Optimization of the design and analysis of an excavator bucket using ANSYS

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ABSTRACT
Excavators are common heavy-duty hydraulic human-operated tools used in a wide range of construction tasks, including digging, leveling terrain, hauling and dumping objects, and straight traction. After performing such a procedure, there is a chance that the pin in the tooth adapter assembly will break and the tooth point may bend. Optimizing the design and analysis of an excavator bucket is the goal of this article. Frequency analysis was done to forecast the failure spots of an excavator bucket in order to compare the numerical models. Also, this project makes use of three distinct materials: stainless steel, AISI 1045, and titanium carbide.

INTRODUCTION
Excavator is the machine that container forcibly excavate the soil of various types and then produce a hydraulic force using the hydraulic system and pull back to the machine using this power bucket. Excavator seagull is replaceable. If front bucket is exchanged with some other attachments then multi- purpose excavator canister is used. For example: hydraulic jack hammer, pile diver etc.

Excavator comes in many sizes depending on the size of the drum, the length of the boom, the arm length and the speed about the operation. Excavator output can be calculated starting manufacturing cycle. The development cycle is the time it took for an excavator to fill the bucket from source, swing, drain, and revisit and dig again. Thus, the faster the operation speed, the faster the complete cycle will be, and therefore excavators are primarily used to dig soils andto fill dump trucks. It is one of;

Crawler excavator
Two infinite tracks (chain wheel system) ride on Crawler excavator. Such kinds of excavators are usedin hilly areas where the danger of machinery slipping is on the verge. Crawler type excavator has low ground pressure due to load spreading over wide area. And it is often used where there is poor soil support.

Wheel excavator
Wheel excavator works on wheels and is used for excavation and loading of dump trucks and is only used for basic field operation a lot of the time. Because of the wheel, the low grip value to the ground make it unfit for hilly areas.

Types of bucket
Digging bucket:
The most popular bucket of excavators is the bucket which digs. Each excavator comes with the standard

bucket. Such all purpose buckets are used to plough filled soil over hard terrain, rocks or even frost. They come with short blunt teeth, of various sizes and shapes, to crack through hard dirt. Depending on the soil's hardness these teeth may be longer and sharper.

Rock bucket

This bucket of an excavator is meant to work with hard rocks. These are similar in style to digging buckets but have increased the strength of the structural components. They have longer, sharper teeth, narrow cutting edge in V-shaped form and can push with more power. They will crack through hard rock while maintaining their integrity to the structure.

V-bucket

The V seal is a special seal for excavators. Ithas a V-shaped structure which helps it to easily penetrate through the soil. The angled laterals make digging easier. It will save on power costs when digging. This type of excavator bucket is best suited for the work involving laying pipes.

Skeleton bucket

A skeleton seal is a modified seal for digging. When digging it performs an additional function. The bucket is made of open plates. During excavation tiny particles fall into those gaps. This usefulness helps to distinguish coarser soil from finer particles.

Objectives of work:

1. To explore material behavior duringanalysis.
2. Investigate the static, dynamic analysisvalues with respect to load.
3. Analyzing the total deformation, strain, frequency ranges with respect to designparameters.

Problem description

Studying about the static, dynamic, frequency analysis performed in order to optimize the geometricparameters and predicting the failure points with respect to stress, strain, deformation and frequency. **Thesis organization**

Modeling and analysis of excavator bucket with respect to geometric properties.

Studying about the material properties forthe selection of materials.

Understanding of static, dynamic, frequency analysis to predict the failure and design optimization of an excavator bucket.

LITERATURE REVIEW

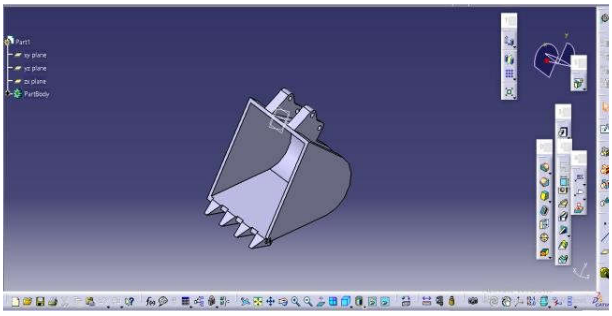
The following academic papers are consulted to get a detailed understanding of the various aspects of the project In this paper author addressed as an excavator is a standard human operated hydraulic heavy duty machine used in normally flexible building operation, such as digging, ground leveling, carrying loads, dumping loads and straight traction [1].

Because of the abrasive nature of soil particles, the Excavator bucket tooth has to carry heavy loads of materials with dirt, rock and prone to abrasion damage. The dent was damaged by abrasive wear and load of shock. This paper discuss the function of the Excavators bucket tooth to evaluate its actual failure [2].

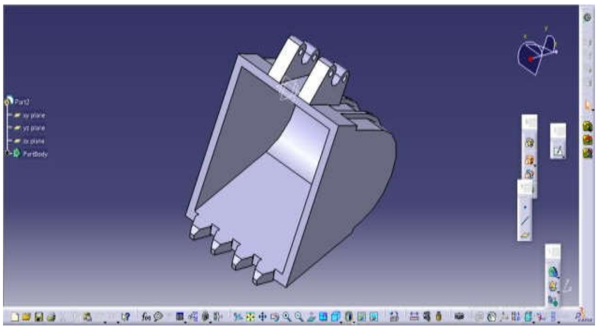
Excavators are used largely to excavate and load it onto trucks or tractors under the natural surface of theground on which the machine sits. Because of the harsh working circumstances, excavator parts are showing to high loads [3].

Design of bucket

Bucket 1



Bucket 2



ANALYSIS OF EXCAVATOR BUCKET 1

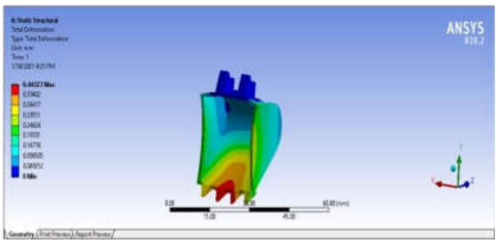
The ANSYS software has much capability in finite- element analysis, ranging from a simple, linear, static analysis to a complex, nonlinear, transient dynamic analysis. A typical analysis about ANSYS shall consist of the subsequent steps:

Build the model using key points, lines, areas and volume commands.

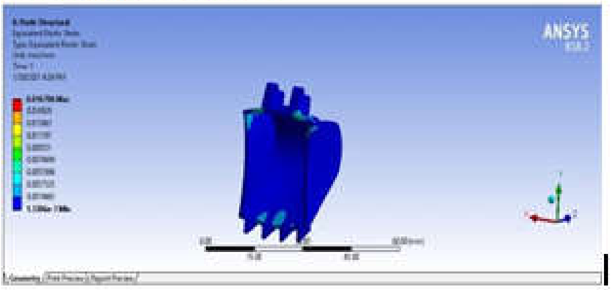
- Giving material properties.
- Choosing proper element.
- Meshing the model to discrete elements.
- Applying the given loads.
- Applying boundary conditions.
- Running solutions phase.
- Review the results using the post processor.

Stainless steel

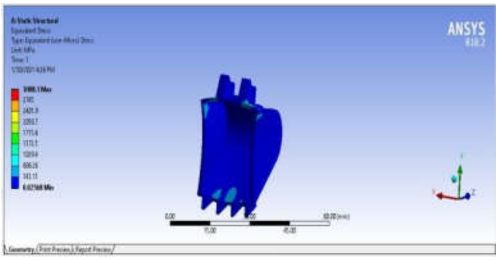
Total deformation



The deformation value at0.000443 m of the bucket in stainless steel



The strain value at 0.01679 of thebucket in stainless steel

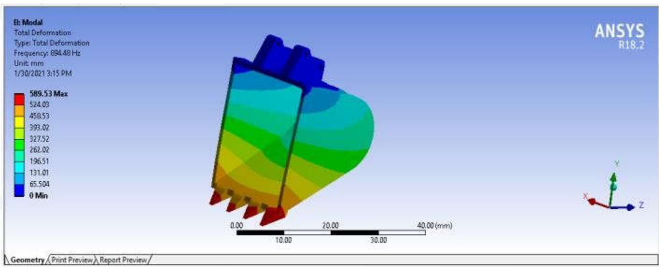


The stress value at 3.0881e9 pa ofthe bucket in stainless steel

FREQUENCY ANALYSIS

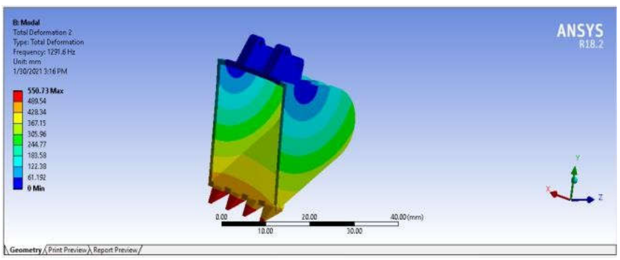
In Finite Element Analysis (FEA), the frequencyresponse analysis is used to calculate the steady-state response due to a sinusoidal charge applied to a single frequency structure. It is a specialized form of transient response analysis, which is extremely successful in solving a very particular model type.

Stainless steel Frequency 1 Hz



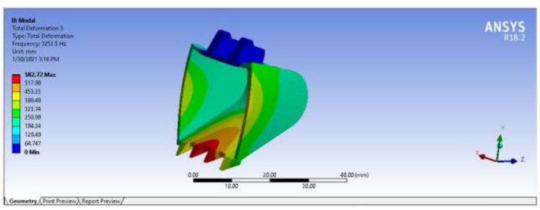
Frequency analysis on excavator bucket 1 at

894.9 HZ (Stainless Steel)Frequency 2 Hz



Frequency analysis on excavator bucket 1 at1291.4 HZ (Stainless Steel)

Frequency 3 Hz



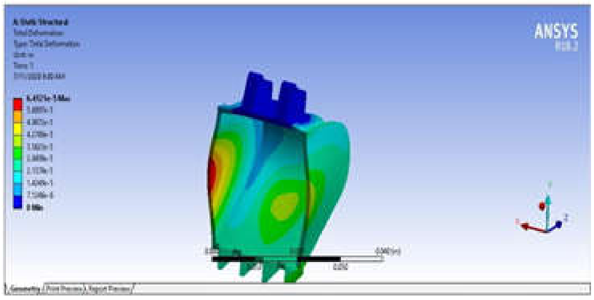
Frequency analysis on excavator bucket 1 at3252.4 HZ (Stainless steel)

DYNAMIC ANALYSIS

Transient dynamic analysis (sometimes called time history analysis) is a technique used under the operation of some general time-dependent loads to evaluate the dynamic response of a system. Transient dynamic analyzes are used to evaluate the time- varying displacements, strains, stresses and forces ina system as it reacts to some mixture of static and time-varying charges while at the same time considering inertia or damping effects.

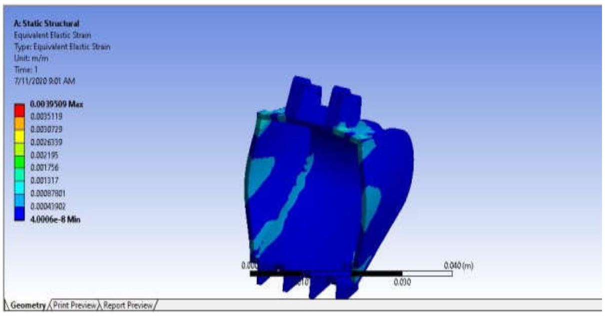
Ti carbide

Total deformation



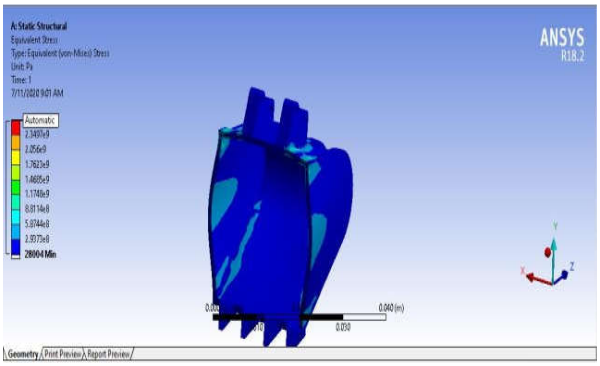
The Dynamic analysis of excavatorbucket 1 at 6.412e-5 m (Ti carbide-Total deformation)

Strain



The Dynamic analysis of excavatorbucket 1 at 0.00334 (Ti carbide-Strain)

Stress



The Dynamic analysis of excavatorbucket 1 at 2.3477e9 (Ti carbide-Stress) Results

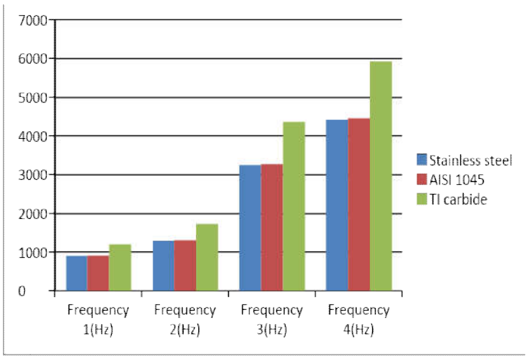
Bucket 1

Tabulated form on static analysis

Material	Stainless steel	AISI 1045	TI carbide
Frequency 1(Hz)	894.9	902.96	1199.5
Frequency 2(Hz)	1291.6	1307.3	1732.1
Frequency 3(Hz)	3252.5	3279.1	4361.7
Frequency 4(Hz)	4419.8	4457.1	5927.1

This tabulated form interpreted the static analysisresults on Stainless Steel, AISI 1045, Ti carbide
Note: After analyzing the static analysis on three materials such as stainless steel, AISI 1045 and TIcarbide with different load conditions Ti carbide is showing the best results due to low deformationvalues.

Graph



The plotted graph is showing the frequencyranges

Tabulated fig on dynamic analysi

Material	Total deformation(m)	Strain	Stress (N/m^2)
Stainlesssteel	0.000443	0.01679	3.0881e9
AISI 1045	0.000426	0.01632	3.1038e9

Frequency 3(Hz)	4125.8	4157.3	5532.8
Frequency 4(Hz)	4784.1	4809.5	6415.4

Note: After analyzing above tabulated values on dynamic analysis AISI 1045 showing best results due to low deformation.

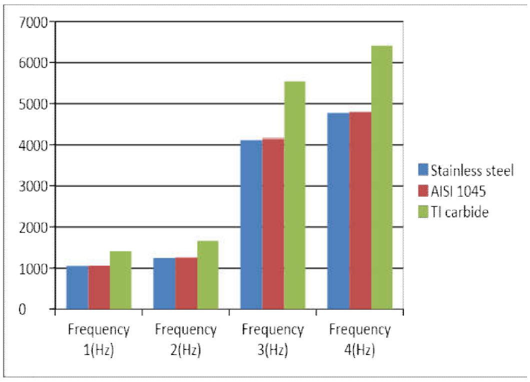
Bucket 2

Tabulated fig on static analysis

Material	**Total deformation(m)**	**Strain**	**Stress (N/m^2)**
AISI 1045	0.000112	0.08857	1.6357e9
TI carbide	3.1897e-5	0.02252	1.8343e9

Note: After analyzing above tabulated values on static analysis TI carbide showing best results dueto low deformation.

Graph



The plotted graph showed up frequency analysis results for the three materials used in thisproject such as stainless steel, AISI 1045 and TI carbide.

Conclusion

The aim of the study is to optimize the design and failure prediction of an excavator bucket by concerning with respect to static, dynamic and frequency analysis. The research work goes on simulations for the dissimilar materials to study and predict the failure of an excavator bucket. The technical work was done with the help of software Ansys for brief analysis of various research papers on fatigue analysis of an excavator bucket. The research work provided the results on design and fatigue analysis of an excavator bucket are discussed by concerning the parameters on stress, strain, total deformation, frequency ranges. After analyzing the above results AISI 1045 is giving the best results due to low deformation which is interpreted in above results.

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