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Experimental analysis of stiffened and un-stiffened flat plate used in log splitting machine

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Abstract - *Wood is the major source of energy, particularly in rural areas. From its utility point of view, the wooden logs are to be split. Splitting the wooden logs is labor intensive, strenuous and time consuming task. During this dissertation work a hydraulically operated vertical log splitting machine is analyzed and redesigned. The top plate of the vertical log splitting machine was deformed by 13mm when 3.5 tons load is applied on it. So to overcome this problem plate analysis is done. To overcome of deformation different types of stiffeners are used. 10mm plate is used to calculate the deformation, stress and strains and after that 10mm stiffened plate is used to study the deformations, stress and strains. The analysis is done by FE Analysis using ANSYS software for different plate thickness.*

***Key Words*: Wedge (cutter), stiffened plate, hydraulic machine.**

1.INTRODUCTION

Family units in India are very reliant on firewood as their primary source of energy, firewood, which is basically handled by the purchaser, is still an imperative source of energy for warming houses in industrialized nations. firewood is a wooden material that is accumulated and utilized for fuel. . For the most part, firewood is not exceedingly prepared and is in some kind of distinctive log or branch shape, compared with different types of wood fuel like pellets or chips. wood is a renewable asset. firewood can either be prepared (dry) or unseasoned (green). It can be classed as hardwood or softwood. A log splitter is a machine utilized for part logs that have been pre-cut into areas (rounds), as a rule by cutting apparatus or on a saw bench.

1.1 NEED FOR LOG SPLITTER

Despite the fact that the cost of human work has gone up yet there is significant decrease in the amount of work utilize. Machines permit us to do numerous things quicker or with less exertion. They also empower us to apply greatest load on logs to part, which generally would not be conceivable to manage without machine.

1.2 Materials properties

Table 1: Material properties of EN8

Material properties	
Material	EN8
Ultimate tensile strength	600MPa
Yield strength	450MPa
Young's modulus	210GPa
Poison's ratio	0.3

1.3 Cutter(Wedge) types

For the splitting process mainly two different types of wedges are used, those are

- Single V cutter with taper.
- Cross V cutter with tapered.

Single V cutter: The single V cutter is fabricated with EN8 material with an Optimum angle 45^0, It is heat treated to strengthen material. It is used to split logs into two pieces. The dimensions used in modeling are – length = 8 inch, height = 4 inch and thickness = 20mm.

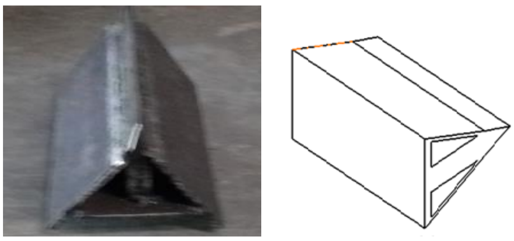


Fig 1 Single V cutter with taper

Cross V cutter: The cross V cutter is fabricated with EN8 material with an Optimum angle 45^0, it is heat treated to strengthen material. It is used to split logs into four pieces. The dimensions used in modeling are – length = 8 inch, height = 4 inch and thickness = 20mm.

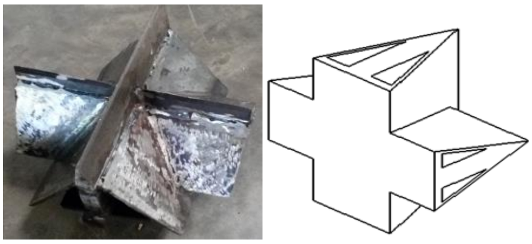


Fig 2 Cross V cutter with taper

Vertical strand: The hydraulic actuator is mounted on this stand and splitting work is done.

Fig 3 Vertical strand

2.MODELING AND FE ANALYSIS

The wedge model created using modeling software "CREO" and Analysis and design of wedge is done using finite element. For accurate results the commercial finite element package ANSYS V14.5 V15. Workbench was used for the solution of the problem. And Based on finite element analysis, design of wedge(cutter) was carried out to get high mechanical strength, ease of manufacturability and reduction in cost.

There are three major steps in ANSYS are

- Pre-processor
- Post-processor
- Solver

2.1 Pre-Processor: In pre-processor the model is prepared and then material property is assigned. Then the meshing is done. The meshing element type which is used here is tetrahedron.

2.2 Model: The design and model is prepared in 'CREO'. Two sorts wedge (cutter) configuration is made. Single cutter and cross cutter investigation is done in ANSYS 15.0 workbench. The ANSYS component library contains more than 150 diverse component sorts which incorporate one, two and three dimensional components, scalar components, liquid components and warmth exchange components. It additionally incorporates a few different components, for example, limitation components, shell components, strong components, straight components, direct strain components, pillar components and funnel components. Every component sort has a novel number and a prefix that distinguishes the component class: the components considered in this examination are solid187. It is a 3-d, 10-node tetrahedral structural solid.

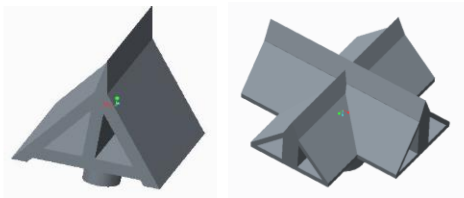


Fig 4 Geometric 3D models of cutters

2.3 Mesh: To improve element quality and also to get more accurate solution model is meshed with Triangular surface element. ANSYS Program will consequently work the geometry with hubs and components. The size and state of the components, which the project makes, can be controlled. In direct the area of every hub and the availability of every component are physically characterized. Free work and Mapped range cross section is accessible in ANSYS. Picking mapped range network with Triangular surface component. Mapped region network contains triangular or quadrilateral components.

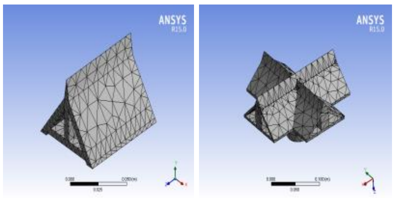


Fig 5 Meshed wedge

Type	single V cutter	cross V cutter
Total no. of nodes	92830	38410
Total no. of elements	52181	20072

Table 2: Nodes and elements of cutters

2.4 Post-processor: In this step, the solution processor used to define the analysis type and which analysis options is used, what are they applied loads, specify force step options, and initiate the start of finite element solution. The component arrangement is normally ascertained at the components combination focuses. The ANSYS program composes the outcomes to the information base and additionally to the outcomes document. Load: 40KN on the edge of the wedges.

Boundary condition:

- Single wedge – Bottom face and back face of wedge are fixed (as fixed in machine)

- Cross wedge – only back face is fixed.

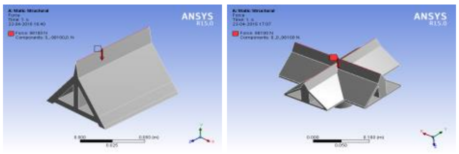


Fig 6 Applied boundary condition on both cutters

2.5 Solver: Based on the inputs which are given the solving process is also done to get the Total deformation in model and Equivalent Von-Misses stresses are calculated. The part strengths of 40KN (4 tons) are connected on the edge of single and cross wedge. The variety in deformation and stresses on wedges from ANSYS. If we take the deformations in both the cutters for 40KN load then values are

Total deformation in mm		
Type of cutter	Single V cutter	Cross cutter
Minimum	0	0
Maximum	0.1429	0.0099

Table 3 Results of total deformation of single and cross v cutter:

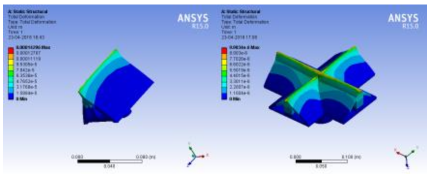


Fig 7 Total deformation of single and cross v cutter

From the analysis results obtained for single V cutter after applying of 4 tons the minimum deformation is 0mm and maximum deformation is 0.14296mm. for cross V cutter after applying of 4 tons the minimum deformation is 0mm and maximum deformation is 0.00990mm.

Equivalent stress(von-Mises) in MPa		
Type of cutter	Single v cutter	Cross v cutter
Minimum	0.6490	0.0650
Maximum	550.9	212.5

Table 4 Results of Equivalent stress of single and cross v cutter

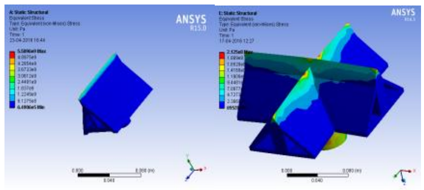


Fig 8 Equivalent(von-Mises)stress distribution of single and cross v cutter

3. EXPERIMENTAL WORK ON LOG SPLITTING

3.1 Dimensions of plate

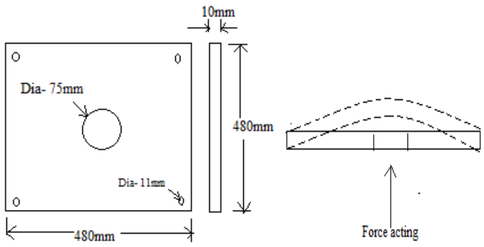


Fig 9 Top plate dimensions

Plate dimension-square plate of length 480mm and thickness 10mm. It is having a centre hole of diameter 75mm. It is fixed at the corners with help of nut and bolts. The hole diameter is 11mm. The axial upward force is acts on plate. The top plate is shown below. There are two types of plates are used. Using hydraulic system load is applied on cutters to split the logs.

Fig 10 Plates with strain gauges

As shown in above figure the strain gauges are mounted. Three element rectangular rosette is used for calculating strains.

3.2 Load cell test conducted in UTM

For the valuation of stain and load we need to conduct test for the load cell on UTM and load v/s strain graph is plotted. The load cell is connected to strain indicator and load is applied in UTM . for each 1000kg of load the strain is noted. And graph is plotted

Fig 11 Test in UTM

Load in kgf	1000	2000	3000	4000	5000	6000	7000	8000	9000	10000
Strain	24	40	61	84	108	134	158	184	205	236

Table 5 Values obtained from test

The strain and load values obtained from UTM and are plotted in graph

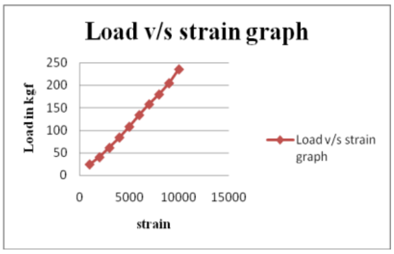


Fig 12 Graph of load v/s strain

Test conducted on plate using different cutters.

- **Using single V cutter**

Fig 13 Single V cutter splitting

The test is conducted on 10mm top plate with and without stiffeners and using single cutter, load cell, strain gauges strain indicator, and stress strain and deformations are calculated. The machine is shown in figure.

- **Using cross V cutter**

Fig 14 Cross V cutter splitting

The test is conducted on 10mm top plate with and without stiffeners and using single cutter, load cell, strain gauges strain indicator, and stress strain and deformations are calculated.

3.3 Splitting load measurement

Test are performed to determine the load require to split of different logs.

- Different diameter to length ratio of logs is collected.
- Load connections are given and test performance is observed using load cell.

Results of log for different length and diameter

Sl. no	Log length in Ft.	Log dia in Ft.	Log splitting load in Kgf		
			Type of log		
			Acacia	Jamun	Honne
1	1	0.5	1900	1800	1900
2	1.25	0.625	2150	2000	1900

Table 6 Splitting load for single V cutter

Sl. no	Log length in Ft.	Log dia in Ft.	Log splitting load in Kgf		
			Type of log		
			Acacia	Jamun	Honne
1	1	0.5	2000	1900	2000
2	1.25	0.625	2350	2100	2200

Table 7 Splitting load for cross V cutter

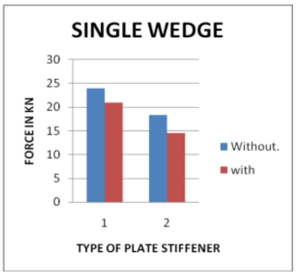
4. RESULTS AND DISCUSSION

Wedge Test Test was carried out for log diameter 20cm and length of 1.5Ft.

S no	Type of wedge	Type of plate	Force re quired to break the bond (in KN)	Force req uired after brea king bond (in KN)
1	Single wedge	Without stiffener	24	18.3
2		With stiffener	21	14.6
3	Cross wedge	Without stiffener	23.5	10.5
4		With stiffener	21.5	8.52

Table 8 Experimental results of wedge test

Graph of splitting strength verse length of log for different plates for single wedge



The graph shown in above figure explains about the forces required to split. The plate with stiffener is having more strength than normal plate. So the plate will not deform.

Sl.no	Length of log in Ft.	Total splitting strength of log (F_s) in Kgf.			
		Plate stiffeners used			
		With stiffener		Without stiffener	
		Expt	Theoretical	Expt	Theoretical
1	1	1400	1400	1750	1720
2	1.25	2100	2000	2500	2400

Table 9 Total splitting strength of various lengths and diameter of different species logs

While using Cross v cutter the compression forces are inducing by the material so the wedge is constrained. Therefore the cross cutter is infeasible. So we use single cutter only.

5. CONCLUSION

From the tests conducted on normal plate and stiffened plate it is observed that plate with stiffeners is having less deformation i.e stiffer in nature. From direct splitting test results it is found that the force required to initiate crack in log was 20KN and force required to propagate crack in log is 25KN.Using single cutter it is easy to split log but using cross cutter the compression load on log is more, so the cross cutter is " infeasible". From this work it is shown that 10mm plate with stiffeners is better to use, such that it can reduce 45% weight.

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BIOGRAPHIES

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