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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 better understanding and models for planning and scheduling of supply chain systems with deteriorating products. Although in practice many types of products have some rate of deterioration in quality, quantity, or value, very limited supply chain planning and scheduling models assume decaying (or deteriorating) products. In this work we intend to address this fundamental gap. Planning and scheduling of supply chain systems is a central topic in modern industrial engineering and management. New approaches for considering product deterioration property in supply chains would be of significant contribution to this field.

Our research will focus on a specific type of supply chain, 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. The isotope supply chain consists of five stages: cyclotron, synthesis, vial filling, delivery to the hospital(s) and injection. The produced isotope is exponentially decaying throughout all these stages. The demand is ordered daily by each hospital, specifying 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 a 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 at a minimum cost of production and inventory holding, while considering the loss of radioactivity.

The research plan consists of four main steps. The first year focuses on accomplishing the development of the basic model, for dealing with the supply chain complexities including lot-splitting and lot-packing in the synthesis, vialling, delivery, and injection planning and synchronizing. The second year is mostly devoted to extending the model and the solution scheme for a wider class of scenarios, including multiples of: cyclotrons, hospitals, injection periods in a hospital, and types of radiopharmaceuticals. The third part will cope with 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 with a thorough survey of the supply chain literature for proposing ways for 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 and offers opportunity for providing a fundamental contribution for industrial engineering and management.