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Effective Methods for Integrated Process Planning and Scheduling

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Foreword

In the international academia and industry, scheduling theory and method of manufacturing system is an interdisciplinary research direction, involving systems engineering, operations research, artificial intelligence, control theory, computer technology, management engineering, and other disciplines. Process planning and shop scheduling are two highly important subsystems in the modern manufacturing system. Process planning decides the process route and processing resource allocation of the jobs, which can transform raw materials into finished form. Scheduling system is to arrange the jobs to the actual processing machines properly, linking the process designing and the production action. The integration of process planning and scheduling in the manufacturing procedure can optimize the production process, improving the efficiency and reducing the cost, which is a key to realize the intellectualization of manufacturing system. The contents in book mainly include the following problems, including flexible process planning problem, shop scheduling problem, integrated process planning scheduling problem, etc. These problems have a large amount of complexity, such as difficulty in modeling, complexity in calculation, multi-constraint, uncertainty, multi-minimal, large problem scale, multi-objective, coexistence of discrete and continuous variables, etc. Therefore, the research of IPPS has important academic and engineering value.

This book is a monograph about the effective methods for IPPS. Based on the research, teaching and engineering experience of the authors and their team for many years, the book mainly classifies in the following three aspects: flexible process planning, job shop scheduling, integrated process planning and shop scheduling. Furthermore, the book also summarizes Genetic Algorithm (GA), Genetic Programming (GP), Particle Swarm Optimization (PSO) algorithm, and other intelligent algorithms for solving the above problems. In addition, this book systematically describes the design thought of the intelligent algorithms, which may provide effective methods for the researchers to solve the practical engineering problems.

This book is divided into five parts, the first part is from Chaps. 1 to 3, which introduces the review of IPPS problem, including the models, methods, and applications. The second part mainly discusses the single-objective optimization of IPPS. The third part introduces IPPS from the aspect of multi-objective optimization. As

for the fourth part, it belongs to the dynamic scheduling problem. Finally, the fifth part is the IPPS simulation prototype system. In general, the main contents of the book are from the second part to the fourth part, where process planning, scheduling, and IPPS will be discussed in details.

The second part is the single-objective optimization, which is discussed in the order of Process Planning (PP), Job shop Scheduling (JSP), Flexible Job shop Scheduling (FJSP), Integrated Process Planning and shop Scheduling (IPPS). In Chaps. 4 and 5, GP algorithm and PSO algorithm are used to solve the PP problem. Chapter 6 introduces the application of hybrid PSO and Variable Neighborhood Search (VNS) algorithm on JSP. In Chap. 7, a modified GA is introduced to solve FJSP, including total new Global Selection (GS) and Local Selection (LS) to generate high-quality initial population in the initialization. Chapter 8 introduces a Multi-Swarm Collaborative Evolutionary Algorithm (MSCEA) to solve FJSP. In Chap. 9, the mathematical model of IPPS and the application of evolutionary algorithm are presented. In Chap. 10, an agent-based approach is applied to solve IPPS. Chapter 11 introduces the application of modified GA on IPPS.

The third part is multi-objective optimization, which is introduced from FJSP to IPPS. Chapter 12 is the application of GA and TS algorithm in multi-objective FJSP. Chapter 13 introduces PSO and TS algorithm to multi-objective FJSP. Chapter 14 presents a Multi-Objective Genetic Algorithm (MOGA) based on immune and entropy principle to solve the multi-objective FJSP. In Chap. 15, an effective genetic algorithm is proposed to optimize the multi-objective Integrated Process Planning and Scheduling (IPPS) problem with various flexibilities in process planning. The research in Chap. 16 focuses on the multi-objective IPPS problem, and a game theory based approach is used to deal with the multiple objectives.

The fourth part focuses on the dynamic scheduling problem from Chaps. 17 to 20. In Chaps. 17 and 18, a genetic tabu search algorithm is developed for dynamic rescheduling job shop problem, while Chap. 18 is considering multi-objectives. In Chap. 19, Dynamic Flexible Job shop Scheduling Problem (DFJSSP) with job release dates is studied, and an approach based on GEP also proposed. In Chap. 20, a new dynamic IPPS model is formulated, the combination of hybrid algorithm and rolling window technology is applied to solve the dynamic IPPS problem.

The fifth part, shown in Chap. 21, introduces a IPPS simulation prototype system which is developed based on the practical requirements of the work shop and theoretical research results. Firstly, the application background of the system is introduced, and then the structure of the system is analyzed. Finally, the implementation and operation of the prototype system are represented through an engineering example, verifying the availability and effectiveness of the prototype system.

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This book is written by Dr. Xinyu Li and Dr. Liang Gao, from State Key Laboratory of Digital Manufacturing Equipment and Technology, School of Mechanical Science and Engineering, Huazhong University of Science and Technology (HUST). In addition, postdoctoral Chunjiang Zhang, graduate students including Guangchen Wang, Yingli Li, Jin Xie, Qihao Liu, Di Fang, Haoran Li, Lin Gui, Yang Li, and other graduate students also participated in the relevant research work.

Due to the limited knowledge of the authors, the book will inevitably have some limitations and even errors. And many contents need to be improved and in-depth researched, so readers are requested to criticize and correct.

Wuhan, China

Xinyu Li
Liang Gao

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