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A Multi-objective Optimization Approach for Integrated Production Planning under Interval Uncertainties in the Steel Industry

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Abstract **-** This paper investigates one of the key decision-making problems referring to the integrated production planning (IPP) for the steelmaking continuous casting-hot rolling (SCC-HR) process in the steel industry. The complexities of the practical IPP problem are mainly reflected in three aspects: large-scale decision variables, multiple objectives and interval-valued uncertain parameters. To deal with the difficulty of large-scale decision variables, we introduce a new concept named "order-set" for modelling. In addition, considering the multiple objectives and uncertainties of the given IPP problem, we construct a multi-objective optimization model with interval-valued objective functions to optimize the throughput of each process, the hot charge ratio of slabs, the utilization rate of tundishes and the additional cost of technical operations. Furthermore, we propose a novel approach based on a modified interval multi-objective optimization evolutionary algorithm (MI-MOEA) to solve the problem. The proposed model and algorithm were tested with daily production data from an iron and steel company in China. Computational experiments demonstrate that the proposed method generates quite effective and practical solutions within a short time. Based on the IPP model and MI-MOEA, an IPP system has been developed and implemented in the company.

Keywords – Steelmaking-continuous casting-hot rolling; Integrated production planning; Interval number; Uncertainty modelling; Evolutionary multi-objective optimization

1. Introduction

The iron and steel industry, which is often seen as the cornerstone for overall industrialized economic growth, has encountered big challenges in recent years. In order to create a responsive production mode in a fiercely competitive market environment, companies have continually paid great attention to technological innovations for employment in the iron and steel making process, especially in the SCC-HR process.

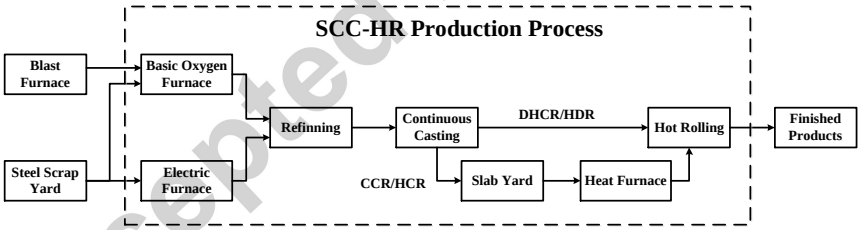

Fig. 1. Typical SCC-HR production process in the steel industry.

In a typical SCC-HR production process as Fig. 1 shows, after melting in a basic oxygen furnace (BOF) and refining in a ladle furnace, the hot molten iron, steel scraps and other raw materials are converted into molten steel. Then, after processing in the continuous casting stage with a tundish, which is a container located at the top of the continuous caster, the hot molten steel will be transformed into solid slabs. These closely related processing operations guided by the cast plans are called steelmaking continuous casting (SCC). The slabs are temporarily stored in the slab yard or directly sent to downstream processing stages for further processing according to different linkage modes, such as hot direct rolling (HDR), direct hot charge rolling (DHCR), hot charge rolling (HCR) and cold charge rolling (CCR). When implementing the hot rolling plans, slabs from the slab yard are delivered to the heat furnace for heating up to the required temperature. Then the heated slabs are rolled into finished steel products according to the specifications of the production plans. These slab heating and rolling processes are called HR.

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