Article ID: 1003－7837(2005)02,03－0297－02

Experience and perspectives of application of gasdynamic coatings in space technology

Bakhvalov Yu.O., Polovtsev V.A., Mikheev V.I.

(Khrunichev State Research and Production Space Center, Moscow, Russia)

The given work deals with the results of the research carried out by the "Salute" DB of the Khrunichev State research-and-production space center concerning the development of special equipment and improvement of the technique of the "cold" gasdynamic method of application of coating for the accomplishment of several specific tasks: (1) development of the technique of application of a fireproof heat-radiating coating to screens made from stainless steel with coefficient of thermal radiation $\varepsilon \geqslant 0.7$; (2) development of technique of sealing ("curing") of microleaks on the weld joints of the propellant tanks made of aluminum alloys; (3) study of the opportunity of sealing of joints of parts made from heterogeneous materials; (4) development of process for copper and nickel coating application for aluminium heat exchangers soldering.

Currently, a lot of various methods of applying the coating are developed and have both advantages and shortcomings due to their application fields. So, such known methods of applying the coating as gas plasma, plasma, electric arc, detonation and others use the high temperature two phase flows that leads the melting of applied powder particles and their interaction with the gas medium with generation of various combinations (oxides, nitrides, etc.) causing in specific cases the undesirable variation of the initial properties of powders and coating itself. The other essential shortcomings include the significant heating of parts and their deformation caused by the high residual voltages, insufficient adhesive strength of particles between each other and with backing, high porosity of coating, usage of explosive gases, complexity of equipment service, high cost of equipment, etc. Application of the "cold" super-speed spraying of coatings[1] permits us to eliminate the above shortcomings.

The gasdynamic method of coating application is a fairly new method and now its introduction to the production practice is begun, finding ever new fields of application. This method consists in application to the surface being treated of powders of metals or their mixtures with the ceramic materials, accelerated with the help of a superspeed gas stream which is created by feeding gas at a high pressure to the input of the convergent-divergent nozzle.

When a powder particle collides with the surface of the part its intrusion into the surface of the part being sprayed is begun. Thus, a layer is formed, which has the dense structure of strongly deformed particles introduced to the surface of the back and high adhesion with it.

In order to protect some spacecraft aggregates against the effect of the high temperature gas flows of the corrective engines, the thermal shields of the stainless steel with the heat-radiant coating are installed on the spacecraft. In this case the coating should have the high heat-emission coefficient ($\varepsilon \geqslant 0.7$) at the

Received date: 2005－09－26

temperature of about 1300K and have the strong adhesion with backing. More than 10 various types of coatings were manufactured and studied with the compositions based on powders Ti, TiN, TiC, SiC, ZrO, etc. The adhesive strength was monitored by the method of the specimen bending with applying the coating at 90° with the bending radius of 5mm and further unbending. The carried out experiments showed that the specimens with the coating of a mixture of powders ZrO_2 and SiC in ratio 1:1 have the greatest coefficient of thermal radiation of ($\varepsilon=0.7-0.78$).

The other important problem which has been solved with the help of the gasdynamic spraying is sealing of weld joints on aluminum propellant tanks of launch-vehicles and spacecrafts. During manufacture by welding of tight containers made from aluminum alloys, there arise from time to time the problems of repair of microleaks in the area of the weld joints, which until recently had been eliminated by backing. However, aluminum alloys and, in particular, alloys of system Al-Cu-Mn have low repair ability and allow no more than 2 backing cycles as each backing cycle involves considerable heat absorption which results in a change of structure and in the lowering of mechanical, corrosion and other properties of the material.

As a result of the carried out investigations the optimum width of the layer and the composition of the aluminum-based composite coating have been established, which safely seal microleaks. The coating has the rapture strength of 80 MPa, tearing adhesion −54 MPa, and shearing strength, not less than 52 MPa. The temperature of the back at the area of spraying did not rise above 373 K, which warranted the absence of change in the structure of the material.

The positive results of sealing the joints of the parts made from heterogeneous materials (steel-aluminum) make it possible to conclude that this method can find application in manufacture of bimetallic adapters necessary for joining by welding of pipelines from heterogeneous materials not welded together by traditional kinds of welding.

The process for the complicated picture application was tested on basis of copper and nickel for the aluminium heat exchangers soldering using the gas dynamic deposition by spraying. These heat exchangers are wildly used for the temperature stabilization and ensuring the normal operation of the special equipment to be installed in the articles working in space. The developed process differs by the simple and higher adhesion and cohesion strength (15−20 MPa) with base and lower labour-expenditures in comparison with the galvanic process.

As a summary it is necessary to note, that the techniques designed and introduced at the enterprise and the equipment for applying different coating by a method "cold" gasdynamic spraying have allowed to lower labor input by 2 to 3 times, reduce the cycle of repair of the propellant tanks by 3 to 4 times, increase quality and reliability of heat-radiating coating on the protective screens of space items, and also map out the paths of developing the new procedures of applying the anticorrosive coats based on the aluminum and zinc coatings for repairing the surface defects on pieces made of aluminium alloys as well as install the principle possibility of sealing the umbilical pipe joints of the dissimilar materials and map out the paths of developing the procedure and special small-size equipment for sealing the microleaks under the space conditions at the orbital stations like the "Mir" station[2].

References

[1] Alkhimov A.P., Kosarev V.F., Papirin A.N. Method of "cold" gasdynamic spraying. Paper/USSR Academy of Sciences, 1990, Volume 315, № 5, pages 1062−1065.

[2] Nedaivoda A.K., Bakhvalov Yu.O., Mikheev V.I., Polovtsev V.A. Composite coatings produced by "cold" gasdynamic spraying for space technology. Scientific and technical journal "Polyot" ("Flight"), № 11, 2002, pages 19−25.