Bridging the Gap between Design and Metrology using Statistical Tolerance Analysis

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1. Introduction

Design and metrology departments are not always properly linked in the industrial context. In the conceptual framework of design for metrology [Morse (2019)], three items can be defined: design for metrology, design using metrology (metrology feedback), and metrology for manufacturing. This contribution falls within the idea of design using metrology. For designers is often difficult to understand the functional impact of metrological inspection, also because metrological reports are created without functionality in mind. In the framework depicted in [Maltauro, Meneghello, and Concheri (2023)] the design department provides the quality control department with the functional geometric specification, and the latter defines and performs an inspection based on this specification, giving back the measurement. To ease the designers' understanding of the measurement report, we propose a framework in which, through statistical tolerance stack-up analysis, the functional impact of each measurand can be determined. This information is used to create a custom inspection report showing only the critical quantities, from a functional point of view, and in a function-based order.

2. Implementations

A statistical tolerance analysis can be performed based on the functional geometric specification defined by the design department. For the present work the software

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CETOL6sigma from Sigmetrix is used. The statistical core of this software is explained in [Cox (1986)]. Each functional requirement, at the assembly level, is translated into a critical dimension, i.e., a gap to be controlled. The critical dimension is statistically computed based on the admissible variability defined by the tolerances at the components level. The results are the statistical distributions of the critical dimension and the contribution factors showing the impact of each geometric tolerance on functionality: the higher the contribution the more the deviation of the geometric feature will degrade the performance. The contribution is defined as the impact of each tolerance on the variability (standard deviation) of the functional output.
A part, pertaining to the assembly, can be inspected based on the functional geometric specification obtaining the actual deviations for the features controlled by the tolerances. Parts from a simple assembly are 3D scanned with ATOS 5 and inspected with GOM Inspect. The inspection is exported in xml format.
A correlation core is programmed in phyton reading the CETOL source file and the GOM Inspect output file. Congruent features in the two files are paired together and the information regarding the contribution, tolerances and deviations is collected.
Based on a specific functional requirement it is possible to generate specific customized measurement reports where the information is displayed in order of contribution. Further filtering is even possible, as displaying only out-of-tolerance measurands, or measurands with a contribution higher that a predefined percentage. A specific report is generated per each part and functional requirement combination.

3. Conclusions

The proposed framework tries to link together two departments whose communication may be difficult. The bonding is given by statistical tolerance analysis that can assign each tolerance, and therefore measurand, a contribution to the quality of the assembly. This information is used to filter and rank the measurand that are displayed in the inspection report resulting in a clean and effective measurement report that can be easily understood by designers.

References

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