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Inventory control for a MARKOVIAN remanufacturing system with stochastic decomposition process

Katsuhiko Takahashi*, Katsumi Morikawa, Myreshka, Daisuke Takeda, Akihiko Mizuno

Department of Artificial Complex Systems Engineering, Graduate School of Engineering, Hiroshima University, 1-4-1, Kagamiyama, Higashi-Hiroshima 739-8527, Japan

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Abstract

In this paper, we consider a remanufacturing system with reproduction and disposal. In the system, a decomposition process where recovered products are decomposed and classified into wastes to be disposed and materials and parts to be used in the processes for producing parts and products, is considered. For the remanufacturing system, two control policies are proposed. The performance of the proposed policies is analyzed by Markov analysis.

Keywords: Remanufacturing system; Stochastic decomposition; Inventory controls; Markov analysis

1. Introduction

Recently, remanufacturing systems that recycle used resources have been popular for saving limited resources. For the remanufacturing systems, research has been done from various view points, and Fleischmann et al. (1997) reviewed the literature on inventory control and production planning in reverse logistics and described the problems. In the literature on remanufacturing systems, Inderfurth and van del Laan (2001) dealt with the model as shown in Fig. 1. In the model, demands from customers can be satisfied not only by brand-new products but also recovered products. But recovered products had only two possibilities, one of that was disposed, and another was stocked with dedicated inventory. Ueno et al. (2000), Kiesmüller and van der Laan (2001), and Mahadeven et al. (2003) used a similar model in their research. Ueno et al. (2000) proposed a control policy based on pull control, and Mahadeven et al. (2003) proposed push inventory policies for the remanufacturing system. Kiesmüller and van der Laan (2001) considered dependent product demands and returns in the remanufacturing system. On the other hand, Kleber et al. (2002) dealt with a different model of remanufacturing system as shown in Fig. 2. Also, Inderfurth (2004) studied inventory control systems for a product recovery system. As shown in Fig. 2, the recovered products are stocked only for reusing them for multiple options. In addition, demands for each product are satisfied by production of new items or by remanufacturing returned products. However, in the paper, the process of decomposing the recovered products was not considered.

*Corresponding author. Tel.: +81 82 424 7705; fax: +81 82 422 7024.
E-mail address: takahasi@hiroshima-u.ac.jp (K. Takahashi).

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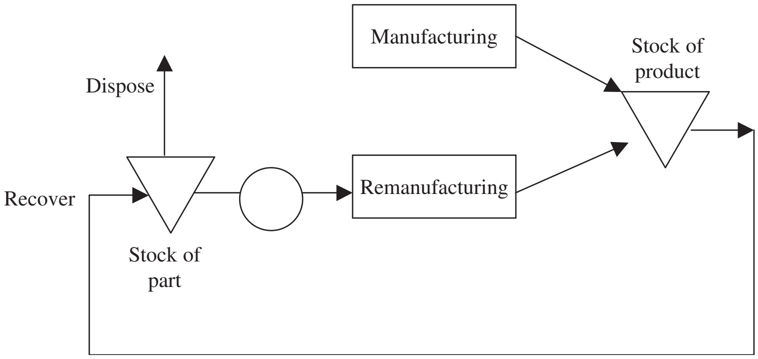

Fig. 1. The model of remanufacturing system shown by Inderfurth and van der Laan (2001).

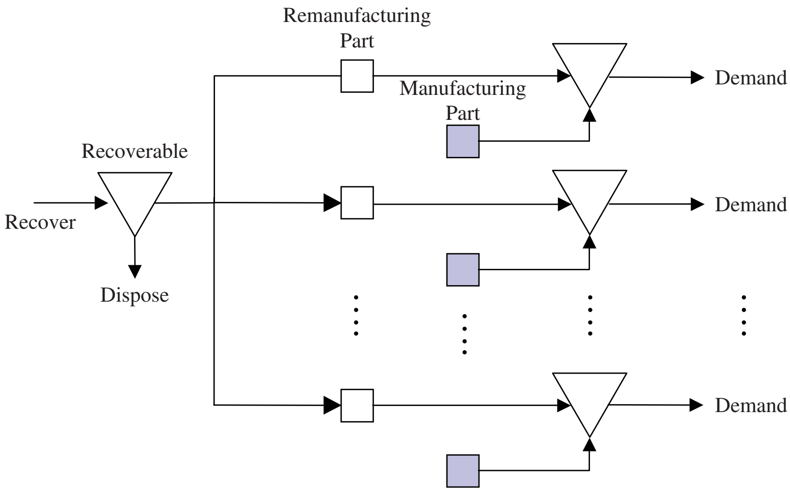

Fig. 2. The model of remanufacturing system shown by Kleber et al. (2002).

Based on this background, this paper considers a decomposition process as shown in Fig. 3 where recovered products are decomposed and classified into wastes to be disposed and materials and parts to be used in the processes for producing parts and products, respectively. Usually, recovered products and the decomposition process are uncertain, and this paper considers the decomposition process as a stochastic process. In the stochastic decomposition process, recovered products are decomposed, and whether the decomposed items are used as material and/or part or should be disposed is determined stochastically. Then, a demand of the product produced by using used and new materials, used and new parts is supposed to be the same in this paper. For the remanufacturing system, this paper proposes policies for controlling inventories of parts, produced products, and recovered products. The performance of the proposed policies is analyzed by Markov analysis, and the optimal policy is obtained. Then, the characteristics of the optimal policy are investigated.

This paper is organized as follows: after the introduction, the remanufacturing system considered in this paper is defined and the control policies are proposed in Section 2. For the system, a Markov chain model is developed and the flow balance equations of the system are formulated in Section 3. After solving the flow balance equations and calculating the performance measures, the performance of the proposed policies is analyzed under various conditions in Section 4. Finally, the findings obtained in this paper are summarized as concluding remarks in Section 5.

2. Production system

In this section, the assumptions of the remanufacturing system considered in this paper are