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# Design And Analysis of Bucket Elevator Bucket using static structural analysis method

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**Abstract**— Bulk, dry, moist, and even liquid items are transported using bucket elevators. Depending on the type of material to be transported, it is constructed for various criteria like as height, speed, and structural strength. The project's major goal is to boost the elevator bucket's weight bearing capability. The relief of strain on the bucket lead edges and clamping bolts is another goal. When bucket elevators are subjected to extreme operating circumstances or buildup (in the case of sticky bulk materials), they are prone to malfunction. High capacity buckets are intended to hold heavier loads in order to prevent these issues. The finite element method can be used to do this. Solidworks 2018 was used to create a 3D model of a Bucket Elevator.and analyzed using ANSYS 16.1.

**Index Terms**— Handling of Material, Bucket Elevator, Bucket, Solidworks 2018, ANSYS, Cad modelling, CAE, FEM, FEA, Static structural

## I. INTRODUCTION

Material Handling is a part of consumer industry. For every product which is produced has to be transported at some point of time or stored at storage. So what is Material Handling? Material handling is defined as the storage and movement of materials. The material handling industry is efficient as the material handling equipment. Material Handling Solutions provides the best material handling equipment available for moving and storing materials affectively and quickly [1]. To move the material from specific points conveyors are used which also divided into based on the type of load handled. Screw conveyor and belt bucket conveyor are the basic example of the conveyor. A conveyor system is used for identification and separation. The conveyor system consists of the roller, flat belt and chute segments which is having variable arms.Central bucket elevators are used to move materials upwards directions at particular height. The elevators use an endless chain/belt which is attached with the buckets. The bulk material is divided based on an inlet hopper where the buckets takes the material and convey it up and over the head sprocket. Thereafter, the buckets take the material out via a discharge spout [3] as shown in Figure 1 The buckets are returned down to the tail sprocket at the bottom. The bucket elevator consists of buckets to contain the material, chain or belt drive to carry the buckets and transmit the pull. In addition, it also has electrical motor to drive the chain or belt, loading and discharge spout for loading the buckets at the boot and receiving the discharged material at the head respectively. Tensioning device is also installed for maintaining the chain/belt tension. All these accessories are enclosed and protected in a casing [1].

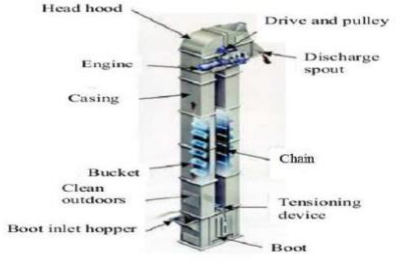


Figure 1: Central chain bucket elevator [3]

## II. LITERATURE REVIEW

**N. Yashaswini**, et al. [1] studied —Design and Optimization of bucket elevator using FEA‖, In this paper Bucket is designed to carry materials at a height of 10m. Bucket is designed in NX software. Vibration analysis is carried out using the ANSYS. In this paper dynamic behaviour of the Bucket is also studied.

**Hemlata H. Mulik** and **Bhaskar D** [2] studied —Design of Sugar Bucket Elevator and Roller Conveyor Chain for 20 Tonnes per Hour Capacity‖, in this paper Roller conveyor is designed and loading condition is described.

**Snehal Patel**, et al. [3] studied —Design and Analysis of different part of Bucket elevators‖, Failure of shaft is the main reason for the failure of bucket. In this paper shaft analysis is done and material is updated to avoid the failure.

**F.J. C. Rademacher** [4] analysed, —Non-Spill Discharge Characteristics of Bucket Elevators‖ Backflow causes failure of bucket. In this paper spill free characteristics of bucket is studied.

**Edward Yin**, et al. [5] studied, —Bucket Elevator central chain links is analysed—. To reduce the production down time it is necessary to replace chain links as soon as possible as it caused the loss of productivity. To study this chemical and Metallurgical analysis is carried out.

**Gazi Abu Taher**, et al. [6] studied, —Automation in Material Handling with different techniques‖. Belt conveyor and Bucket elevator is used to move the material from one point to other point. In this paper mainly the difference between both this technique is carried out with the experimentation.

**Kulkarni Digambar**, et al. [7] studied, —Chain breakdown of Bucket elevator using analysis‖, in this paper chain drive is designed and analysed which is used to drive the bucket elevator. Roller chain and Sprocket chain is replaced by the duplex chain.

In this section, two buckets made up from different material is studied. We have chosen a bucket from the manufacturer catalogue to obtain the required size. Based on the size, CAD model is formed in Solidworks. We have considered the Coir pith material for loading and unloading. After finalizing the CAD model, Analysis is done using the ANSYS for two different materials which is Steel and Epoxy. Based on the analysis results, final conclusion is obtained.

## III. BUCKET ELEVATOR

A bucket elevator is used to move the various bulk materials in upwards direction. Vertical elevators depend on centrifugal force so that materials will flow in to the discharge chute and runs at high speed. Centrifugal bucket elevator is having the spaced bucked with rounded bottoms. These buckets are mounted on elevator either close to each other or mounted apart. Bucket elevator is consists of flat chain on which small bucket is bolted. Most of the times rubber belt with plastic bucket is also used. Pulleys are used on top and bottom with specified diameter. The pulley is driven by an electric motor. The elevator allows the materials sent to the chosen bin.

**Attachments of Buckets**

**CHAIN**

With the used of hex head bolts, bucket is attached to the chain with lock washers. As from the figure 2, bolt head is inside the bucket.

**BELTS**

To attached buckets to the belt, Norway bolt or oval head type bolt is used. As from figure 2, the flat of oval head is placed on the pulley side of the belt with the use of a lock washer and nut. Pliable washer is used between the belt and bucket.

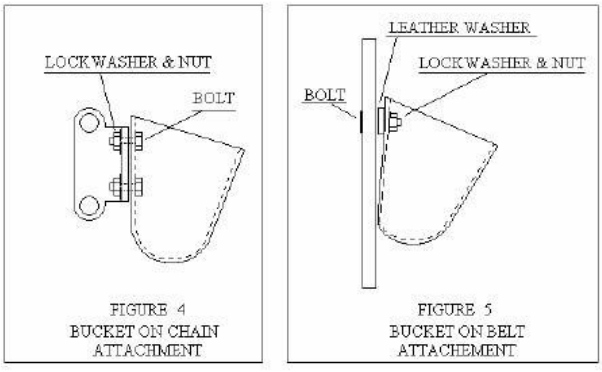


Figure 2: Bucket Attachments [9]

## IV. PROBLEM STATEMENT AND METHODOLOGY

**Problem Statement**

Bucket elevators are widely used equipment in mechanical industry. Satisfactory level of materials we are using till now for buckets are not sufficient so it is always advisable to find the new material. Vibration can cause failure of structure.

**Systematic Methodology for project**

- To study about the bucket including the type of failure.
- To study the various work on this subject including reading previous research papers on this subject.
- To design the bucket for the particular application by using the analytical method.
- Modeling the geometry in the CAD software.
- Pre-processing of geometry in the Analysis software.
- Processing the results.
- Post-processing the result including getting various results.
- Experimentation of the bucket.
- Validation of the results.

## V. ANALYTICAL DESIGN

To handle varieties of dry and wet materials, design and manufacturing criteria is very important which is handled by Martin Conveyor Designs In this project, we are selecting Centrifugal Discharge Chain elevator for design and analysis of bucket. For design of bucket we are referring Martin catalogue, this catalogue is designed to make a preliminary selection of a bucket elevator and bucket size.

**Style AA**

Malleable iron buckets generally used for free flowing materials. Centrifugal Discharge buckets can be mounted on chain or belt.

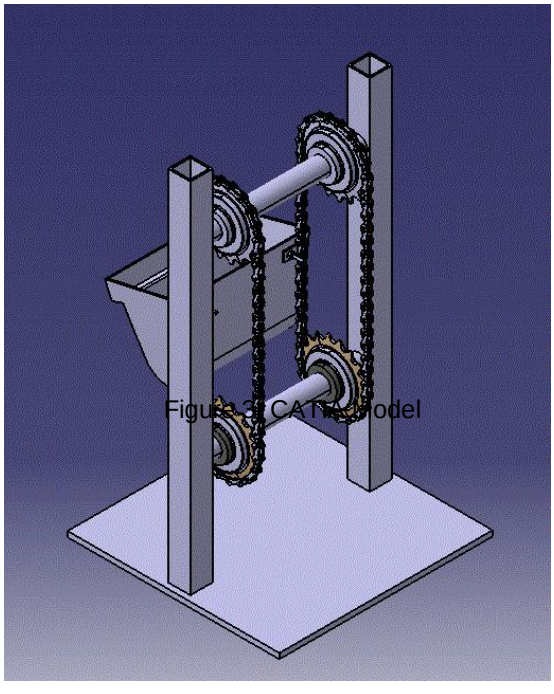

Figure 3: CAD Model

**Design Calculation**

Figure 4: Bucket volume detail view

Volume of a semi-circular

$$V_1 = \frac{\pi r^2}{2} \times h$$

$$V_1 = \frac{\pi(25)^2}{2} \times 150$$

$$V_1 = 117.81 \times 10^3 mm^3$$

Volume of rectangle

$$V_2 = L \times H \times W$$

$$V_2 = 88 \times 21 \times 150$$

$$V_2 = 605.79 \times 10^3 mm^3 \; V_2 = 605.79 \times 10^3 mm^3$$

Volume of rectangle

$$V_3 = L \times H \times W$$

$$V_3 = 88 \times 21 \times 150$$

$$V_3 = 277.2 \times 10^3 mm^3$$

Total volume of elevator bucket

$$V_T = V_1 + V_2 + V_3$$

$$V_T = 117.81 \times 10^3 + 605.79 \times 10^3 + 277.2 \times 10^3$$

$$V_T = 1000.8 \times 10^3 mm^3$$

$$\rho = \frac{m}{v}$$

Particle density = 0.8g/cc = 800 $Kg/m^3 Kg/m^3$

$$800 = \frac{m}{1000.8 \times 10^3 \times 10^{-9}}$$

m= 0.8Kg

Total mass of coir pith collected in bucket 0.8 Kg

Force apply on bucket is mass $\times g \times g$

= 0.8$^{\times\times}$9.8

= 7.84 N

## VI. ANALYSIS

The FEM is mathematical approach to solve the engineering application and Physics problems. This method is used to solve Heat Transfer analysis, Structural analysis problems. The method gives approximate values at discrete number of points. From this method we can calculate the Stress and Strain at various part of the model.

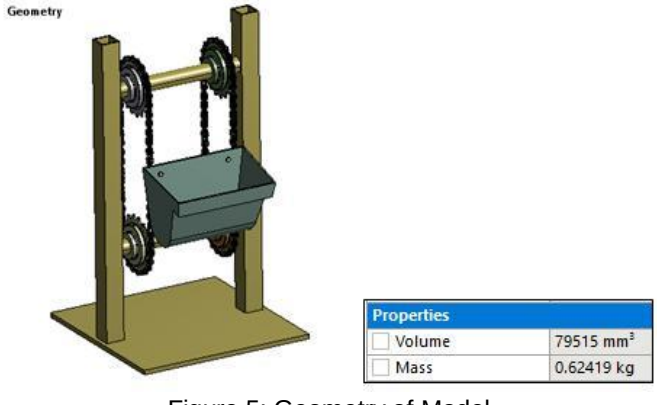


Figure 5: Geometry of Model

| Material | Steel | Epoxy |
|---|---|---|
| Young Modulus (GPa) | 200 | 35 |
| Poisson's Ratio | 0.3 | 0.4 |
| Density(Kg/m$^3$) | 7850 | 1.8 |
| Yield Strength (MPa) | 250 | 80 |

**Boundary Condition**

A boundary condition for the model is set a load at particular point to define the factors like displacements and stress. These applied to points, surfaces and edges. Before applying the Boundary condition we need to constraint the model first. Over and under constraints gives an inaccurate results.

**Total Deformation**

The total deformation & directional deformation are general terms in finite element methods irrespective of software being used.

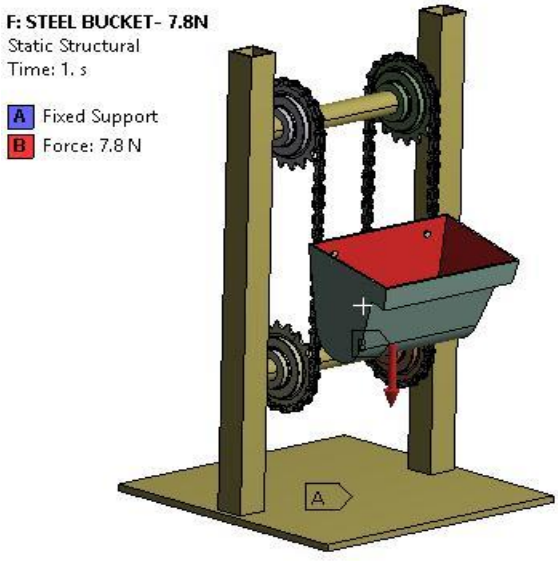


Figure 6: Boundary Condition

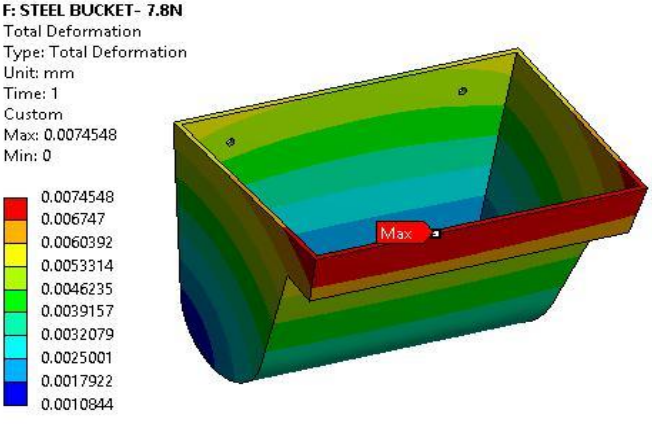


Figure 7: Total Deformation of Steel Bucket

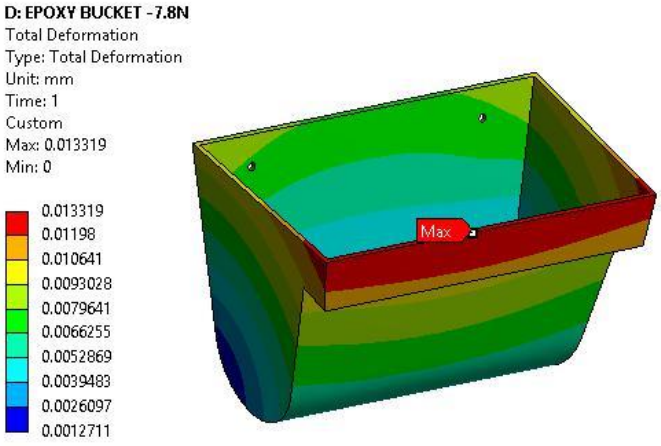


Figure 8: Total Deformation of Epoxy Bucket

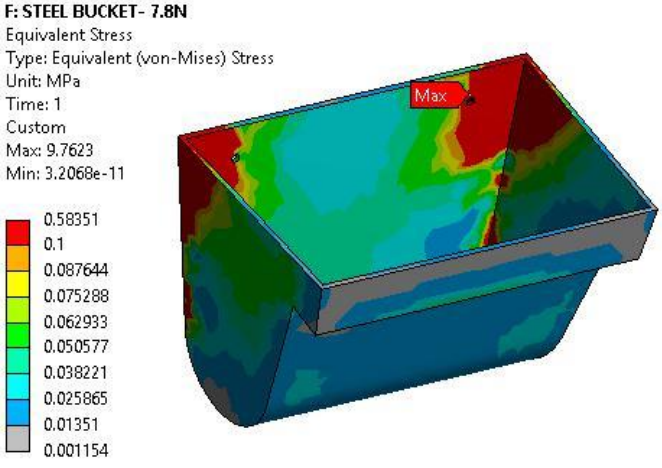


Figure 9: Equivalent Stress of Steel Bucket

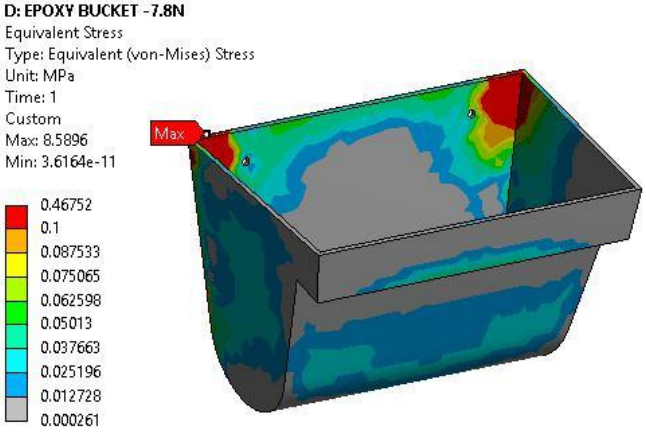


Figure 10: Equivalent stress of Epoxy Bucket

## VII. EXPERIMENTAL TESTING

A universal testing machine (UTM) is used to test tensile strength and compressive strength of material. Below is the specification of the UTM.

**Specification:**

- High Speed Latest Micro controller-based Technology
- Capacity / 20000 Optional On board Extensometer facility with 1-micron resolution & up to 20 mm travel. 20 data set storage ( 00 to 19) 75 Results Storage ( Related to one data set) Data Entry & Parameter selection through Keyboard Non Volatile memory for Result & test data storage.
- All Stored Results & Last test complete data with Graph will be available.
- Result & Graph printout, Certificate, Batch & Statistics Printout including Standard deviation.
- kN / kg unit selection for Displayed Load & Results.
- On Board Overload Relay for Load Safety & Encoder Over, travel safety.
- Accurate 2 point Digital Calibration from Panel & PC Software.
- RS232c serial interface for PC connection with variety of latest Windows based software for data logging & analysis.
- Real time Online Graph on PC.
- Once PC connected this becomes complete PC controlled system, with all Displays & Key functions on PC screen.

**Test Plots**

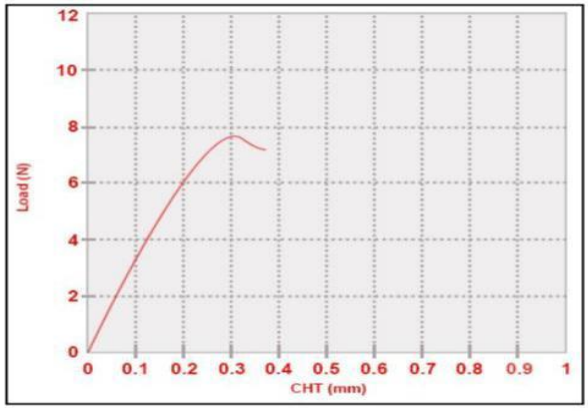


Figure 11: Load vs. Deformation plot for Steel Bucket

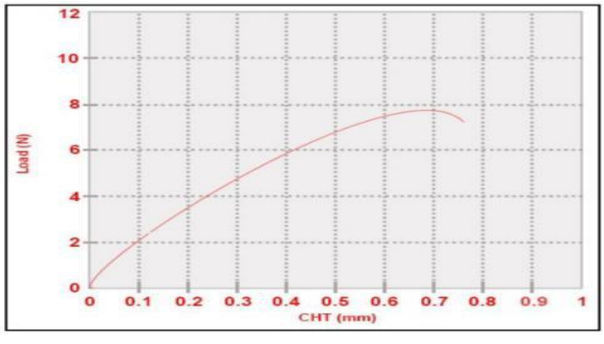


Figure 12: Load vs. Deformation plot for Epoxy Bucket

## VIII. RESULTS AND DISCUSSIONS

Bucket elevator was studied thoroughly. Design was based on the application and Bucket manufacturer catalogue is mentioned. 3D model is drawn in CATIA V5. The Analysis was carried out with the help of ANSYS software.

- 20000 Load Counts in one Range, Load Resolution = Machine

From the analysis results, it is clear that the strength of the epoxy bucket is more than that of the original material of the bucket. From the UTM testing, Load carrying capacity for both the bucket is carried out. Steel bucket is having load carrying capacity up to 10 kg and Epoxy bucket is sustain up to 6 kg.

**Table 2: Static Analysis Result**

| Sr. No. | Specifications | Steel Bucket | Epoxy Bucket |
|---|---|---|---|
| 1. | Total Deformation (mm) | 0.0074 | 0.013319 |
| 2. | Equivalent Stress (MPa) | 9.76 | 8.58 |

**Table 3: Weight Comparison**

| Sr. No. | Case | Weight (Kg) |
|---|---|---|
| 1 | Steel Bucket | 0.624 |
| 2 | Epoxy Bucket | 0.147 |

Weight Reduction = (Existing - Optimized) / Existing
= (0.624 – 0.147)/0.624
= 76.4 %

## IX. CONCLUSION

- Bucket elevator was studied thoroughly. Design was based on the application and Bucket manufacturer catalogue is mentioned. 3D model is drawn in CATIA V5. The Analysis was carried out with the help of ANSYS software.
- From the analysis results, it is clear that the strength of the epoxy bucket is more than that of the original material of the bucket.
- From static analysis, we get weight of each bucket steel, epoxy is 624g and 147g respectively that conclude that weight of bucket decreases due to use of glass fibre bucket hence overall weight of bucket elevator decreases.
- From UTM testing we get reading maximum load carrying capacity of bucket, steel bucket sustains 10kg load and epoxy bucket sustain 6 kg load hence it conclude that design bucket is safe for coir pith application

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