modeling of gas flow in the cylindrical channels of high-voltage ac plasma torches, taking into account the heating

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The physical characteristics of plasma torches depend on the arrangement of plasma gas supply and on the interaction nature of the gas flow with electric arcs. Therefore an attempt is made to simulate gas flow, which provides tangentially for the axial stabilization of the electric arc in the channel, taking into account the interaction with cylindrical channel’s area heated by electric arc. The single-phase two-channel and three-phase three-channel high-voltage AC plasma torches appear to be under investigations. These plasma torches have identical electrode sites, but different lengths of the channels and forms of the mixing chambers. The calculation area’s mesh was built for the simulation of plasma gas flow using GAMBIT software, the calculations of the gas flow were made using FLUENT software with Spalart-Allmares turbulence model; the gas (air’s) density was determined by equation of ideal gas, the viscosity, the specific heat capacity and the thermal conductivity was calculated by kinetic theory; the molar mass of the gas was constant, and degrees of freedom number was equal to 5. The mass flow of the plasma working gas was asked for various work modes of plasma torches at the temperature of 20ºC and at the normal atmospheric pressure in tangential feed’s inlet sections, united in one surface; the viscous conditions with the temperature of 20ºC were asked on the walls of investigated plasma torches and on the surfaces of electrode modules, the relevant materials, such as steel, copper and plastic were selected for the construction elements; heat flux and heat generation rate (the ratio of electric arc’s heat power to its surface area and to its volume respectively) were asked on the surfaces of electric arcs, burning in the cylindrical channels, in the mixing chambers and in the environment, where electric arcs meet and close each other; the return flows, the temperature of 20ºC and normal atmospheric pressure were asked on the surfaces of the environment, which were taken into account by the external mesh of GAMBIT software. Thus the air flow was simulated in the tangential feed’s areas, in the cylindrical channel, in the mixing chamber of plasma torches and in the environment, taking into account the heating by electric arc. The contours of gas velocities, such as velocity magnitude, tangential, radial and axial velocity components, and of gas temperature were built in the various sections on the longitudinal coordinate; mass-average values of these parameters were also calculated and their dependences on the longitudinal coordinate were built. It was revealed that the velocity magnitude takes the maximum value in the section of the channel, nearest to the tangential feed, in this case the major contribution is introduced by mass-average tangential component; but the minimum value of velocity magnitude of the working gas flow is observed in the output section of the channel, in this case the major contribution is introduced by mass-average axial component. The gas temperature is commensurable with the environment temperature inside the channel in the tangential feed’s area and in the electrode’s area, and the significant increase of gas temperature is observed in the channel during movement to output section of the channel. The gas is being cooled gradually in the mixing chamber, and the gas temperature decreases dramatically in the environment. The significant decrease of the mass-average velocity of gas flow is observed in the channels of both plasma torches during movement to exit and outside during movement from the mixing chambers. The values of gas velocity magnitude at the exit of mixing chambers of plasma torches, taking into account the heating by the electric arc, are 4-5 times higher, than the values calculated earlier for cold gas flow.