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Integrated process planning and scheduling with minimizing total tardiness in multi-plants supply chain

Chiung Moon^{*}, Jongsoo Kim, Sun Hur

Department of Industrial Engineering, Hanyang University, Ansan 425-791, South Korea

Abstract

In this paper, we propose an integrated process planning and scheduling (IPPS) model for the multi-plant supply chain (MSC), which behaves like a single company through strong coordination and cooperation toward mutual goals. The IPPS problem is one of the most important issues for supporting the global objectives, because the function takes part in the assignment of factory resources to production tasks. The problem is formulated as a mathematical model considering alternative machines and sequences, sequence-dependent setup, and distinct due dates. The objective of the model is to decide the schedules for minimizing total tardiness through analysis of the alternative machine selection and the operation sequences in MSC. In order to obtain good approximate solutions, genetic algorithm-based heuristic approach is developed. Numerical experiments are carried out to demonstrate the efficiency of the proposed approach. © 2002 Elsevier Science Ltd. All rights reserved.

Keywords: Integrated process planning and scheduling; Supply chain; Traveling salesman problem; Genetic algorithm

1. Introduction

There exist many different types of supply chains, depending on the diversity and the complexity of the products, the logistics between multi-sites, and the degree of outsourcing. The multi-plants supply chain (MSC) is a type of those supply chains, which behaves like a single company through strong coordination and cooperation toward mutual goals. The MSC means extended integration beyond a single production site by means of stronger distribution management capabilities, electronic data interchange, and coordinated multiple plant management. The performance of a MSC is often determined by conflicting attributes of manufacturing and distribution, such as time, cost and capacity (Arntzen, Brown, Harrison, & Trafton, 1995). Its management goal is thus the minimization of inventory level and overall costs throughout the chain, while maximizing customer service performance for the

^{*} Corresponding author. Tel: +82-31-400-5268.

E-mail addresses: cumoon@hanyang.ac.kr (C. Moon), cumoon@hanmail.net (C. Moon).

customers and speeding up the manufacturing process. The integrated process planning and scheduling (IPPS) in a MSC is one of the most important issues for supporting the goals, because the function takes part in the assignment of factory resources to production tasks. Therefore, the IPPS should focus upon the following issues: (1) how to make a flexible process plan considering shop floor status and design information; (2) how to make an efficient dynamic schedules considering the job shop's dynamic situations and the complexity of the resource constraints; (3) how to make an appropriate integrated model, which includes various constraints.

In the traditional approaches, process planning and scheduling are done sequentially, where the process plan is determined before the actual scheduling is performed. But, this simple approach ignores the relationship between the scheduling and planning.

Some research works have been published for the IPPS on the flexible manufacturing environment. Tan (2000) presents a review of the research in the IPPS area and discusses the extent of applicability of various approaches. Hankins, Wysk, and Fox (1984) discuss the advantages of using alternative operations sequences to improve the productivity of the machine shop. They show that the efficient planning considering the alternative machines results in reduced lead-time and improved overall machine utilization. Nasr and Elsayed (1990) present two heuristics to determine an efficient schedule for the n jobs, m machines problem with alternative machine routings for each operation. Their objective is to minimize the mean flow time. Palmer (1996) and Sundaram and Fu (1988) solve the IPPS problem using a simulated annealing. Bandeimarte and Calderini (1995) develop a two-phase hierarchical tabu search. Saygin and Kilic (1999) propose a framework for IPPS with the objective of reducing the completion time. To solve the problem, a heuristic method is proposed. Morad and Zalzal (1999) develop a genetic algorithm (GA) based method to tackle a similar problem.

However, the major weakness of the models introduced so far lies in that they consider the alternative machines for each operation with a fixed sequence or with a non-constraint operational sequence, when constructing a schedule. Most models assume an infinite resource capacities on the shop floor, a common due date for all jobs, and idle plant when assigning resources to jobs. As a result, schedules based on the approaches may end up in an infeasible task, even before the start of manufacturing.

In this paper, we consider the IPPS problem with minimizing total tardiness for a MSC composed of a network of production facilities, and of multiple product flows through manufacturers. The problem is formulated as a mathematical model, which considers alternative machines and sequences, sequence-dependent setup, and distinct due dates. We assume that the alternative machines have different capabilities and require unequal processing time for an operation. The operations sequences for each job include precedence constraints. In order to obtain good approximate solutions for the problem described, we develop a GA-based heuristic approach.

2. Problem definition

A process plan should be able to represent all possible precedences, which occur during the planning and processing decisions. Homem de Mello and Sanderson (1990) used an AND/OR directed graph to represent the sequential and parallel structure of machining processes. An example to illustrate the technically feasible sequence of processes is shown in Fig. 1.

From an unordered set of machining processes with precedence relations, operations sequencing is to determine a sequence by exploiting a sequence space derived from the combination of parallel

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