# NSC 2010 Midterm report

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Control charts are important tools in statistical quality control (SPC) and are used to effectively monitor a process. In SPC, when dealing with a variables quality characteristic, $\overline{X}$ -S or $\overline{X}$ -R control charts are used to monitor the process mean and the spread. While the $\overline{X}$ chart is used to monitor the process mean shift, the S (or R) chart is used to detect the variation change. However it is more advantageous to use a single chart to monitor both of the mean and the variation. The obvious advantages are (i) simple to use and interpret, (ii) cut down the time, resource, manpower, money and effort, (iii) easily detect the shift of the process mean, and/or the change of the process variability, and (iv) identify the cause of the changes – due to mean or/and variation (see Cheng and Thaga [1]). In recent years, some literatures were contributed to the design of various single control charts, like the T chart (Chen, Cheng and Li [2]), the single B chart (Grabov and Ingman [3]), the Likelihood Ratio chart (Sullivan and Woodall [4]), the Max chart (Chen and Cheng [5]), the MSE chart (Cheng and Spiring [6]), and the weighted-loss chart (Wu and Tian [7]). Cheng and Thaga [1] gave an overview of the single variables charts.

In industry, the quality and the loss of products are important factors among competing companies. Loss function is used to measure the loss due to poor quality (Spiring and Yeung [8]). Taguchi emphasized the importance of the target value in a process (Gopalakrishnan, Jaraiedi, Iskander and Ahmad [9]). Sullivan [10] gave examples that stress the importance of monitoring a target value and variability. In practice, the in-control process mean may not be the process target. Hence, a single control chart would be effective if it could detect the deviation from process target and the shift in process variability with small loss. Moreover, many papers on the performance of adaptive control charts had suggested using adaptive control scheme to the fixed control scheme. However, some researches had been proposed to use the double adaptive charts or a single adaptive chart to simultaneously monitor the process mean and variance, like Chengular, Arnold and Reynolds [11], Costa [12], Reynolds and Stoumbos [13], Zhang and Wu [14], Costa and Rahim [15], Costa and Magalh [16], Yang and Chen [17], Yang and Yang [18], Yang and Yu [19], Wu, Wang and Wang [20] and Prajapati and Mahapatra [21]. So far, in a single process, no one had proposed a single variable sampling interval (VSI) loss function chart to detect both the deviation from process target and the shift in process variability with small loss. We propose to construct a single VSI loss control chart to monitor both the process target and the variability with smaller loss. The performance of the VSI average loss control chart is described. Finally, an example of the metallic film thickness of the computer connectors system is used to illustrate the application of the optimal VSI average loss chart. The performance comparison among the VSI, FSI average loss charts and $\overline{X}-S$ charts shows that VSI chart is much better than the latter.

The above approach is extended to VP loss control chart. We found that using VP loss chart may save much detection time and more sensitive in the shifts of process target and variance than VSI and FP loss charts. The VP loss chart is thus recommended.

To detect small and median shifts in target and variance and with smaller loss, EWMA loss control chart is constructed. The performance is measured by Average Adjustment Time to Signal (AATS). The AATS is derived by Markov chain approach. The numerical analyses illustrate the EWMA loss chart performs Shewhart-type loss chart. The approach of deriving EWMA loss chart is extended to VSI, VSSI and VP EWMA loss control charts. For VSSI and VP EWMA loss charts, the distributions of EWMA loss statistics cannot be derived, some asymptotic distributions are used. We found that using adaptive EWMA loss chart may save much detection time and more sensitive in the shifts of process target and variance than adaptive and FP loss charts. The adaptive EWMA loss charts are thus recommended.

All above study is for variables data. So far, for a single process the study of loss chart for attribute data with binomial distribution has not been studied. We derive the FP loss chart for binomial data, then extend the approach to VSI, VSSI and VP loss charts. Since the loss statistics are discrete not variable, their average run lengths (ARL) or average time to signal (ATS) are always not the required 370 when the process is in control and the ARL's and ATS's are always not decrease as sample size increases. Hence, transformation for the discrete loss statistics seems necessary.

Two of the reports had been submitted to SCI journals. Some other studies will be written and submitted to SCI journals in the coming summer.

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