Design Project #4

Multiple Parameter Design

Due: Friday April 23, 2021 uploaded to Blackboard by 11:59pm

Introduction: The purpose of this design project is to give you an opportunity to analyze multiple parameters in a design. This project will focus on uncertainty and ambiguity in design and using a computational program to analyzing multiple design parameters in an analysis. For this project, you will use concepts you have learned in classes such as curved beam mechanics, principle stress analysis, and static as well as fatigue failure theories.

Project Description: You are tasked with a parametric design analysis of a pair of ice tongs as shown in Figure 1. The ice that is carried weighs 50 lb. and is 10 inches wide across the tong. The distance between the handles is 4 inches and the mean radius (r) of a tong is 6 inches. In order to determine the different options for design, the tongs need to be analyzed for cases of static failure and fatigue failure, investigating different geometry and materials for the tongs.

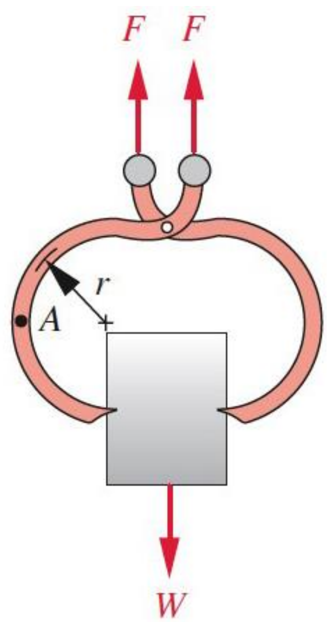

Figure 1: Ice tongs (shown in red) supporting Ice block (shown in grey) of weight (W) with opposing equal vertical forces (F).

You have three varying cross sectional geometries and three different materials to investigate. For geometry of the cross section, you want to analyze a rectangular cross section of 0.75 x 0.312 inches, a circular cross section with diameter of 0.312 inches, and a trapezoid cross section with outer width 0.312 in, inner width 1.62 inches and height of 0.75 inches. The materials you want to investigate are 1020 hot rolled carbon steel (S_y = 30 kpsi, S_{ut} = 55 kpsi), 2024 sheet cold-rolled annealed Wrought-Aluminum (S_y = 11 kpsi, S_{ut} = 26 kpsi), Class 40 Gray Cast Iron (S_{ut} = 42 kpsi, S_{uc} = 140 kpsi). You want to see investigate the failure of the tongs under two loading situations; picking up one piece of ice, and repeatedly picking up ice for 5×10^5 cycles, with forged tongs that operate in a temperature range of 32°F – 70°F, and 99.99% reliability. (Hint: If you cannot find an equation for A_{95} of one of the geometries can you estimate it in some other way (look at the formula for A_{95} of a solid rectangle on page 364 in your book, can you come up with a similar equation for a trapezoid?).

You want to investigate a design factor for each combination of geometry and material for each loading case. You can do this by writing a program that will help fill out Table 1.

Table 1: Comparison of fatigue design factors for geometries and materials under static and dynamic loading.

		Static Failure	*Fatigue Failure*
Geometry	**Material**	**Safety Factor**	**Safety Factor**
Rectangle	1020 Steel		
	2024 Aluminum		
	Class 40 Cast Iron		
Circle	1020 Steel		
	2024 Aluminum		
	Class 40 Cast Iron		
Trapezoid	1020 Steel		
	2024 Aluminum		
	Class 40 Cast Iron		

Design Project 4 Report Requirements

Generate a maximum 5 - 8 page write up that contains at least the following:

1. A short introduction to the project (a paragraph is sufficient).
2. Follow the format below in order to give a description walking through the main principles and equations.
    - Definition of the problem (include a figure)
    - State the givens
    - Make and justify any appropriate assumptions
    - Explain mathematical models that will be used in the solution
    - Develop a procedure for analysis of the problem
    - Brief explanation of anticipated results
3. Results containing:
    a. The filled out Table 1. Note: display safety factors to the nearest tenth.
4. A comparison and discussion of your table. Make any observations you have about material combinations and geometries (such as “by reading this table we can see that the ideal geometry and material combination for static loading is… because…”). You can include supplemental plots in order to enhance your discussion.

Project Grading Rubric Guideline

INTRODUCTION (15%)

- Describe the problem that is being studied
- Explain the importance and relevance of the problem
- Must have properly listed citations

ANALYTICAL PROCEDURE (20%)

- Explain steps taken and pertinent equations used to solve the problem (with description of what variables mean)
  - Definition of the problem (include a figure)
  - State the givens
  - Make the appropriate assumptions
  - Explain mathematical models that will be used in the solution
  - Develop a procedure for analysis of the problem
  - Brief explanation of anticipated results

RESULTS (20%)

- Copies of all asked for plots

INTERPRETATION (25%)

- Descriptions of the significant results in the plots
- Engineering observations about utilization of plots
- Addressing how engineering design standards (ASME, etc.) influence decisions.

CODE LISTING (10%)

FORMATTING AND CORRECT CITATIONS (10%)

Common mistakes that cost points:

- Project is turned in late
- Incorrect Calculations
- Figures not labeled (with legends if necessary)
- No references
- Incorrect, poorly formatted, or misleading tables and charts
- Grammar mistakes
- Irrelevant results
- Not addressing ASME standards
- Repetition