Tobias Helle

Tolerance Optimization with CeTol 6σ and optiSLang
Phoenix Contact GmbH & Co. KG

• electr. Connectors- and electr. Interface Components
  industrial automation
• 15,000 Employees worldwide
  Phoenix Contact Group include
  15 Companies
• 14 Manufacturing locations worldwide

Phoenix Contact Headquarter

Location Berlin

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Content

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1. Target: Motivation

Workflow Robust Design Optimization Relay Development – until now

3D CAD – Model

FEM-Simulation

Material data

Tolerance Simulation

Process data

Optimization

Robustness Reliability

safe, Failure

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1. Target: Motivation

Workflow Robust Design Optimization Relay Development – Target

3D CAD – Model

FEM-Simulation

Material data

Process data

Optimization

Robustness Reliability

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2. Method: Tolerance Simulation – Kinematic Model

3D CAD - Model

Kinematic model

Drawing

GD-Tolerances

Measurement

worst-case / statistical

Contribution

Sensitivity

Process data

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- **Parametrical System created by Wizard**

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3. Solution Approach: Process Integration CeToI with optiSLang

- **Parametrical System created by Wizard**
  Import parameter und tolerances from CeToI *.cxml-file by Input Node

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- **Parametrical System created by Wizard**
- CeTol solver call

![Diagram of parametrical system with CeTol and optiSLang integration](image-url)

- **Parametrical System created by Wizard**
  Import results from CeTol result.xml-file by Output Node

- **Parametrical System created by Wizard**
  Parameter modification in parametric system possible

- **Parametrical System created by Wizard**

  **Python-Node**

![Diagram of parametrical system created by Wizard Python-Node](image)

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- Parametrical System created by Wizard Python-Node
4. Example: Tolerance Optimization Relay

- Optimization objectives 1: Contact Gap NO=0,25mm
4. Example: Tolerance Optimization Relay

- Optimization objectives 1: Contact Gap NO=0,25mm
4. Example: Tolerance Optimization Relay

**Optimization objectives 2: Overtravel NO=0,25mm**

Constraint:
Contact Gap NC > 0,2mm
4. Example: Tolerance Optimization Relay

- Results from Sensitivity Analysis

Sensitivity Analysis: CeToI vs. optiSLang

Optimization based on MoP
4. Example: Tolerance Optimization Relay

- **MoP from Sensitivity Analysis**
  CoP $\approx$ 100%

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4. Example: Tolerance Optimization Relay

**Settings**

- OT_obj: Objective
  - Expression: abs(State3.oSL_OT.MSMResults.Distribution.Mean-0.25)
  - Criterion: MIN
- KA_NO_obj: Objective
  - Expression: abs(State1.oSL_NO_Kontaktabstand.MSMResults.Distribution.Mean-0.25)
  - Criterion: MIN
- KA_NC_min: Constraint
  - Expression: State2.oSL_NC_Kontaktabstand.MSMResults.Distribution.Mean \( \geq \) 0.2
4. Example: Tolerance Optimization Relay

- **Serial Robust – Design Optimization**
4. Example: Tolerance Optimization Relay

- **Serial Robust – Design Optimization 2nd Iteration**

[Diagram showing Robustness_6 process involving inputs and outputs, with graphs illustrating output distributions.]
4. Example: Tolerance Optimization Relay

- Nested Robust Design Optimierung

- Evaluation of robustness of results in every optimization step
5. Outlook: Next steps

- Improvement of design process due to automated geometrical modelling
- Apply Excel-MOP of tolerance model for manufacturing
- Link between geometrical conditions of CeTol-Kinematic model and ANSYS FEM-Model (deformed springs)