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Design, Analysis and Optimization of Bucket Elevator

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ABSTRACT: Bucket elevators are powered equipment for conveying bulk materials in a vertical or steep inclined path, consisting of an endless belt, or chain to which metallic buckets are fixed. Bucket elevators always faces problem during buildup loads. In the present paper a bucket elevator is designed and analyzed for conveying limestone at the height of 28m at the rate 50tph. This paper gives basic design aspects for the development of the bucket elevator, in 3D environment of SolidWorks. Static and fatigue analysis are carried out on the shaft after applying different materials to ensure high strength and life.

Keywords: Bucket elevator, Endless belt, SN curve, Gear shaft.

1. INTRODUCTION:

Material handling is an engineering field of design of equipment used for the handling of bulk materials such as ores, coal, cereals, grains, sand, gravel and stone etc. in loose bulk form. Bucket Elevators are powered equipment consisting of an endless belt, or chain to which metallic or non-metallic buckets are fixed for conveying bulk materials in a steep or vertical or steep inclined path. Buckets attached to flexible belt/chain move unidirectional within a casing. Bulk materials is collected at bottom end of the elevator and delivered at the top end.

It consists of:

1) Buckets to contain the material;
2) A belt to carry the buckets and transmit the pull;
3) Means to drive the belt;
4) Accessories for loading the buckets or picking up the material, for receiving the discharged material, for maintaining the belt tension and for enclosing and protecting the elevator.

A bucket elevator works by connecting many buckets via chains or a conveyor belt around a powered pulley system. The buckets are first filled with bulk material at the bottom of the elevator. Then the buckets ascend the elevator ramp, until they reach the very top where the material is discharged. The buckets are designed to stay upright to prevent spillage. The head is one of the major structural elements of the overall elevator. It supports the weight of buckets and belt, and also accommodates the drive and anti-runback back device.

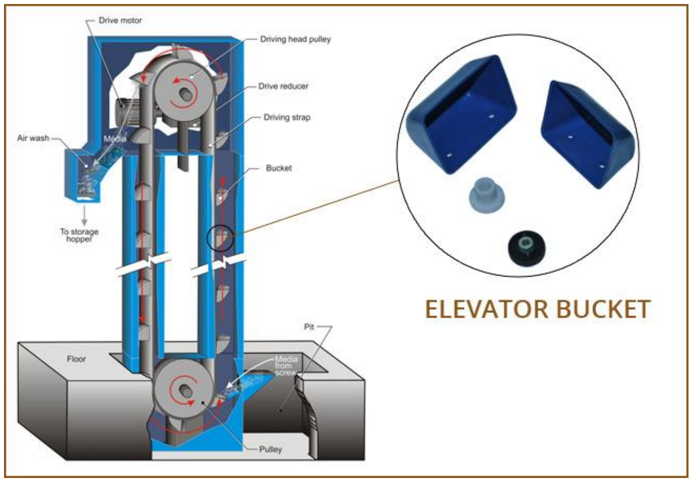


Fig 1: Basic Components of Bucket elevator

2. LITERATURE REVIEW:

1. Jigar Patel carried out a modified design of bucket elevator to increase capacity to 2 tonnes/hr for a height of 12m.
2. Snehal Patel, Sumant Patel gave a brief review on design of bucket elevator in their research paper. The study shows negative influence parameter on the performance of bucket elevator.
3. Swapnil Deokar, Prof, Ashish Lagad modified design of bucket with weight reduction of approximately 36% is achieved in bucket material.
4. N. Yashaswini, Raju. B and A. Purushottham, gives the dynamic behavior of the bucket and gear shaft assembly.

3. METHODOLOGY:

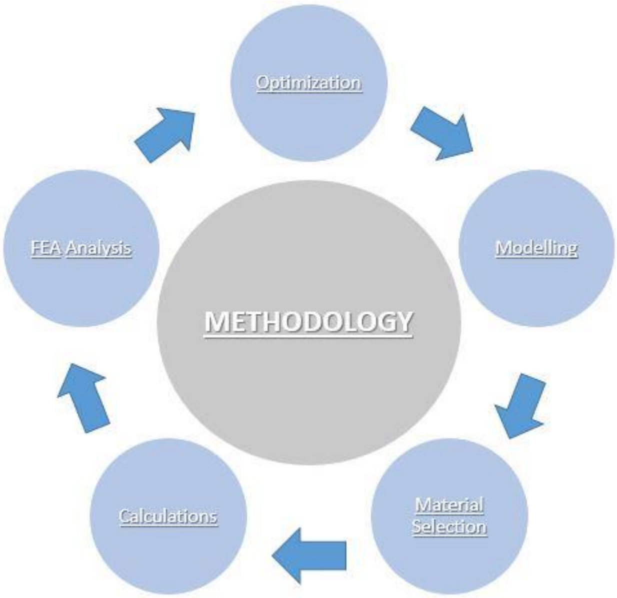


Fig.1: M.

4. PROBLEM STATEMENT:

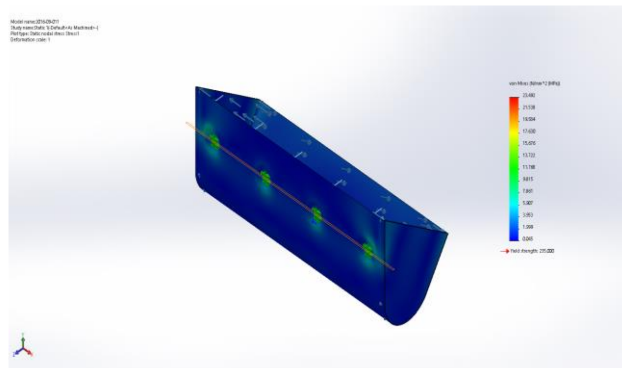
- Drawback was related to Factor of Safety obtained while designing the bucket is 10 which was found to be over designed and so it should be modified to acceptable F.O.S.
- Bucket elevators always faces problem during buildup loads. So new material should be selected based on SN Curve and ASHBY chart.
- Due to shape of bucket 20% material remain after the discharge which should be reduced by optimizing the bucket shape.
- Weight of overall assembly of bucket elevator should be reduced by reducing the weight of the bucket and shaft.

5. RESULTS:

- **Analysis on Initial bucket design:**

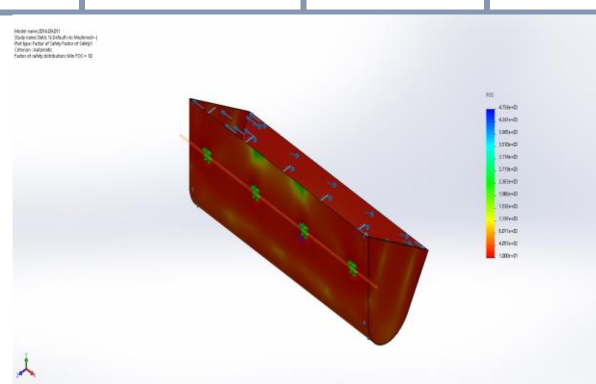
Stress value for the initial bucket of bucket elevator is 23.492 N/mm^2 which is well below the critical value (i.e. 235N/mm^2) and deformation for bucket elevator is 0.129 mm. Hence, design is safe. But the difference in stress value obtained in analysis is much below the yield strength of the material due to which the minimum F.O.S. of the bucket in about 10 which is high and can be reduced.

Name	Type	Min	Max
Stress1	VON: von Mises Stress	0.045 N/mm^2 (MPa) Node: 5477	23.492 N/mm^2 (MPa) Node: 6740



2016-09-011-Static 1-Stress-Stress1

Name	Type	Min	Max
Factor of Safety1	Automatic	1.000e+01 Node: 6740	4.756e+03 Node: 4665

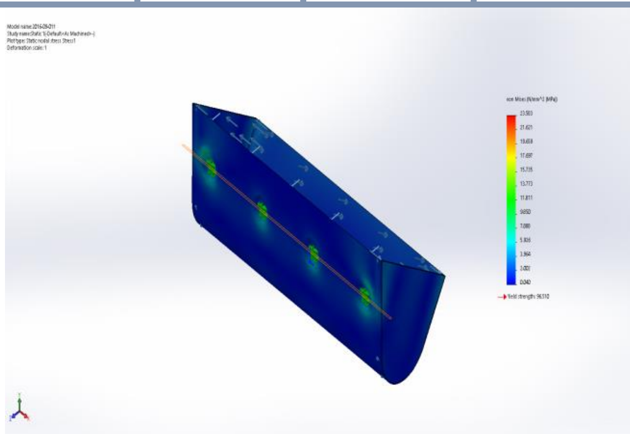


2016-09-011-Static 1-Factor of Safety-Factor of Safety1

- **Analysis on Optimized bucket design:**

The reduction in F.O.S. is done by changing the material of the bucket from Structural Steel (S235JR) to Aluminum Alloy (2014 alloy). Stress value obtained for this bucket is 23.583N/mm^2 which is below the critical value (i.e. 96.51N/mm^2) and the deformation for bucket elevator is 0.367mm. Hence, the design is safe and also the F.O.S. obtained for these bucket is 4, which acceptable by the customer.

Name	Type	Min	Max
Stress1	VON: von Mises Stress	0.040 N/mm^2 (MPa) Node: 10228	23.583 N/mm^2 (MPa) Node: 6740

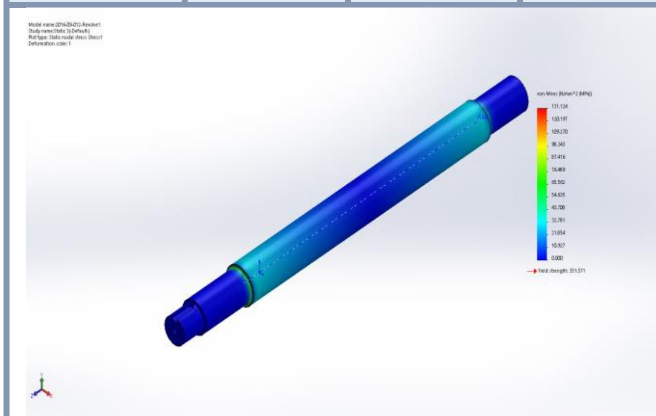


2016-09-011-Static 1-Stress-Stress1

- **Analysis on Initial Shaft (AISI 1020)**

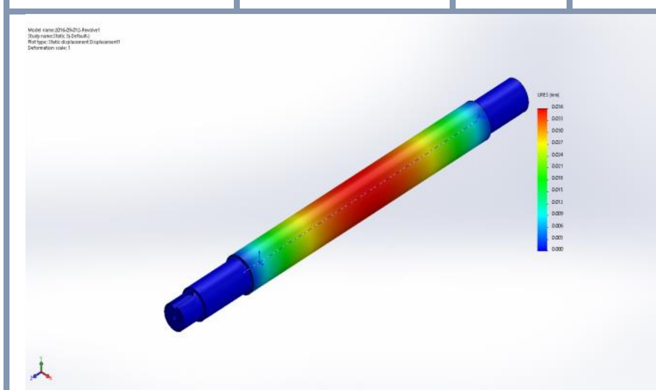
  According to the analysis report obtained, the stress value for the shaft is 131.124 N/mm^2 which is below the yield strength of the material (i.e. 351.571 N/mm^2) and the deformation of the shaft was 0.036mm. Hence, the design is safe. But the diameter of the shaft is the major concern that is 187.17mm which can be reduced by changing the material of the shaft.

Name	Type	Min	Max
Stress1	VON: von Mises Stress	0.000 N/mm^2 (MPa) Node: 8183	131.124 N/mm^2 (MPa) Node: 13056



2016-09-012-Revolve1-Static 3-Stress-Stress1

Name	Type	Min	Max
Displacement1	URES: Resultant Displacement	0.000 mm Node: 68	0.036 mm Node: 384

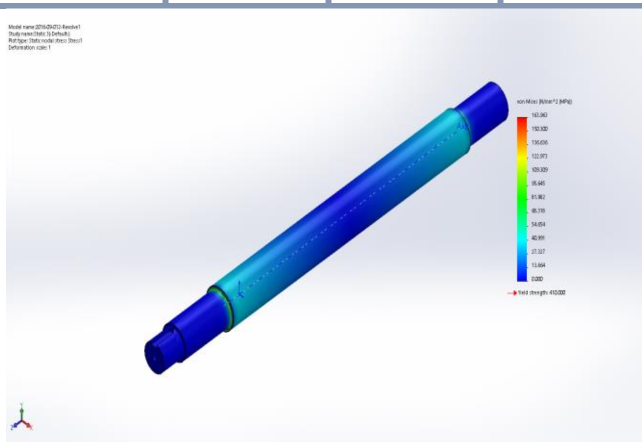


2016-09-012-Revolve1-Static 3-Displacement-Displacement1

- **Analysis on Optimized Shaft(EN 8)**

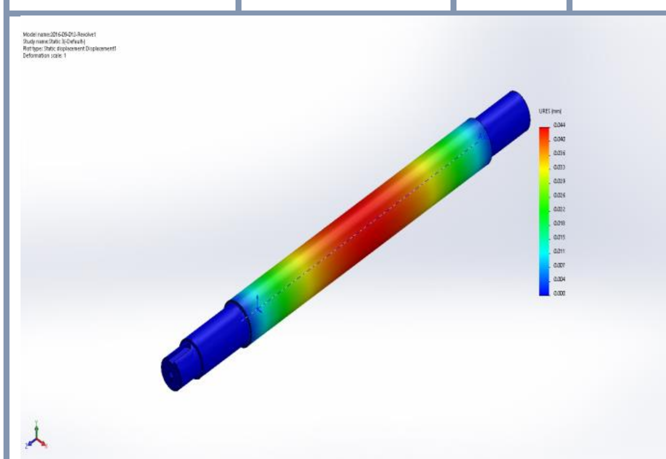
  After changing the material to EN 8, the stress value for shaft is 163.96N/mm^2 which is below the yield strength of the material (i.e. 410N/mm^2) and the deformation of the shaft was 0.044mm. Hence, the design is safe. Also the shaft has been reduced to 168mm which reduces the weight of the shaft.

Name	Type	Min	Max
Stress1	VON: von Mises Stress	0.000 N/mm^2 (MPa) Node: 8133	163.963 N/mm^2 (MPa) Node: 13056



2016-09-012-Revolve1-Static 3-Stress-Stress1

Name	Type	Min	Max
Displacement1	URES: Resultant Displacement	0.000 mm Node: 68	0.044 mm Node: 384



2016-09-012-Revolve1-Static 3-Displacement-Displacement1

6. DISCUSSION:

The existing model is analyzed for limestone material and the analysis is carried out by changing the material of the bucket and the shaft. The existing model of the bucket is first analyzed and then the material is changed to reduce the F.O.S. of the bucket as required by the customer. Also the weight of the bucket is reduced.

Table: Weight Reduction

Sr. No.	Case	Weight(Kg)
1.	Existing Bucket	3.24
2.	Optimized Bucket	2

Weight Reduction = (Existing - Optimized) / Existing

= (3.24 - 2)/3.24

= 38.27 %

Along with the weight reduction in bucket, the weight is also reduced by optimizing the shaft. In this, the material of the shaft is changed to EN 8 which reduces the shaft diameter to 168mm from 187mm. The material of the shaft is selected by ASHBY chart and then best material obtained by calculations and then analyzed.

7. CONCLUSION:

In this paper the belt driven bucket elevator, for material transport is modeled in SOLIDWORKS and analysis studies are made to optimized the weight and discharge capacity of bucket elevator. The proposed bucket elevator model is almost similar to the model developed by industry for a 45TPH capacity which is increased to 52TPH. The stresses and deformations are critically examined on two critical components of the setup (i.e. Buckets and Shaft).

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