An Inventory Decisions Support system to the Glass Manufacturing Industry

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Abstract

This paper addresses the problem of computing the optimal parameters for production control policies in the glass manufacturing industry, providing a framework of analysis related with the structure of the production policies. We consider a multi-product, multi-stage, and capacitated discrete-time production-inventory system with random yield. The optimal parameters for a given production control policy are determined in order to minimize the expected costs or reach a given service level. Three different production strategies are discussed: Make-to-Order (MTO), Make-to-Stock (MTS), and Delayed-Differentiation (DD). We use real data from a glass manufacturing company, providing the evaluation of the relative performance of the different strategies. The approach used to analyze this problem will be simulation based optimization and gradient estimates are obtained through Infinitesimal Perturbation Analysis (IPA). The simulation-optimization package (SimulGLASS for Windows) was developed in order to provide a tool for production decisions support. Given the demand, yield and cost structures, the machines capacity, the processing times (and other issues inherent to the glass manufacturing process) the application returns, for a fixed policy, not only the recommended inventory levels in order to minimize the total cost, but also the corresponding service level.

1 Synopsis

This paper proposes a framework to study the glass manufacturing production process. It considers four different production strategies - make-to-stock, make-to-order, delayed-differentiation, and a combination of these three strategies according to the demand level (MTS/DD/MTO). We also analyze their impact on several performance measures: average total cost, in-house costs, and products' delivery time (lead-time).

The process was modeled as a discrete time, capacitated, multi-stage, multi-product, production-inventory system, with random yield, operating under multi-echelon base stock policies. A simulation-based optimization was the tool used to analyze the glass production system, given the complexity of an analytical approach for those types of systems. The gradient components are computed via IPA. Therefore, the simulation is used as an optimization tool to derive the optimal parameters for the proposed production strategies.

A set of computational experiments is presented in order to get some insights about the impact of the different production strategies on the performance measures.

One of this paper' motivations is to try to understand why, in the glass industry, the management teams usually decide for a production-to-order strategy. The numerical results clearly show that a make-to-order strategy incurs less in-house costs than all the other strategies, while having the highest average total cost and the worst lead-times. Therefore, what could justify the actual common strategy? Some insights on this issue are also presented.

Under the actual business context, where strong competition is a factor, and time and customer service level are critical issues, it sounds logical to pursue strategies different from the MTO. Despite the uncertainty associated with intangible costs estimation, management policies tending to valorize service level measures could be more profitable in the medium/long term horizon. Moreover, given the high uncertainty induced by the random yield, an MTO strategy seems inappropriate given that lead times are higher than they would be on more reliable processes, where MTO could make more sense.

Usually, the estimation of the holding and penalty costs is a difficult task. Moreover, not only it is hard to place the real value added by a given operation, but also it is hard to measure the exact impact of backlog in terms of cost. The optimality condition introduced in the paper establishes an equivalence between penalty costs and service level. Additionally, we know that the relative proportion between holding and penalty costs defines the system's performance. Therefore, setting a target service level is an easier task than to determine what the penalty costs should be.

As a final remark, one can state that the decision of producing-to-order, producing-to-stock, or any other composite strategy cannot be taken independently of the business context. All the aspects must be evaluated in order to understand what are the critical issues for success, or, in other words, what are the factors most valued by the customer. The framework developed in this paper provides means to measure the impact of a strategy change, helping management evaluating the exact trade-offs involved.

The simulation-optimization package, SimulGLASS for Windows, determines, for a given production policy, the base stock levels and the production limits which minimize the total cost and the corresponding service level. The user need to define the demand pattern and processing times of each product, the raw-material costs, the energy and direct labor costs, the capacity and yield structure of all machines.