DESIGN AND ANALYSIS OF EXCAVATOR BUCKET

DHARMESH H. PRAJAPATI[1], PRAYAG H. PRAJAPATI[2], BRIJESH D. PATEL[3]

[1] *Student of Mechanical Engineering at Samarth College Of Engineering And Technology Himatnagar, Gujarat, India*
[2] *Student of Mechanical Engineering at Samarth College Of Engineering And Technology Himatnagar, Gujarat, India*
[3] *Student of Mechanical Engineering at Samarth College Of Engineering And Technology Himatnagar, Gujarat, India*

ABSTRACT

Rapid growth rate of construction activity is assured through automated high performance construction machineries with complex mechanism like excavator. Excavator is very importance member of earth moving equipment family. Our project is titled on design and analysis of excavator bucket. Excavator bucket is very crucial element of it. The whole loads of excavated materials have been carried out by this element. So it should has sufficient load sustainable capacity for long working life, because it is cost too. Our main aim is to analyze excavator bucket based of different load condition for safe design.

Keyword : - *Excavator bucket, static load, Total deformation, equivalent von stresses, etc….*

---

1. INTRODUCTION

A bucket is specialized container attached to the machine which is used as bulk material handling component. The bucket could be attached to the lifting hook of a crane, at the end of the arm of an excavating machine, to the wires of a dragline excavator, to the arms of a power shovel. Buckets can have a distinct quality from the traditional bucket (pail) whose purpose is to contain things.

Excavator buckets are made of solid steel and generally present teeth protruding from the cutting edge, to disrupt hard material and avoid wear-and-tear of the bucket.

1.1 Types of Bucket

1) Digging Bucket: The most common excavator bucket is the digging bucket. It is the standard bucket that comes with every excavator. These all purpose buckets are used to plough through hard soil, rocks or even frost covered soil. They come in various sizes and shapes with short blunt teeth, to break through hard soil. These teeth may be longer and sharper, depending on the hardness of the soil.

2) Rock Bucket: This excavator bucket is meant to work with hard rocks. They are similar in design to digging buckets but have reinforced structural parts for strength. They have longer, sharper teeth, narrow V-shaped cutting edge, and can push with more power. They can break through hard rock while maintaining their structural integrity.

3) V-Bucket: The V bucket is a special excavator bucket. It has a V shaped structure that helps it penetrate easily through the soil. The angled sides make it easier to dig. This saves costs on power while digging. Work that involves laying pipes is ideally suited to this type of excavator bucket.

4) Skeleton Bucket: A skeleton bucket is a modified digging bucket. It accomplishes an additional task while digging. The bucket is made up of bars that have gaps. Small particles fall through these gaps during excavation. This utility is helpful in segregating coarser soil with finer particles.

5) Cleanup Bucket: These buckets are similar in function to an ice cream scoop. They have a larger capacity, no teeth and are used for scooping applications. They are used to scoop soft materials and soil. Their solid build and handling of soft materials, usually keeps maintenance costs low. These excavator buckets are used for work such as backfilling, ditching, sloping, and leveling.

1.2 LITERATURE REVIEW

Shiva Soni, S. L. Ahirwar, Reliance Jain, Ashish kumar Shrivastava The forces applied in the analysis were calculated by using INVENTOR software, and reported that the Arm, Boom and Bucket shows stress in the attachment are coming under allowable limit. For reducing stresses and for optimum weight of the excavator parts, thickness of the material is reduced in the modeling[1].

Ashitkumar Choudhary, Gian Bhusan Excavators are earth moving equipment and the main component for completing its function is arm; which directly affect the working performance and reliability of the excavator. However, using the finite element method for structural analysis of excavator arm is the premise for the structural design of the arm[2]

Daqing Zhand, Qinghua He, Peng Hao, HaiTao Zhang According to the highly system dynamic, and parameters uncertainties, external disturbance, the dead region and nonlinear gain coefficient of the proportional direction valve, this paper presents a discontinuous projection based on an adaptive robust controller to approximate the nonlinear gain coefficient of the valve and the nonlinear of the whole system, the error is deal with robust feedback and an adaptive robust controller was designed. Finally, the experiment of the boom motion control is presented to illustrate the feasibility[3].

R M Dhawale, S R Whag Excavators are intended for excavating rocks and soils. It consists of four link members: the bucket, the stick, the boom and the revolving super structure (upper carriage). The excavator mechanism must work reliably under unpredictable working conditions. Thus it is very much necessary for the designers to provide not only a equipment of maximum reliability but also of minimum weight and cost, keeping design safe under all loading conditions[4].

2. METHODOLOGY

We have setup design procedure based on reference design data book and past literature research papers.

- First we will calculate the Bucket digging force form the below equation,

$$F_B = \frac{Bucket\ cylinder\ force}{d_D}\left(\frac{d_A \times d_C}{d_B}\right)$$

- Breakout force is calculate
- Bucket Capacity is calculate

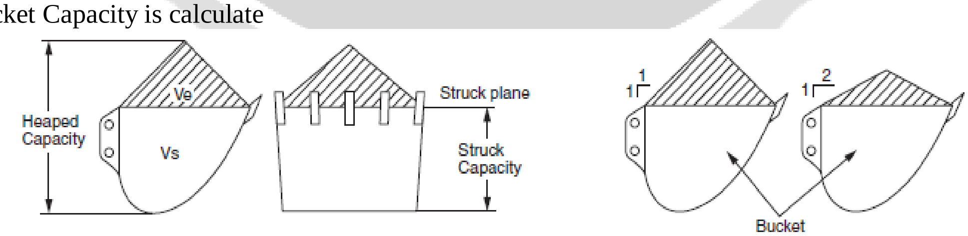

Figure 1 : Terminology of Bucket capacity

- Struck capacity,
- Excess material,
- Force calculation when the bucket cylinder is activate,
- Force acting on the bucket,

- Bucket pin is designed on the base of the strength as under,

- Failure of bucket pin under shear(double shear)
- Failure of bucket pin under bearing pressure
- Failure of bucket pin with UDL in bending

- **Design Parameters**
  - d_A = Distance between Boom and arm fixed point = 480 mm
  - d_B = Distance between arm and bucket cylinder fixed point = 410 mm
  - d_C = Distance between arm end and cylinder end fixed point = 340 mm
  - d_D = Distance between bucket end to the tip of teeth of bucket = 1420 mm
  - d_E = Distance between boom cylinder end and arm cylinder end = 285 mm

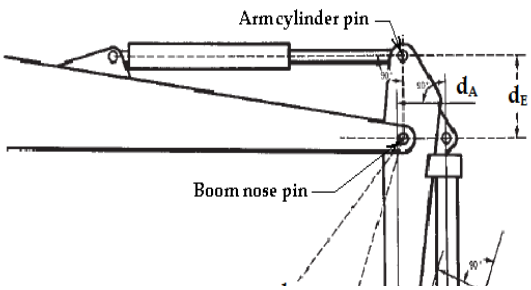

Figure 2 different kind of bucket forces

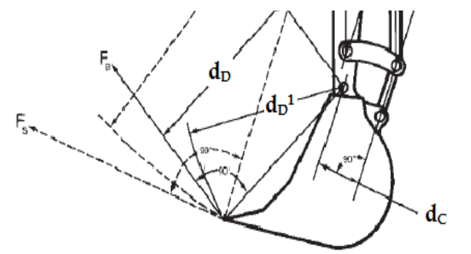

Table 1 Existing Bucket forces

Bucket digging force*(FB)*	Breakout force *(Fs)*	Bucket capacity *(Vh)*	Cylinder force *(Fcylinder)*	Cylinder force on bucket *(Fbucket)*
776.79KN	334.06KN	1.37m³	2771.12KN	455.15KN

Based on above dimensions and forces we prove that design of pin and design of teeth is safe
This safe design proved base on different kind of theories:
For pin : bearing pressure theory, double shear, UDl load and maximum bending moment
For teeth: centiliter beam theory

2.1 Main dimensions Of Existing Bucket

We are make solid model and its draft design in solid work (CAD) software base on existing bucket dimensions

Table 2 design detail of existing bucket

Plate thickness	Number of teeth	Height of bucket	Width of bucket	Length of bucket	Volumetric capacity of bucket
20mm	4	769.8mm	1000mm	1557.87mm	150 kg

2.2 Main dimensions Of Modified Bucket Design

We are make solid model and its draft design in solid work (CAD) software base on Modified bucket dimensions

Table 3 Design Detail of modified bucket

Plate thickness	Number of teeth	Height of bucket	Width of bucket	Length of bucket	Volumetric capacity of bucket
20mm	6	1148.8mm	1850mm	1846.0mm	300 kg

3. ANALYSIS

We are both design analysis in ansys software. First of all we did check existing bucket solid model total deformation on different node and equivalent von-misses stresses

Table 4 Equivalent Von-Misses Stresses

Existing bucket (Mpa)	Modified Bucket (Mpa)
779.56 max	659.32 max
0.19602 min	0.23062 min

Table 5 Total Deformation

	Existing bucket (mm)	Modified Bucket (mm)
1	2.1428	1.4716
2	2.757	1.599
3	3.1182	2.0158
4	4.6203	2.1578

3.1 Equivalent Von-Misses Stresses and Total Deformation

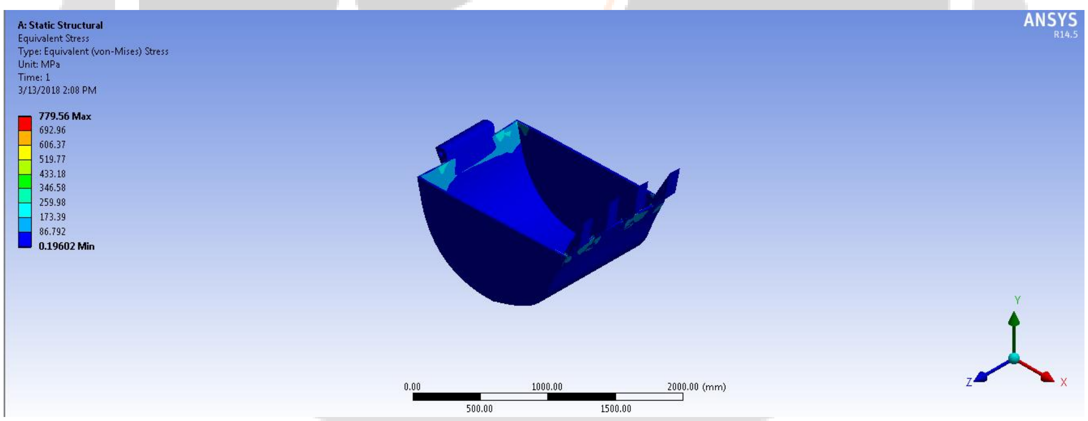

Fig 3- Equivalent Von-Misses Stresses of existing bucket

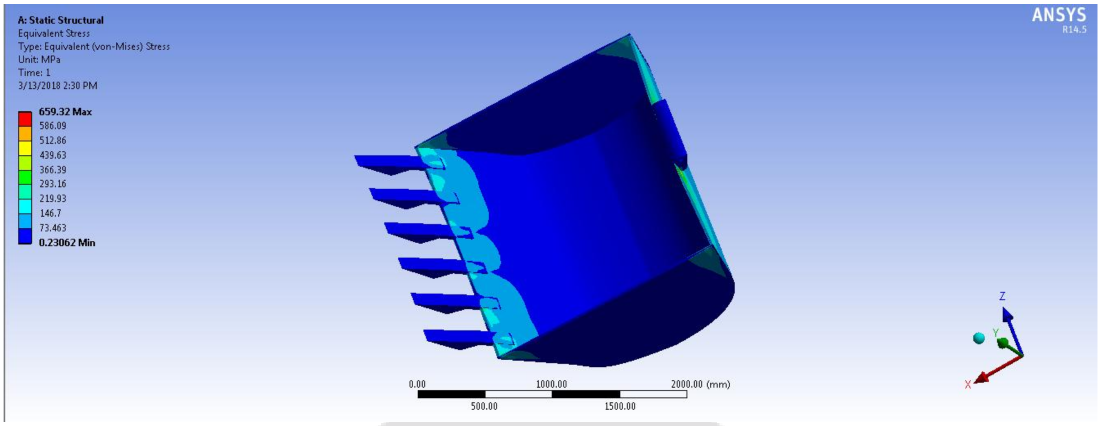

Fig 4- Equivalent Von-Misses Stresses of modified bucket

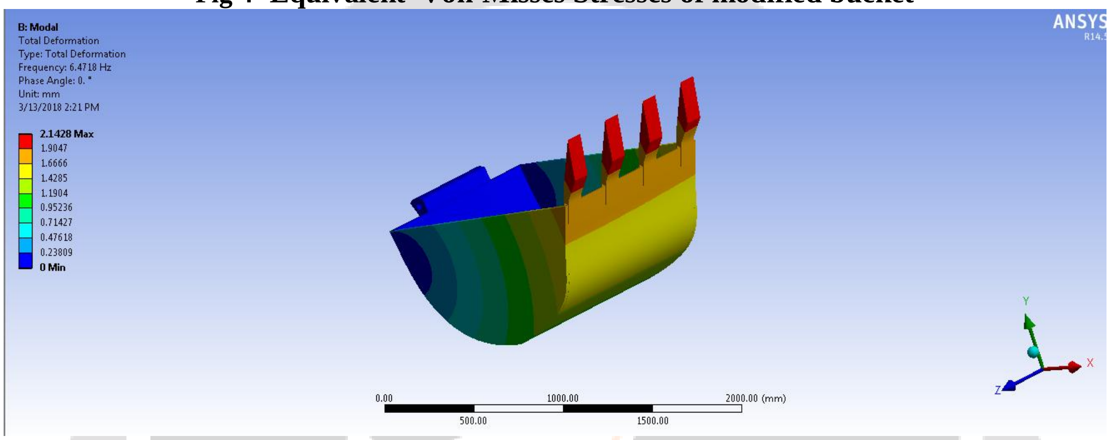

Fig 5– Total deformation of existing bucket

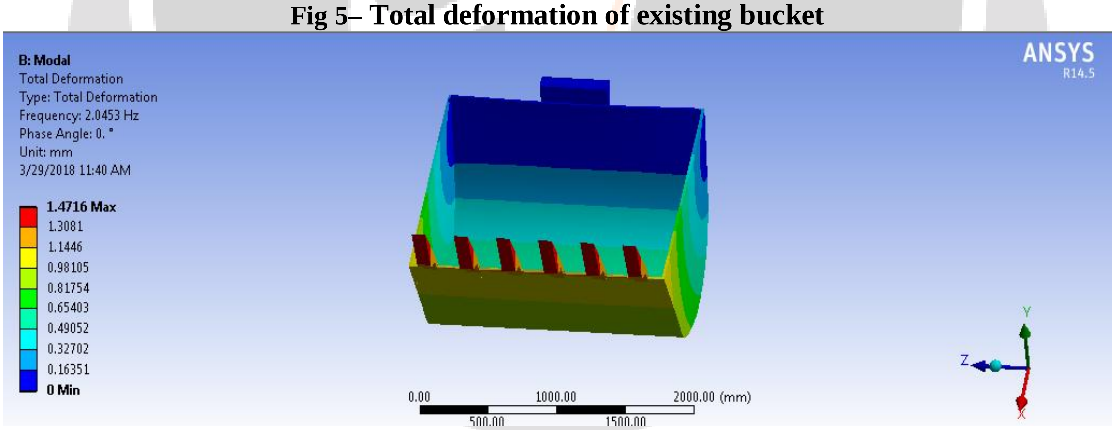

Fig 6– Total deformation of modified bucket

4. CONCLUSIONS

- Based on our project work, we have concluded that the capacity of bucket have been increased up to 300 kg from 150 kg. We have modified design and increased capacity also by adding two more teeth to full feel the functional requirements.
- We have also check Bothe design of excavator bucket under given different load at different node the both design gate safe.
- We have increase the volumetric capacity as well as reduce the total deformation of modified bucket.

- We have also reduce the equivalent von-misses of the modified bucket
- Also base on the analysis part, our new design is also safe to carry this much load while in fully operating condition

5. ACKNOWLEDGEMENT

"Obstacles are what we see when we tack out eyes off the goals" First and foremost, We wish to express my sincere appreciation to my project guide, Asst. Prof. Sanket t.gandhi who has always been a constant motivation and guiding factor throughout the thesis time in and out as well. It has been a great pleasure for me to get an opportunity to work under him and complete the present work successfully.
We wish to extend my sincere thanks to **Ass. Prof. Sanket T. Gandhi** Head of our Department, for approving our project work with great interest.
We would also like to thank **Dr.Paras kothari**, Principal of our institution for giving me moral guidance. We wish to express my heartiest regards to my parents for their guidance and moral support.
We are thankful to **Mr. Vipul Rokad** for giving me guidance in the process and opportunity to carry out experiments in his company.
Our sincere thanks to **Asst. Prof. Sunil J.** Patel, and entire staff of Mechanical Department. Last but not the least, Our sincere thanks to all of Our friends who have patiently extended all sorts of help and motivate for accomplishing the undertaking.

6. REFERENCES

1) Shiva Soni, S. L. Ahirwar, Reliance Jain, Ashish kumar Shrivastava 2014. "Simulation and static analysis on improved design of Excavator Boom"
2) Ashitkumar Choudhary, Gian Bhusan, 2017. "Finite element analysis of an Excavator arm using CAE tool"
3) Daqing Zhand, Qinghua He, Peng Hao, HaiTao Zhang, 2005. "Modeling and Controlling for Hydaulic Excavator Arm"
4) R M Dhawale, S R Whag, 2014. "Finite Element analysis of componenets of Excavator arm – A Review"