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Powder Coating Oven

Structural Analysis

Section 1

Introduction

For this project, the team was assigned to design and fabricate a powder coating oven for our client Professor Carson Pete, which will be used primarily in the renewable energy lab. The details of this oven are the following; the oven must exceed up to 400-500F, it has to be mobile and able to carry up to 300lbs of weight (approximated weight of the bumper from the bumper capstone team). This analysis will determine the structural suitability of the oven design and its qualification for the build and use. The structural analysis is a method provided by engineers to evaluate the quality of a build and its structural integrity. By using statical analysis, the forces and reactions of the structures will be determined, then it will be used to determine the safety factor of the structure, which will determine its qualification.

Method

To accommodate for this analysis, few assumptions were made:

1) The oven will be stationary, so as the trolly carrying the oven.
2) Because the trolly is not interacting with the oven, two separate yet similar analysis will be conducted for each.
3) The trolly will be experiencing the weight of the bumper (300lbs), while the oven will experience the weight of the frame and its components (lights, heating fan, etc, 560.24lbs).

Aside from the assumptions made, to conclude in the analysis, the primary variable that will be calculated will be the factor of safety, presented in the equation below;

$$FS = \frac{\sigma_{allowable}}{\sigma_{overall}} \quad (1)$$

Where the $\sigma_{allowable}$ is the maximum stress that the material could handle, which can be found via multiple sources, and the $\sigma_{overall}$ is the calculated stress from the structure with the applied weight, and FS is the factor of safety, which is accounted to be equal to 2 for this type of structure. Due to the complexity of the analysis, the finite element method was used for the calculation for the $\sigma_{overall}$ for trolly and the oven frame, which was conducted via SolidWorks. The oven was designed to be a rectangular form, to accommodate for the size and shapes for the powder coating projects:

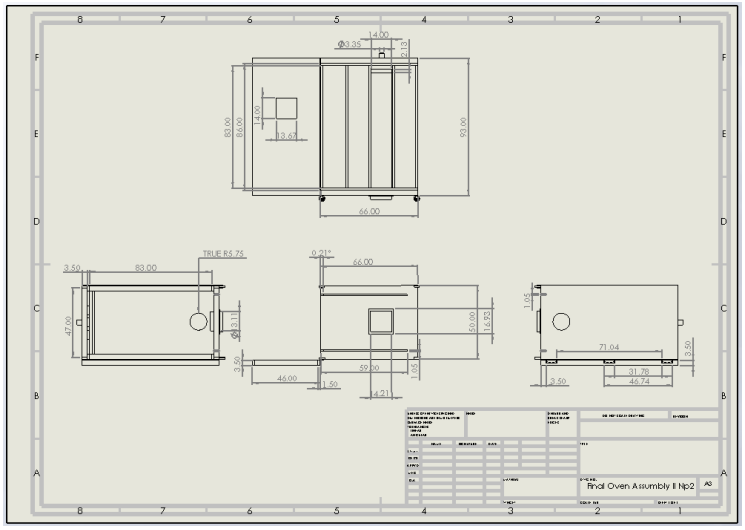

Figure 1: Oven Assembly Schematics

The trolly's design includes similar aspect to the oven assembly, with the inclusion of a smaller design to fit inside the oven while carrying powder coating parts, as shown in figure 2:

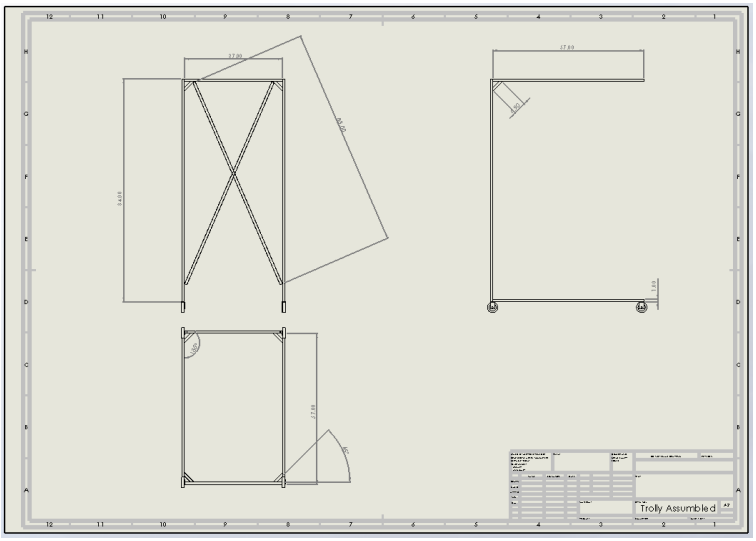

Figure 2: Trolly Assembly Schematics

Results

After conducting the static analysis for both the oven's frame and the trolly, it showed the results as follows. As shown in figure 3 in the reference section, the yield strength was calculated from the applied weight of 560.24lbs, resulted to be equal to $\sigma_{overall} = 2.039 * 10^8 \frac{N}{m^2} = 29{,}573.19\ psi$. On the other hand, from the same statics analysis done on the trolly, the yield strength was calculated from the applied weight of 300lbs, resulted to be $\sigma_{overall} = 1.8 * 10^8 \frac{N}{m^2} = 26106.79\ psi$. Using these numbers, the factor of safety for each was calculated by dividing the overall strength over the allowable strength. Recognizing that the allowable yield strength of the frame used for the oven (25 gauge steel studs) to be equal to 29,579 psi, the factor

of safety was calculated to be equal to $FS = 1.0001$, while the overall strength of the trolly (Cold roll steel tubes) is estimated to be 67,000 psi, which resulted in a factor of safety to be $FS = 2.566$.

Discussion

As shown from these results, it would seem that the trolly have accommodated a much higher factor of safety than the oven's frame, which indicate more sturdiness in the design. Thus, from the conducted analysis, the design of the oven did not meet the requirement for safety and qualification, while the trolly has proven to provide structural integrity and sturdiness overall.

Conclusion

Moving forward with the project, to produce better results for the oven, potentially a new design will be made and tested to make up for the required factor of safety, including other types of studies that will be conducted to meet the desired results.

References

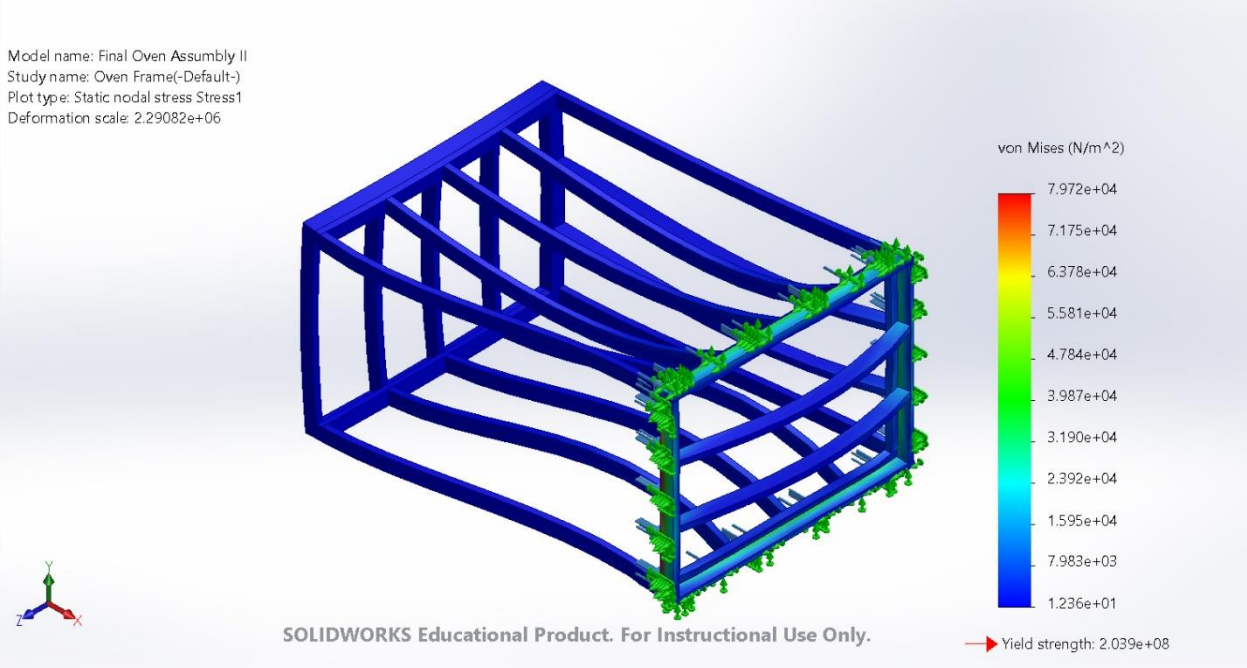

Figure 3: Static load analysis on the oven's frame (560.24lbs)

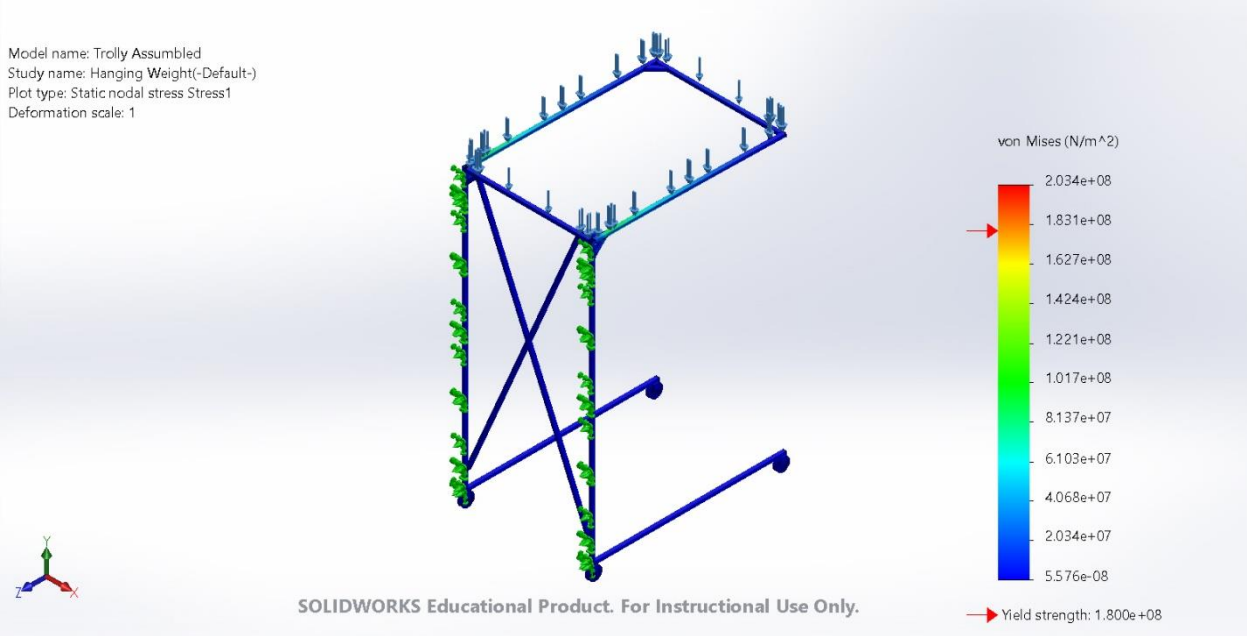

Figure 4: Static load analysis on the Trolly (300lbs)