Statistical model for predicting picture discoloration, An approach to robust design.

Jiby J Joseph and Sumit Talukdar
Samtel Color Limited, Village Chhapraula, Ghaziabad 201009, India

Abstract: *This paper explains a systematic and scientific design method to consider the variability of design input parameters to the response parameters. The study involves developing a statistical model to address the variability of manufacturing process to predict the performance of the product at the design stage itself. The model is applied for the robust design of 20" color picture tube to improve the discoloration of picture.*

INDRODUCTION

To achieve quality improvements in manufactured products, a good understanding of interrelationship between key product parameters and manufacturing processes are required. Modern quality improvement methods use planned experiments to guide the designer in getting optimized values for the product parameters. A robust design is achieved when these values make the product performance insensitive to variability in manufacturing processes and product operating conditions. But sometimes due to the limitations in conducting planned experiments, performance variation of the product will be unacceptable. In that cases a statistical model-based robust design approach is needed which can predict the performance variation of the product at design stage itself without conducting any planned experiments.

IDENTIFY INPUT / OUTPUT VARIABLES

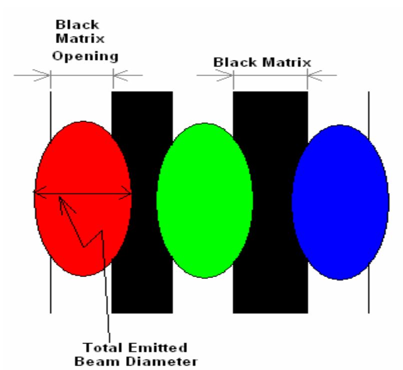


Figure 1

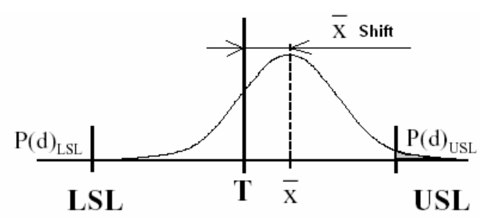
Color picture tubes exhibit white uniformity problems in the area generally at the corner of the screen due to improper landing of beams on the intended phosphor stripe. Picture discoloration is the key characteristic that must be controlled. It is considered as output variable. Picture discoloration is affected by such factors as Beam Landing error (BL), Beam Movement (BM), Black Matrix Opening (BMO), Total Emitted Beam Diameter (TEBD) and Black Matrix Width (BMW). These factors are considered as input variables. Variability and central tendency of input variables can be mapped form the existing manufacturing processes for any existing products. The calculated values for 20" Color picture tube is shown in Table 1.

TABLE 1

Input variables	Average (Micron)	Standard deviation (Micron)
Beam Landing error (BL)	19.4	14.7
Beam Movement (BM)	32	3.4
Black Matrix Width (BMW)	115	2.5
Black Matrix Opening (BMO)	155	3.8
Total Emitted Beam Diameter (TEBD)	250	1.3

FITTING INPUT/ OUTPUT VARIABLE TO STATISTICAL MODEL

A statistical principle of the standard normal probability distribution is applied to predict the probability of a defect in product performance. μ (mu), a measure of central tendency, is the mean or average of all values in the population. When only a sample of the population is described, mean is more properly denoted by X bar.s (sigma) is a measure of dispersion or variability. When only a sample of the population is described, standard deviation is more properly denoted by S.



$$Z_{LSL} = \frac{\bar{x} - LSL}{S}$$

$$P(d)_{LSL} = \text{from Z table}$$

$$Z_{USL} = \frac{USL - \bar{x}}{S}$$

$$P(d)_{USL} = \text{from Z table}$$

$$P(d)_{Total} = P(d)_{LSL} + P(d)_{USL}$$

All normal distributions can be related to the standard normal distribution with mean 0 and standard deviation 1. Z is the number of standard deviations which will fit between the mean and the value of x. For the design calculation to predict the discoloration of picture, the input and output variables can be fitted to standard normal probability distribution.

$P(d)_{Total}$ is the probability that discoloration of picture will occur as a beam falls on an unintended phosphor stripe.

T is the center of phosphor stripe where the beam is intended to land.

X bar = BL + BM

$S = \sqrt{(SigmaBL)^2 + (SigmaBM)^2 + (SigmaBMW)2 + (SigmaBMO)2 + (SigmaTEBD)2}$

USL - LSL = 2 X BMW + BMO - TEBD

DESIGN OPTIMIZATION

Three design scenarios are taken as the scope of this paper to predict the improvement of discoloration of picture in 20" color picture tube.

Design scenario 1: Reduce the Beam Landing error form 19.5 micron to 10 micron.

Design Scenario 2: Reduce the Beam Movement from 32 micron to 16 micron.

Design Scenario 3: Increase the spec limit (USL – LSL) from 135 micron to 170 micron.

The probability of defects (discoloration of picture) for three scenarios are calculated and shown in Table2.

TABLE 2

	Design scenario 1	***Design scenario 2***	***Design scenario 3***
Sigma S *(Micron)*	15.8	15.8	15.8
X bar *(Micron)*	42	35.4	51.4
USL –LSL *(Micron)*	135	135	170
$P(d)_{Total}$	.055	.023	.018

CONCLUSION

Statistical model for predicting the discoloration of picture is developed by fitting the factors affecting the discoloration of picture to standard normal probability distribution curve.

The model is used for calculating optimized design values in the robust design of 20" CPT. The probability of the defect due to the variability of manufacturing process and chosen design values is calculated at the design stage itself.

REFERENCE

1. *Basic CRT Technology -Mitsubishi Electric Co. (MELCO)*

2. *Six Sigma Black Belt Training manual – Samtel Color Ltd.*