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An inventory control model using fuzzy logic

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Abstract

A model based on fuzzy logic is proposed for inventory control. The periodic review model of inventory control with variable order quantity is considered. The model takes into account the dynamics of production–inventory system in a control theoretic approach. The control module combines fuzzy logic with proportional-integral-derivative (PID) control algorithm. It simulates the decision support system to maintain the inventory of the finished product at the desired level in spite of variations in demand. The effectiveness of the proposed control model is illustrated using the actual data of a typical packaging organization operating in the Sultanate of Oman.

Keywords: Inventory control; Fuzzy logic; Control theory; System dynamics; Decision support system

1. Introduction

Control of inventory in production and operations systems is very important for better management and utilization of resources. Techniques based on the principles of linear control theory had previously been proposed in the field of inventory control [1–4]. In a recent work [5], inventory ordering models had been proposed in terms of control system theory taking into account the non-linear characteristics of the ordering rules. In those models, the current level of inventory was compared with the pre-assigned set value, either periodically at specified time intervals or continuously. The order was triggered as a sequence of impulses whenever the inventory reached the set value (trigger level). The dynamics of the system had been modeled in the form of only finite time-delay. In another recent work [6], the concept of fuzzy set theory had been applied to inventory control models considering the fuzziness of inputs only. The dynamics of the system was not taken into consideration.

In the present work, a fuzzy logic-based model is presented for inventory control in a medium-scale production system. The main objective is to maintain the inventory at a desired level in spite of fluctuations in the demand taking into account the dynamics of the production system. The production process is modeled in the form of a first-order dynamic system with a representative production time constant. The production quota is decided on the basis of the difference (error) between the present and the desired inventory level. The decision

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process is simulated using fuzzy logic controller (FLC) coupled with a conventional proportional-integral-derivative (PID) controller. In this, the concept of fuzzy precompensation proposed by Kim et al. [7] has been combined with the improvized PI-type FLC proposed by Lee [8]. The type of FLC, proposed in the present work, has the advantage of fast response with lower overshoot in tracking a varying target inventory level. The method is used to simulate the typical inventory control scenario for finished product. The procedure is illustrated using the data for a typical packaging organization operating in the Sultanate of Oman. The selected company manufactures corrugated paper boxes for packaging.

2. Production–inventory dynamic model

Fig. 1 shows a typical control-theoretic model for a production–inventory system. The production process is modeled in the form of a first-order dynamic system, $G_p(s)$, with a representative production time constant (T), i.e.,

$$G_p(s) = \frac{P(s)}{P'(s)} = \frac{1}{Ts+1}, \tag{1}$$

where $P'(t)$ and $P(t)$ represent the required amount of production and its actual value, respectively, in time domain, $P'(s)$ and $P(s)$ being their corresponding Laplace domain forms.

The demand (or sale), $I_s(t)$, is represented as a time series in the disturbance block $D(s)$ in the form of an array $[t, I_s]$. The desired level of inventory, $I_p(t)$, is represented as a time series in the reference block $R(s)$ in the form of an array $[t, I_p]$. The actual inventory, $I(t)$, is obtained integrating the difference of production, $P(t)$, and the demand, $I_s(t)$. The integrator with saturation, $G_1(s)$, takes

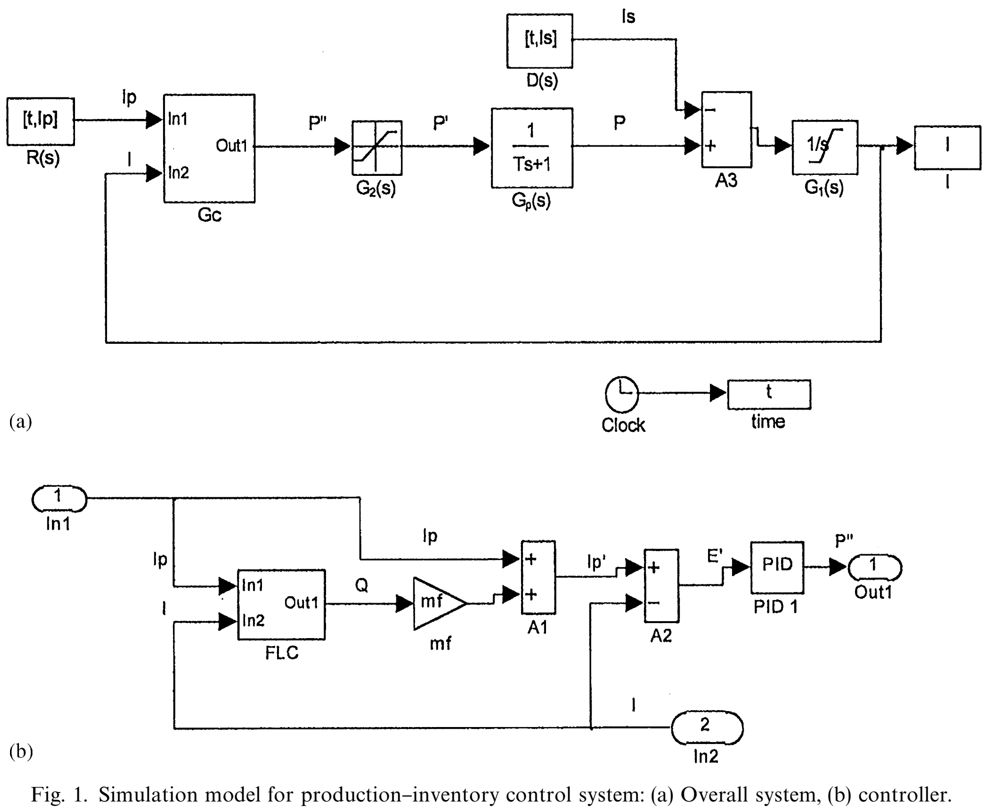

Fig. 1. Simulation model for production–inventory control system: (a) Overall system, (b) controller.