World Academy of Science, Engineering and Technology
International Journal of Industrial and Manufacturing Engineering
Vol:16, No:05, 2022

Optimization Approach to Integrated Production-Inventory-Routing Problem for Oxygen Supply Chains

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Abstract : With globalisation, the need to have better coordination of production and distribution decisions has become increasingly important for industrial gas companies in order to remain competitive in the marketplace. In this work, we investigate a problem that integrates production, inventory, and routing decisions in a liquid oxygen supply chain. The oxygen supply chain consists of production facilities, external third-party suppliers, and multiple customers, including hospitals and industrial customers. The product produced by the plants or sourced from the competitors, i.e., third-party suppliers, is distributed by a fleet of heterogenous vehicles to satisfy customer demands. The objective is to minimise the total operating cost involving production, third-party, and transportation costs. The key decisions for production include production and inventory levels and product amount from third-party suppliers. In contrast, the distribution decisions involve customer allocation, delivery timing, delivery amount, and vehicle routing. The optimisation of the coordinated production, inventory, and routing decisions is a challenging problem, especially when dealing with large-size problems. Thus, we present a two-stage procedure to solve the integrated problem efficiently. First, the problem is formulated as a mixed-integer linear programming (MILP) model by simplifying the routing component. The solution from the first-stage MILP model yields the optimal customer allocation, production and inventory levels, and delivery timing and amount. Then, we fix the previous decisions and solve a detailed routing. In the second stage, we propose a column generation scheme to address the computational complexity of the resulting detailed routing problem. A case study considering a real-life oxygen supply chain in the UK is presented to illustrate the capability of the proposed models and solution method. Furthermore, a comparison of the solutions from the proposed approach with the corresponding solutions provided by existing metaheuristic techniques (e.g., guided local search and tabu search algorithms) is presented to evaluate the efficiency.

Keywords : production planning, inventory routing, column generation, mixed-integer linear programming
Conference Title : ICIE 2022 : International Conference on Industrial Engineering
Conference Location : Rome, Italy
Conference Dates : May 05-06, 2022