Some Bayesian insights for statistical tolerance analysis

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Abstract:

Functionality of assembled products mostly rely on the ability of the manufacturer to produce under some quality requirements. Parts which do not meet these requirements represent a manufacturing waste which can be at the origin of substantial losses in terms of money and credibility. Quality control and defect detection are two keypoints of predictive process management. At the design stage, a statistical tolerance analysis can be performed to predict the process quality. This imply to estimate a so-called defect probability which quantifies the probability that the final assembly does not meet functional requirements. In general, this quantity depends on a number of process specifications (tolerances, capability levels) set a priori by the manufacturer, but also on the monitoring of the process itself since the process parameters (mean shift value and standard deviation) vary statistically for different batches. In this paper, we give an alternative point of view on an existing method, namely the Advanced Probability-based Tolerance Analysis of products (APTA), proposed in literature to estimate the defect probability. This method, originally relying on a double-loop sampling strategy, is revisited within the Bayesian framework, and an augmented approach is proposed to estimate the defect probability in a more efficient way. The efficiency of the augmented approach for solving tolerancing problems with APTA is illustrated on a linear reference test-case.

Keywords: APTA / tolerance analysis / defect probability / reliability / Bayesian approach