A FRAMEWORK FOR THE APPLICATION OF ROBUST DESIGN METHODS AND TOOLS

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Introduction and Objective

Robust Design
- Design to achieve consistent functional performance in spite of variation
- Minimize variation of functional performance regardless of manufacturing, assembly and load variations, variation due to ambient conditions and variation over time
- Knowledge in industry is poor [1], [2], [3]
- Application of RD tools in industry often incorrect [1], [2], [3]

Previous Studies
- Focused on attributes, philosophies, practices of RD
- Limitations in increasing the understanding of the tools

The aim of the framework is to increase the understanding and provide support for the application of RD methods.

A Framework for the Application of RD Methods and Tools

Methodology
- List of methods and tools associated with RD in literature has been extracted from previous reviews and classifications
- Augmented with tools from authors’ experiences
- Find main premise of methods and tools
- Create framework by means of KJ-Analysis and Faceted Classification

Facets of the Classification

Robust Design Guidance and Principles
Methods and tools support the designer from the concept level to the final product in designing in robustness. Design rules and proposals from experiences in mechanical design are utilized to decrease the sensitivity to variation.

Robustness Evaluation
Methods and tools give relative or absolute (metric) information about how sensitive to variation a design is. Per se these tools do not improve the robustness of a product but give an important input for comparisons of design solutions or even estimated yield rates and the prediction of reliability as a support in the decision making process.

Robustness Optimization
Methods and tools support the designer in exploring the design space and optimizing the design on the basis of the gained information.

Robustness Visualization
Robustness Visualization refers to tools, for instance, figures, diagrams or matrices that help to increase the awareness of robustness to variation without improving or quantifying the robustness of the design.

Example Case – Design of DVD Player Sled

Design of a DVD player sled with following main functional requirements
1. Sled driving force = Friction + F laser
2. Laser position accuracy = A laser

Robust Design Guidance and Principles

• Design Clarity
• Kinematic Design
• Locating Scheme

Robustness Evaluation
Derive Transfer function:
F laser = m·a + Friction + F laser
Transfer Function for the dependence of the driving force to the parallelism of the rails for both design concepts

Robustness Optimization
Taguchi Method for Concept B:
- Parameter Design
- DoE / Orthogonal arrays (or Transfer Functions)
- Selection of DPs (a-m) considering constraints (size of DVD, structural integrity, manufacturability, etc.) for smallest variation of the functional performance
- maximize SN-Ratio (variation ∝ noise)
- Tolerance Design

Example: angular displacement of laser
Laser displacements due to tilting:
Function of (a ,c ,e ,f ,h ,g ,k) with Laser displacements due to tilting:
required accuracy

Conclusions
- Framework clarifies the underlying premises of the methods and tools related to RD and supports the application
- Lack of options for Robustness Evaluation in early design
- Classification can help to identify overlaps as well as differences between methods and finally lead to successful integrations and combinations of tools.
- Robustness Visualization
  Increasing the awareness of sensitivity to variation and visualization of important factors to be considered in the design process: