Title: A simulation-optimization approach to integrate process design and planning decisions under technical and market uncertainties: a case from the chemical-pharmaceutical industry

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Highlights

A novel approach, combining a mixed integer linear programming (MILP) model with a two-step Monte Carlo simulation (MCS), to specifically address technical and market uncertainties during new product development, in the pharmaceutical industry

- Integration of strategic (process design and capacity extensions) and tactical (quantities to produce and store) decisions, simultaneously considering: a) the resources limitations associated to the need of processing, in the same plant, products under development and products in commercialization; and b) lots traceability.
- This new approach has proven to be effective in capturing the effects of uncertainty in process design and scale-up decisions, as well as in capacity and production planning decisions, during product-launch planning.
- Results clearly show the inherent risks associated to decisions taken under deterministic scenarios, and the gains associated to a large-range analysis of the uncertainty parameters, such as the access to valuable information early enough, for a sound long-term decision making process.

A simulation-optimization approach to integrate process design and planning decisions under technical and market uncertainties: a case from the chemical-pharmaceutical industry

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Abstract

This study addresses the product-launch planning problem in the chemical-pharmaceutical industry under technical and market uncertainties, and considering resource limitations associated to the need of processing in the same plant products under development and products in commercialization. A novel approach is developed by combining a mixed integer linear programming (MILP) model and a Monte Carlo simulation (MCS) procedure, to deal with the integrated process design and production planning decisions during the New Product Development (NPD) phase. The Monte Carlo simulation framework was designed as a two-step sampling procedure based on Bernoulli and Normal distributions. Results show the unquestionable influence of the uncertainty parameters on the decision variables and objective function, thus highlighting the inherent risks associated to the deterministic models. Process designs and scale-ups that maximize expected profit were determined, providing a valuable knowledge frame to support the long-term decision-making process, and enabling earlier and better decisions during NPD.

Keywords: Process design; Capacity planning; Scale-ups; Mixed Integer Linear Programing; Monte Carlo simulation; Uncertainty.

1. Introduction

1.1. Motivation

The pharmaceutical industry operates in a very dynamic, highly regulated and competitive business context, being one of the most important manufacturing sectors in Europe (EFPIA, 2016). The specificities of this industry are well known in the Process System Engineering (PSE) community. The heavy regulatory burden, high investment in R&D with very low success rates, and long periods for new product launch, clearly differentiate this industry from other sectors and impose significant managing challenges (Laínez et