Adaptive Multi-Objective Particle Swarm Optimization for Four-Objective Optimal Power Flow on IEEE 57-Bus and IEEE 30-Bus Systems

Mr. Dhavalbharti Goswami
Goa College Of Engineering, Goa University, Ponda Goa, India

Dr. Suneeta Raykar
Graduated, Goa College Of Engineering, Goa University, Ponda Goa, India

Dr. Anant Naik
Goa College Of Engineering, Goa University, Ponda Goa, India

Abstract:

The Optimal power flow problem consists of simultaneous optimisation of conflicting objectives i.e. fuel cost, emissions, transmission losses, and voltage stability. The constrained OPF literature suffers from a systematic issue of evaluator-verifier inconsistency where relaxed online feasibility criteria inflate the reported sizes of the Pareto set compared to strictly verified results, however, the bias has not been formally quantified. In this paper, we present Adaptive Multi-Objective Particle Swarm Optimisation (AMOPSO) to minimise all four objectives simultaneously using a voltage-only feasibility gate (εV = 0.003 p.u.) with identical plain Newton Raphson power flow at every evaluation stage. The algorithm uses dual-archive mechanism, adaptive parameters (w, c1, c2), crowding-distance archive management, stagnation-triggered diversity injection, 30% seeded initialisation about the base case operating point, and TOPSIS based compromise selection. This gap is directly quantified by sensitivity analysis: a relaxed gate (εV =0.010 p.u.) archives 100 solutions but only 50% survive strict post-run verification, while the proposed gate achieves 69%. The AMOPSO for 30 independent runs on IEEE 57-bus system (12 control variables) has 100% convergence, mean Hypervolume of 0.8131 (CV = 3.91%), and fuel cost CV of 3.75%. The TOPSIS compromise solution is 41,810.97 $/h, 4,836.18 kg/h, 8.91 MW, and L-index 5.9546, with all 57 bus voltages within [0.94, 1.06] p.u. On IEEE 30-bus (10 control variables), all 100 archived solutions are strictly verified in each run with mean HV of 1.1794 (CV = 0.60%) and fuel cost CV of 1.74%, confirming consistent verified Pareto fronts for various network scales.

Keywords:

Optimal power flow, multi-objective optimisation, particle swarm optimisation, pareto front, IEEE 57-bus.