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Design Optimization of Miniature Mechanical Drive Systems Using Tolerance Analysis Approach

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Abstract : Geometrical deviations and interaction of mechanical parts influences the performance of miniature systems.These deviations tend to cause costly problems during assembly due to imperfections of components, which are invisible to a naked eye.They also tend to cause unsatisfactory performance during operation due to deformation cause by environmental conditions.One of the effective tools to manage the deviations and interaction of parts in the system is tolerance analysis.This is a quantitative tool for predicting the tolerance variations which are defined during the design process.Traditional tolerance analysis assumes that the assembly is static and the deviations come from the manufacturing discrepancies, overlooking the functionality of the whole system and deformation of parts due to effect of environmental conditions. This paper presents an integrated tolerance analysis approach for miniature system in operation.In this approach, a computer-aided design (CAD) model is developed from system's specification.The CAD model is then used to specify the geometrical and dimensional tolerance limits (upper and lower limits) that vary component's geometries and sizes while conforming to functional requirements.Worst-case tolerances are analyzed to determine the influenced of dimensional changes due to effects of operating temperatures.The method is used to evaluate the nominal conditions, and worse case conditions in maximum and minimum dimensions of assembled components.These three conditions will be evaluated under specific operating temperatures (-40°C,-18°C, 4°C, 26°C, 48°C, and 70°C). A case study on the mechanism of a zoom lens system is used to illustrate the effectiveness of the methodology.

Keywords : geometric dimensioning, tolerance analysis, worst-case analysis, zoom lens mechanism
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