DC - Plasma Torches with Diverging Nozzles for Advanced Plasma Spraying

Rudolf H. Henne
DLR Stuttgart, Inst. of Technical Thermodynamics
Pfaffenwaldring 38 - 40, D - 70569 Stuttgart, Germany

Present standard DC - plasma torches for atmospheric plasma spraying have merely cylindrical anode nozzle contours and even in torches for vacuum application this contour is simply conically shaped in most cases. The resulting plasma jets show disadvantageous strong radial and longitudinal gradients of temperature and velocity together with heavy turbulences and cold gas entrainments especially with atmospheric operation which restricts detrimentally the plasma volume where favorable conditions for acceleration and melting of the powder particle exist. Supersonic plasma jets in vacuum surrounding are mostly characterized by shocks and Mach knots which are evidences of non-adapted nozzle lay-out and parameters and of non-optimum spray conditions.

To improve the quality of jet and spray process for vacuum and atmospheric applications special interior anode nozzle contours have been designed for subsonic and supersonic jets. Goal of this development is a controlled expansion of the plasma flow to get shock-free plasma jets resp. jets with softened gradients and diminished interaction with the surrounding cold gas, resulting in higher jet laminarity and extended volume of high temperature conditions.

Spectroscopy, enthalpy probe, LDA and other tools for investigation have shown already the improved conditions for plasma particle interaction and the superiority of such anode nozzles. Also, the application of such nozzles in spray experiments has demonstrated improved coating quality with respect to homogeneity and density and especially considerably increased deposition efficiency. With these new properties DC-plasma spraying becomes attractive for some new applications. Some of them are especially in the field of electrodes for electrochemistry. State of the art and results of recent activities fabricating of electrode layers for electrolysis and of multilayers for high temperature fuel cells applying such nozzles will be described.