Tolerance Analysis of Surge Arrester
Design of Surge Arrester

Application from Infolytica Corporation
Field Simulation in Infolytica-ElecNet

V - Field

|E| - Field
Design Specifications

Design Parameters and Tolerances

<table>
<thead>
<tr>
<th>Name</th>
<th>Nominal</th>
<th>Tolerance</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radius Ring 1</td>
<td>0.04</td>
<td>0.002</td>
<td>m</td>
</tr>
<tr>
<td>Radius Ring 2</td>
<td>0.04</td>
<td>0.002</td>
<td>m</td>
</tr>
<tr>
<td>X-Position Ring 1</td>
<td>0.4</td>
<td>0.02</td>
<td>m</td>
</tr>
<tr>
<td>Y-Position Ring 1</td>
<td>5.2</td>
<td>0.02</td>
<td>m</td>
</tr>
<tr>
<td>X-Position Ring 2</td>
<td>0.5</td>
<td>0.02</td>
<td>m</td>
</tr>
<tr>
<td>Y-Position Ring 2</td>
<td>4.1</td>
<td>0.02</td>
<td>m</td>
</tr>
</tbody>
</table>

Design Constraints

- Max. $|E|$ of all Resistors $\leq 127500$ V/m
- Max. Induction Current $\geq -3269300$ A
OptiY Process Work Flow

Workflow shows the processing sequences: Static and Current Flow Solver

Design of experiment: 100 calculations of original model in ElecNet
Meta model is the mathematical relationships between input and output parameters of the original model. It is much more computing-non-intensive compared to the original model.
Some 3D-Graphics of the Meta Model

X = Y-Position Ring 1
Y = Y-Position Ring 2
Z = Max |E| of Resistor 1

X = X-Position Ring 1
Y = Y-Position Ring 2
Z = Max |E| of Resistor 2

X = X-Position Ring 1
Y = Radius Ring 1
Z = Max Induction Current
Residual Plots

Plots show the absolute differences between original and meta model based on design of experiment. Small values indicate high quality of the approximated meta model.
Design Objective Distributions

Total failure probability = 22.32%
Sample size = 100,000 based on the fast meta model
Sensitivity: Design Parameter Importance

All parameters are equal important for electrical field strength $|E|$
Radius of both grading rings are most important for induction current
Sensitivity: Design Parameter Interactions

There are only small and negligible interactions for electrical field strength $|E|$. The interactions of grading ring radius are most significant for induction current.
Conclusion

Nominal design using classical nominal simulation cannot warranty the reliability and quality of the products, because the nominal parameters are only one fix value.

Tolerance analysis is a power-full tool for design of reliable and quality product in the early design stage without any cost. It considers the tolerances as stochastic distributions.

In the case of the surge arrester, the design failure probability of 22.32% can be shown for the mass manufacturing.

OptiY® is the leading software platform for robust design of all engineering fields using different commercial CAD/CAE-software or in-house codes.