Available online at www.sciencedirect.com
ScienceDirect
European Journal of Operational Research 182 (2007) 755–763
EUROPEAN JOURNAL OF OPERATIONAL RESEARCH
www.elsevier.com/locate/ejor

Production, Manufacturing and Logistics

Determining the optimum process mean based on quadratic quality loss function and rectifying inspection plan

Chung-Ho Chen [a,*], Min-Tsai Lai [b]

[a] Department of Industrial Management, Southern Taiwan University of Technology, 1 Nan-Tai Street, Yung-Kang, Tainan 710, Taiwan
[b] Department of Business Administration, Southern Taiwan University of Technology, 1 Nan-Tai Street, Yung-Kang, Tainan 710, Taiwan

Received 23 July 2004; accepted 6 September 2006
Available online 13 November 2006

Abstract

In 1996, Pulak and Al-Sultan presented a rectifying inspection plan for determining the optimum process mean. However, they did not consider the quality cost for the product within the specification limits and did not point out whether the non-conforming items in the sample of accepted lot is replaced or eliminated from the lot. In this paper, we propose a modified Pulak and Al-Sultan's model with quadratic quality loss function of product within the specification limits. Assume that the non-conforming items in the sample of accepted lot are replaced by conforming ones. Finally, the numerical results and sensitivity analysis of parameters of modified model and those of Pulak and Al-Sultan are provided for illustration.

Keywords: Rectifying inspection plan; Process mean; Quadratic quality loss function

1. Introduction

Traditionally, the product characteristic within specifications is the conforming item. Taguchi [33] redefined that the product quality is the total loss to the society. According to Taguchi's opinion, a producer needs to manufacture a product based on its target value in order to reduce the society's loss. Taguchi [33] proposed the quadratic quality loss function for evaluating product quality. If the process mean approaches the target value and the process standard deviation approaches zero, then the process is under optimum control. Taguchi's quadratic quality loss function has been successfully applied in on-line and off-line quality control.

The economic selection of optimum process parameters is a major problem for the filling/canning industry. Recently, there are considerable attentions to the study of economic selection of process mean, e.g., [21,20,14,5,32,7–9,25,27,35,18,17].

Lee and Elsayed [21] presented a two-stage screening procedure for obtaining the optimum process mean and screening limits of the surrogate variable. They assumed that the performance and surrogate variables are jointed normally distributed. Lee et al. [25] extended Lee and Elsayed's model and emphasized two surrogate variables are used simultaneously in single screening procedure for determining the

* Corresponding author. Tel.: +886 6 2533131x4129; fax: +886 6 2422029.
E-mail address: chench@mail.stut.edu.tw (C.-H. Chen).

0377-2217/$ - see front matter © 2006 Elsevier B.V. All rights reserved.
doi:10.1016/j.ejor.2006.09.035

Nomenclature

A_1	is the selling price per item for items in a 100% inspected lot
A_2	is the selling price per item for items in a lot accepted by acceptance sampling, $A_2 \leqslant A_1$
c	is the cost of processing per item
D	is the number of non-conforming items found in a sample of size n
d_0	is the allowance number of non-conforming items found in a sample of size n
d_{rl}	is the expected number of defective items in a rejected lot (=the expected number of defectives found in the sample, given that the lot was rejected + the expected number of defectives in the non-sample portion of the lot), $d_{\mathrm{rl}} = E(D\|D > d_0) + p(N - n)$
I_c	is the inspection cost per item
k	is the quality loss coefficient $\left(= \frac{R_{\mathrm{I}}}{\Delta^2}\right)$
L_1	is the upper specification limit
L_2	is the lower specification limit
LF_0	is the expected quality loss for per un-inspected item in the accepted lot
LF_1	is the expected quality loss for per inspected item in the rejected lot
n	is the sample size
N	is the lot size
p	is the probability of a defective item $\left(= \Phi\left(\frac{L_2-\mu}{\sigma}\right)\right.$ for Pulak and Al-Sultan's model; $= 1 - \Phi\left(\frac{L_1-\mu}{\sigma}\right) + \Phi\left(\frac{L_2-\mu}{\sigma}\right)$ for modified Pulak and Al-Sultan's model)
R_{I}	is the cost of replacing a defective item by an acceptable item
R_{L}	is the expected cost of replacing all rejected items found in a rejected lot $(=R_{\mathrm{I}} \cdot d_{\mathrm{rl}})$
t	is the target value of a product
y	is the quality characteristic
$\mathrm{ETP}(\mu)$	is the expected profit function per item for Pulak and Al-Sultan's model
$E(\mu)/N$	is the expected profit function per item for modified Pulak and Al-Sultan's model
$P(D \leqslant d_0)$	is the probability of acceptance of a lot $(=1 - P(D > d_0))$
μ	is the process mean
σ	is the process standard deviation
$\phi(\cdot)$	is the probability density function of the standard normal variable
$\Phi(\cdot)$	is the cumulative distribution function of the standard normal variable
Δ	is the tolerance $(=\|L_1 - t\| = \|L_2 - t\|)$

process mean and screening limits. Kim and Cho [20] adopted the truncated Weibull quality characteristic and quadratic quality loss function for determining the optimum process mean. Duffuaa and Siddiqui [14] considered the three-class screening of product and the presented the effect of measurement error on the optimum process mean, the expected profit per item, and the inspection policy. Bowling et al. [5] first presented the problem of setting the optimum process mean for a multi-stage serial production system. They adopted the Markovian approach for formulating the model. Assume that the quality characteristic is normally distributed and consider the product with both-sided specification limits. When the work-in-process product performance falls below a lower specification limit or above an upper specification limit, it is necessary to be reworked or scrapped, respectively. If its performance falls within the specification limits, the work-in-process product goes on to the next stage until the product finished. Chen and Chung [11] presented the quality selection problem to imperfect production system for obtaining the optimum production run length and target level. Rahim and Tuffaha [32] further proposed the modified Chen and Chung's model with quality loss and sampling inspection. Chan and Ibrahim [7–9] addressed the multivariate quadratic quality loss functions applied in the determination of optimum process mean for nominal-the-best, smaller-the-better, and larger-the-better quality characteristics, respectively. Li [27] proposed the optimum process mean setting by considering the asymmetric linear quality loss function in the application of industry. Teeravaprug [35] considered the two grades of product. The product may be sold in the primary market or secondary market if the product quality is accepted. If the quality cannot be accepted by the secondary market, then the product is scrapped. He adopted the quadratic quality loss function for evaluating the quality cost of product and obtained the optimum process mean based on maximizing the expected profit per item. Hariga and Al-Fawzan