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Improvement of Fatigue Resistance of Tubular Welded Connections by Ultrasonic Peening

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ABSTRACT

The welded structures of tubular cross-section elements have a lower fatigue resistance of the nodes, which makes necessary an unjustified increase in the weight of the constructions and items in order to ensure the required service life. The use of additional strengthening treatments of the welded joints is one of the ways of improving the fatigue life of the welded structures. This paper describes an efficient method of improvement of the welded joint fatigue resistance by surface cold working applied by ultrasonic peening, which was developed over the last years. The effectiveness of ultrasonic peening is confirmed by the results of fatigue testing of both the welded joints and tubular welded connections. The high effectiveness of the proposed method of technological treatment of the welded joints and the good prospects for its application in structures are shown.

INTRODUCTION

The experience of tubular welded structures' service and numerous studies by Marshall (1984), Ingram and Satton (1979) and Marsh (1982) are convincing evidence of the fact that in the majority of cases the fatigue resistance of welded connections determines the fatigue life of the structure as a whole. Here, a certain contradiction is found between the selection of the optimal geometrical parameters of the elements' cross-sections, which permit the weight parameters of the structure to be lowered, and the strength of the node joints formed by them. Thus, it can be stated that improvement of the fatigue resistance of the welded connections allows reduction of the structures' weight or extension of their service life.

One of the ways of improving the cyclic fatigue life of tubular welded structures is the application of the additional strengthening treatments of welded joints and, first of all, of the joints in the connections. The known methods of improvement of welded joint fatigue resistance by Trufiakov (1973) and Mikheev (1981) are labour-consuming, not effective enough, or difficult to use for the tubular structure connections.

The efficient method of improvement of the fatigue resistance of the welded joints developed over the last years by Mikheev et al. (1984, 1986, 1990) has essential advantages over the known methods. The method is based on ultrasonic peening of the welded joint zones, in which fatigue crack initiation is found. Compared to the traditional surface cold working by a hammer or shot (Gurney, 1979; Kudryavtsev and Naumchenko, 1976), ultrasonic peening is characterized by a higher efficiency, greater depth of the cold-worked metal layer and, in a number of cases, lower power consumption. This method of welded joint treatment can be used both in the fabrication of structures in plants, and for building or servicing constructions if the welded joints are accessible. Improvement of the fatigue life of welded joints by ultrasonic peening is achieved by lowering the concentration of the working stresses in the welded joint zone, elimination of sharp transitions from the base metal to the welded joint and of the possible fine notches, formation of the compressive residual stresses favourable from the viewpoint of joint performance in the stress raiser zones, and strain hardening of the surface layer of metal.

EQUIPMENT AND TREATMENT FEATURES

The ultrasonic treatment of the welded joints with unremoved weld reinforcement and of the complex-shaped connections is performed using a compact hand tool (Statnikov, 1977) with a multi-element end effector (Fig. 1a). The tool includes a magnetostriction converter, a waveguide and a holder with striker-needles. The tool initiates the pulsed action on the surface being treated, and transmission of the ultrasonic converter oscillations to the item by the multi-striker end effector.

The magnetostriction converter, waveguide and holder with the

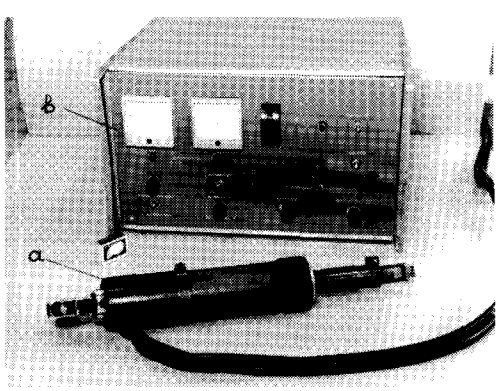

Fig. 1 Equipment for ultrasonic treatment of welded joints: a) hand tool; b) thyristor-generator unit

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