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An optimization-based decision support system for strategic planning in a process industry: The case of a pharmaceutical company in India

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Abstract

We describe how a generic multi-period optimization-based decision support system (DSS) can be used for strategic planning in process industries. Built on five fundamental elements — materials, facilities, activities, storage areas and time periods — this DSS requires little direct knowledge of optimization techniques to be used effectively. It is user friendly and requires little knowledge of optimization. Results based on real data from a pharmaceuticals company in India demonstrate significant potential for improvements in revenues and profits.

Keywords: Optimization; Manufacturing; Process industries; Decision support systems; Pharmaceuticals

1. Introduction and motivation

The primary motivation for this work comes from previous work done by the authors (Dutta and Fourer, 2004, Dutta and Fourer, 2000), in which a generic optimization based decision support system was developed for strategic planning in process industries. This was then customized for an integrated steel plant in North America. The result was a potential increase of 16–17% in the bottom-line of the company. It was claimed that the same approach, being generic, could be applied to various other process industries. In this paper, we demonstrate the application of the same decision support system (DSS) to a Pharmaceutical Company in India.

The applications of linear programming based techniques to a process industry (specially the steel industry) have been many. A series of publications (Dutta et al., 1994; Sinha et al., 1995; Dutta and Fourer, 2000) report the conceptualization, development and implementation of a mixed integer linear programming model for optimal power distribution that took about 20 person years. This work resulted in a 58% increase in profitability (or a direct financial benefit of 73 million dollars) during the last six months of the fiscal year 1986–1987, and

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accrued similar benefits in later years. However, in both of the above cases, the models were customized only for the steel industry.

The production system of a pharmaceutical industry is an intermittent one. It produces several types of drugs in varying quantities, which are routed through several machines and share a common set of resources. This leads to an inherently large number of constraints, making the determination of optimality go well beyond the scope of human comprehension and intuition and too complex to be attained manually. We therefore present this optimization based DSS which is aimed at providing strategic support to the pharmaceutical industry. In Section 2, we give a brief account of previous attempts at applying OR/MS concepts in a pharmaceutical setup. In Section 3, we discuss the basic approach of modeling in a process industry. The elements of the database required to define the mathematical model and the optimization steps are discussed in Sections 4 and 5, respectively. In Section 6, we discuss the application of the model in a pharmaceutical company in India. The paper concludes by describing some of the experiments made on the model using real time data from the company and their results, illustrating the possible impact on the bottom-line in Section 7. The mathematical formulation of our model is provided in the Appendix A.

2. Literature review

The literature pertaining to OR/MS applications in process industries is quite diverse and a comprehensive review is beyond the scope of this paper. However, a comprehensive survey of mathematical programming models in the steel industry (Dutta and Fourer, 2001) indicates that very little work has been done in the area of planning with multi-period linear programming models. Also, in contrast to the extensive literature on OR/MS applications in process industries, reported work in the context of DSS for pharmaceutical industries is fairly recent and quite sparse.

Yang and Mou (1993) discuss the implementation of a LP based integrated DSS at the Dalian Dyestuff Plant, one of the largest of its kind in China. The DSS consisted of subsystems for production planning, accounting and finances, inventory, and information services. Operational results indicate that the system increased the annual profits by at least 4 million RMB in 1987 (about one million US dollars). However, not much was discussed about software implementation and actual results. Jager et al. (1989), present a DSS for time-phased planning of chemical components of active ingredients and intermediates in a pharmaceutical company in Netherlands. Artiba and Tahon (1992) considers the case of a parallel multi-product and multi-machine production problem for the development of a knowledge based system in a pharmaceutical company. Two other papers (Vickery and Markland, 1986; Boykin, 1985) focus specifically on optimizing production parameters like lot-sizes and other cost operating parameters.

Apart from the above, literature is also available on applications for network distribution and supply chain restructuring. Camm et al. (1997), implemented an integer programming based network optimization model to streamline work processes, drive out non-value–added costs, and eliminate duplication in order to restructure P&G's supply chain in North America. Gupta et al. (2002), have reported the most recent work in this field. The authors constructed a DSS to help the distribution network of Pfizer/Warner Lambert. This improved the company's ability to take rapid, well-informed decisions in several areas of distribution and supply chain management ranging from individual customer deliveries to long term manufacturing location and technology issues. The development and validation of generic algorithm based facility layout is decribed in a work by Hamamoto et al. (1999). A complete different type of model is the queuing network model (Viswanadham and Narahari, 2001) for lead time compression for drug development.

As already discussed above, none of the available literature focuses on multi-period models. There is also a lack of sufficient literature that discusses software development and optimal results from implementation. Hence, this paper discusses the development of a multi-material, multi-facility, multi-activity and multi-period generic model, implementable across a spectrum of process industries. We conclude this section by noting that the current case of a pharmaceutical company, complemented by the previous success in integrated steel industries, is an effort to illustrate the same.

3. Modeling a Process Industry

In this section we describe our generic approach towards modeling a process industry. This approach is similar to the manner in which the authors have