Asian Journal of Convergence in Technology **Volume 4 Issue III**
ISSN No.:2350-1146, I.F-5.11

DESIGN AND ANALYSIS OF BUCKET ELAVATOR

A. Sanket Hiralal Lunawat, P.G. Student, Mechanical Department, D Y Patil Institute of Engineering & Technology, Ambi, Talegaon, Pune

B. Kiran C. More, Associate Professor, D Y Patil Institute of Engineering & Technology, Ambi, Talegaon, Pune
(Corresponding author- kiran.more @dyptc.edu.in)

***Abstract*—Bucket elevators are the most used systems for vertical transport of bulk, dry, wet and even liquid materials. It is designed with various options of height, speed and constructive details depending on the type of material to be transported. The main aim of the project is to Design and Analyze elevator bucket using the two different materials. This can be achieved from finite element approach. For this a 3D model of bucket of elevator will be modeled using CATIA and analyzed using ANSYS**

Keywords— Material Handling, Bucket Elevator, CATIA, ANSYS.

I. INTRODUCTION

Material Handling is a part of almost every consumer industry. No matter what product is being produced, at some point in its production cycle it is likely to be transported or stored by material handlers. So what is Material Handling? Material handling is defined as the movement, storage, control and protection of materials, goods and products throughout the process of manufacturing, distribution, consumption and disposal. We made a short video to show just how important the material handling industry is to the global supply process. Find out what it takes to get all the products everyone needs to the places they need to go. The material handling industry is only as efficient as the material handling equipment powering it. Premier Handling Solutions provides the best material handling equipment available for moving and storing materials quickly and efficiently. Check out our great selection of Pallet Trucks, Pallet Stackers and Lift Tables today! The activity includes loading, unloading, palletizing (storing and transporting goods stacked on pallets, shipped as unit loads) [2].

II. LITERATURE

N. Yashaswini, et al. [1] studied “Design and Optimization of bucket elevator through finite element analysis”, International Journal of Mechanical Engineering Authors have designed a bucket elevator and analyzed it for conveying granular materials to the height of 15m at the rate of 10 tones/hour output. This paper gives basic design calculations for the development of the bucket elevator, in 3D environment of NX software. Static and vibration analysis carried out on the bucket elevator in order to need the required output from 10 tones/hr-20 tones/hr. This paper also gives the dynamic behavior of the bucket and gear shaft assembly. The results obtained from the analysis study critically examine the modification of design parameters

Hemlata H. Mulik, and [2] studied “Design of Sugar Bucket Elevator and Roller Conveyor Chain for 20 Tones per Hour Capacity”, International Journal of Engineering Trends and Technology. In this paper the different components of roller conveyor chains are designed for sugar bucket elevator used in sugar industries for 20 tons per hour capacity and the loading conditions are described. The advantages of chain drive as compared with other drives are discussed. The chain wear mechanisms found in literature are listed. Abrasive and adhesive wear between pin, bushing, and roller are also discussed.

Snehal Patel, et al. [3] studied “Productivity Improvement of Bucket Elevator by Modified Design”, International Journal of Emerging Technology and Advanced. This work deals with the design and analysis of elevator for conveying granular materials at 2 tonnes/hr output and lifting height 12m. Modelling of different components of bucket elevator has been done using 3d Solid Modelling software based upon the dimensions obtained from analytical design. The new modified design of the bucket elevator is proposed and validated using CAE tools which are well within the safe limit. Bucket elevator mainly fails due to breaking occurs at the inner edge of the pulley, it consider as fretting corrosion. So new material EN24 has been suggested for the shaft. From the analysis, it can be seen that for modified design has higher FOS than existing design.

F.J. C. Rademacher [4] analysed, “Non-Spill Discharge Characteristics of Bucket Elevators”, Elsevier Sequoia S.A., Lausanne. One of the well-known disadvantages of a simple type bucket elevator is still the backflow or spill. The accordingly lower capacity and increased power consumption are not always the worst consequences, provided that the boot does not become too full. With the considerable heights of modem bucket elevators, up to 225 ft. and over, serious damaging of the conveyed material, an intensified noise level and increased wear can be far more inconvenient. The discharge of the buckets has been recognized as an extremely complicated phenomenon which strictly speaking cannot be analyzed theoretically. This holds even more for free-flowing materials. Nevertheless, an analytical approximation has been worked out for the relatively simple case of cylindrical buckets filled with cohesive bulk material, to start with. With the developed approximate theory a spill-free combination of the relevant parameters has been found.

Edward Yin, et al. [5] studied, “Failure Analysis on Conveyor Chain Links of a Central Bucket Elevator“, International Journal of Engineering Research and Applications This paper deals with the design and analysis of different parts of elevator for conveying different types of materials. The modeling of bucket elevator done using solid modeling software and analyzed using conventional finite element software (ANSYS) and stresses and deflections are obtained. This study also shows that the negative influences of support of the shaft reflected through the increase in the stress concentration and occurrence of the initial crack are the main causes of the shaft fracture which is occurred at the keyway of the shaft and zone of contact between shaft and gearbox.

The bucket elevator is a machine to transport granular industrial materials in the vertical direction or along inclined planes. The design and performance of the elevators vary with the characteristics of the material, and must at least consider the geometry of the bucket and the operational speed.

In any case this simplification is useful for certain simple calculations, such as obtaining the important angle of detachment –angle at which the material leaves the bucket. The results of these calculations, complemented with many experiments, have resulted in the following criteria for bucket elevator design

–It is advisable to use buckets designed with the detector inclined about 45 degrees.

–Deep, high-capacity buckets are defined by a tulip-shaped outer wall with double curvature.

–The deeper the bucket and the smaller it’s opening angle, the harder will be to empty the contents, especially under high centrifugal action.

Bucket elevators are efficient machines to transport granular materials in industrial and civil engineering applications. These materials are composed of hundreds, thousands or even more particles, the global behavior of which is defined by contact interactions. The first attempts to analyze the transportation of granular materials were treated by very simple continuum methods that do not take into account these interactions, producing simulations that do not fit the experimental results accurately.

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 CATIA. 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

The Concept of the elevator has been around for many years. Variations that have changed to the elevator are its method of manufacture and types of materials used. As new materials are developed and quality materials become more readily available, then changes in design have been made to adapt to these materials. New technology has improved both design and manufacturing procedures. Computer technology has helped reduce design time, reduce rework and understanding the behavior of materials under different loadings. New technologies in manufacture have reduced manufacturing time, costs, weight and increased tolerances. These changes have allowed increase discharge height and greater capacities to be obtained. [4]

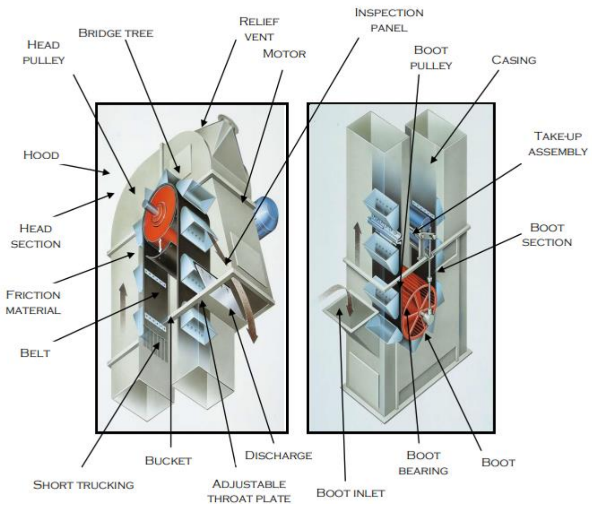

Figure 1 Parts of simple belt bucket elevator [1]

A. *Elevator uses*

An elevator is ideally used where the product needs to be elevated and consume only a small amount of ground area. Conveyed products are mostly granular solids, which range from powders to rocks. Limitations depend on how easily product can be loaded into and discharged from the bucket. Large granular products create difficulty loading and sticky products discharging. For products that are fragile and easily crushed, slower conveyance speeds are used. [5]

B. *Parts of an elevator*

The elevator has five main areas being the head, legging, boot, belt & buckets, elevator access and elevator support. Each of these areas can be broken into smaller areas as listed below.

The head consists of:

- Main structural sheet metal frame
- Covers with or without wear liners
- Throat wiper
- Head pulley and lagging
- Drive Shaft

- Bearings
- Gearbox and Motor or Gearbox, coupling (belts, chain, etc.) and motor
- Backstop

Legging consists of:

- Sheet metal trunking
- Flange connections
- Inspection windows and access doors

Boot consists of:

- Main Structural sheet metal frame
- Inlet chute with or without wear liner
- Boot pulley and shaft
- Bearings
- Pulley take-up for belt tensioning

Belt & buckets consist of:

- Belt with holes
- Buckets
- Bolts, spacer washers and anti-loosen nuts
- Belt joiners

Elevator access consists of:

- Stairs or ladders with cages
- Intermediate platforms with handrails
- Distributor or valve access platforms with handrails
- Platform to elevator connection
- Head Platform with handrails

Elevator support consists of:

- Elevator attachment lugs
- Guy ropes
- Concrete piers into the ground
- Structural tower in which the elevator is supported or hung
- Connections between elevator and tower

One of the most efficient ways to elevate bulk materials vertically is with a bucket elevator. A Bucket Elevator consists of a series of buckets attached to a belt or chain with pulleys or sprockets located at the top and bottom of the unit. The buckets are located in a casing or housing to contain the material. Bulk materials are loaded into each bucket as the bucket moves past an inlet point. KWS designs and manufactures a wide variety of bucket elevators based on the characteristics of the bulk material and the process requirements. [3]

IV. DESIGN

Computer-aided design (CAD) is the use of computer systems (or workstations) to aid in the creation, modification, analysis, or optimization of a design. CAD software is used to increase the productivity of the designer, improve the quality of design, improve communications through documentation, and to create a database for manufacturing. CAD output is often in the form of electronic files for print, machining, or other manufacturing operations.

From the Manufacture's Catalogue from Martin, We have considered C64-102 elevator number. For this elevator, Recommended Bucket size is 6 x 4 inch.

Based on the size, we have done 3D cad model in CATIA.

Calculations:

From the CAD data volume of Bucket is 825337 mm^3

Density of coconut fiber is 10gm/cm^3

The total mass of Coconut Fiber carried out by Bucket is calculated, which is 8.25 Kg.

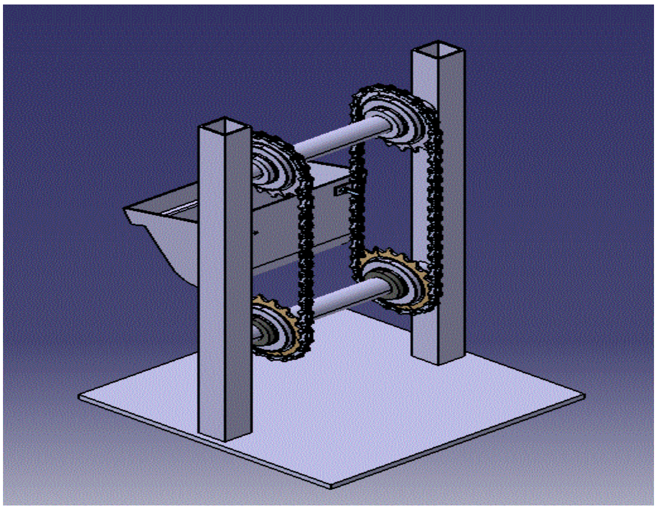

Figure 2 CATIA model of Bucket Elevator

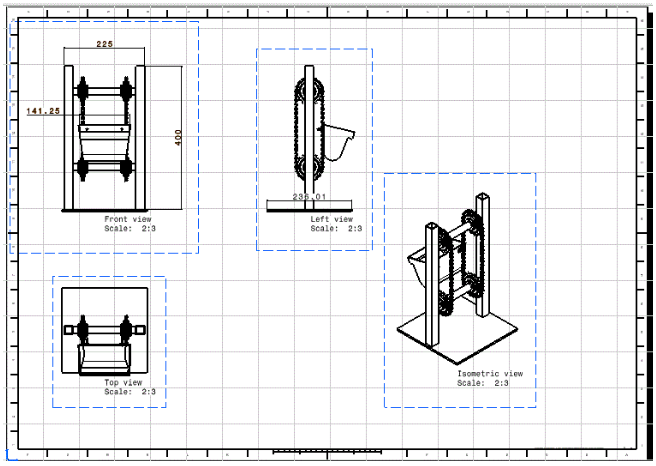

Figure 3 Drafting of Bucket Elevator

V. ANALYSIS

The Finite element method (FEM) is a numerical method for solving problems of engineering and mathematical physics. Typical problem areas of interest include structural analysis, heat transfer, fluid flow, mass transport, and electromagnetic potential. The analytical solution of these problems generally require the solution to boundary value problems for partial differential equations. The finite element method formulation of the problem results in a system of algebraic equations. The method yields approximate values of the unknowns at discrete number of points over the domain. To solve the problem, it subdivides a large problem into smaller, simpler parts that are called finite elements. The simple equations that model these finite elements are then assembled into a larger system of equations that models the entire problem. FEM then uses variation methods from the calculus of variations to approximate a solution by minimizing an associated error function.

Mesh

ANSYS Meshing is a general-purpose, intelligent, automated high-performance product. It produces the most appropriate mesh for accurate, efficient Multi physics solutions. A mesh well suited for a specific analysis can be generated with a single mouse click for all parts in a model. Full controls over the options used to generate the mesh are available for the expert user who wants to fine-tune it. The power of parallel processing is automatically used to reduce the time you have to wait for mesh generation.

Boundary Condition

A boundary condition for the model is the setting of a known value for a displacement or an associated load. For a particular node you can set either the load or the displacement but not both.

The main types of loading available in FEA include force, pressure and temperature. These can be applied to points, surfaces, edges, nodes and elements or remotely offset from a feature.

Total Deformation

The total deformation & directional deformation are general terms in finite element methods irrespective of software being used. Directional deformation can be put as the displacement of the system in a particular axis or user defined direction. Total deformation is the vector sum all directional displacements of the systems.

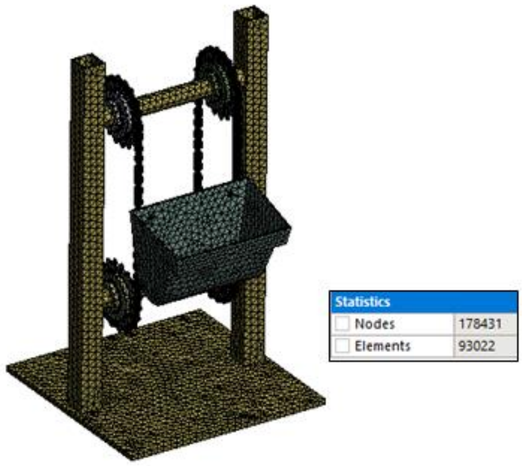

Figure 4 Meshing of Model

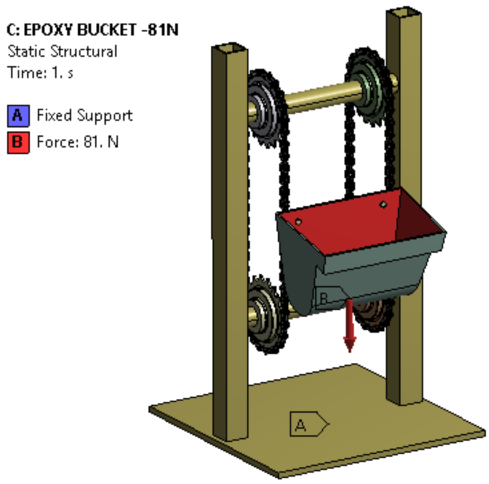

Figure 5 Boundary Condition

Static Analysis

Following are the mechanical properties of the steel and epoxy material have been taken to analysis of Bucket under static condition.

TABLE 1 MECHANICAL PROPERTIES OF MATERIALS

Material	*Young Modulus (GPa)*	*Poisson's Ratio*	*Density (Kg/m3)*	*Yield Strength (MPa)*
Steel	200	0.3	7850	250
Epoxy	35	0.4	1.8	80

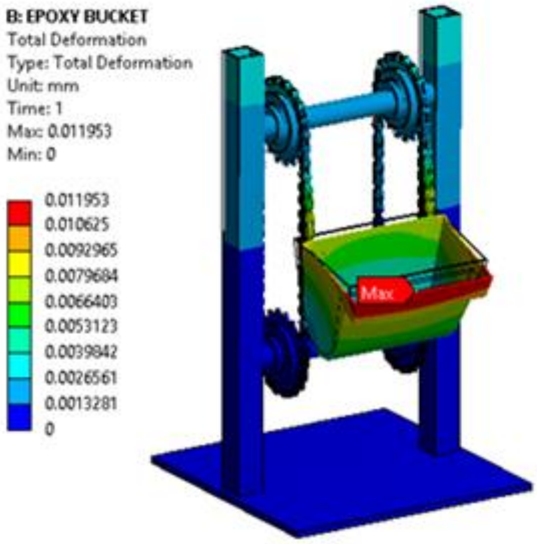

Figure 6 (b) Total Deformation

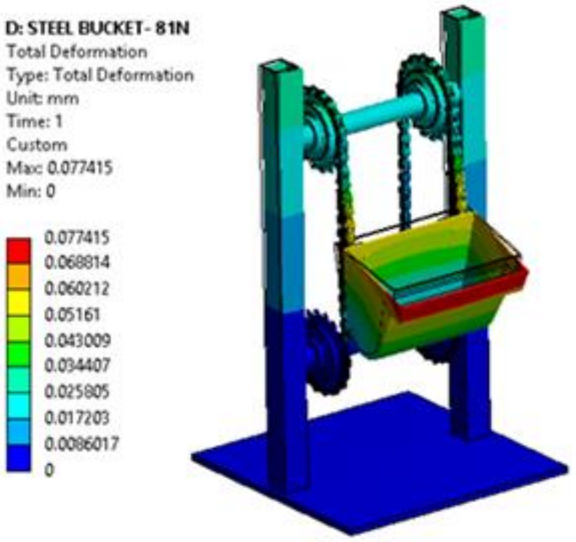

Figure 6 (a) Total Deformation

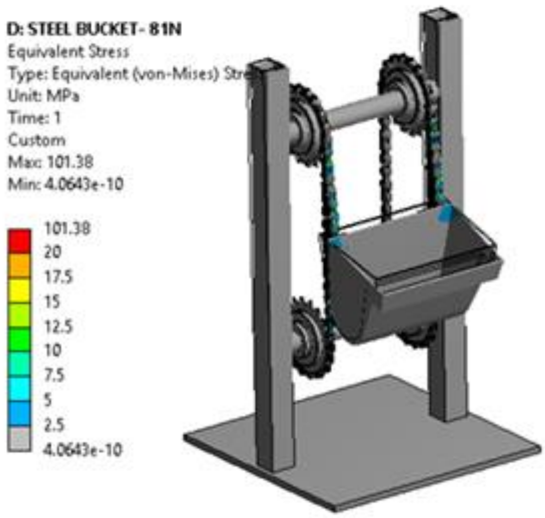

Figure 6(a) Equivalent Stress

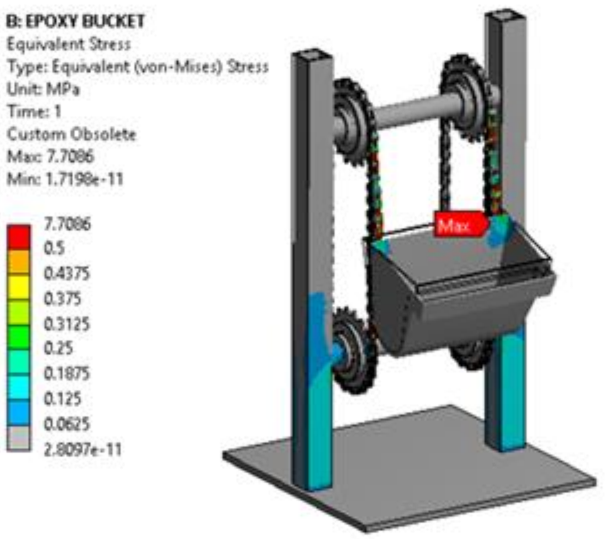

Figure 6(b) Equivalent Stress

VI. RESULTS & DISCUSSION

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.

TABLE 2 STATIC ANALYSIS RESULT

SR.NO.	***SPECIFICATIONS***	***Steel Bucket***	***Epoxy Bucket***
1.	Total Deformation (mm)	0.077	0.01195
2.	Equivalent Stress (MPa)	101.38	7.7086

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 %

VII. CONCLUSION

In this paper, Static Analysis of Steel and Epoxy Buckets are done. This Paper outlines the analysis study of two different buckets with the use of ANSYS software. FEA techniques can be effectively used for the effective performance and weight reduction of the bucket elevator.

By using the EPOXY material, Study has shown better results as compared to Steel. From the Table 2, we have seen that Stress and Deformation are in within permissible range for the EPOXY Bucket.

With EPOXY material, Weight reduction up to 76% is achieved in bucket material.

References

[1] N. Yashaswini, Raju. B and A. Purushottham, design and optimization of bucket elevator through finite element analysis, International Journal of Mechanical Engineering Volume 2, Issue 9, ISSN 2321-6441, September 2014.

[2] Hemlata H. Mulik, Bhaskar D. Gaikwad, Design of Sugar Bucket Elevator and Roller Conveyor Chain for 20 Tones per Hour Capacity, International Journal of Engineering Trends and Technology, Volume 20 Number 1 – Feb 2015.

[3] Snehal Patel, Sumant Patel, Jigar Patel, A Review on Design and Analysis of Bucket Elevator, International Journal of Engineering Research and Applications ISSN: 2248-9622 Vol. 2, Issue 5, pp.018-022, , September- October 2012.

[4]] F. J. C. Rademacher, Non-Spill Discharge Characteristics of Bucket Elevators, Elsevier Sequoia S.A., Lausanne.

[5]] Edward Yin, Onumus Muvengei, John Kihiu, Kenneth Njoroge4 "Failure Analysis on Conveyor Chain Links of a Central Bucket Elevator"IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) e-ISSN: 2278-1684, p-ISSN: 2320-334X, Volume 13, Issue 4 Ver. VII, PP 56-63, Jul. - Aug. 2016.

[6] Ghazi Abu Taher, Yousuf Howlader, Md. Asheke Rabbi, Fahim Ahmed Touqir "Automation of Material Handling with Bucket Elevator and Belt Conveyor" International Journal of Scientific and Research Publications, Volume 4, Issue 3, March 2014.

[7] Kulkarni Digambar Rangnathrao, Prof Swami M.C, Mr. Shinde V.V3 "Experimental Analysis of Bucket Elevator Chain Breakdown" International Research Journal of Engineering and Technology (IRJET) Volume: 05 Issue: 05, May-2018.

[8] Tushar S Hingve, Y .A .Kharche, N.A Kharche "Diagnosis for the failure of sprocket and chain drive", 2394-8280, 3 June 2017.