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Scientific abstract – *Supply chain model of a decaying product – The case of radiopharmaceuticals*

The goal of the proposed research program is to contribute to a better understanding of and models for the planning and scheduling of supply chain systems for deteriorating products. Although in practice many types of products deteriorate over time in terms of quality, quantity, or value, very few supply chain planning and scheduling models assume decaying (or deteriorating) products. In this work, we intend to address this fundamental gap. The planning and scheduling of supply chain systems is a central topic in modern industrial engineering and management. New approaches for considering the property of product deterioration in supply chains would be a significant contribution to this field.

Our research will focus on a specific type of supply chain, one that is based on the radiopharmaceutical cyclotron. These systems are small supply chains with several cyclotrons serving a network of customer hospitals. Radioactive isotopes are used for medical diagnosis and treatment, and the isotope supply chain consists of five stages: cyclotron, synthesis, vial filling, delivery to the hospital(s), and injection. The produced isotope decays exponentially throughout all these stages. The demand is ordered daily by each hospital, which specifies each treatment’s dose and time of injection. The system may consist of several cyclotrons of various types of isotopes, several synthesis and vialling production cells, and a network of customer hospitals.

To demonstrate the applicability and potential of our approach, we conducted a preliminary study on a basic case of a single cyclotron, single material, and single hospital. We present and analyze a new relaxed model for this case, together with a solution scheme for the detailed discrete injection plan. The relaxed model determines the optimal number and sizes of the daily cyclotron batches to meet the hospitals’ demand while minimizing the costs of production and inventory holding and considering the loss of radioactivity.

The research plan consists of four main steps. The first year focuses on developing the basic model for dealing with the supply chain complexities, including lot-splitting and lot-packing in the synthesis stage, vialling and delivery, and injection planning and synchronization. The second year is mostly devoted to extending the model and the solution scheme to a wider class of scenarios, including multiple cyclotrons, hospitals, injection periods in a hospital, and types of radiopharmaceuticals. The third part will consider various types of uncertainties, including production disruptions, deteriorating production yield, logistical disruptions, and injection plan changes. The last part deals with experimenting with the model and solution scheme at an industrial site, and includes a thorough survey of the supply chain literature for proposed ways of considering deteriorating products.

The research team combines practical and theoretical expertise in operations research, production management, industrial control, decision support systems, scheduling, and various related research methodologies, offering an opportunity to provide a fundamental contribution to industrial engineering and management.