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Applications of a New Electron Beam Welding Technology in Vacuum Equipment Design

Nova tehnologija varjenja vakuumskih sistemov z elektronskim curkom

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When constructing vacuum and high vacuum systems and parts, we often encounter the task of joining materials with considerably different metallurgical properties, e.g., stainless steel-Al, stainless steel-Cu, Ti-Al. If the classical melting technique is used for welding, in most cases fragile intermetallic compounds arise and the quality of joints is often inadequate. Mechanically resistant and vacuum tight joints can be produced by electron beam heating so that only the material with the lower melting temperature is melted and in this melt the higher-melting-point material is partially dissolved. The contribution describes a novel form of a joint in construction of vacuum devices.

Key words: electron beam welding, novel form of joints, new technology of welding

Pri konstruiranju visokovakuumskih sistemov in sestavnih delov Cesto naletimo na problem spajanja materialov z različnimi fizikalnimi lastnostmi, kot n.pr. nerjavno jeklo - aluminij, nerjavno jeklo - baker, titan - aluminij. Pri uporabi klasične varilne metode s taljenjem v mnogih primerih dobimo krhke intermetalne zlitine in neprimerno kvaliteto zvarov. Mehansko odpornost in vakuumsko tesnost zvarov lahko dobimo z ogrevanjem z elektronskim curkom tako, da se stali samo material, ki ima nižjo temperaturo tališča, v talini pa je delno topljen material z višjo temperaturo tališča. Opisana je nova oblika spojev, nova tehnologija izdelave spojev in prikazana praktična uporaba spojev v konstrukcijah vakuumskih naprav.

Ključne besede: varjenje z elektronskim curkom, nove oblike zvarov, nova tehnologija spajanja

The weld joints of materials which have considerably different metallurgical properties, such as stainless steel-aluminium, titanium-aluminium, etc. made using the classical way of melting, during which both materials in liquid state mix, are of limited use, because in most cases fragile intermetallic compounds arise which decrease the strength . Efforts to influence the composition of the weld metal by deflecting the electron beam toward one of the welded materials*, when two independent beams[3] or the welding technique which makes use of an additional material in the form of a flake[4] are used, mostly do not prevent establishment of concentration conditions giving the rise of fragile phases. The prerequisite for the creation of vacuum-tight and mechanically strong joints of quite different metallic materials is the preparation of a weld metal in the form of a solid solution composed of components of both materials to be welded. This can be achieved by heating the parts to be joined so that the electron beam melts only the lower-melting-point material in which the higher-melting-point metal is partially dissolved and so a peripheral solid solution is produced. The precondition for the creation of the solid solution is the existence of a partial solid-state solubility region in the phase diagram, and of a sufficiently high difference in melting temperatures of both metals.

Using the mentioned method, we made welds of aluminium with copper, nickel, titanium, silver, stainless steel, and of stainless steel with copper, molybdenum and niobium. All joints of the mentioned combinations are vacuum-tight and mechanically resistant, even after repeated heating to a temperature of 400°C, followed by cooling that was carried out by immersing the joint into liquid nitrogen. So far, main attention has been paid to the welding of aluminium with titanium. These welds were investigated metallographically. Mechanical tests were made and the distribution of elements in the joint was determined[5,6].

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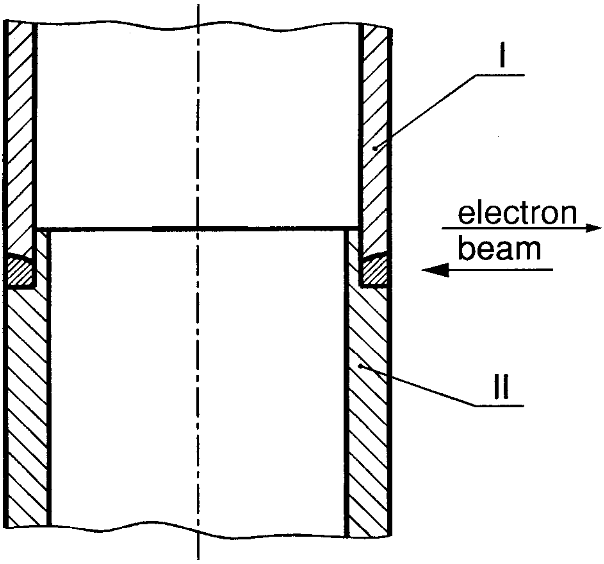

Figure 1: Constructional arrangement of the joint I- Lower-melting-point material, II- Higher-melting-point material

The described welding technology makes certain demands on the constructional arrangement of the joint. A suitable arrangement is shown in **Fig. 1.**

The steps of the welding technigue are as follows: (1) Both parts to be welded are rotated and, by using a defocused electron beam, they are heated in the region of the joint to a temperature close to the melting temperature of the lower-melting-point material. (2) Using the focused beam, the lower-melting-point material is melted so that it wets the other material which is in the solid state.

The following are examples of use of the joints in vacuum engineering. When constructing a zeolite sorption vacuum pump, we weld its body made of a ribbed aluminium sheet and neck of stainless steel. The use of an aluminium body leads to a decrease in time necessary for cooling the vacuum pump. The stainless steel - silver joint was used for the construction of an oxygen valve where a 0,5 mm thick silver tube of 12 mm in diameter was welded to a flange of stainless steel. The aluminium - stainless steel weld joints enable the use of copper-ring sealed flange connections (CF) of apparatus made of aluminium. In this case it is more appropriate to weld rings of aluminium and of stainless steel first and, after verifying the vacuum tightness of the joint (after multiple heating and cooling), to produce the less demanding joints aluminium - aluminium, and stainless steel - stainless steel.

The use of the weld joints of materials with considerably different properties can bring an improvement of properties of vacuum and ultrahigh vacuum equipment or some simplification in their construction.

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