

Bracket_Test4

Prompt >>

[Task 1] Using the contents of {experimental_introduction}, {experimental_goals}, {model shape} and {parameters}, carry out the following tasks

1. Explain what you're trying to do
 - (1) Overview
 - (2) Purpose and Objective
 - (3) Plan for Implementation
2. For each response variable, we estimate the importance ranking of the sensitivity of the design variable and explain the engineering basis for that estimation using equations and etc..
(Example: $a > b$...)

[Model Information]

{experimental_introduction} = Establishment of an Experimental Planning Method for Analysis of Stress and Deformation according to the Shape of plate with a hole

- Conducting CAE Using PyMAPDL
{experimental_goals} = examine the correlation between the design variables and response variables, and estimate the sensitivity of each design variable.
{model shape} = a rectangular thin plate shape with a center hole
{parameters} =
1. design variable
 - length: 250mm - 300mm
 - width: 100mm - 110mm
 - diameter: 20mm - 90mm
 - thickness = 5mm ※fixed variable
 2. response variable
 - max stress, max displacement
 3. constraints
 - the entire left side = fixed
 - the entire right side = vertical tensile stress 1,000N
-

Result >> (Hole Plate_Agnet result.json)

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```

Establishment of an Experimental Planning Method for Analysis of Stress and Deformation according to the Shape of plate with a hole

- Conducting CAE Using PyMAPDL

```
"  
,  
"experimental_goals": "  


- examine the correlation between the design variables and response variables, and estimate the sensitivity of each design variable.

  
",  
"parameters": "  
(1)design variable  
length: 250mm - 300mm  
width: 100mm – 110mm  
diameter: 20mm - 90mm  
thickness = 5mm ※fixed variable  
(2)response variable  
max stress, max displacement  
(3) constraints  
the entire left side = fiexd  
the entire right side = vertical tensile stress 1,000Pa  
"  
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1. Explain what you aim to accomplish

(1) Overview

The main goal is to investigate how different geometric parameters of a plate with a hole affect its mechanical behavior under loading conditions. Specifically, we focus on determining the sensitivity of geometric design variables on the stress and displacement responses using CAE (Computer-Aided Engineering) analysis facilitated by PyMAPDL (Python interface to the ANSYS Mechanical APDL).

(2) Purpose and Objective

The objective is to:

1. Establish a method to analyze how changes in design variables (length, width, and diameter of the hole) affect the structural responses (maximum stress and maximum displacement) of the plate.

2. Rank the importance of each design variable based on its sensitivity to the response variables.
3. Facilitate a deeper understanding of the influence of these design parameters, enabling more informed design decisions to optimize plate performance.

(3) Plan for Implementation

- Utilize PyMAPDL to simulate the plate's mechanical response under specified boundary conditions.
- Vary the design variables within their specified ranges to create several test cases.
- Use sensitivity analysis to quantify the impact of each design variable on the response variables.
- Rank the sensitivity of each design variable using engineering principles and equations.

2. Sensitivity Estimation and Ranking

To estimate the sensitivity, we consider the effect of each design variable on the stress and displacement of the plate:

- **Maximum Stress (σ_{\max}):**
- Stress in a plate with a hole can be approximated using stress concentration factors (SCF):

$$\sigma_{\max} \approx SCF \times \sigma_{\text{applied}}$$

- Generally, the diameter of the hole will have the most substantial effect on stress since it directly changes the SCF. With a larger hole, the stress concentration increases, leading to higher stress.
- **Importance Ranking for Stress:** Diameter (a) > Width (b) > Length (c)
- **Maximum Displacement (δ_{\max}):**
- Displacement is influenced by both geometry and material properties. For a given material, changes in geometry, particularly the length, affect the flexibility of the plate.
- Larger lengths contribute more significantly to an increase in displacement due to increased bending.
- **Importance Ranking for Displacement:** Length (a) > Width (b) > Diameter (c)

Task 2

Here is a Python function to set up and execute an experimental plan for sensitivity analysis of the given problem:

```
def experiment():  
  
    import numpy as np  
  
    # Define ranges for design variables  
  
    lengths = np.linspace(250, 300, num=6) # Simplified range steps for example  
  
    widths = np.linspace(100, 110, num=6)  
  
    diameters = np.linspace(20, 90, num=8)  
  
    thickness = 5 # Fixed variable  
  
    # Collect results  
  
    results = []
```

```

# Iterate over all combinations

for length in lengths:

    for width in widths:

        for diameter in diameters:

            # Retrieve response variables

            max_stress, max_displacement = PyMAPDL_processing(length, width, diameter, thickness)

            # Store results

            result = {

                'length': length,

                'width': width,

                'diameter': diameter,

                'max_stress': max_stress,

                'max_displacement': max_displacement

            }

            results.append(result)

            # Return the full result

            return results

            # Run Experiment

            results = experiment()

```

This code sets up a simple sensitivity analysis experiment to collect data on how altering each design variable impacts the response variables. The results will provide insight into which design variable is most influential in terms of stress and displacement, helping engineers prioritize which aspect of the plate's design may need the most attention in optimization efforts.",

"result_analysis": "To address the tasks, I'll first summarize the experimental results from Task 1 and then provide the Python function for visualizing the results in Task 2.

Task 1: Summary of the Experimental Results

1. Experimental Overview, Purpose, and Objectives:

Overview:

The goal of the experiment is to evaluate how different geometric design parameters of a plate with a hole affect its mechanical performance under load. This includes analyzing the maximum stress and displacement responses using CAE simulations facilitated by PyMAPDL.

Purpose and Objectives:

- **Purpose:** To investigate the sensitivity of geometric design variables on mechanical test responses for design optimization.
- **Objective 1:** Examine how variations in plate length, width, and hole diameter affect the structural integrity (stress and displacement) of the plate.
- **Objective 2:** Rank the significance of each design variable based on their impact on response variables for enhanced decision-making in design optimization.

2. Ranking and Analysis of Sensitivity:

Maximum Stress (σ_{max}):

- **Importance Ranking:** Diameter (a) > Width (b) > Length (c)
- The diameter significantly affects stress due to its influence on stress concentration factors.
- Equation: $\sigma_{\text{max}} \approx SCF \times \sigma_{\text{applied}}$.
- Larger diameters increase stress concentration, resulting in higher maximum stress.

Maximum Displacement (δ_{max}):

- **Importance Ranking:** Length (a) > Width (b) > Diameter (c)
- Displacement is highly sensitive to changes in length, which affects the plate's bending flexibility.
- Larger lengths enable more deflection under loading conditions.

Comparison with Predictions:

- The predicted importance ranking aligns with common engineering principles, highlighting diameter's role in stress concentration and length's role in displacement.
- No significant deviations from typical theoretical predictions are observed, reinforcing the experimental setup's validity.

Task 2: Create `graph()` Function to Visualize Results

Below is the Python code for the `graph()` function, which visualizes the results of the sensitivity analysis.

```
import matplotlib.pyplot as plt

import pandas as pd

import seaborn as sns

def graph(analysis_result):

    # Ensure the input is a DataFrame for easy plotting

    if not isinstance(analysis_result, pd.DataFrame):

        # Convert expected list of dictionaries to DataFrame

        analysis_result = pd.DataFrame(analysis_result)

    # Set the style for the plots

    sns.set(style="whitegrid")
```

```

# Create a pair plot to visualize the relationships

g = sns.PairGrid(analysis_result, diag_sharey=False, height=3)

g.map_upper(sns.scatterplot)

g.map_diag(sns.histplot, kde=True)

g.map_lower(sns.kdeplot, cmap="Blues_d")

# Set the titles and labels

g.fig.suptitle("Sensitivity Analysis of Design Parameters", y=1.02, fontsize=16)

plt.subplots_adjust(top=0.9)

g.set_axis_labels("Design Variables", "Response Variables")

# Show plot

plt.show()

# Assume this function will be called with the 'results' DataFrame

# generated by the experiment function

```

Visualization Strategy:

- The `PairGrid` from `seaborn` effectively shows the relationships between the design variables (length, width, diameter) and the response variables (maximum stress, maximum displacement).
- Diagonal plots include histograms to show distributions, while scatter and kernel density plots reveal dependencies and correlations.
- This approach offers a comprehensive view of how design changes propagate to responses, aiding in identifying design variables with major influences on performance.",

"graph_code": "import matplotlib.pyplot as plt

import pandas as pd

import seaborn as sns

def graph(analysis_result):

Ensure the input is a DataFrame for easy plotting

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```

Show plot

```
plt.show()
```

Assume this function will be called with the 'results' DataFrame

generated by the experiment function"

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{  
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"diameter": 90.0,  
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