**MAE 190 Shaft Design Project**

A Simple Circular Rotating

Shaft Design Problem

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**Introduction:**

**Nature of the Problem:**

Designing a circular shaft that satisfies both strength and fatigue life requirements under dynamic loading conditions is critical in mechanical systems. This involves calculating the appropriate diameter to resist stresses due to bending moments and torsion while considering safety factors and failure criteria.

**Origin of the Equations Used:**

The equations originate from fatigue theory and static stress analysis, incorporating criteria like:

* Modified Goodman
* DE-Gerber
* DE-ASME Elliptic
* DE-Soderberg

These criteria are widely applied in fatigue design to ensure safety under varying load conditions.

**Challenges in the Project:**

* Accurate computation of the stress concentration factor based on geometry and loading conditions.
* Reliable determination of the endurance limit considering surface, temperature, size, and reliability factors.
* Ensuring convergence in iterative diameter calculations under the trial-and-error approach.

**Review of Similar Methods:**

* Traditional methods often involve manual trial-and-error or limited computational tools with rigid assumptions.
* This project introduces an automated approach to improve efficiency and accuracy.

**Approach:**

The code integrates all relevant material properties and failure criteria into a single MATLAB-based framework. It employs interpolation for stress concentration factors, systematic material property retrieval, and a robust iteration loop for diameter calculation.

**Results:**

**Algorithm and Code Sections:**

* **Material Selection:** Functionality to retrieve material properties (e.g., ultimate tensile strength, yield strength) from a CSV database.
* **Stress Concentration and Geometry Consideration:** Linear interpolation is used to determine stress concentration factors based on and ratios.
* **Endurance Limit Determination:** Incorporates surface, temperature, size, and reliability modifying factors.
* **Trial-and-Correction Procedure:** Iteratively refines the shaft diameter to satisfy design criteria.
* Fatigue Failure Design Criteria: Implementation of fatigue life equations (e.g., DE-Gerber) for stress analysis.
* **Yielding Check:** Ensures that the computed diameter also satisfies static yield strength.

**Numerical Examples:**

Include results from the code with various inputs:

1. **Material:** Steel, Aluminum.
2. **Loading:** Different combinations of bending moment and torsion.
3. **Safety Factor:** Compare results for safety factors of 2, 3, and 4.
4. **Failure Criteria:** Analyze and compare results under different criteria (Modified Goodman, DE-Gerber).

**Discussion**

**Convergence Behavior:**Discuss how the code converges to the final diameter. Include:

* Plot showing iterations vs. computed diameter.
* Examples of convergence speed with different initial guesses.

**Input Variations:**Explore how the output diameter changes with different inputs (e.g., material properties, stress concentration factors).

**Exit Conditions:**Explain how the code determines when to exit the trial-and-correction loop (e.g., tolerance limit).

**Conclusion**

**Strength of the Code**:

* Automates complex computations, reducing manual errors.
* Integrates material databases and stress analysis into a cohesive framework.

**Advantages for Users**:

* Saves time and ensures accuracy in shaft design.
* Provides flexibility with multiple failure criteria and user-defined inputs.

**Suggestions for Future Development**:

* Extend the database to include additional materials and their fatigue properties.
* Add visualization features (e.g., stress distribution plots).
* Explore optimization algorithms to replace the iterative approach.

**Closing Remarks**:  
The developed tool demonstrates robust performance in circular shaft design and holds potential for wider applications in mechanical component design.

**Appendix:**

MATLAB Code used to plot the data: