"Topological Optimization of JCB ARM using Additive Manufacturing Technique"

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Abstract- *The weight reduction is one of the important domains of new product development (NPD) and this could be achieved using topological optimization and use of lattice structures. The current research investigates the application of lattice structure and topological optimization tool in design of JCB arm to achieve weight reduction without much compromise in strength. The CAD model of JCB arm is developed in Creo design software and FEA analysis is conducted using ANSYS software to determine stresses and safety factor. The results have shown that significant weight reduction is possible with the use of lattice structure or topological optimization tool.*

Key Words: **JCB arm, FEA, Optimization.**

1. INTRODUCTION

The JCB machine encompasses arm, backhoe, boom and loader. Altogether all these parts or piece work in synchronization to lift, remove or dig material. The material which is lifted are usually of heavy weight and thus necessitates high strength of these parts. And therefore the strength analysis of these parts is essential.

Figure 1: JCB-Loader.

2. LITERATURE REVIEW

G. V. R. Seshagiri Rao et al [1] Have emphasized on "Static analysis of Backhoe Loader chassis" is to evaluate stress as well as declination spectrum for the various situation load. The static examination is taken for two various situations of load in ANSYS workbench. The cases are maximum reaches and torque situation. The process of structural is generating 4020.783 Kg & 4254.273 Kg of rapture force load situation in both cases. In both the situation of the load, there are two subcases. 1(a) Stabilizer legs are fixed and 2(a) Loader pivot points are also fixed. They may note that stresses produced are higher at stabilizer legs for load case 1(a). They may note that the stress produced is higher at stabilizer legs for load case 2(a) as compared to other components.

Vimal Kumar A. Patel et.al [2] In the linear static analysis of JCB of backhoe loader chassis, the stress and dislocations profile of JCB of the Backhoe Loader chassis is noted while backhoe is reached at maximum value situation. The substance is made up of steel alloy. The characteristics of the substance are Modulus of Elasticity and Mass Density are 200 GPa and 7850kg/m3. In this proposed paper, they have used two different situations of load that are the Maximum reach and torque condition. In these cases, there are two sub cases. When stabilizer legs are fixed for load case 1(a). They may notice that stresses produced are higher at stabilizer legs than other components.

Bhaveshkumar P. Patel, Jagdish M. Prajapati [3] Operated on Mini Hydraulic Backhoe Excavator Structural Optimization Attachment, utilising the FEA Trial and Error system technique. With weight optimization was done and results related to the test and error approach with equal results. The outcome is also equivalent. This FEA of the optimized model was also carried out and its findings were verified by classical theory.

Bhaveshkumar P. Patel and J. M. Prajapati [4] Offered the platform to learn about the simulation, FEA, and enhancement of backhoe excavator attachment that other researchers have already applied for their relevant applications.

Sachin B. Bende, Nilesh P. Awate et.al. [5] The concentrated on analysis of the excavator components to evaluate the issues of raising and drilling and to include a design approach utilizing CADCAE systems. The current system used in the excavator arm is torsional and bending pressures during the process of raising and drilling, which is why loss always happens at the end or last part of bucket of the arm.

Reeves et al [6] Documents other instances of mass customization or personalized of AM. And details associated with the financial and constructing model for computers, hearing aids, phones cases, etc.

Hopkinson and Dickens et al [7] Provide a successful cost model to illustrate the breakeven point of AM vs SM for volume. The overall study examined the cost of fabricating a small plastic lever using AM powder bed fusion process vs conventional injection molding process. The study concluded for a making volume less than 10,000 AM had a lower unit cost compared to injection molding process [8]. While SM dominates the Mass Constructing part/region financially, AM is best for fabricate tooling and fixtures needed for conventional Mass Constructing molds [9, 10].

3. OBJECTIVE

The current research investigates the efficacy of lattice structure in weight minimization JCB arm. The topological optimization of JCB is also performed to determine possible zone of mass reduction. The FEA analysis is conducted using ANSYS software.

4. METHODOLOGY

The Computer Aided Design (CAD) model of JCB arm is modelled in Creo design software using sketch, extrude and pattern tool.

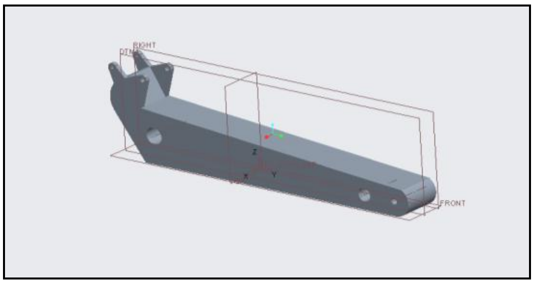

Figure 2: CAD model of JCB arm.

The CAD model of JCB arm is meshed using tetrahedral elements due to complexity of geometry involving hard edges and curvatures. The medium mesh relevance, smoothing medium and smooth inflation is set to get mesh as shown in figure 2 below.

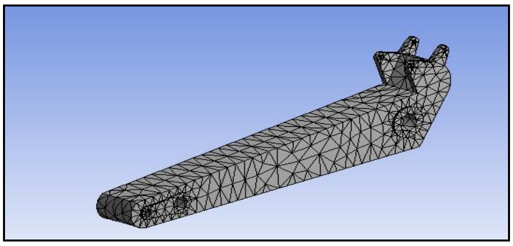

Figure 2: Meshed model of JCB arm.

The loads and boundary conditions applied on JCB arm is taken from literature. The fixed support is applied on face A, force is applied on location B and other force is applied on location C.

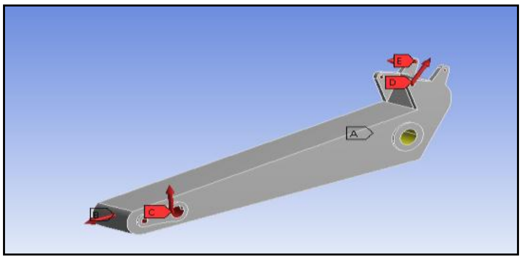

Figure 3: Loads and Boundary Conditions.

The sparse matrix solver is used to solve FEA simulation which involves matrix formulation, multiplication and inversions.

5. RESULTS AND DISCUSSION

The contour plot of deformation and fatigue life are generated for generic design as shown in figure 4 and figure 5 respectively.

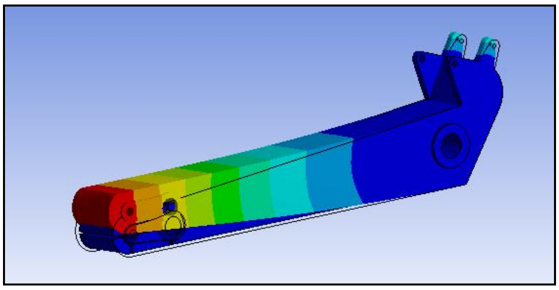

Figure 4: Deformation plot.

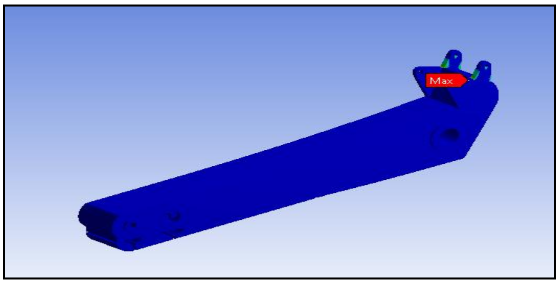

Figure 5: Fatigue life plot of arm.

The fatigue life plot JCB arm is shown in figure 5 above. The plot shows that for the given geometry the failure occurs at the location of maximum equivalent stress concentration. The fatigue life for the component is 7647 cycles.

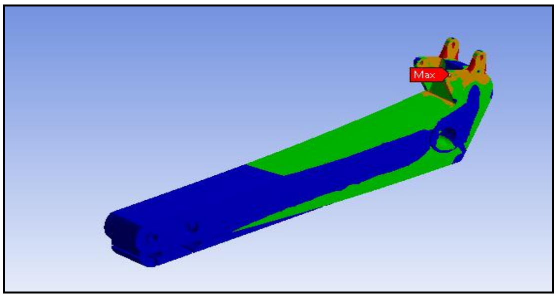

Figure 6: Safety factor plot of arm.

The safety factor plot of JCB arm is obtained as shown in figure 6 above. The plot shows minimum safety factor at corner region shown by red color and higher safety factor for other regions as shown by green and dark blue color. The minimum safety factor for the given geometry is .3. Further analysis is conducted with lattice structure models and topologically optimized models.

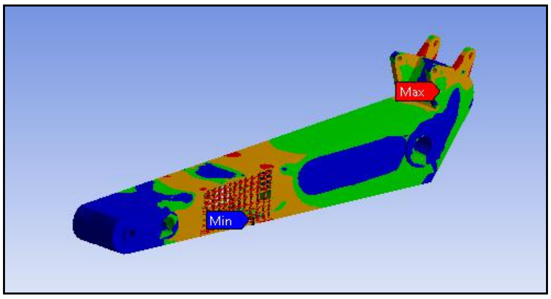

Figure 7: Safety factor plot of arm.

The safety factor of JCB arm obtained after using lattice structure is .17 and is observed near the lattice structure as shown by red coloured regions.

6. CONCLUSIONS

The FEA analysis is conducted on JCB arm using ANSYS software. The material of JCB arm is reduced by using technique of lattice structure and topological optimization. The feasibility of using lattice structure for weight minimization is also assessed by evaluating stress, deformation, strain and fatigue life. The detailed conclusion are as follows:

1. The deformation obtained for lattice design is 1.145mm and in generic design is .335mm which is nearly 70% more.
2. The equivalent elastic strain observed for lattice structure is .00183mm/mm which is nearly 23.46% higher.
3. The fatigue life observed for lattice type structure is 3960 cycles which is nearly 47.8% lower than generic design.
4. The safety factor comparison plot shows that lattice type structure has safety factor of .179 which is nearly 40% lower than generic design.

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BIOGRAPHIES

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