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Welding in Space

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In the late 50s of this century was born a new branch of human activity – astronautics. This was made known to the whole world the signals of the first Soviet satellite, thereby approving the leading role of our country in space exploration.

Space has delivered a wide range of tasks before and welders : it took radically revise and improve many processes, welding technology to create special light and heat-resistant alloys , develop and master the production of highly reliable automated welding equipment. And in the early 60s on the initiative of the chief designer of space-rocket systems Academician Sergei Korolev was given a brand new task - to explore the possibility of welding directly in space.

When conducting research suggests that welding in space will be used primarily for the following works: a) repair spaceships, space stations and different metal are in space flight or on the Moon and other planets; b) the assembly and installation of steel structures that are in orbital flight or on the surface of the moon and other planets.

It was necessary to develop the techniques and technology of welding works in a fundamentally new for the human environment - the space, the main differences are:

1) Weightlessness;

2) a high vacuum at a high pumping speed (diffusion) of gases and vapors ,

3) a wide range of temperatures at which it may be welded product (approximately 180 to 400 K).

Should take into account a number of additional adverse factors that have a negative impact on the quality of welded joints (extremely limited mobility operator in open space, the complexity of fixation and orientation, the presence of various types of radiation).

Getting the job done, first of all, had from the variety of existing welding methods to select the most promising with regard to the possibility of their use in such unusual circumstances At the same time guided by specific welding evaluation criteria (universality, technology, simplicity, ability to perform cutting), as well as the criteria adopted for space equipment (reliability, safety, low energy consumption, minimal weight and volume. In the early stages of research were selected following welding methods: electron beam, consumable electrode arc, plasma, contact, cold and diffusion.

In electron beam welding and cutting pressure beam and jet vapor pressure of a liquid metal tend to displace the tub from the melting zone. Therefore, it was important to determine whether the molten metal held in the weld or cut cavity at work in weightlessness. Experiments have shown that

the surface tension force in electron beam welding is sufficient to securely hold the metal and normal formation of a seam.

Considerable difficulties had to be overcome in welding compressed low-pressure arc consumable and non-consumable electrodes. It was necessary to develop reliable methods of plasma arc contraction under high vacuum at high pumping speed and techniques of active management and melting electrode metal transfer in weightlessness. The fact that the arc processes at low pressure associated with a significant defocusing of the arc and consequently, a sharp decrease in the penetrating power, and the electrode is melted in a weightless weld metal becomes a very large size droplets. Therefore, the researchers had to pay more attention to the development of specific methods and apparatus for focusing the arc and plasma in a vacuum, as well as finding ways to effectively manage melting and transfer of electrode metal.

On the basis of the research was designed and manufactured a special welding system "Volcano", the purpose of which is to test the possibility of using the above methods of welding in space. "Volcano" is a comprehensive, fully self-contained unit (Figure 1), which allows you to perform automatic electron beam welding and arc welding consumable and non-consumable electrodes.

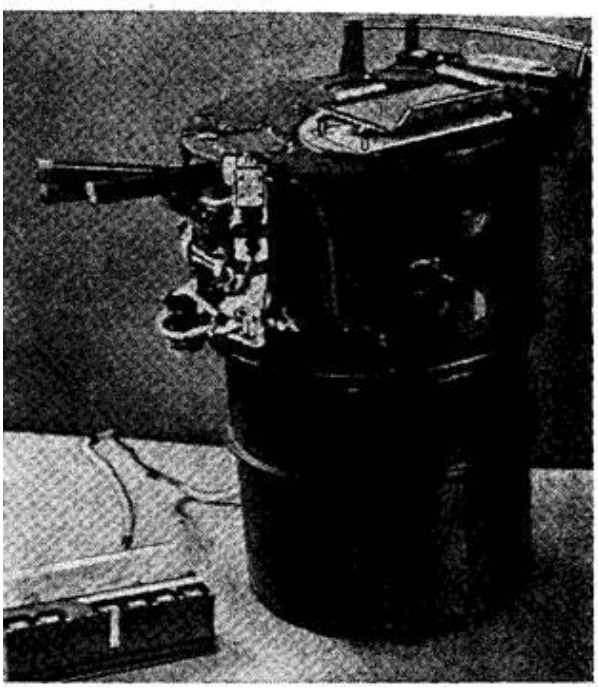

Figure 1 - Installing the "Volcano"

Compact welding device included in a complex installation "Volcano", showed sufficient reliability and performance in space. The principal decisions taken in the design of these devices proved to be correct and suitable for the construction of welding machines, designed for welding in space of particular products.

Thus, by the early 70s the question of whether the possibility of the automatic welding in space was resolved favorably. At the same time there was a large category of works, including almost all kinds of repairs that almost could not be performed using automated welding. It is therefore very urgent is the problem to study the possibility of the manual welding in space. And there were good reasons to fear that the astronaut operator, filled in a space suit under considerable overpressure, due to the extremely limited mobility will not be able to perform such a high quality professionally complicated process, such as welding. The task was further complicated by the need to ensure complete safety of the operator.

All of the above made in the initial stages to refuse to work in a space suit directly in a vacuum. Found a compromise solution. For research on manual welding in conditions as close to

space, E. O. Paton Electric Welding Institute in 1972 developed a special test stand 06-1469 (Figure 2).

Stand is a sealed working chamber volume of about 0.8 m3, the front wall of which was mounted a special fragment of a space suit. Between the fragment and the camera could generate the required pressure drop that best reproduces the real working conditions of the astronaut. Inside the working chamber housed tools and manual welding devices. Glazing mask suit was supplied with a set of replaceable filters that deal with heating sources of varying brightness. The most important advantage of the design of the stand is a reliable security operator Accidental release that provides a favorable psychological environment when working with high-temperature objects. Of great importance was also the possibility of free medical and biological monitoring of the operator and the convenience of a variety of ergonomic research.

It should be noted that during the 70's work on welding in space were carried out on a broad front. It was suggested that cosmic conditions, a number of promising new welding methods , such as heliowelding, explosion welding , exothermic welding and brazing , etc. This contributes to accelerated solution of problems faced by welders working in the field of space research.

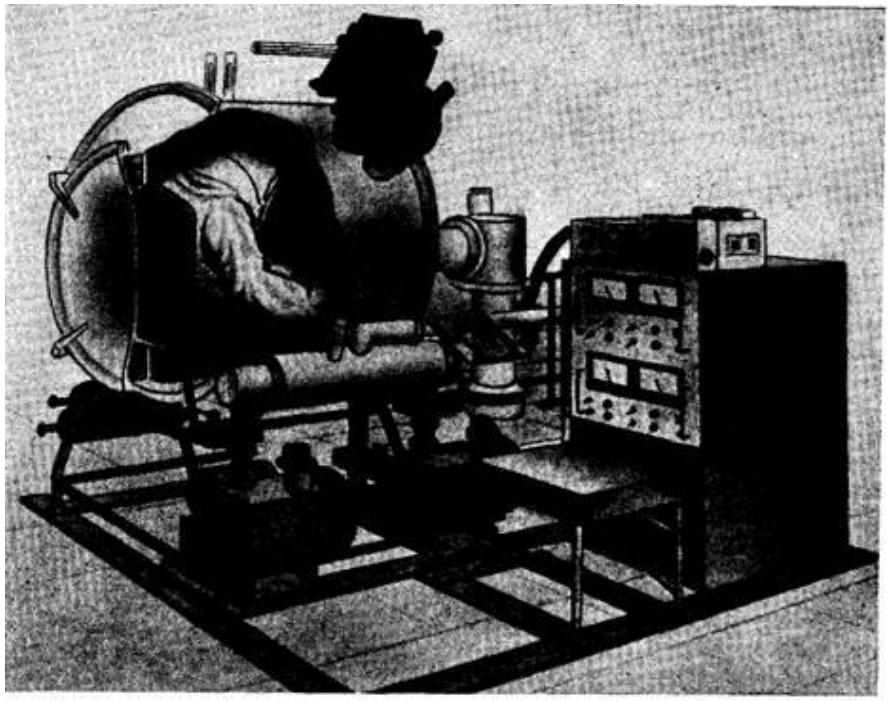

Figure 2 - Stand simulator for the study manual welding in simulated space

We note an important aspect of the research on welding in space: space environment designed for highly compact welding machines, such as electron beam welding or welding compressed low-pressure arc, are increasingly being used in industry in the world.

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