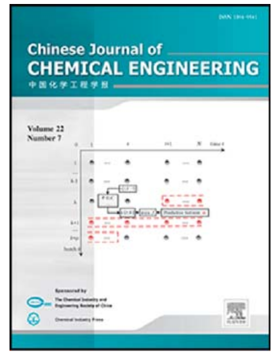

Solving Chemical Dynamic Optimization Problems with Ranking-Based Differential Evolution Algorithms

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Solving Chemical Dynamic Optimization Problems with Ranking-Based Differential Evolution Algorithms

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Abstract: Dynamic optimization problems (DOPs) described by differential equations are often encountered in chemical engineering. Deterministic techniques based on mathematic programming may become invalid sometimes when the models are non-differentiable or explicit mathematical descriptions do not exist. Recently, evolutionary algorithms are gaining popularity for DOPs as they can be used as robust alternatives when the deterministic techniques are invalid. In this article, a strategy named ranking-based mutation operator (RMO) is presented to enhance the performance of previous differential evolution (DE) algorithm to solve DOPs using control vector parameterization. In the RMO, better individuals have higher probabilities to produce offspring, which is helpful for the performance enhancement of DE algorithms for DOPs. Three DE-RMO algorithms are designed for constrained DOPs by incorporating the RMO. The three DE-RMO algorithms and their three original DE algorithms are applied to solve four constrained DOPs in literature. Experimental results indicate that DE-RMO algorithms exhibit better performance than previous non-ranking DE algorithms and other four evolutionary algorithms.

Keywords： Dynamic optimization; Differential evolution; Ranking-based mutation operator; Control vector parameterization

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1. Introduction

Dynamic optimization problems (DOPs) are often encountered in chemical engineering, as most industrial process models are time-dependent and described by differential equations. The solution of DOPs is usually very difficult because of their highly nonlinear and multidimensional nature, as well as the presence of constraints on state and control variables and implicit process discontinuities [1]. Given the profound importance of DOPs in industrial and engineering practices, developing efficient methods for DOPs has attracted great interest. Dynamic optimization methods can be roughly divided into three categories: dynamic programming (DP), indirect methods, and direct methods.

Classic DP method relies on Bellman's optimality [2]. DP is a successful method for solving DOPs, except for dimension curse. To overcome this drawback, Luus [3] proposed iterative dynamic programming method by use of coarse grid points and search region reduction strategies. However, its high computational cost for systems involving a large number of differential-algebraic equations has restricted its application to problems on a smaller scale [4].

With indirect methods, DOPs are solved by using Pontryagin's maximum principle [5]. It converts the original problem into a two-point boundary value problem, which rarely has an analytical solution and requires