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Extended adaptive control for electrical discharge machining

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Electrical discharge machining (EDM) has been used widely in industries over 8 decades because of its two remarkable advantages over conventional machining technologies: non-contact machining and machining conductive materials of any hardness. However, its essentially weak stability of machining restricts sustained machining in poor flushing conditions, especially in machining materials of high melting points like molybdenum-titanium-zirconium (TZM) alloy and the materials of low thermal conductivities like titanium and Inconel 718, etc. To solve this issue, some efforts of analyzing and disclosing EDM process dynamical properties had been paid. EDM process is, in fact, a non-stationary and nonlinear process with strong stochastic disturbances and the adaptive control theories seemed most likely fit for it. However, the first developed adaptive control system with minimum-variance control law, though the machining rate has been doubled, still had troubles in stabilizing EDM processes, especially in non-stationary stages. A new approach with minimum-variance and pole-placement coupled control law was studied and testified more feasible in dealing with machining in non-stationary stages. However, significant improvements had been achieved when two-step-ahead prediction control law was studied. Further explorations of EDM processes revealed that both of machining situation and machining state were changing all the time while in machining. If machining situation and machining state were considered simultaneously, more robust control systems for EDM would become possible. Thus, a new control system which was called an extended adaptive control system has been developed. In this system, there were two control variables working harmoniously in parallel to control the machining situation and the machining state respectively. This control system not only sustained fast and stable EDM, but also extended its efficient machining in machining molybdenum-titanium-zirconium (TZM) alloy, titanium alloy, and Inconel alloy, as well. More importantly, this new approach solved an issue once considered bottleneck constraint in 1991 that there existed coupling disturbances from one control variable to another in machining which has restricted the development of multivariable control systems for EDM.

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