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# Analysis and Improvement of Sealing Technology for Automation Packaging Process for Water Bottles

Dinesh Koya, Dr. Jeremy (Zheng) Li
*Department of Mechanical Engineering/University of Bridgeport, USA*

**Abstract:** This project provides a design of a carton sealing machine that uses adhesive tape to seal the top and bottom part of the carton. This sealing machine is designed for automation that reduces intensive labour that would otherwise be required to carry out sealing of cartons filled with water bottles.

This design adopts the use of pushers, in this case, a conveyor with rollers instead of conveyor belt. This reduces power usage that will be required by the motor to rotate the conveyor belt and increases the safety of the operation. The conveyor's height will be made adjustable to allow for increase and lowering of the height as required during operations. The system also ensures that the carton once inside the sealing machine does not open upbefore or during the sealing process. The paper also elaborates the designed sealing mechanism of the carton sealer which comprises of fixed system, adhesive tape adhering units, and tape cutting unit. The system also uses side belts that automatically pulls in the carton to be sealed without human intervention and ensures the case is also pushed out once sealed. Finite Element Analysis of the major components of the Sealer proves the system is safe fail as the stress values are much less than the yield strength of the material used in the design.

## 1. Introduction

One of the main challenges in production, mainly FMCG sector producing large amount of goods iscartoning, especially sealing. For proper transportation and storage of produced goods, the final products are mostly packaged in cartons. Cartons are predominantly used because of their sustainability to the environment; they are light to handle and protect the product inside from being squashed and ruined.

When packing of final water bottles, cardboard cartons are used in this case and this process require proper sealing of the cartons. This process of packaging and sealing, however, are normally labour intensive as most of the work is done manually with little help of machinery. This process has low efficiency, and packaging and sealing of large batches have prolonged delivery period, with high labour cost, with low accuracy due to the fatigue that comes with manual handling.An example is the use of hand-held carton sealer for sealing of the carton.

The designed sealing system comprises of Fixed frame where all other components are attached, adhesive tape sleeve which holds the sealing unit to the fixed frame directly, the front roller, which rolls the adhesive tape onto the carton to start the sealing process, the swinging arm that provides the space for the carton to pass to the cutting cylinder in which the cutting blade is attached which cuts the adhesive tape once the sealing is complete. The movement of the carton is fully facilitated by the conveyor rollers and the rotating belts.

## 2. Design of the Carton Sealing Machine

The design of the components of the Carton Sealing Machine is done with SolidWorks CAD software. This software provides the best design in 3-Dimensions.The design is an incorporation of the mountain bracket the carries all other components, tape dispenser mechanism, bottom frame that holds the rollers and transports the carton (Technologies, 2024).

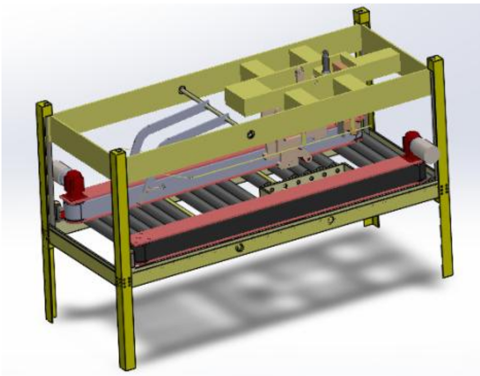

Figure 1: Main Assembly

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## 3. Method and Analysis

**Materials Selection**

The design of the carton sealing machine for water bottles requires material with the best mechanical properties. In this case, the most important property is corrosion as the application will be in a highly moisturised area. The effect of water on the metallic components should not be effective. In this design the best material to be used is 316 Stainless Steel.

| Properties | |
|---|---|
| **Name:** | AISI Type 316L stainless steel |
| **Model type:** | Linear Elastic Isotropic |
| **Default failure criterion:** | Max von Mises Stress |
| **Yield strength:** | 1.7e+08 N/m^2 |
| **Tensile strength:** | 4.85e+08 N/m^2 |
| **Elastic modulus:** | 2e+11 N/m^2 |
| **Poisson's ratio:** | 0.265 |
| **Mass density:** | 8,027 kg/m^3 |
| **Shear modulus:** | 8.2e+10 N/m^2 |
| **Thermal expansion coefficient:** | 1.65e-05 /Kelvin |

## 4. Finite Element Analysis

The finite element analysis is a numerical technique. In this method allthe complexities of the problems, like varying shape, boundary conditions and loads are maintained as they are but the solutions obtained are approximate (M.Yugender, 2023). FEA solves the forces in the most accurate manner using equations that would otherwise be unsolvable by hand. The result also provides visual presentation of the impact of the load applied onto the components (J. Ed Akin, 2009), (Akin, 2009).

The FEA calculates Von Mises stress, which uses a criterion that a material will not begin to fail as long as the maximum distortion energy value does not exceed the distortion energy (Kurowski, 2023). It is used to determine if a material will begin to yield as long as the maximumVon Mises Stress value does not exceed the yield strength of the material.

### 4.1. Top Dispenser Holder FEA

In this study, the design and FEA analysis are done using SolidWorks software. FEA
In this study, we used the maximum mass of water in the carton as follows:

$$Mass\ of\ full\ 500\ ml\ water\ bottle = 0.53kg$$
$$= 0.53\ x\ 10N = 5.3N$$
$$Taking\ a\ maximum\ of\ 35\ bottles\ in\ 1\ carton:$$
$$= 5.3N\ x\ 35 = 185.5N$$
$$A\ corrugated\ cardboard\ carton\ is\ made\ up\ of\ 3\ layers:$$
$$Mass = 500\ grams\ (At\ maximum) = 0.5Kg = 5N$$

Using the mass of 185.5N in the finite element analysis for the bottom frame since it is the part on which the cartons run. The results of the FEA are as follows: The green arrows mark the fixed geometries as it is not moving and not forces are assumed to be acting on its surface. The purple downwards facing arrows shows the downward load acting on the surface.

### 4.2. Fixed Geometry and loading

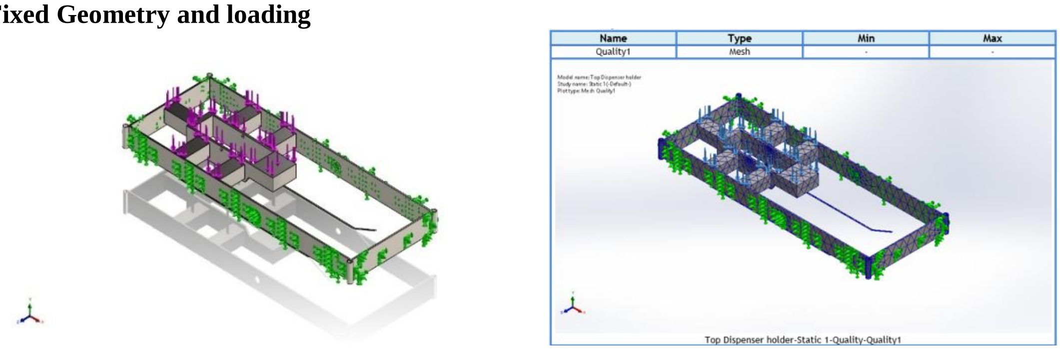


Figure 2: Top Dispenser Loading

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### 4.3. FEA Stress and Displacement Analysis

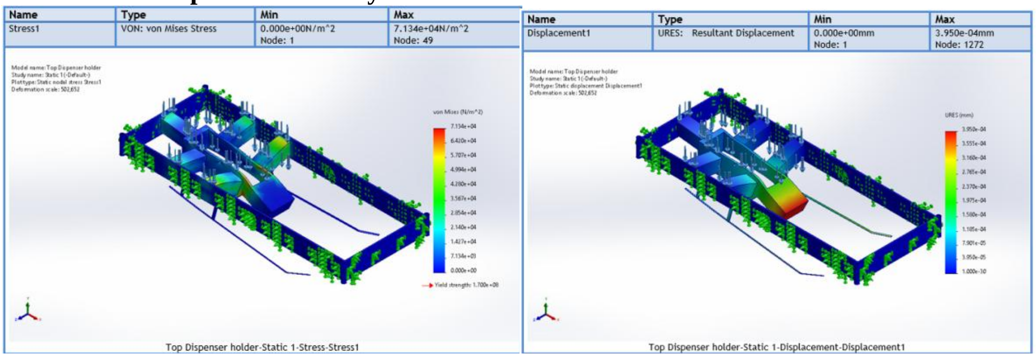



Figure 3: Stress and Displacement

### 4.4. FEA Strain Analysis

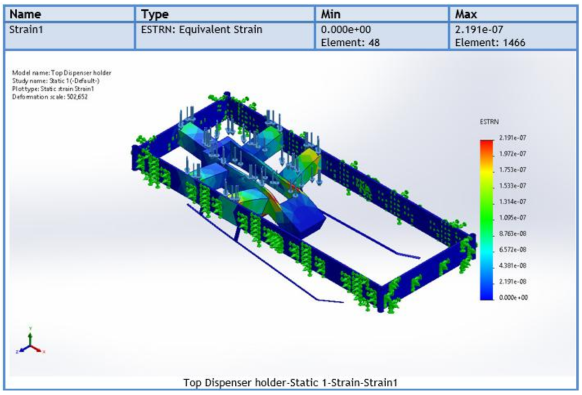



Figure 4: Strain

### 4.5. Conveyor Tray

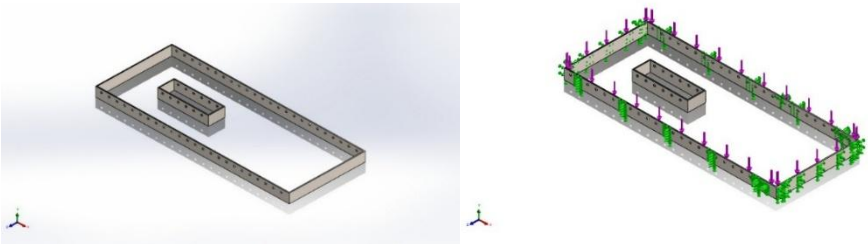


Figure 5: Conveyor Tray for FEA

### 4.6. Fixed Geometry and loading

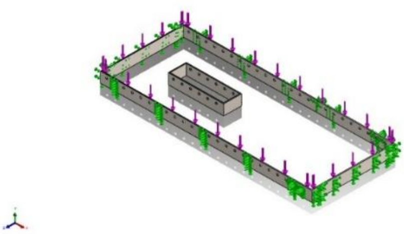


Figure 6: Forces load and fixed geometry

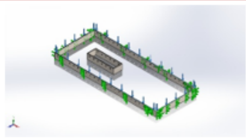
| Load name | Load Image | Load Details |
|---|---|---|
| Force-1 |  | **Entities:** 1 face(s)<br>**Type:** Apply normal force<br>**Value:** 200 N |

Figure 7: Load Details

### 4.7. FEA Stress Analysis

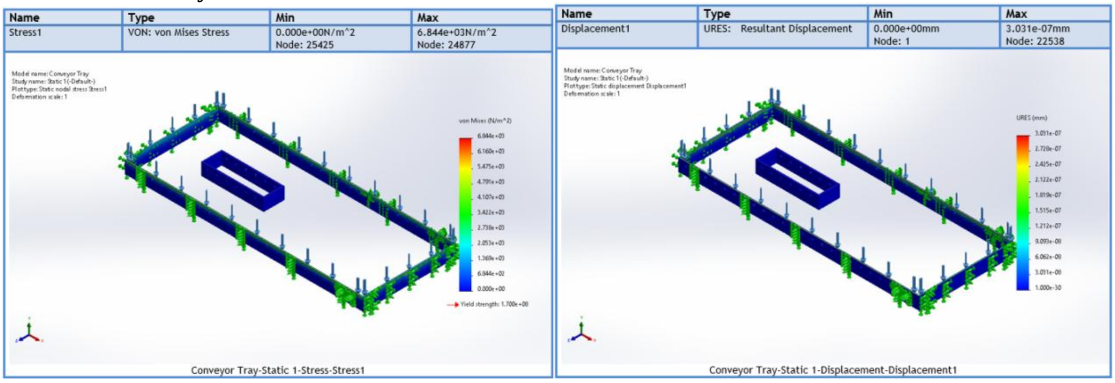



Figure 8: Stress Analysis

### 4.8. FEA Strain Analysis

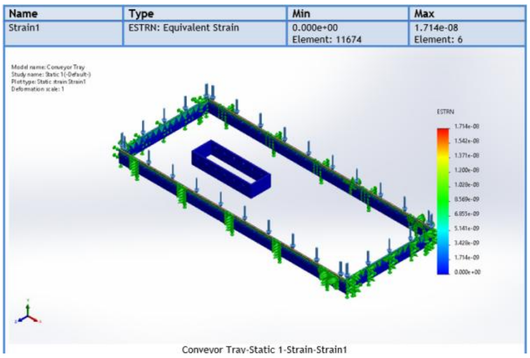
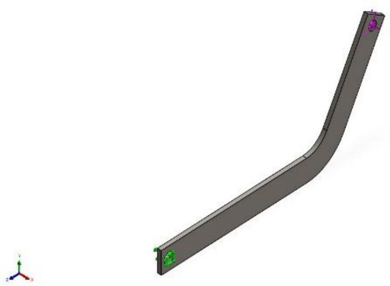
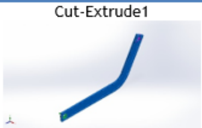
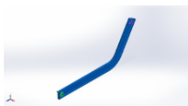


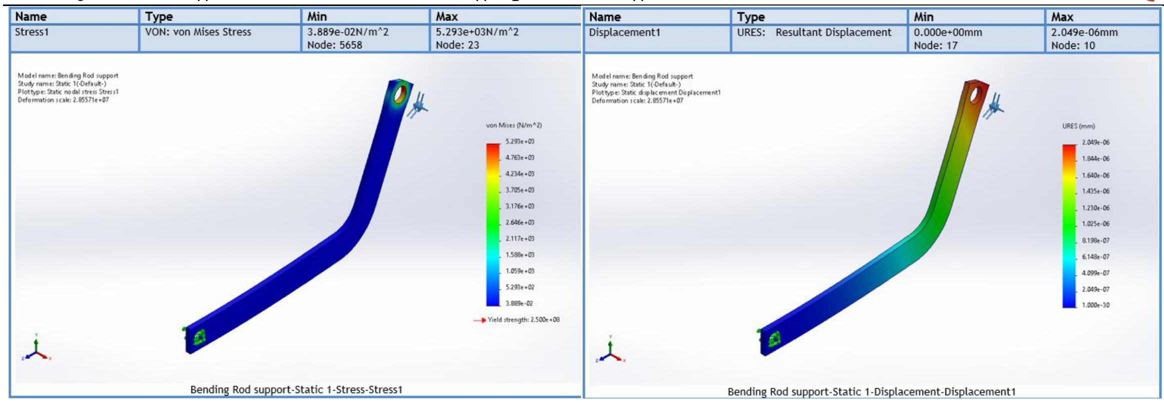

Figure 9: Strain Analysis

### 4.9. Bending Rod Support



| Document Name and Reference | Treated As | Volumetric Properties |
|---|---|---|
| Cut-Extrude1<br> | Solid Body | Mass:2.57682 kg<br>Volume:0.000328258 m^3<br>Density:7,850 kg/m^3<br>Weight:25.2529 N |

| Model Reference | Properties |
|---|---|
|  | **Name:** ASTM A36 Steel<br>**Model type:** Linear Elastic Isotropic<br>**Default failure criterion:** Unknown<br>**Yield strength:** 2.5e+08 N/m^2<br>**Tensile strength:** 4e+08 N/m^2<br>**Elastic modulus:** 2e+11 N/m^2<br>**Poisson's ratio:** 0.26<br>**Mass density:** 7,850 kg/m^3<br>**Shear modulus:** 7.93e+10 N/m^2 |




## 5. Results Discussion

**Conveyor Tray Results Comparison**

| | FEA ANALYSIS | CALCULATION |
|---|---|---|
| STRESS | 6844 N/m2 | 3360.507 N/m2 |
| STRAIN | 3.031 x 10^-7 | 1.741 x 10^-10 |
| DISPLACEMENT | 1.714 x 10^-8 m | 4.8057 x 10^-10m |

**Top Dispenser Holder Results Comparison**

| | FEA ANALYSIS | CALCULATION |
|---|---|---|
| STRESS | 71340 N/m^2 | 1261.034 N/m2 |
| STRAIN | 2.191 x 10^-7 m | 6.5338 x 10^-11 |
| DISPLACEMENT | 3.950 x 10^-4 | 111.08 x 10^-9 m |

**Bending Rod Support**

| | FEA ANALYSIS | CALCULATION |
|---|---|---|
| STRESS | 5.293e+03N/m^2 | 316.1 |
| STRAIN | 1.918e-08 | 1.58e-9 |
| DISPLACEMENT | 2.049e-06mm | 7.9026e-14 |

From the calculations and FEA analysis for the main component results above and comparing the results, the stresses calculated vs the FEA are not far apart. The stresses calculated and the FEA are below the Yield strength of the material whose value is 1.7 x 10^8 N/m2. This shows that the material used will not yield or fail at the given loads or any loads above that.

The displacement values from the calculation and the FEA analysis also bring out values that are almost negligible. This is an indication that the materials used in this design will be able to hold onto all the components load subjected to it.

## 6. Future Improvements

For the future improvements and to increase efficiency and functionality of the Case sealing machine, introduction of an automated carton reject mechanism will be highly effective. This involves introduction of an automated mechanical rejecting component that automatically pushes away any carton that has been detected to have poor sealing on either the bottom or top section. This will improve the efficiency of the machine as it will ensure no poorly sealed carton passes through to the correctly sealed cartons.

This is highly practical as it will involve installation of a new conveyor that will divert the poorly sealed cases to a collection point where they will be collected for resealing. The mechanism will work hand in hand with the film sensor that detects the adhesive tape on the case.

## 7. Conclusion

The main object of the project, design of an automated carton sealing machine has been achieved. The machine components, especially the metallic parts are designed with material 316 Stainless Steel with the best mechanical properties, which in this case best corrosion resistance. This is an important property as this is applied in the water packing industry and this means contact with moisture is unavoidable. The high tensile strength is also very important as it will be used to seal heavy cases of filled water bottles, in this case with an application of 200N giving a stress of 6844N/m2 against a yield strength of 1.7x10^8N/m2 provides a fail-safe unit for the designed parts.

The application of sensors also plays a very important role in eliminating manual interventions and saving on labour and operation costs as they control the entry of the carton, conveying to the sealing section and stops the conveyors whenever there is no sealing to be done or when there is insufficient adhesive tape.

## 8. References

[1]. Abraham Asmamaw, B. Z. (2015). *Design of Carton Packing Machine.* Kombolcha.
[2]. Akin, J. E. (2009). *Finite Element Analysis Concepts Via SolidWorks.* Houston, Texas.
[3]. Garoma, S. (2017). *Evaluation of Stress, Strain and Deflection of Flexible Pavements: Using Finite Element Method Case Study on Bako toNekemte Concrete Asphalt Highway.* LAP LAMBERT Academic Publishing.
[4]. J. Ed Akin. (2009). *Finite Element Analysis Concepts via SolidWorks* . Houston: World Scientific .
[5]. Kurowski, P. (2023). *Engineering Analysis with SOLIDWORKS Simulation 2023.* SDC Publications.
[6]. Lei, L. F. (2025). Design and Simulation of Automatic Cartoning Machine. *Journal of Engineering Research and Reports*, 180-188.
[7]. M.Yugender. (2023). *FINITE ELEMENT ANALYSIS (R20A2137)* . India.
[8]. Technologies, A. (2024). *square-photoelectric*. Retrieved from ADS Technologies Website: https://www.adstechnologies.co.in/square-photoelectric/