ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

Modeling and Analysis of Excavator Bucket with Replacing Material

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ABSTRACT:
In this project, i have modelled excavator bucket used in earth mover's present material for excavator bucket is EN19 steel. The main changes in the model are done by adding material on the inner layer of the excavator bucket like adding ribs in the form of rectangular, round and half sphere ribs using cero software.The material used are EN19 steel by adding material to the excavator bucket it gradually increase the weight of the bucket by the effect of it there is a problem occur in the mechanism of the excavator. To avoid any problem faced so we replaced material with AISI 1059 carbon steel for this low density by replaced material we achieved better result in form low cost, more durability, life of excavator bucket gradually increase etc…Static and buckling analysis is done on the excavator bucket. By analysing the results, the stress values of half sphere ribs are less than other three models.

1.1 Introduction to Excavator:
Excavator is the computing device which excavates the soil of a variety of kinds forcefully and then use of hydraulic machine a hydraulic pressure is generated and utilising this force bucket is pull again toward the machine. Bucket can be replaceable. If the front bucket is trade with some different attachments excavator can execute for multi-task[3][14].

Example: Hydraulic-jackhammer, pile diver etc…

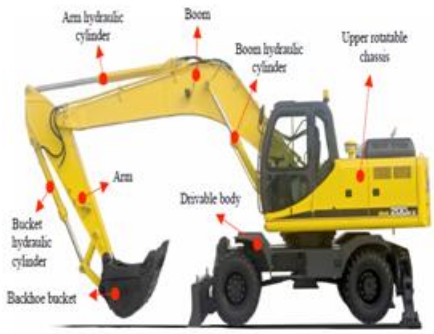

Fig 1.2 Main parts of excavatorfrom website ref (15)

1.2 General Parts of Excavator Bucket

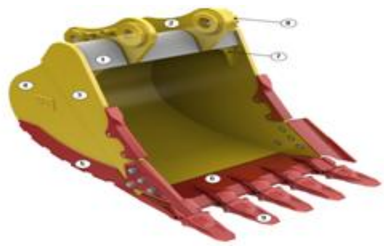

Fig.1.5 Excavator bucketfrom website ref (15) Hinge, Hinge Plates, SideBar, Side Plate, Side Wears Plates, Base Edge, Gussets, Adjuster group, Side cutters & sidebar protectors, Teeth (tips)

1.3 Objective:
To create simulations onexcavator bucket design that focuses on increasing the strength of the current model.

Cite this article as: Chinta Ranjeet Kumar, BH Sridhar & J. Pradeep Kumar, "Modeling and Analysis of Excavator Bucket with Replacing Material", International Journal & Magazine of Engineering, Technology, Management and Research, Volume 4 Issue 11, 2017, Page 115-121.

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The main changes considered in the model are to add various shapes of ribs to the inner surface of the bucket, along with material optimization Thereby the load applied and stress induced on this particular area will be very less[4].

1.4 Methodology:

This is an attempt to improve bucket life with in low budget.

The following process is followed to fix the problems in bucket.

- Deep observation of working methodology and previous research
- Preparation of 3D models
- Evaluating original model, structural characteristics and life.
- Preparation of model with modifications.
- Analyzing the prepared models to get optimized design.

LITERATURE REVIEW

2.1 Structural Optimization of Mini Hydraulic Backhoe Excavator Attachment Using FEA Approach:

In reference paper [1], they have used reverse engineering method to study excavator bucket. During the part of challenge a static evaluation used to be carried out the use of FEA package. These paper emphases on structural weight optimization of backhoe excavator attachment the usage of FEA strategy via trial and error method, theoptimization is also performed for weight and results are compared with trial and error approach which shows equal results. The FEA of the optimized mannequin also carried out and their consequences are confirmed by using making use of classical theory. Comparison two shows two that the versions in results of character components are very much less and whole version in result is of only 3.93% which mirror that the consequences of structural weight optimization carried out with the aid of trial and error approach are correct and acceptable.The variations in outcomes of the Von Mises stresses and the classical concept are very less and we can say that the effects are equal and acceptable.

2.2 Optimization of Equipment "Rake cup Type" Using Finite Element Analysis

In reference paper [2], as part of this challenge a static and Model evaluation was once carried out using FEA package. The 3D model of the excavator bucket was designed the use of Solid Edge software VS5. Simulation used to be performed the use of Autodesk Inventor software. They find out the complete stress with the aid of the usage of FEA software. The statistics received permits graphical simulations of the cup in special indispensable work ranges for the period of operation. Two it is allowed optimizing the optimistic sketch answer for averting shortcomings in service. Actually, the calculation approach can be extended to any type of work equipment. The work iterates finite factor analysis of a new constructive answer of the tools rake kind attachable to the excavator arm.

MODELING OF AN EXCAVATOR BUCKET

3.2 2-D Drawings of excavator bucket:

The 2-D drawings of an excavator bucket are used for study review only for design and to modify for the sake of better assumption of the job[5].

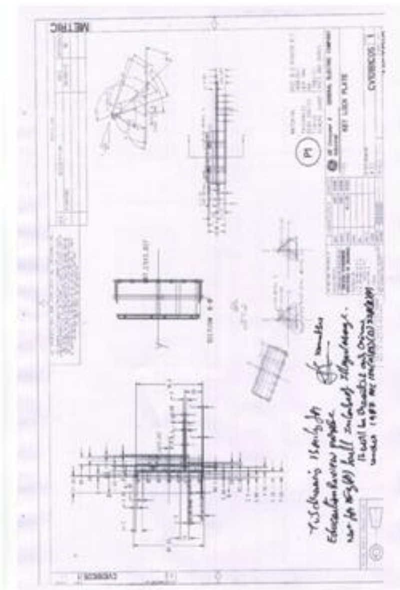

Fig 3.1 2-D drawing of shovel bucket of excavator

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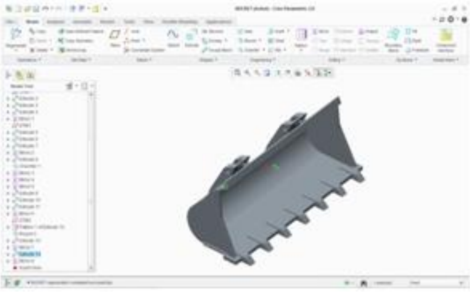
3.3 MODELLING SCREENS

3.3.1 Modeling of Original Excavator Bucket (plane)

3.3.1.4 Final Model:

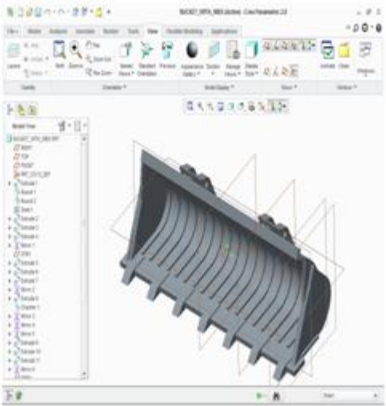
The shell model is then modified and teeth are added to the model. The sharp edge is rounded off for fine surface of the model[6].



3.3.2 Modeling of Modified Excavator Bucket (Rectangular Ribs)

3.3.2.1 Final Model:

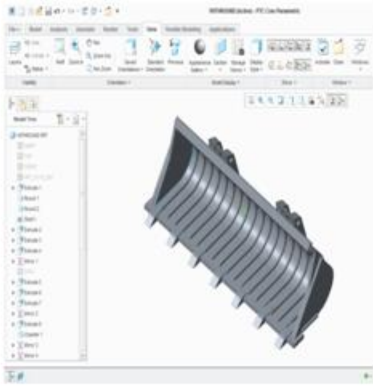
The model of the excavator bucket is added with rectangular ribs at the inner surface of the model[7].



3.3.3 Modeling of Modified Excavator Bucket (round Ribs)

3.3.3.1 Final Model

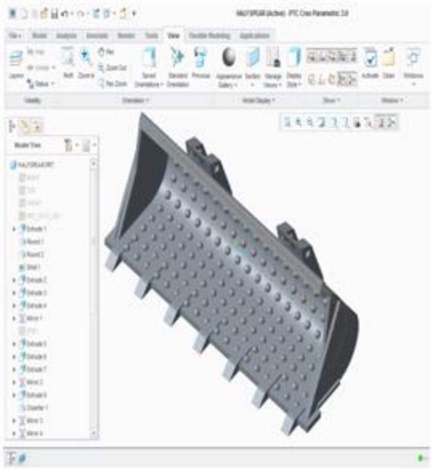
The final model of the excavator bucket is added with round ribs at the inner surface of the model[8].



3.3.4 Modeling of Modified Excavator Bucket (Half-Sphere Ribs)

3.3.4.1 Final model

The final model of the excavator bucket is added with half sphere ribs in the inner surface of the model[9].



CALCULATIONS OF EXCAVATOR BUCKET

4.1.2 Excavating forces as per the American Standard (SAE)

Penetration of material into the bucket is obtained from bucket Curling Force (F_B) and arm Crowd Force (F_S). The grade of these excavating forces is prescribed by American standard (SAE). These rated excavating forces are the forces which can be exerted at the extreme cutting point [4]. These forces can be obtained by applying working relief hydraulic pressure to the cylinders providing the excavating force of the bucket

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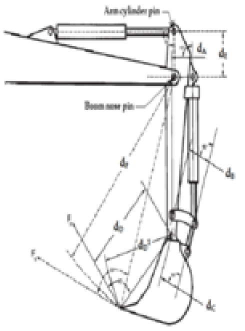

Fig.4.4 Determination of excavating forces by following American Standard (SAE)

Fig. 4.4 shows the measurement of bucket curling force F_B, arm crowd force F_S, terms in the figure d_A, d_B, d_C, d_D, d_D^1, d_E, and d_F shows the distance as shown in Fig. 4.4.

$$F_B = \frac{\text{Bucket cylinder force}}{d_D}\left(\frac{d_A \times d_C}{d_B}\right) \quad \text{.....(4.5)}$$

Where,

Bucket cylinder force = (Working pressure) × (End area of bucket cylinder) If the end diameter of the bucket cylinder = D_B (mm) and the working pressure is p (MPa) and other distances are in mm then the equation (4.5) can be written in the form of,

$$F_B = \frac{P \times (\frac{\pi}{4}) \times D_B^2}{d_D}\left(\frac{d_A \times d_C}{d_B}\right) \quad \text{.....(4.6)}$$

$$F_S = \frac{P \times (\frac{\pi}{4}) \times D_A^2 \times d_E}{d_F} \quad \text{.....(4.7)}$$

Where, d_F = bucket tip radius (d_D) + arm link length and D_A = end diameter of the arm cylinder.

When the assembly of proposed model is placed in the position as shown in Fig. 4.4 it holds the values of the parameters as:

d_A = 257 mm,
d_B = 220 mm,
d_C = 181 mm,
d_D = 547 mm,
d_E = 285 mm, and
d_F = (547 + 723) = 1270 mm.

The working pressure p = 157 bar or 15.7 MPa,
$D_A = D_B$ = 40 mm.

So by using equations (6) and (7) the bucket curl or breakout force

F_B = 7626.25 N = 7.626 KN,

and

Arm crowd force or excavating force

F_S = 4427.419 N = 4.427 KN.

The crowd force of the bucket is 4.427 KN and the breakout force of the bucket is 7.626 KN. Modeling the bucket as per given forces is be done in the CREO and ANSYS.

ANALYSIS OF EXCAVATOR BUCKET

5.2 Structural Analysis of Excavator Bucket of Modified Model (With Rectangular Ribs)

5.2.1 Static Analysis

5.2.1.1 En19 Steel

The excavator bracket is modeled in Creo and been imported in ansys and is shown fig 5.11 3D isometric view[10][15].

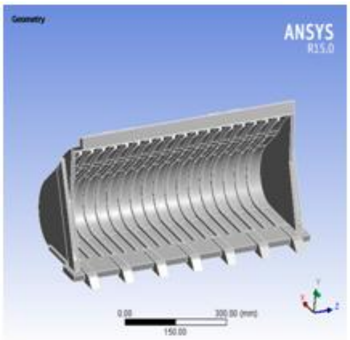

Fig 5.11The imported model of excavator bucket

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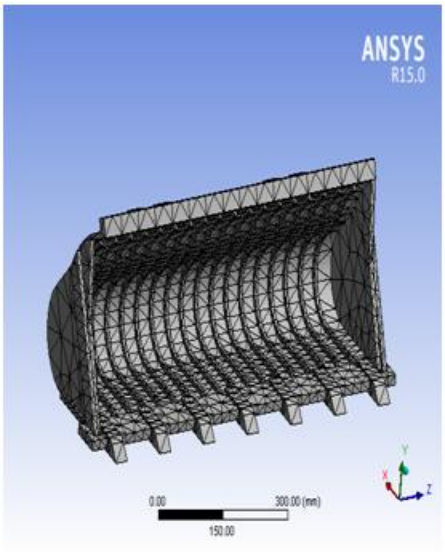

Fig 5.12The meshed modal

Model results:

After post processing maximum deformation is at lower section as shown fig5.13 is 3.4451 near to the middle teeth of bracket[11].

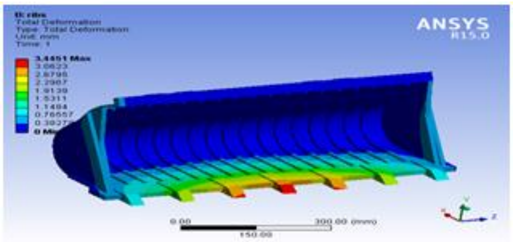

Fig 5.13Displacement result

Maximum von misses stress of bracket is near to middle section of bracket as shown fig 5.14 is 420.28[13].

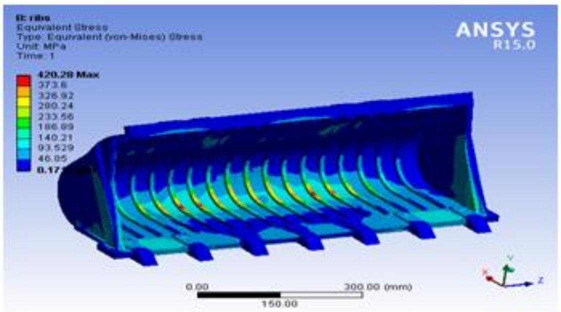

Fig 5.14Von-misses stress result

Equivalences elastic strain is shown fig 5.15 is 0.0021096 and is a very small quantity. So there is a very small deviation on the strain[16].

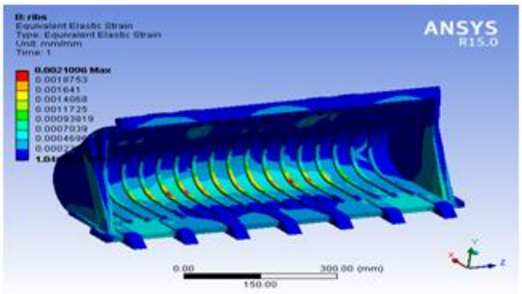

Fig 5.15Strain result

5.2.2 Buckling analysis

5.2.2.1 EN19 Steel

After post processing maximum deformation is at upper section as shown fig 5.19 is 1.2827 near to the middle of bracket[12].

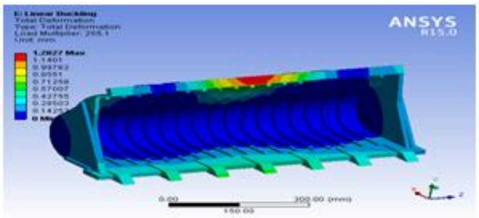

Fig 5.19Buckling analysis result

RESULTS AND TABLES

6.1 STRUCTURAL ANALYSIS

6.1.1 Static Analysis

	E N19			
	Exiting Model	Modified Models		
		Rectangular Ribs	Round Ribs	Half Spear Ribs
Displacement	4.844	3.4451	2.4235	3.0757
Stress	373.39	420.28	310.42	254
Strain	0.00187	0.00210	0.00155	0.001279

Table.6.1 Static analysis result table of EN19 Steel material

	Carbon Steel			
	Exiting Model	Modified Models		
		Rectangular Ribs	Round Ribs	Half Spear Ribs
Displacement	13.644	9.7131	2.0773	2.6912
Stress	371.36	418.76	266.08	222.25
Strain	0.005249	0.00592	0.00133	0.00111

Table.6.2 Static analysis result table of AISI 1059 Carbon Steel material

6.1.2. BUCKLING ANALYSIS

	E N19 STEEL			
	Exiting Model	Modified Models		
		Rectangular Ribs	Round Ribs	Half Spear Ribs
Displacement	1.2848	1.2827	1.2255	1.2138
Buckling load factor	160.77	255.1	280.20	188.13

Table6.3 buckling analysis result table of EN19 Steel material

	AISI 1059 Carbon Steel			
	Exiting Model	Modified Models		
		Rectangular Ribs	Round Ribs	Half Spear Ribs
Displacement	1.2839	1.2818	1.0255	1.2713
Buckling load factor	58.298	92.199	327.19	259.58

Table.6.4buckling analysis result table of AISI 1059 Carbon Steel material

CONCLUSION:

- The main changes in the model are done by adding rectangular ribs, round ribs and half sphere ribs to the inner surface of the bucket and also EN19 Steel material was replaced with AISI1059 Carbon Steel for better results. And we have achieved it.
- Static and buckling analysis on the excavator bucket is done. By observing the analysis results, the stress values for half sphere ribs are less than other three models.
- When, I compare the results for materials, the stress value is less for AISI 1059 Carbon steel and also its weight is less compared with EN19 Steel.
- Finally, I can conclude that Half sphere ribs excavator bucket with AISI 1059 carbon steel is better.

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