Static Analysis of a Load-Carrying Hanger Assembly

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Abstract

In this study, a static analysis of a load-carrying hanger assembly was performed using SolidWorks Simulation software. The study was carried out in two stages. In the first stage, a suitable 3D model of a load-carrying hanger assembly was developed, and in the next step, stress analysis was conducted keeping one side of the assembly fixed to a wall. The main focus was to understand where the maximum stress was developed when the load was applied from the top of the hanger. In addition to the stress data, deformation data was analyzed to develop a better understanding. Results show that for all loads applied to the hanger, the maximum stress is developed on the upper horizontal part where it is attached to the wall. None of the three parts failed/yielded due to loads tested in the study.

Keywords: Solid Works Simulation, hanger, load, von Mises stress, strain

1. Introduction

Load-carrying hangers are one of the most frequently used fixtures employed for shelfing purpose that provides effective space utilization. We use these hangers in our kitchens, storage rooms, offices, departmental stores, warehouses, and many other business places to support shelves on which we place different objects to organize them. Hangers are designed in different ways based on their needs, but the simplest hanger is essentially made up of two major parts, a horizontal part that supports the shelf and an inclined part to support the horizontal part. One end of both these parts is attached to a wall, with the horizontal part right above the angular part. The other ends are attached together and kept free; this yields a cantilever action on the hanger assembly. The free ends of the two parts are connected by means of a pin of some type of screw. The top surface of the horizontal part is made flat so that it can support flat shelves. The parts of a typical hanger assembly are shown in Fig. 1; 1(a) shows the exploded view and 1(b) represents its assembly view. In this simplest type of hanger, the left ends of both the upper horizontal and inclined parts are attached to the wall and the load is applied on the top of the upside flat face.

When a load is applied on a shelf by an object placed on top of that, the load transfers to the hangers and develops stress on its flat and angular parts. Many people face a point of confusion when parts of their shelves break causing massive wreck of objects supported by them. One major reason behind that is the misunderstanding of the maximum load, stress, areas of stress, and deformation. The main objective of the present study is to carry out a static analysis of a load-carrying hanger assembly to provide a better understanding of the stress developed on that when subjected to bending load from the top. SolidWorks simulation software was used for this purpose. To do that, the three basic parts of a hanger assembly were created as Part files according to some suitable dimensions in SolidWorks.

The parts were then assembled to create a 3D hanger assembly model and a bending load was applied on top of the horizontal part. The first simulation was run for 10 lbs. To investigate the effects of loading, four more simulations were carried out with 20, 30, 40 and 50 lbs keeping the end conditions the same. For all simulations, the stress and deformation plots were recorded.

2. Parts and Assembly

As seen in Fig. 2, at least two hanger assemblies are required to support a shelf. For simplicity, no shelf was included in the present simulation model. The simulation was carried out for one hanger assembly only and the weight on the shelf was modelled by a bending load on the flat horizontal part.

The dimensions of the three parts of the hanger are shown in Fig. 3. All dimensions are in inch. It should be noted that the dimensions were arbitrary chosen by the authors; they were not replicated from any existing model of hanger assembly. After creating the three separate Part files (Tran, 2014) according to the dimensions, an assembly file was prepared for SolidWorks simulation.

3. Simulation Model

The 3-dimensional model for the hanger assembly is shown in Fig. 4. The left end of both the horizontal and angular parts is kept fixed and shown by green arrows (arrows facing right). The applied load is shown by the purple arrows (downward arrows). The material assigned for all parts were Alloy Steel. As mentioned before, the applied load was varied from 10 to 50 lbs with an increment of 10 lbs. Five sets of results (one with each load) were produced.

4. Results

The Von Mises stress and displacement plots (SolidWorks Corp, 2013) for all five loads are shown in Figs. 5 and 6, respectively. These figures show the stress and deformation distributions on the parts along with their location of maximum and minimum values (Lee, 2014). It should be noted that the deformations of parts shown in these two figures are not their actual deformations. The deformation scale in these figures is 1500. This was done intentionally for better representation of deformation in different regions of the hanger assembly.

A summary of maximum stresses and displacements for all five sets of simulation is presented in Table 1.

As expected, the stress increases with the load. The maximum stress is developed for 50 lbs which is 706.4 psi. The upper horizontal part is subjected to more stress regions than the lower part. A comparison of the five plots in Fig. 5 shows that the change in load does not cause any change of stress distribution over the parts. The maximum stress is always located on the left side of the upper horizontal part close to the wall due to the cantilever effect.

It is observed from Fig. 6 that for all loads, the maximum deformation takes place in the middle of the upper horizontal part. As the load increases, the amount of deformation also increases. The maximum deformation, 9.08×10^{-4} inch, is obtained for 50 lbs load. The ends close to the wall for both parts and the region where the two parts are connected are the lowest displacement regions. Similar to stress, any change in loads does not modify the regions of deformation over the parts.

The maximum stress developed in this study is 706.0 psi, which is much lower than the yield stress, 89984.6 psi (Hibbler, 2013) of the selected material of the study, Alloy Steel. This means that none of the three parts yielded/failed due to the developed stress caused by the applied loads tested in the study. The design factor of strength (SolidWorks Corp, 2013) in this case is 89984.6/706.0 = 126.04. Thus, a minimum load of 50×126.04 = 6302.03 lbs will be required to yield the upper horizontal part.

5. Conclusions and Future Work

A load-carrying hanger assembly with specific dimensions and material has been modelled by SolidWorks simulation and tested for loads from 10 to 50 lbs with an increment of 10 lbs.

For all five loads applied to the hanger, the upper horizontal part was more stressed than the lower part, and the maximum stress was developed where it is attached to the wall.

For all loads applied to the hanger, the maximum displacement took place in the center of the horizontal part, and the ends close to the wall for both parts and the region where the two parts are connected were subjected to lower displacement.

As expected, the amount of stress and displacement kept increasing with the increase of load. Any change in load did not cause any modification of stress and displacement distribution over the parts.

None of the three parts failed/yielded due to loads tested in the study. With the same fixture and material, it is expected that the hanger assembly might fail when a load of 6320 lbs (approximately) is applied on the horizontal part.

As a next step, the authors plan to study the effect of material for the same model. In future, the authors also want extend their study by creating a complete model that consists of two hanger assemblies, the wall, and the shelf (as shown in Fig. 2), and conducting a static analysis for more detail understanding of stress and displacement distributions.

Acknowledgement

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Table 1: Summary of Von Mises Stress and Displacement

Loads (lbs)	Von Mises Stress (psi)	Maximum Displacement (inch)
10	134.8	1.82×10^{-4}
20	282.6	3.63×10^{-4}
30	423.9	5.45×10^{-4}
40	565.1	7.27×10^{-4}
50	706.4	9.08×10^{-4}

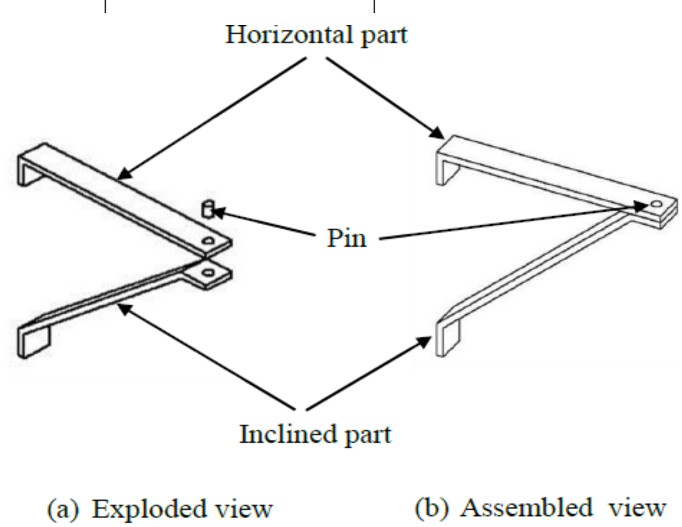

Fig. 1: Components of a Load-Carrying Hanger Assembly

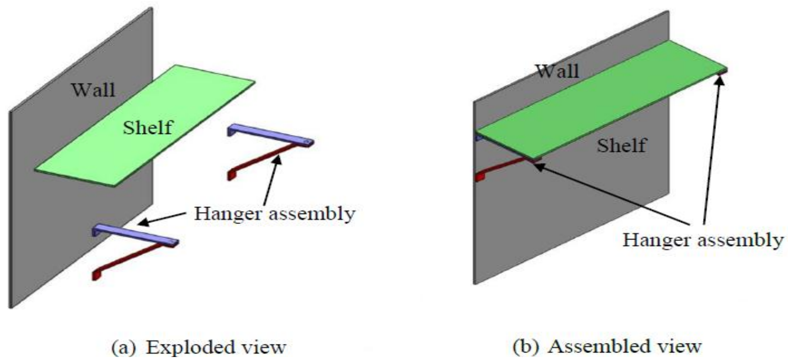

Fig. 2: Two Hanger Assemblies Attached to a Wall and Supporting a Shelf

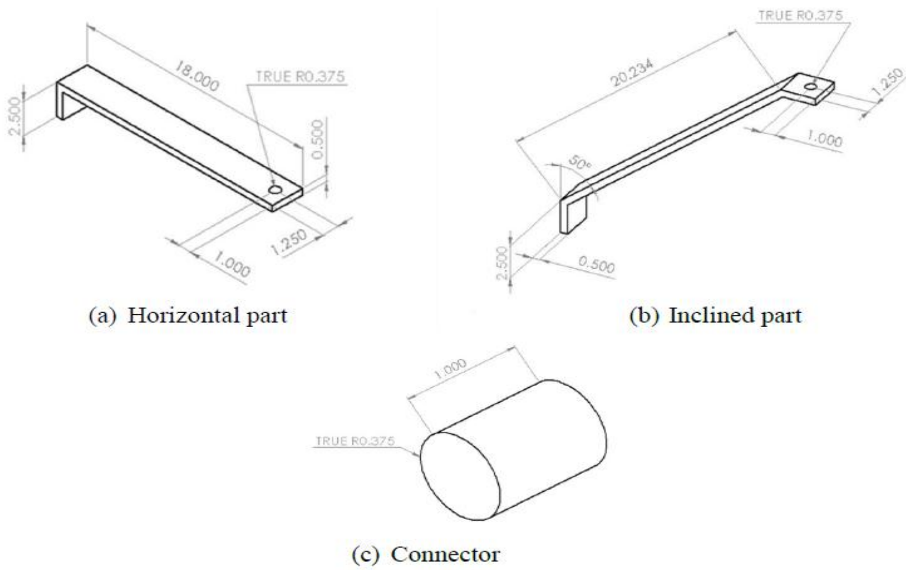

Fig. 3: Dimensions (in inch) of the Hanger Components

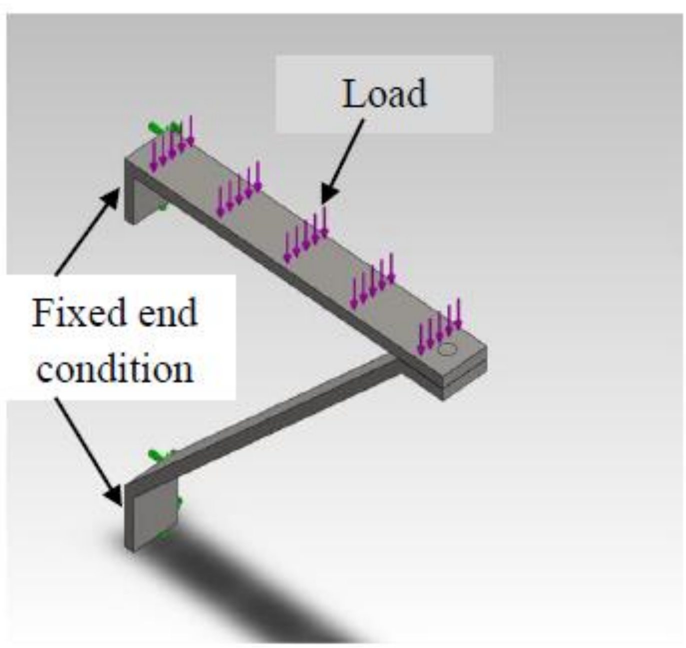

Fig. 4: Simulation of Load and End Conditions

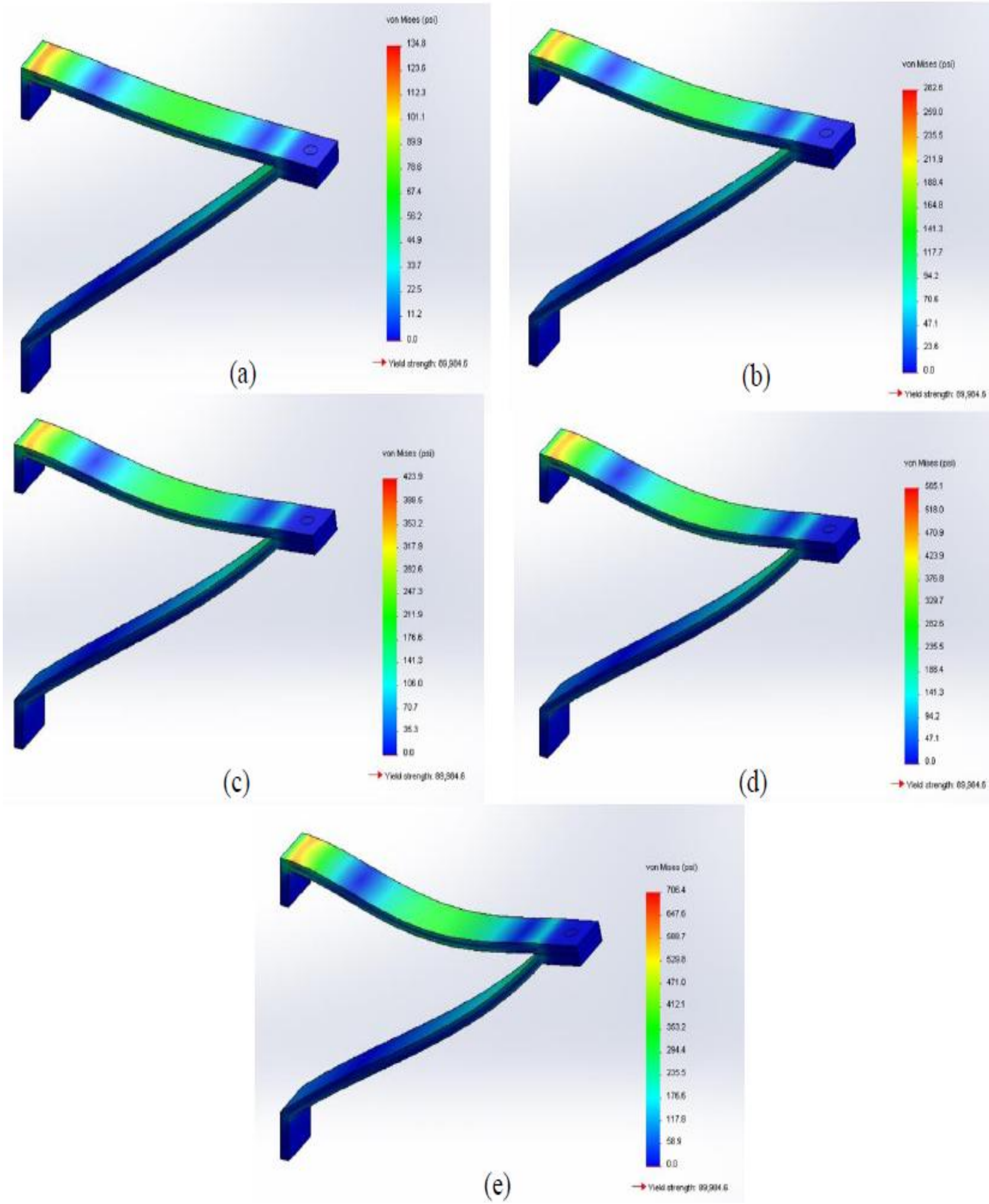

Fig. 5: Von Mises Stress (in psi) Plots for (a) 10 lbs, (b) 20 lbs, (c) 30 lbs, (d) 40 lbs, and (e) 50 lbs

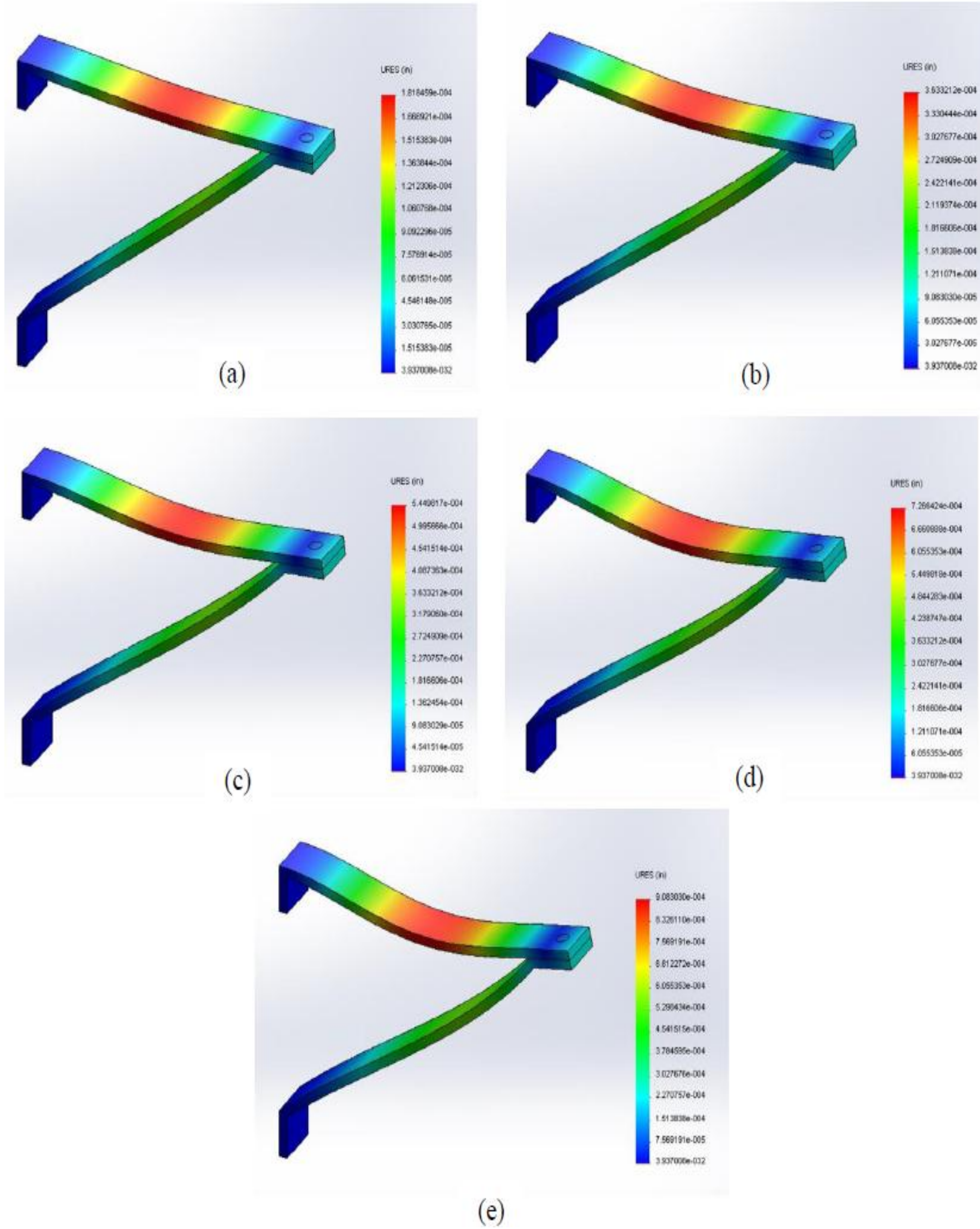

Fig. 6: Displacement Plots (in inch) for (a) 10 lbs, (b) 20 lbs, (c) 30 lbs, (d) 40 lbs, and (e) 50 lbs