Analysis and Optimization of Boom

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***Abstract*—A Mini hydraulic excavator is man operated heavy duty machines which are used in versatile operating conditions. The main objective of present work is to analyse the boom structure of mini hydraulic excavator for given load condition and to optimize the structure by reducing the mass of structure without exceeding the yield limit.**

The boom model is created by CAD tool and the developed model is imported into hypermesh V12.for pre-processing. In this process, geometry cleanup, element type and material properties are defined. After meshing process in hypermesh tool element quality check is made. Analysis and optimization is done on given loads and boundary conditions on the basis of given severe position of boom. And solver ABAQUS is used to solve and read the results.

Keywords - ABAQUS,CAD, Hypermesh, Yield ,Versatile

I. INTRODUCTION

In present world mini hydraulic excavators are mainly used in all severe conditions such as excavation, construction, cleaning of sewage, and sometimes it is used in rescue operations after disaster conditions so for proper working in such critical condition the hydraulic excavator attachments must work properly throughout the condition.

The main three excavator attachments are boom structure, arm and bucket as in our study we are concentrating about boom structure, it should support arm and bucket during operations so it is a important and complex structure to inspect as it will undergo stresses throughout its working life. To work in critical conditions excavator attachments must be strong enough to withstand different loading condition in severe condition position. The designers should design the components of excavator for such severe condition, nowadays weight is major subject considered during design process for cost reduction. As our main objective of work is to analyse boom structure and optimize it for severe position for given load and boundary condition, analysis and structural Optimization is done by varying thickness of the boom plates without exceeding yield limit.

II . LITERATURE REVIEW

Many researchers have been carried out on hydraulic excavator and on its attachments. For my study I have referred the work carried out by authors named by Bhaveshkumar p.patel and Jagdish M.Prajapati[1], authors presented their research paper in the year 2013 on mini hydraulic excavator titled with "structural optimization of mini hydraulic backhoe excavator attachment using fem approach". The authors optimize the attachments of mini hydraulic excavator and carried out analysis by fem approach, they considered thickness of the plates as variable and adopted trial error method for optimization. The optimized model is checked for limiting safe stress.

The boom structure is modified based on the standard thickness of plates. The weight of boom before optimization is 51.65kg and after optimization the weight was 41.99kg, and weight reduction of boom was about 9.608kg.the results of the research shows that maximum voin misses stress acting is 287.11Mpa which is less than yield stress 500Mpa which indicates that boom is safe for strength.

Onther work carried out by authors Bhaveshkumar P.Patel and J.M.Prajapati [2] on "static analysis of mini hydraulic backhoe excavator attachment using FEA approach*"*. Their work focuses on solid modeling of the mini hydraulic backhoe excavator to get light weight boom structure and its analysis is done by FEA approach to check its strength. Gaurav.K .Mehta,V. R Iyer and Jatin Dave[3] , presented FEA of robotic mechanism of excavator attachments using CAM & CAE tools. Design modification in regions are done where stress is less than allowable. Li Zhi-Jai, wen-Quan etc[4] , illustrated analysis of excavator in their research , bucket digging conditions is considered foe calculating load. Mathematical equations are derived for each hinge points. By Pro/E model is prepared, meshing and analysis is done by ansys workbench. The results depicts that maximum equivalent stress is in safe limit

III. METHODOLOGY

The boom structure of mini hydraulic excavator is modelled using CAD tool i.e solid edge and for pre-processing it is imported into hyperworks tool, where meshing, element quality check ,material properties, boundary condition and loading conditions are specified. For solution purpose it is exported as inp file. The file is imported in ABAQUS software for solutions and to read the results.

A. Load Calculation

Load calculation is done on reverse calculation of given pressure of cylinders for given severe position condition. Pressure in cylinders is given to exert certain force for digging purpose for given severe condition position. With help of given pressure and cross section at both sides of boom resultant force and force in x and y directions are calculated.

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Location1

Cylinder diameter =25mm

C/section area =491mm^2

Pressure on cylinder =106.38Mpa

Resultant Force on the boom at Location 1= P*A =52228N

Angle of orientation of cylinder At position 1= 16.34^0

Location 2

Cylinder diameter =30mm

Cross section area =706.9mm^2

Pressure of cylinder =111.98

Force on the boom at location= P*A =79168N

Angle of orientation of cylinder at position 2= 25.79^0

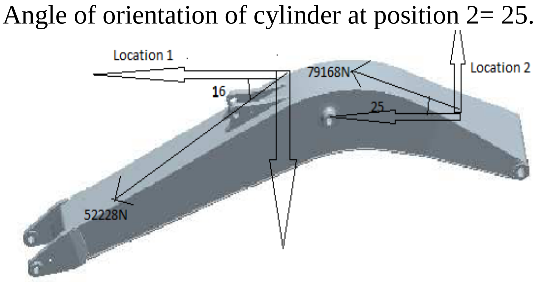

Fig 1: Resultant forces and angle of orientation for given position

The boom structure of mini hydraulic excavator is meshed in hypermesh tool and the meshed model consists of quadrilateral and triangular elements.

The number of elements in meshed model is 39182. The meshed model is shown below.

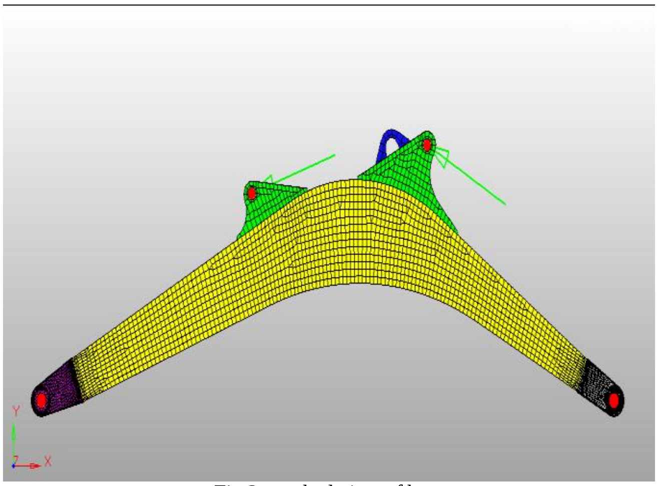

Fig 2: meshed view of boom

IV. RESULTS AND DISCUSIION

By varying thickness of boom structure for 6mm,5mm and 4mm analysis is done and results are obtained. The below figures shows results of voin misses stress, maximum principal stress, minimum principal stress and deflection for6mm,5mm and 4mm boom .

A) Results of 6mm thickness boom

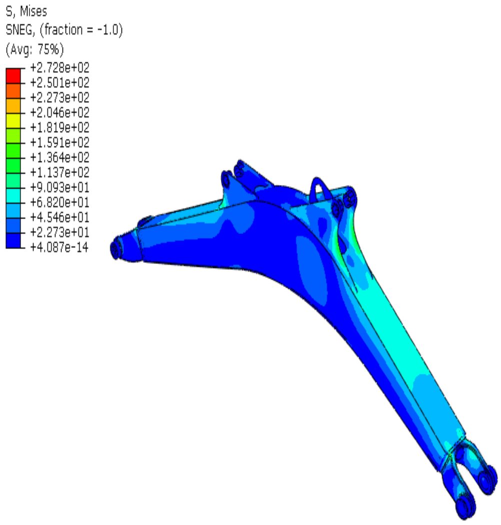

Fig 3: Voin mises stress for 6mm thickness boom

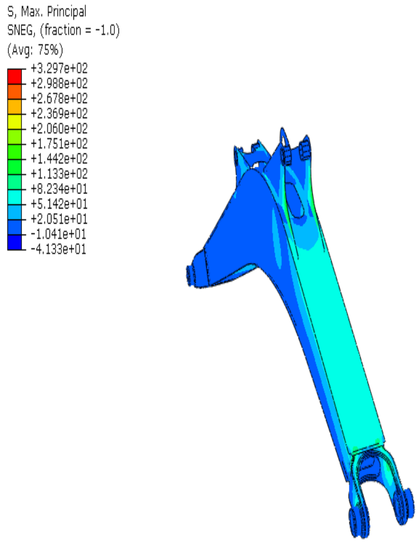

Fig 4: maximum principal stress for 6mm thick boom

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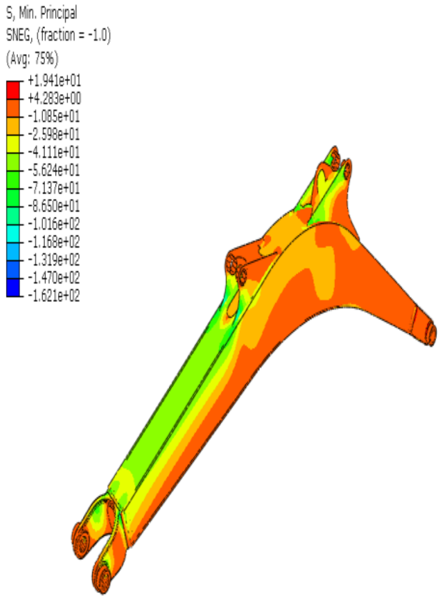

Fig 5: minimum principal stress for 6mm thick boom

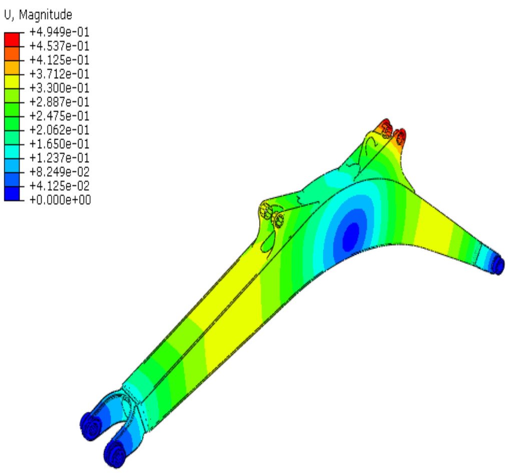

Fig 6: deflection of 6mm thickness boom

b) Results of 5mm thickness boom

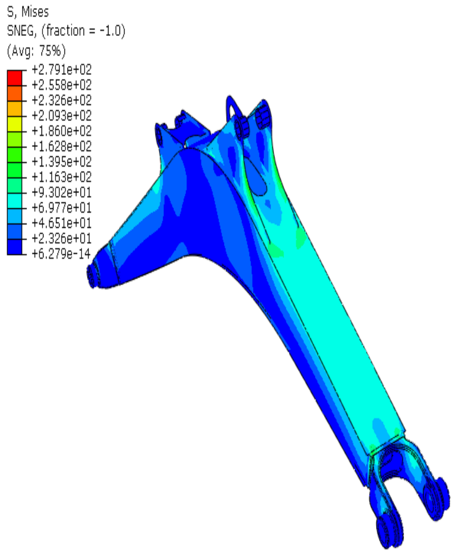

Fig 7: Voin misess stress of 5mm thickness boom

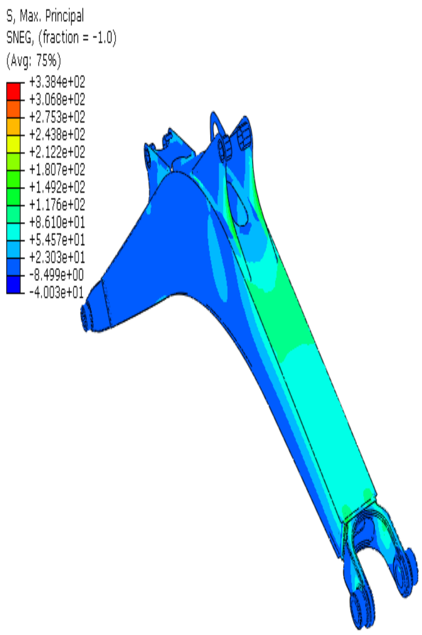

Fig 8:Maximum principal stress of 5mm thickness boom

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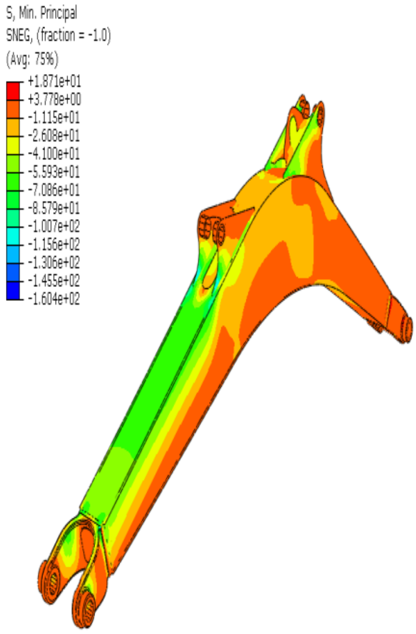

Fig 9: minimum principal stress of 5mm thickness boom

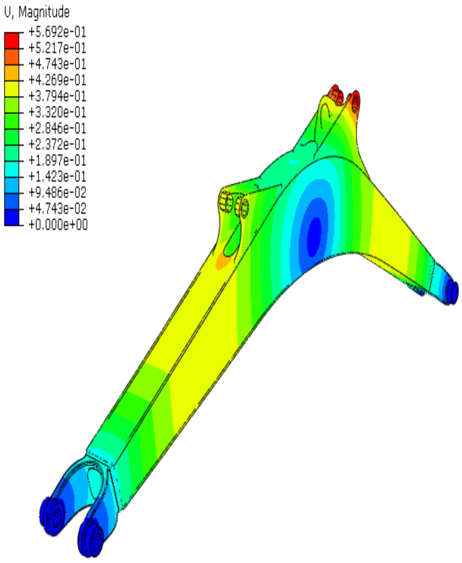

Fig 10: Deflection of 5mm thickness boom

C) Results of 4mm thickness boom

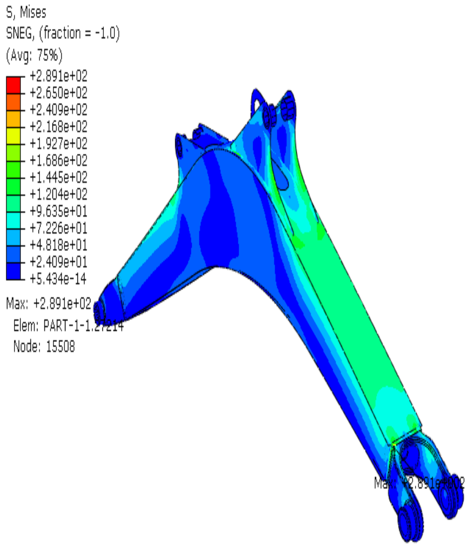

Fig 11: voin misess stress of 4mm thickness boom

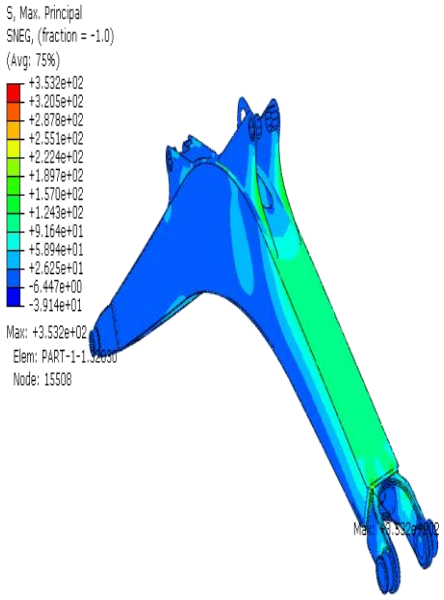

Fig 12: maximum principal stress of 4mm thickness boom

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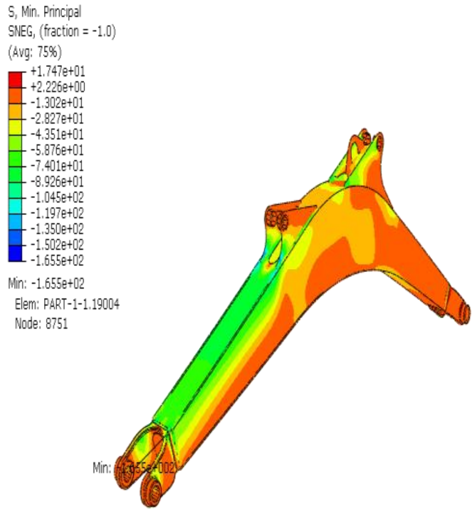

Fig 13: minimum principal stress of 4mm thickness boom

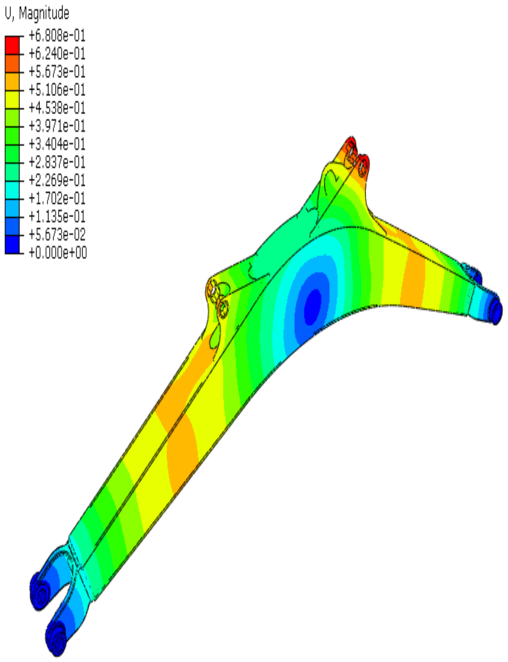

Fig 14: deflection of 4mm thickness boom

Table 1: summary of weight reduction by varying thickness of boom plates

Sl.no	Thickness	Stress	Weight (kg)	%of weight reduction	FOS
1	6mm	272Mpa	67.5	-	1.30
2	5mm	279Mpa	59.5	11	1.27
3	4mm	289Mpa	51.5	13	1.22

The above table shows the stresses on boom part for given load condition and percentage of weight reduction obtained by varying thickness of boom plates. The weight of the boom before optimization was 67.5kg for 6mm thickness boom structure and after optimization for 4mm weight was 51.5kg. The total percentage of weight reduction is 23.70%.

The maximum voin misses stress on 4mm is about 289Mpa which is less than yield stress of the material i.e 355Mpa. The results shows that it is safe for strength.

CONCLUSION

This work deals with analysis of boom structure, FE model of boom is formulated to study behavior of boom with considering various thickness of boom. The results shows that the optimized boom structure is safe even after optimizing it. And it is subjected to safe stresses at given severe position which is below its ultimate yield limit. It can be concluded that all the objectives of present work are met and results obtained are satisfactory.

Hence it is safe for strength and there is always possibility for weight reduction as induced stress is within yield strength.

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