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Optimized rescheduling of multiple production lines for flowshop production of reinforced precast concrete components

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ABSTRACT

Flowshop production is adopted as the major type of production of reinforced precast concrete components and it has higher requirements on shop floor schedules than other types, especially that from rescheduling. However, up to now, very few approach for the optimization of the shop floor rescheduling has been proposed in spite of its vital importance. This research proposes an approach for optimizing shop floor rescheduling of multiple production lines for flowshop production of reinforced precast concrete components. The approach comprehensively utilizes the over-assigned time, which is the difference value between the assigned production time and the estimated one of a production step for a precast component to deal with production emergencies. Meanwhile, it keeps the adjustment of schedules at minimum to avoid massive material re-dispatch. First of all, the optimization objectives and constraints of optimized shop floor rescheduling of multiple production lines for flowshop precast production are analyzed and a mathematic model is thus formulated. Then, the solver of the model is established by using genetic algorithm. Finally, the approach is validated by case studies. It is concluded that the approach contributes to the effective and efficient optimized rescheduling of multiple production lines for flowshop precast production.

1. Introduction

The adoption of reinforced precast concrete components (precast components for short hereafter) enables the application of advanced industrial production and management approaches in construction and thus enhances the construction quality and efficiency. In general, scheduling is crucial for the production of precast components (precast production for short hereafter), which consists of master production scheduling, material requirement planning and shop floor scheduling. Among them, shop floor scheduling is the most detailed and difficult one, in which production tasks are assigned to specific workshop sections, teams or even operators [6]. Moreover, flowshop production is adopted as the major type of precast production and it has higher requirements on shop floor schedules than other types, because its production steps are closely linked to each other.

Since shop floor schedules should be coordinated with the assembly ones of construction sites, precast production is sensitive to production emergencies that may result in delay in precast production process, such as resource shortage, machinery breakdown, rush orders, etc. Over-assigned time for each precast step is always included in the planned shop floor schedules for production emergencies. Namely, during scheduling, the required production time of each production steps is assigned slightly more than the estimated one in case of production delay [1].

The current operation procedure for the production emergency is shown in Fig. 1 [1,7,8]. First, the emergency information is collected by site supervisors. Then, the operators and site supervisors try to eliminate its negative influence by using the over-assigned time of the corresponding workstation and slightly adjusting the production schedule of the workstation. Third, if the order requirements can be fulfilled just by doing so, the procedure ends and precast components are produced according to the new schedule. Otherwise, such counterplans as outsourcing orders, activating backup production lines, extending working hours, adding workers and reducing production requirements [7,8], will be adopted by schedulers. Fifth, rescheduling is conducted based on the heuristic rules such as the right shift, left shift, opportunistic insertion, deterministic insertion and overall adjustment [2] and then go back to the third step.

However, the procedure cannot satisfy the current production requirements in the following two aspects. For one thing, because the over-assigned time among all the production steps in the plant is not fully utilized, schedulers rely on counterplans to deal with production

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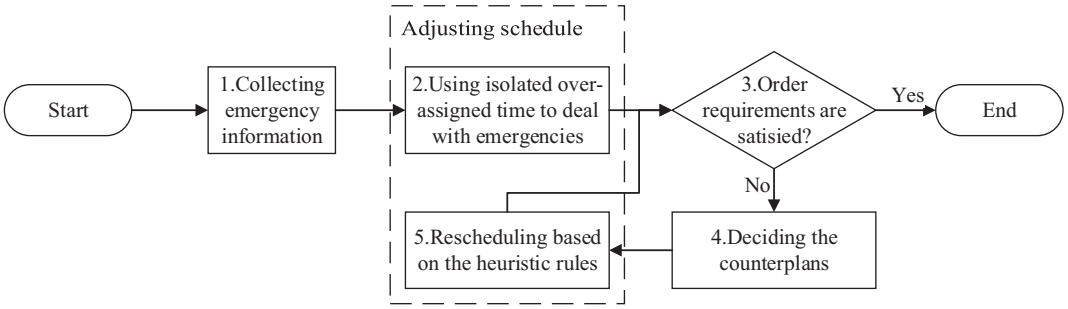


Fig. 1. Current operation procedure for production emergencies.

emergencies, which lead to rise in production cost or failure in fulfillment of order requirements. For another, the heuristic rule based rescheduling approach do not guarantee optimal schedules theoretically and is significantly influenced by the experience of schedulers so that it may result in waste of production capacity, increase of inventory demand and consequential rise of cost [2].

This research proposes an approach for the optimized shop floor rescheduling (the optimized rescheduling hereafter for short) of multiple production lines for flowshop precast production. The approach can not only take into account the traditional ways for schedule adjustment, such as outsourcing orders, activating backup production lines and/or extending working hours, but also make use of the over-assigned time of each production step as a whole to deal with serious production emergencies.

The flow chart of the main part of the paper is shown in Fig. 2. First, the optimization objectives and constraints of the shop floor rescheduling of multiple production lines for flowshop precast production are analyzed based on the MP-FSM (Flowshop Scheduling Model of Multiple production lines for Precast production) that the authors proposed previously. Second, the corresponding mathematic model, i.e., optimized Rescheduling Model of Multiple production lines for Flowshop Precast production (RM-MFP), are formulated accordingly. Third, a solver for the model is established by using Genetic Algorithm (GA for short hereafter). Finally, the way to apply the approach is introduced and the approach is validated by case studies. For better understanding, all the symbols of the paper are listed as an appendix of the paper with their units.

2. Relevant studies

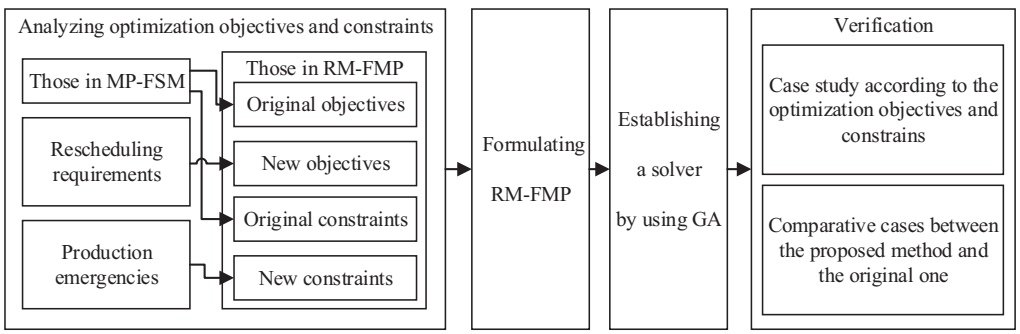
The existing relevant studies of this research can be divided into two aspects, i.e., scheduling and rescheduling of precast production. It is obvious that rescheduling is essentially the scheduling with additional constraints.

As far as scheduling is concerned, Chan and Hu [3] introduced an artificial intelligence based flowshop scheduling approach utilized in manufacturing industry and formulated the FlowShop Sequencing Model (FSSM) for precast production by analyzing the characteristics of precast production. Benjaoran et al. [4] studied the impact of the quantity of moulds on shop floor schedules of precast production and proposed the FlowShop Scheduling Model for Bespoke Precast production (BP-FSSM). Ko and Wang [18] improved the feasibility of the schedules using artificial intelligence by including the constraint of the buffer size, namely size of the temporary storage place, between workstations for the partially finished precast components waiting for completion (work-in-processes for short hereafter) storing into the optimization model and developed a corresponding scheduling system. Yang et al. [6] proposed the Flowshop Scheduling Model of Multiple production lines for Precast production (MP-FSM) to facilitate optimized scheduling of precast production with multiple production lines.

As far as rescheduling is concerned, Chan and Zeng proposed schedule adjustment approach of precast production based on the heuristic rules and Genetic Algorithm (GA for short here after) [2,5]. Although the existing research development can be applied to improve shop floor rescheduling of multiple production lines for flowshop precast production, the optimization of the schedules still cannot be guaranteed.

3. Analyzing optimized rescheduling

During rescheduling, the over-assigned time utilization as well as counterplans, if they are applicable, contributes to deal with production emergencies. According to literature [7,8], common counterplans include outsourcing orders, activating backup production lines, extending working hours, adding workers and reducing production requirements. However, counterplans application should be decided by schedulers before rescheduling, because they lead to extra cost or is contract-related so that normally it needs to be approved by multiple managerial departments. Moreover, by using the proposed approach to empower the software to optimally reschedule the precast production with the



Notes. MP-FSM is the abbreviation for Flowshop Scheduling Model of Multiple production lines for Precast production. RM-FMP is the abbreviation for optimized Rescheduling Model of Multiple production lines for Flowshop Precast production

Fig. 2. Flow chart of the paper.