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MODELLING AND 3D PRINTING OF JCB ARM

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Abstract-The Hydraulic excavator machines are heavy duty earth movers consisting of a boom, arm and bucket. It works on principle of hydraulic fluid with hydraulic cylinder and hydraulic motors. The Hydraulic excavator arm operation require coordinated movement of boom, arm and bucket. The important criteria for the design to be safe is that, the digging forces developed by actuators must be greater than that of the resistive forces offered by the surface to be excavated. The main objective of this paper is to perform design and analysis Excavator Arm for the calculated Force. The CATIA software is used for making the 3D model of the excavator arm linkage. By using ANSYS workbench software analysis of the excavator arm is done at existing digging force and lifting force. Excavator bucket is very crucial element of hydraulic excavator. The whole loads of excavated materials have been carried out by this element. As the present mechanism used in excavator arm is subjected to deformation and bending stresses during lifting and digging operation respectively, because of which failure occurs frequently at the bucket end of the arm.

Keywords: Excavator arm, Digging force, CATIA, ANSYS 16.0.

1.INTRODUCTION

1.1 MODELLING: Modelling a JCB (or any similar heavy equipment) arm in detail requires attention to specific components and their functionalities. Here's a detailed breakdown of how you can approach modelling a JCB arm.

Fig.1.1 Modelling of JCB Arm

Modelling a JCB (or any similar heavy equipment) arm in detail requires attention to specific components and their functionalities. Here's a detailed breakdown of how you can approach modelling a JCB arm:

1. **Reference Gathering**:

Collect reference images, technical drawings, and specifications of the JCB arm you want to model. Ensure you have clear views from multiple angles and close-up shots of important details.

2. **Software Selection**:

Choose a 3D modelling software that suits your needs and skill level. Software like Blender, Autodesk Maya, or SolidWorks are commonly used for this purpose.

3. **Basic Block out**:

Start by creating a rough blockout of the arm using simple geometric shapes like cylinders, cubes, and cones. This will help establish the overall shape and proportions of the arm.

4. **Segmentation**:

Identify the main segments of the arm, such as the base, boom, stick, and bucket. Create separate components for each segment to facilitate easier manipulation and detailing.

5. **Detailing**:

Add details to each segment based on reference images and technical drawings. This includes features like hydraulic pistons, hinges, bolts, brackets, and structural reinforcements. Pay attention to the placement and scale of these details to ensure accuracy.

6. **Hydraulics**:

Model the hydraulic system responsible for powering the arm's movement. This involves creating cylinders, hoses, valves, and connectors. Pay close attention to how these components interact and articulate during movement.

7. **Mechanical Connections**:

Model the joints and connections between different segments of the arm. These connections should allow for realistic movement and articulation. Consider using rigging or constraints to simulate the mechanical behavior accurately.

8. **Surface Detailing**:

Add surface details such as weld seams, surface textures, and paint markings to enhance realism. Pay attention to wear and tear patterns, especially in areas prone to friction and stress.

9. **Materials and Textures**:

Apply appropriate materials and textures to different parts of the arm. Use references to accurately represent materials like metal, rubber, and plastic. Consider factors like rust, scratches, and paint chipping for added realism.

10. **Testing and Refinement**:

Test the arm's movement and functionality to ensure it operates realistically. Make adjustments as necessary to improve performance and accuracy.

11. **Final Touches**:

Finalize the model by cleaning up geometry, optimizing for performance, and adding any last-minute details. Ensure the model is well-organized and ready for presentation or further use.

12. **Documentation**:

Optionally, create documentation detailing the modeling process, key features, and technical specifications of the JCB arm model. This can be useful for reference and sharing with others.

1.2 3D PRINTING:

Fig.1.2 3D Printing of JCB Arm

3D Printing, is also known as additive manufacturing is a process of creating three dimensional objects by layering successive material using plastic, metal or resin and it is

Unlike traditional subtractive manufacturing methods, which involve cutting away material from a solid block, 3D printing builds objects layer by layer, allowing for complex geometries and intricate designs to be produced with relative ease.

1. **Design Phase**:

CAD Modelling: Use Computer-Aided Design (CAD) software like SolidWorks, Autodesk Inventor, or Fusion 360 to create a detailed 3D model of the JCB arm. Ensure accurate dimensions and proportions based on reference images and technical drawings.

Segmentation: Break down the arm into manageable segments to fit the 3D printer's build volume. Consider how these segments will assemble to form the complete arm.

Tolerances: Account for tolerances in your design to ensure parts fit together properly after printing. Test-fit prototypes if necessary to refine tolerances.

1. **Preparation for 3D Printing**:

Orientation: Orient each segment of the arm optimally for printing to minimize supports and ensure structural integrity. Consider the geometry of each part and how it will interact with the print bed and nozzle.

Supports: Add supports as needed to overhanging features and complex geometries. Ensure supports are strategically placed to minimize post-processing efforts.

Slicing: Use slicing software like Cura, Simplify3D, or PrusaSlicer to prepare the 3D model for printing. Adjust slicing settings such as layer height, infill density, and print speed based on your printer and material.

2. **Material Selection**:

Choose a suitable 3D printing material based on your requirements for strength, durability, and surface finish. Common materials for detailed models include PLA, ABS, PETG, or resin for SLA/DLP printers.

3. **Printing Process**:

Printer Setup: Calibrate your 3D printer and ensure it's properly leveled and calibrated for accurate prints.

Printing: Start the printing process for each segment of the JCB arm. Monitor the print progress and address any issues that arise, such as adhesion problems, warping, or layer shifting.

Post-Processing: After printing, remove supports and clean up any imperfections using tools like flush cutters, sandpaper, or a hobby knife. Ensure mating surfaces are smooth and free from defects to facilitate assembly.

4. **Assembly**:

Assemble the printed segments of the JCB arm according to your design. Use adhesive, screws, or other fasteners as necessary to secure the parts together.

Test the articulation and movement of the arm to ensure it functions correctly. Make any necessary adjustments or refinements to improve fit and performance.

5. **Finishing Touches**:

Apply surface finishes or paint to enhance the appearance of the model if desired. Consider adding decals or markings to replicate real-world details.

Perform a final inspection to ensure the model meets your quality standards and accurately represents the JCB arm.

6. **Documentation and Display**:

Document the printing and assembly process for future reference. Display the finished model in a suitable location or use it for educational or promotional purposes

1.3 JCB ARM:

Hydraulic system is used for operation of the machine while digging or moving the material. Excavators are used primarily to excavate below the natural surface of the ground on which the machine rests and load it into trucks or tractor pulled wagons or onto convey or belts.

Fig.1.3 JCB Arm

The JCB arm stands as a quintessential embodiment of cutting-edge engineering and innovative design within the realm of heavy equipment. Serving as the pivotal extension of JCB's renowned excavators, loaders, and backhoes, the JCB arm represents the epitome of versatility, strength, and precision in construction and earthmoving applications.

At its core, the JCB arm embodies decades of engineering expertise and relentless commitment to pushing the boundaries of performance and efficiency. Crafted with meticulous attention to detail, each component of the arm is meticulously designed to withstand the rigors of demanding worksites while delivering unparalleled productivity and maneuverability

The JCB arm's design seamlessly integrates advanced hydraulic systems, rugged structural components, and precision-engineered joints to enable smooth and precise movements in a variety of operating conditions. Whether excavating trenches, loading materials, or performing delicate maneuvers, the JCB arm offers unmatched control and agility, empowering operators to tackle tasks with confidence and precision.

Beyond its formidable performance capabilities, the JCB arm also exemplifies a dedication to user-centric design and operator comfort. Ergonomically engineered controls, intuitive interfaces, and spacious operator cabins ensure that operators can work efficiently and comfortably even during extended hours on the job.

Moreover, the JCB arm's versatility extends beyond its primary functions, with modular design features and customizable attachments allowing it to adapt to a wide range of applications and environments. From excavation and grading to lifting and material handling, the JCB arm stands as a multifaceted tool capable of tackling diverse tasks with ease and efficiency.

In essence, the JCB arm represents more than just a piece of heavy machinery—it embodies a legacy of innovation, reliability, and performance that has cemented JCB's reputation as a leader in the construction industry. As a symbol of engineering excellence and unwavering commitment to customer satisfaction, the JCB arm continues to set the standard for excellence in heavy equipment worldwide.

2. METHODOLOGY:

EXPLANATION:

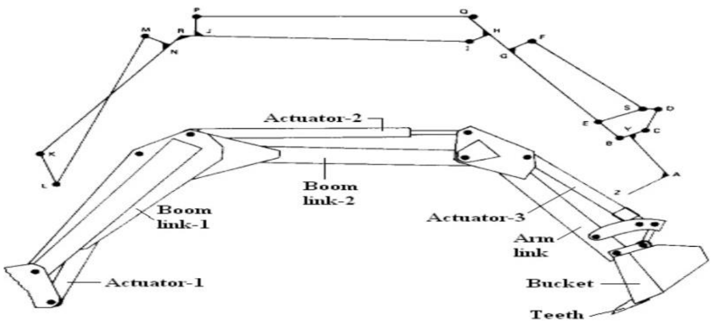
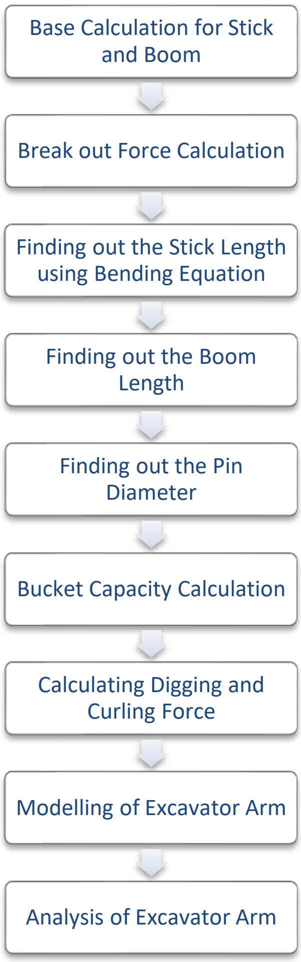


Fig.2.1 Line Diagram of JCB Attachment



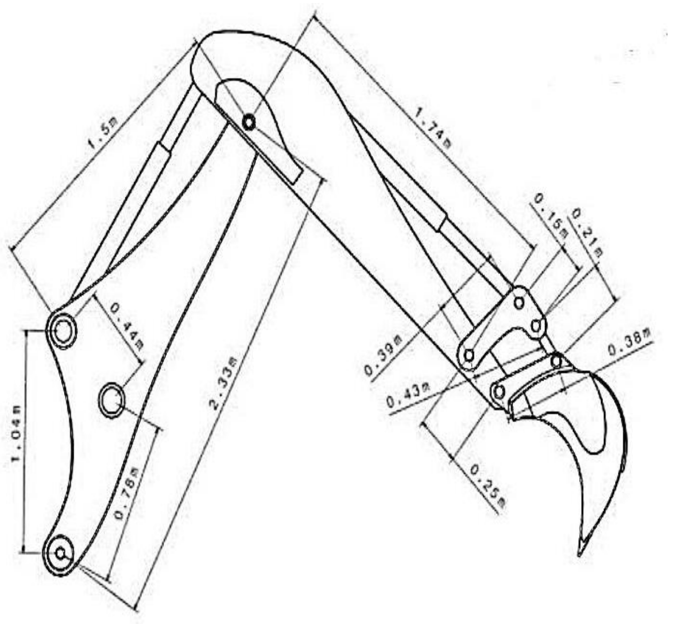


Fig.2.2 Line Diagram of JCB Attachment With Dimensions

2.1.1 JCB Attachment:

A JCB Attachment has three main components:

Boom: The extendable arm of the excavator that is used to reach into the excavation area.

Arm: Also known as the dipper or stick, it is attached to the boom and controls the depth and direction of excavation.

Bucket: Attached to the arm, the bucket is the tool used for digging, scooping, and lifting materials.

When using the bucket to dig, the angle of the bucket rod should be within 45 degrees at the front and 30 degrees at the back. Using the boom and bucket at the same time can improve mining efficiency. Mining point should not be too far from the centre of the excavator as this will affect its machine stability. he JCB 220LC xtra is a large excavator that has a maximum lift capacity of 22,000 pounds (about 10 metric tons) at a reach of 15 feet (4.6 meters). Meanwhile, the JCB 3CX backhoe loader has a maximum lift capacity of 7,198 pounds (about 3.3 metric tons) at a maximum reach of 14 feet 7 inches
(4.45 meters).

The Generation of the 3D model consists of mathematical and computer modelling. We have gone through the mathematical calculations and obtained the geometrical parameters for the 3D model of an excavator parts. Once the design calculations are carried out the final dimensions are fixed and Modelling of the excavator arm is carried out using modelling software CATIA. After the completion of parts modelling parts are subjected to Structural analysis and modal analysis using Finite Element packages like ANSYS.

Factor of safety = 5. According to Roymeck, UK standards "FOS=5", should also be used with better-known materials that are to be used in uncertain

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3. PROBLEM STATEMENT:

Backhoe Loader is a versatile machine and able to operate in different conditions. It is used in different excavation operation like trench digging, laying pipes construction etc Now adays buildings are built very closely. for the heavy duty excavator It is difficult for them to operate in this condition. We have developed with a minimum dimension of the parts for the construction

4. RESULTS AND DISCUSSION

4 .1Structural analysis:

Table 4.1 Structural Analysis

SNO.	Structural Analysis		
1	ARM	Total deformation	1.007 mm
		Directional deformation	0.1255mm
		Equivalent elastic strain	0.000419
		Equivalent stress	75.775 Mpa
2	BOOM	Total deformation	5.7877 mm
		Directional deformation	0.514596 mm
		Equivalent elastic strain	0.00089
		Equivalent stress	180.97Mpa
3	BUCKET	Total deformation	1.9515 mm
		Directional deformation	0.111434 mm
		Equivalent elastic strain	0.00076303
		Equivalent stress	146.06 Mpa

In structural analysis the total deformation developed due to force acting on the excavator

parts is less than the thickness of the sheet material used for the manufacturing. The level of stress developed is below the yield strength of the material used i.e., 450Mpa

4.2 Modal Analysis:

Table 4.2 Modal analysis

S .no	Mode	Frequency [Hz]	Deformation (mm)
1	1	3.52	1.1486
2	2	5.2715	1.1538
3	3	10.94	1.3674
4	4	13.457	1.8007
5	5	20.595	2.75
6	6	33.547	2.2305

5. FUTURE SCOPE

Because of the surge of medium density housing construction, together with changing regulations have caused builders to rethink construction methods, including the use of construction equipment. In some cases where homes are built only meters apart, the mobility of the excavating machines in such compact areas along with the movement of materials, and the size of the excavating equipment play a crucial role in excavation.

This indicates the urgency in the development of such compact excavation equipment or a compact backhoe excavator attachment which has higher digging depth, dumping height, and digging reach with minimum dimensions so that the machine can be easily accommodate in the workspace. Thus, developed compact backhoe attachment parts have to be equally better in strength as the parts of the heavy-duty backhoe loaders are. Design of such a backhoe excavator attachment is carried out by developing a 3D model.

6.CONCLUSION

We designed an Excavator bucket by using CATIA V5 software and analysis is done by ANSYS 16.0 software. From the analysis results, it is proved that the design is safe for the calculated digging force. During designing of excavator arm, the important factors taken into account are factor of safety, breakout force and maximum lifting capacity. The maximum stress values were found at the cylinder mountings. The material used is the medium strength alloy steel. Yield strength of the material is 450Mpa. From the analysis results it is observed that the stress developed due to applied force is less than the yield strength of the material for boom, arm and bucket. The deformation values are also less than the plate thickness i.e.,6mm. from the modal analysis, the deformations developed due to the natural frequencies levels is also less.

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