quality butt or lap welds, is used. For butt welding, the length of the pin is similar to the thickness of the work piece, so that the tool penetrates almost completely through the joint line.

The FSW tool consists of a profiled pin, which is contained in a shoulder of larger diameter than that of the pin. The pin for FSW experiments was given in Fig. 4. Subsequently, the pin depth, rotating speed and forward speed for pin which are the parameters for FSW were designed and FSW experiments were made.

The optimum parameters were designed according to literature studies and FSW pre-experiments.

3. Conclusion

The different research issues that can occur during friction welding of dissimilar materials were described in this paper. The structural effects during welding, mechanical properties of joints, and different configurations of the process in order to obtain high-quality welds were analyzed.

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Welding in Space Conditions

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Introduction to the history

The first idea of the necessity to work on welding and cutting in space was stated by S.P. Korolev in 1965. The main differences between the space environment and the earthly environment are a deep vacuum with virtually unlimited speed of gas diffusion from the welding zone, a wide range of temperatures at which the products are to be welded, and weightlessness. Moreover, there are a number of secondary factors: limited abilities of the astronaut-operator in the spacesuit, high safety requirements, etc. Undoubtedly, all these affect the quality of welding. The first welding experiments in space were held in October 16, 1969 on the spaceship “Soyuz-6” by G.S. Shonin and V.N. Kubasov using the installation “Volcano”. The installation enabled automatical arc welding, plasma and electron beam welding.

Objectives of welding in space

It is known that welding in space will be used for the following purposes:

a) repair of spaceships, space stations and various metal equipment which are in outer space, on the moon and other planets;

b) assembly and installation of steel structures that are in orbital flight or on the surface of the moon and other planets.

Arc welding

In arc welding in space, the electrode metal transfer process varies to the greatest extent. A drop grows to a large size, and then falls on the ground several times larger than the diameter of the electrode. It holds at the end of the electrode for a long time (for about 3 seconds). The increase of the drop size reduces the current density and the stability of the arc. It slightly improves the process of applying of the arc current pulses. The mechanical characteristics of the welding are high enough; they have no more defects than in terrestrial conditions.

Electron-beam welding

The best results were obtained with electron-beam welding. The power electron beam gun was carried out from the battery. DC voltage was converted to AC by the inverter. Then with the use of the transformer, the increases and rectifies. Instead of the magnetic focusing, the electrostatic is applied in the gun. It simplifies the design and reduces the weight of the installation.

Work undertaken

In the period from 1979 to 1984, the experiments in space were conducted on the thin-film deposition of metallic coatings on the samples of structural steels by thermal evaporation and condensation. The experiments were performed on such facilities as “evaporator”, equipped with two electron beam guns.

In total, nearly 100 samples were obtained with unique properties.

In July 14, 1984 the experiments on electron-beam welding with spacewalk were firstly carried out by the astronauts S.E. Savitskoy V.A. Dzhanibekovym. The welding machine URI (universal hand tool) was used during the experiments. It allowed welding, cutting, brazing, heating of the metal and coating. All these operations were carried out by a short electron beam gun which the astronaut held in his hand. The mass of the entire apparatus was about 30 kg, and the electron beam gun was 2.5 kg. The power of consumption was 750 Watts.

The samples were from welded steel and titanium. Due to weightlessness during the cutting, the molten metal was removed from the bad cut.

When it is heated, it is difficult to control the temperature around the metal, as discolorations of metal are formed in outer space.

The experiments were carried out on 20 different samples. They showed high reliability and availability of welding in space. Currently, a new device for welding in space “Universal” has been created.

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Fräser mit optimierter Geometrie für die luft- und Raumfahrt

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Hochwarmfeste Stähle, Titan, Composites oder Aluminium – Hersteller in der Luft- und Raumfahrt sind mit Werkstoffen konfrontiert, die in vielen Fällen selbst mit beschichteten