

Simulation Study of Cooling Airflow Process Optimization in Internal Diameter Atmospheric Plasma Spray

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Abstract The weak heat dissipation capacity from narrow space in Internal Diameter Atmospheric Plasma Spray (ID-APS) causes significant heat accumulation from the plasma jet, affecting the spray gun safety and coatings performance. The mechanism of heat accumulation in ID-APS remains unclear, and cooling device design has not specifically addressed areas where heat accumulation is severe, requiring improvement in cooling process. The study uses numerical simulation to investigate the temperature and velocity fields during ID-APS within cylinders. The influence of radial and axial cooling airflow processes is analyzed through comparison. Upon impact on the internal wall, the plasma jet is confined by the curved substrate, enclosing the internal space and spray gun. The confined space significantly increases both the plasma jet and environment temperature. The heat accumulation is directly proportional to the spray time and inversely proportional to the heat dissipation capability of cylinders. The introduction of cooling airflow increases the heat dissipation capacity, effectively reducing the internal environment temperature. Radial cooling airflow on both sides of the plasma jet effectively hinders the fastest path of the jet along the wall surface, causing the jet to be deflected to either side, though excessive flow rates can significantly disturb the jet and affect the spray process. Axial cooling airflow introduced at the far end effectively prevents the spread of the jet and heat toward the spray gun. The extent of the impact on plasma jet depends on the flow rate and the position of airflow introduction. The application of radial and axial cooling airflows together can provide a double protection effect to ID-APS, but make the flow field more complex.

Keywords Internal diameter atmospheric plasma spray; Plasma jet simulation; Heat accumulation; Cooling airflow process