gives data for specimens after fusion welding, and the denominator those after friction welding.

The microhardness of the transition zone of a joint made by friction welding is 68 H, which is typical for solid solution of copper in aluminum. From x-ray analysis data its chemical composition is as follows (in atomic fractions): 2.2% Cu and 96.7% Al. According to the results of x-ray structural analysis the transition zone contains a small amount of secondary θ-phase.

Results of the studies showed that with fusion butt welding the joint forms as a result of developing a readily melting hypereutectic alloy. It is possible to consider it as a solder which provides a joint.

In friction welding the welded joint forms without developing a liquid phase by a diffusion mechanism caused by thermal activation of the surfaces in contact by friction forces. Here a narrow transition zone forms in which a solid solution of copper in aluminum predominates.

Mechanical tests of welded specimens in tension showed that failure occurs through the basic metal, i.e., aluminum; σ_f = 58 N/mm^2, which corresponds to the ultimate breaking strength for aluminum AD1 and it confirms the absence of brittle θ-phase in the welded joint.

Conclusions

1. Formation of a Al—Cu-joint structure made by butting contact fusion welding occurs by a soldering mechanism, i.e., welding with development in the joint of hypereutectic alloy.

2. The structure of the transition zone of joints made by friction welding consists of a solid solution of copper in aluminum with a very small amount (∿1.5%) of θ-phase which provides quite high strength properties for these joints.

LITERATURE CITED

1. A. E. Vol, Structure and Properties of Binary Metal Systems, Vol. 1 [in Russian], Fizmatgiz, Moscow (1959).