Application of six-jet plasmatron in science and technology

F G Karikh, I M Arslanov
Kazan Federal University

Arslanov_IM@mail.ru

Abstract. The design and operation of the six-jet plasmatron are considered. Experiments using a six-jet electric arc plasmatron are described and their results are shown.

1. Introduction.
To get a low-temperature plasma, an electric-arc two-jet plasmatron is widely used at present as a source of excitation of the spectrum of solutions and powder materials, as well as for the thermal treatment of metals and alloys.

The disadvantage of using an electric arc two-jet plasmatron in spectroanalytics is unsuitable for monitoring the composition of gas streams and powders with a complex fractional composition.

2. The construction of a six-jet electric arc torch plasmatron.
This disadvantage is eliminated by using a six-jet plasmatron, assembled using three two-jet plasmatrons, powered from a three-phase current network [1]. It’s device shown in the plan in Fig. 1, where the plasma-forming copper heads 1 mounted on the dielectric plateaus 2 are rigidly attached to the arms 3 with the ability to move along the axes of the heads 1 in a direction perpendicular to the tubular posts 4. Above them, a tubular chamber 5 feeding into the argon heads protecting the electrodes from oxidation and the working gas (air) distribution chamber 6 by means of flexible hoses 7. The supply of protective gas to the copper anodes with contacts A1, A2, A3 and a tungsten cathode m with contacts K1, K2 and K3 is carried out by means of flexible hoses 8. Above the posts 4, the cooling water inlet chamber 9 and the water discharge chamber 10 are inserted into channel 19 in axial chambers 5 and 6. The cooling water inlet in the head section is made from the vertical channel 17 (Fig. 2, which shows a vertical section of the plasmatron along a plane passing through the axes of a pair of heads, powered from one of the phases of the three-phase rectifier used, in particular connected to an anode head with an electrode A2 with an auxiliary cathode VK2 and a cathode head with a cathode m K2 with auxiliary anode A2). Next to the annular chamber 9 is a water discharge chamber 10 in the duct 19. The connection of the chambers 9 and 10 to the head sections is carried out by means of flexible hoses 11 and 12. The water stream 19 heated by the operation of the plasmatron is directed to cool into the radiator (in Fig. 2, it is not shown) from which the cooled water returns to the channel 16. The posts 4 are located on the mounting table 20, between which is rigidly mounted a branch pipe 14 forming the analyzed gas flow or the processed powder material 15. A cylinder 13 is mounted axially to the nozzle 14, synchronous change in the angle of convergence of the six heads by means of a hinge system 21 providing a synchronous change in the angle of inclination of the heads with respect to the plane of the table 20. The system 21 comprises a plateau 22 with movable arms 3.
mounted on them, providing a change in the magnitude of the interelectrode gap between the plasmatron plasma-forming heads that are mounted on dielectric plateaus rigidly connected to brackets with the possibility of moving heads along their axes in a direction perpendicular ohm with respect to the tubular posts, above which an annular chamber for supplying argon to the plasma-forming heads is annularly disposed, a working gas distribution chamber and a water-cooling chamber connected to the heads by means of flexible hoses. Between the posts located on the mounting table, a stiff pipe is assembled to form the analyzed gas flow or the processed powder material and a cylinder providing the synchronism of the angle of convergence of the axes of the six heads by means of the system shown in Fig. 2, which comprises a plateau with movable brackets, providing a synchronous change in the magnitude of the interelectrode gap of each pair of plasma-forming heads.

![Diagram](image-url)

Fig.1

3. Application of a six-jet electric arc torch plasmatron in engineering and results

Production tests of the ability to control the smelting conditions in real time by the composition of waste gases carried out at the foundry of JSC "KamAZ" established that the application of the method [2] carried out in 28 batches on an electric arc furnace of the DSP-50 grade allowed:

- adjust the composition of the alloy in the process of its preparation by pre-washing the required components;
- reduce electricity consumption by 10% with a reduction in the consumption of electrodes by 3%;
- control the temperature of the liquid metal, both during the melting period and during the period of the furnace standstill;
- reduce metal losses associated with the fumes of remelting disperse waste by more than two times;
- reduce the time constant of the process of measuring the chemical composition of the alloy being prepared by an order of magnitude.

In the tests carried out using the method [3], the example of obtaining castings of aluminum alloys during the operation of the Dozamat-400 dispenser by monitoring the content of the modifier in the melt, reduced the marriage from 22% to 15%.
It should be noted that the methods of [2] and [3], like the whole work [4], were realized using a high-voltage flare discharge [5] and [6], which makes it possible to obtain spectral lines only with excitation energies less than 5 eV, without the possibility of determining the total. This meltdown is eliminated only by using an electric arc six-jet plasmatron. Considering the undesirability of a significant flow of argon in the operation of a six-jet plasmatron, a switch has been developed for the ratio of the flow rates of two gas streams, which makes it possible to reduce argon consumption by two orders of magnitude, allowing the possibility of its considerable consumption only during the launch phase.

4. Application of a six-jet electric arc torch plasmatron in science

It is interest to use a six-jet plasmatron in combination with other sources of excitation of the spectrum, for example, in the invention of patent RF No. 2303255 [7], the source of excitation of the spectrum in which is laser radiation. The joint application of a plasma torch and a laser is a scientific task. Now in science the question is raised on the possibility of diagnosing the state of human health. This task was carried out in the invention patent No. 2119768 [8]. However, its using is associated with using of labor-intensive and expensive chemical methods for analyzing hair composition. Elimination of these drawbacks was achieved using the method of laser atomic emission spectral analysis of hair [9] in combination with the use of a six-jet plasmatron, which allows reducing the cost of hair composition analysis by more than an order of magnitude compared with the method [8].

References
[1] Karikh F.G. and others. Electric arc six-jet plasmatron. Patent RF, No 2529740, BI, 2014. Byul. No. 27.
[2] Karikh FG, Mukhametyanova GF, Petrov DM Method of spectroanalytical control of the determination of the content of trace elements in gas flows with a hydrocarbon matrix. Patent
RF, No. 2229114, BI, 2004. Bul. No. 14.

[3] Karikh FG, Karikh AF Method for determining the composition of gas streams. Patent RF, No.2231776, BI, 2004. Bul. No. 18.

[4] Karikh F.G. Methodology for determining the physical and chemical parameters of melting metals on the basis of spectroanalytical data. // Thesis for a degree of Doctor of Technical Sciences. Chelyabinsk-2004, 310 with.

[5] Karikh FG Device for excitation of the gas flow spectrum. Patent RF, No. 2085871, BI, 1997. Bul. No. 21.

[6] Karikh F.G. Method of spectroanalytical determination of smoke composition. Patent RF, No. 2090857, BI, 1997. Bul. No. 26.

[7] Savilov S.V. and others. The laser atomic emission spectrometer "ЛАЭС". Patent RF, No.2303255, BI, 2007. Bul. No. 20.

[8] Chernozubov E.I. The method of diagnosing the state of human health. Patent RF, No. 2119768, BI, 1998, Bul. No. 14.

[9] Karikh F.G., Mukhametzyanova G.F. Method of laser atomic-emission spectral analysis of hair. Patent RF, No.2589960, BI. 2016, Bul. No. 19.