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(57) Abstract :
An intelligent wire arc additive manufacturing system (100) with adaptive energy input and in-situ diagnostics is described herein for scalable fabrication and repair of metallic components via layer by layer deposition. The system (100) includes: an arc-based deposition unit (10) operating at 80–350 A current and 15–35 V voltage for stable molten pool generation and uniform bead formation; a wire feed mechanism (20) supplying wire at 2–8 m/min to achieve 2–6 kg/h deposition rates with steels, aluminum alloys, titanium alloys, etc.; a motion control system (30) using multi axis robotic arm or CNC gantry at 200–800 mm/min torch speeds for adaptive toolpaths and high accuracy; a real time sensing network (40) monitoring arc voltage/current, interpass temperature (50–300 DEG C), bead width (3–8 mm), layer height (1–3 mm), heat input, and cooling rate; an adaptive control unit (50) with closed loop algorithms dynamically adjusting parameters to minimize porosity, residual stresses, distortion, and lack of fusion while ensuring consistent mechanical properties; a data communication module (60) for real time visualization, analytics, and predictive maintenance; and a power management unit (70) optimizing energy use.

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