Abstract

The field of batch chemical process has seen a significant rise in research over the last five decades as changes in the economic climate have lead to an increased demand for the manufacturing of high-value small-volume products. Due to the dependency on time, batch processes are considerably more complex than their continuous process counterparts. The predominant approach in batch process literature makes use of mathematical programming, whereby binary variables are utilised to indicate the assignment of certain tasks to capable units. This mathematical programming strategy, coupled with the aforementioned time complexity can lead to computational intractability due to the extended enumeration of binary variables. In this thesis, the reduction of computational time required in the solution of multipurpose batch plant scheduling is considered.

Due to the infeasible computational times required to solve mathematical programming models in multipurpose batch plant scheduling, often close-to-optimal solutions rather than global optimal solutions are accepted. If close-to-optimal solutions are acceptable then it is reasonable to explore non-deterministic metaheuristic strategies to reduce the required computational time. In order to apply these strategies, generalised frameworks consistent with metaheuristic approaches are necessary. Presently, no decoupled generalised framework suitable for various metaheuristic implementation exists in the literature.

As a result, this thesis presents two novel mathematical frameworks for the representation of batch scheduling. Specifically, one framework for discrete-time approaches and another framework for continuous-time approaches. In each framework, two well-known literature examples are considered. In addition, three metaheuristic techniques are applied to these literature examples, namely, genetic algorithms (GA), simulated annealing (SA) and migrating bird optimisation (MBO). The resultant framework allows for experimentation of 12 variants of the literature examples to be investigated, which can be compared to the currently accepted mixed integer linear programming (MILP) approach.

In the aforementioned experiment, simulated results with the metaheuristics implemented under the newly introduced frameworks showed a reduction in computational time of up to 99.96% in the discrete-time approach and 99.68% in the continuous-time approach. Additionally, the genetic algorithm showed to be the best performer of the metaheuristic suite, often obtaining the global optimum in short-time horizons and close-to-optimal solutions in the medium-to-long time horizons. Furthermore, parallel implementations were explored and showed additional time reduction would be possible, with certain workloads terminating 2 orders of magnitude less in computational time than serial implementations.