Industrial Quality Control based on Control Charts for the Desirability Index with Applications to Warehouse Control

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Abstract:

The Desirability Index (DI) is a method for multicriteria optimization in industrial quality control. By design of experiment methods and transferring the multivariate into a univariate optimization problem settings of influence factors are selected that lead to a process with simultaneously optimized quality measures. In this paper a new field of application for the DI is introduced — the field of process control. When a process was designed with the objective of reaching the optimal value of the DI, the DI therefore is the most appropriate measure to monitor this optimality over time. Based on the distribution of the DI control charts for individual measurements are presented and advantages compared to the traditional approaches are pointed out, especially caused by an innovative procedure for the interpretation of out-of-control signals.

Based on the distribution of the DI a control chart for single measurements of the DI and an Extreme Value Control Chart is introduced. The statistical distribution is made available for Harrington's Desirability Functions and a Desirability Index which is either specified as the geometric mean or the minimum of the Desirability Functions.

In comparison to existing control charts the introduced control charts prove to be superior when applied to the DI. A simulation study was carried out to assess the performance of the Single-Measurements control chart (SMCC) in contrast to the Shewart-Single-Measurements- (SHCC) and the Fence Control Chart (FCC) based on the theoretical distribution of the DI by a computation of their In- and Out-Of-Control Average Run Lengths (ARLs). When analyzing the simulation results the most important observations come out as follows: The usage of the SHCC and FCC may lead to control limits outside the domain of the DI especially in presence of high variances of the Quality Measures. In general the ARL behaviour of the SHCC and the FCC gets more and more problematic with increasing skewness of the distribution of the DI. Thus summing up all mentioned points the advantages of the SMCC in comparison to the SHCC and FCC become obvious especially in the presence of skewed distributions of the DI. Analogous results are obtained for the Extreme Value Control Chart in comparison to the Shewart-$\bar{x}$-Control Chart.

As a practical application the introduced control charts are utilized for overall quality control of a specific warehouse that is integrated into a research project of the "Fraunhofer Institute for Material Flow and Logistics" in Dortmund, whereby the field of Logistics is a new application for the Desirability Index.