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An imperfect production process in a volume flexible inventory model

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Abstract

This paper hypothesizes an imperfect production/inventory system where the items produced are a mixture of perfect and imperfect quality. Some of the imperfect quality items can be sold at a reduced selling price. The unit production cost is taken to be a function of the finite production rate which is treated as a decision variable. The mathematical expression for the expected profit function is derived and it is maximized subject to different constraints of the system using *Interior Penalty Function Method* for *Constrained Optimization*, the algorithm of which is given. The solution procedure is illustrated with the help of numerical examples. The sensitivity of each variable to changes in the values of the parameters of the system is examined. Lastly, various issues conforming the system are discussed.

Keywords: Volume flexible manufacturing system; Inventory; Perfect and imperfect quality items; Reduction rate; Constrained optimization

1. Introduction

It is important to a supply manager of any modern organization to control and maintain the inventories of *perfect* and *imperfect* quality products. In the Classical *Economic Production Lot Size* (*EPLS*) model, the amount produced is available at a constant rate. The rate of production is assumed to be predetermined and inflexible (Hax and Candea, 1984). According to Schweitzer and Seidmann (1991), machine production rates can easily be changed. Empirical observations indicate that as the production-run-time increases, thereby the production system starts producing imperfect units as well. Some imperfect items are sold in the market by reducing selling price per unit and the rest of the imperfect items remain unsold. This type of production system usually occurs in many industries. The logistic diagram of the physical scenario is shown in Fig. 1.

At the start of production of a lot, the machine is adjusted so that the production process is *in-control* and the items produced are of acceptable quality.

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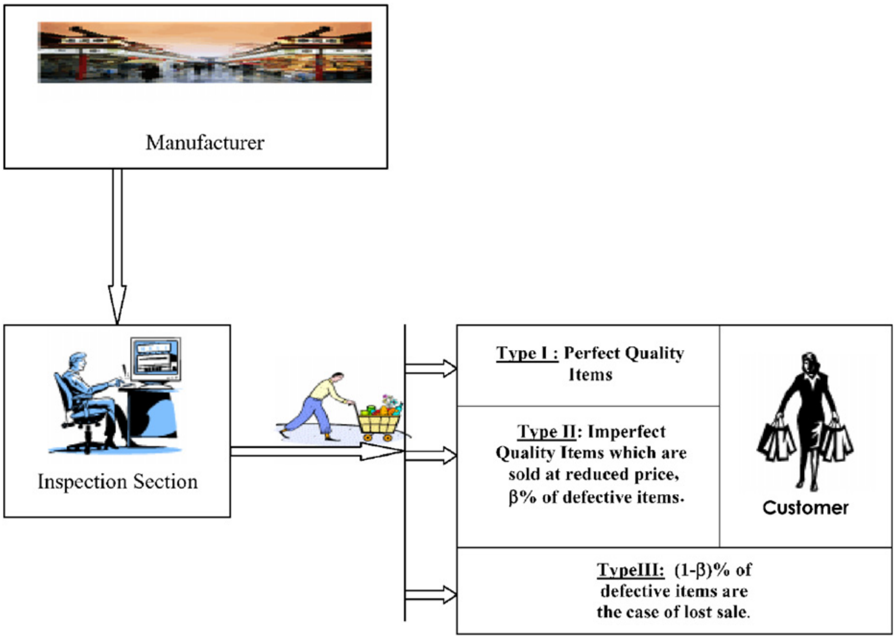

Fig. 1. Logistic diagram of the model.

Generally, increasing production-run-time increases the probability of components of machine failure and impatience of labor staff, and thus accelerates the deterioration of the quality of the production process. Several authors like Porteus (1986), Rosenblatt and Lee (1986), Cheng (1991), etc., extended the *EOQ* (*Economic Order Quantity*) and *EPLS* models to imperfect production processes, assuming non-zero defective items. Khouja and Mehrez (1994) assumed the elapsed time until the production process shifts to *out-of-control* state to be an exponentially (Chiu, 1975a, b, 1976; Gibra, 1978; Duncan, 1956; Ben-Daya and Hariga, 2000) distributed random variable. Zang and Gerchak (1990) considered that defective units cannot be used at all and thus must be replaced by non-defective ones. The effect of defective items on the lot sizing policy is noted in the works of Chakravarty and Shtub (1987), Moinzadeh and Lee (1987), Urban (1992) and Anily (1995).

Specifically, we note that in Rosenblatt and Lee's (1986) study, they assumed that the defective items could be reworked instantaneously at a cost and found that the presence of defective products motivates smaller lot size. Salameh and Jaber (2000) assumed that the defective items could be sold in a single batch at a discounted price prior to receiving the next shipment, and found that the economic lot size tends to increase the average percentage of imperfect quality items. Thereafter, Goyal and Cardenas-Barron (2002) reconsidered the task done in the model of Salameh and Jaber (2004) and presented a simple approach for determining the optimal lot size. Recently, Chang (2004) investigated the inventory problem for items received with imperfect quality. Building upon the work of Salameh and Jaber (2000), he proposed two fuzzy models. The first model incorporates fuzziness into the defective production rate. In the second model, not only the defective production rate but also the annual demand is considered as a fuzzy number.

In this paper, we consider a volume flexible (see Sethi and Sethi, 1990) manufacturing system with two types of demand rates: first is the demand rate of *perfect quality* items and second is the demand rate of defective (*imperfect quality*) items which is a function of the reduction in selling price. The unit production cost is a function of production rate. Inspection cost for categorizing the items is considered also because the remuneration of decision makers who categorize the products into three types (*perfect*, *imperfect and case of lost sale*) should not be neglected.