1. INTRODUCTION

The in-process inventory control problem stated several decades ago, in particular, in Buchan and Koenigsberg (1963) remains a topic of considerable and widespread interest up to now. This problem is important from both theoretical and practical point of view. Since the pioneering works (Simon, 1952; Yokoyama, 1955), the classical control theory becomes a tool for dealing with the control of manufacturing systems containing the in-process inventories. A significant breakthrough in this research area has been made in Axsater (1985), Kuntsevich (1973), Shin et al. (2008), Skurikhin (1972), Wiendahl and Breithaupt (2000) who studied the dynamic processes arising in typical production control systems. Their ideas were extended in Azarskov et al. (2006), Zhiteckii et al. (2007).

Recently, different approaches inspired by novel results achieved in the modern control theory have been advanced to tackle the manufacturing control problems. Among them they include linear programming and dynamic programming, robust and adaptive control concepts, genetic algorithms, \( t_1 \)-optimization, etc. (Aharon et al., 2009; Azarskov et al., 2013; Bauso et al., 2006; Boukas, 2006; Grubbstrom and Wikner, 1996; Hennet, 2003; Hoberg et al., 2007; Ignaciuk and Bartoszewic, 2010; Kostić, 2009; Rodrigues and Boukas, 2006; Taleizadeh et al., 2009; Towill et al., 1997).

To implement a perfect inventory control for a manufacturing system, the exact mathematical model with respect to the machining is required (Skurikhin, 1972). In practice, however, there is only approximate model of the machining that may be used in the decision-making system. Moreover, machine failures are possible, in principle. Due to these facts, there is some uncertainty when the order (reorder) policy is formed (Azarskov et al., 2006; Zhiteckii et al., 2007). The two approaches are proposed in modern control theory to deal with uncertainty: either a nonadaptive robust approach (Sanchez-Pena and Szanier, 1998) or an adaptive approach (Landau et al., 1997).

In this paper, the adaptive control concept is extended to cope with uncertainty in the inventory control. Its main contribution is a new adaptive control algorithm that makes it possible to improve the decision-making system via the use of a novel reorder policy formed by this system. Contrary to (Azarskov et al., 2013), it does not require a priori information related to some bounds on uncertainty. This feature seems to be important from a practical point of view.

2. DESCRIPTION OF A BASIC INVENTORY CONTROL SYSTEM

2.1 Mathematical Model

Consider the system for controlling the so-called in-process inventory (Buchan and Koenigsberg, 1963, Chap. 22) of a typical machine-building enterprise whose production line includes the machining, the transport, the storage and the assembly line depicted diagrammatically in Fig. 1. This control system operates as follows. At the start \( t = t_n = nT_0 \) of each \( n \)th scheduled time interval \( [t_n, t_{n+1}] \) \((n = 0, 1, 2, \ldots)\) having the same duration \( T_0 = t_{n+1} - t_n \), the decision-making system sends the request about the current product stock level \( H(t) \) equal to \( H(t_n) = H_n \). After receiving this information, the deviation
of $H_n$ from the required level of safety stock value, $r^0$, is determined. Next, it places the order (reorder), $\theta_n$, defining the product volume to be produce during the planning interval $t_n \leq t \leq t_{n+1}$ in accordance with the rule

$$\theta_n = \begin{cases} \theta_{\text{max}} & \text{if } \theta_n^c > \theta_{\text{max}}, \\ \theta_n^c & \text{if } 0 \leq \theta_n^c \leq \theta_{\text{max}}, \\ 0 & \text{if } \theta_n^c < 0, \end{cases}$$

where \(\theta_{\text{max}}\) denotes maximum order size which might be satisfied at \(t \in [t_n,t_{n+1}]\) by introducing all available manufacturing capacity, and \(\theta_n^c\) is defined by a given order policy. Usually (Kuntsevich, 1973; Skurikhin, 1972) \(\theta_n^c\) is specified by

$$\theta_n^c = e_n \quad \text{(in units)}. \quad (3)$$

The expression (2) together with (1) and (3) implies that if $H_n > r^0$ then $\theta_n = 0$ because the order quantity $\theta_n$ cannot be negative. Note that (3) corresponds to the simplest order policy.

![Fig. 1. Configuration of the basic inventory control system.](image)

Based on the value of $\theta_n$, the decision-making system determines the production capacity $q_n$ necessary to produce the order quantity $\theta_n$. This capacity may be expressed as

$$q_n = q(\theta_n) \quad (4)$$

with some vector-valued operator $q$. Equation (4) gives formally an operation schedule for each machine.

The product fabricated by machining to the end of time interval $[t_n,t_{n+1}]$ is

$$Q_{n+1} = P_{n,n+1}(q_n) - \xi_{n,n+1} \quad \text{(in units)} \quad (5)$$

where $P_{n,n+1}$ represents, in general, the time-varying operator.

\(\xi_{n,n+1}\) may be understood as an additive non-negative noise ($\xi_{n,n+1} \geq 0$) caused by the machine failure during a time range $\Delta T \leq \Delta T_{\text{max}} < T_0$. It is assumed that \(\xi_{n,n+1}\) is an irregular bounded variable.

As in Azarskov et al. (2006), Skurikhin (1972) and Zhiteckii et al. (2007), it is assumed that all the product whose quantity $Q_{n+1}$ is delivered through the intermediate transport to the storage at the time instant $t = t_{n+1} + \tau$ with some time delay $\tau < T_0$. The product is taken from the storage bunker on the

demands coming from the assembly line with a rate $k(t) \geq 0$.

Thus, for all time the stock level $H(t)$ varies so that it decreases “continuously” until the lot of size $Q_{n+1}$ arrives to the storage when $H(t)$ increases step-wise. Fig. 2 illustrates such a typical inventory history over the time interval $[t_{n+1},t_{n+2}]$.

![Fig. 2. Inventory level.](image)

The lot size $\nabla Q_{n+1,n+2}$ taken on the demand of the assembly line from storage bunker during the period $t_{n+1} \leq t \leq t_{n+2}$ is

$$\nabla Q_{n+1,n+2} = \int_{t_{n+1}}^{t_{n+2}} k(t) \, dt \quad \text{(in units)} \quad (6)$$
دریافت فوری متن کامل مقاله

امکان دانلود نسخه تمام متن مقالات انگلیسی
امکان دانلود نسخه ترجمه شده مقالات
پذیرش سفارش ترجمه تخصصی
امکان جستجو در آرشیو جامعی از صدها موضوع و هزاران مقاله
امکان دانلود رایگان ۲ صفحه اول هر مقاله
امکان پرداخت اینترنتی با کلیه کارت های عضو شتاب
دانلود فوری مقاله پس از پرداخت آنلاین
پشتیبانی کامل خرید با بهره مندی از سیستم هوشمند رهگیری سفارشات