Journal of Computing and Information Science in Engineering

Editorial

Special Issue on Computing Technologies to Support Geometric Dimensioning & Tolerancing (GD&T)

Under mass production conditions, mechanical parts cannot be manufactured to exact geometric perfection. Dimensional and geometric tolerances communicate the design intent to manufacturing, i.e., all the ways that variations in sizes and shapes are expected and acceptable. There are many different aspects to GD&T:

- How variations will affect design function
- How to divide the acceptable variations between dimensions in a stack (Tolerance allocation/synthesis)
- How to reduce manufacturing costs (tolerance optimization)
- How variations combine or stack up (tolerance analysis)
- How to determine if a given part is manufactured to specifications (inspection planning, data/error analysis, surface reconstruction).

Over the past decade, availability of computing power and increasing product complexity have prompted the need to introduce uncertainties and variations within CAD models to allow for functional requirement computations and thus virtual product validation from a dimensional, geometrical and metrological point of view. As evidenced by papers in this issue, mathematical models of tolerances are being developed by the research community to address these needs. After years of efforts, it is still an ongoing work. Several reasons can be accounted for this. The mathematical formulation must be suited for 3D tolerance based computations and simulations. In addition to this, the complexity of the problem is being further increased by the fact that it can be tackled using deterministic (worst case) or stochastic approaches. The ideal model would therefore have to preserve the richness of the GD&T specifications while allowing 3D tolerance analysis and allocation in either a deterministic or stochastic context.

Yet, an industrial view of the problem reveals that commercial software are readily available to address these issues. However, a closer look at these discloses weaknesses that are linked to the above mentioned constraints. For instance, most software will not truly discriminate between location, orientation and form tolerances, not to mention runout. Indeed, the computation they perform will often be based on repetitive simulations using parts with minute variations on their design parameters. Also, it has been shown that various software might not produce the same results for a given problem. In the end, these software appear to be most suited to address complex geometries constrained with simple GD&T specifications which underscores the need to continue the research efforts in this field.

The major problems in inspection are integration, measurement uncertainty, determination of measurement density, and partitioning. Integration refers to unambiguous mappings of metrology information from different steps of the specification, production, verification, use, and reuse life-cycle. The complete characterization of uncertainty contributors during specification and verification, to date, has focused on hardware effects but it is clear that design and verification software significantly contribute to measurement uncertainty. Progress in sensors and computing now allow for measurement densities that are orders of magnitude greater than what was possible only ten years ago. These densities call for new verification techniques that differ greatly from classical metrology and inspection practices that are based on geometric techniques that have been known for centuries or millennia. As sampling densities increase in verification, it is more difficult to decide whether a sampled measurement belongs to one design feature or another. We lack both a theoretical model of how measurements should be partitioned among features and practical tools to accomplish this during verification.

Thus, GD&T problems offer exciting new opportunities for research that could have significant impact on the quality and cost of products and product development.

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Guest Editors for GD&T Special Issue