International Journal of
Scientific Engineering and Technology Research

ISSN 2319-8885
Vol.04,Issue.09,
April-2015,
Pages:1611-1616

www.ijsetr.com

Computer Aided Design and Analysis of Swing Jaw Plate of Jaw Crusher

M.AVULAIAH[1], T.SESHAIAH[2]

[1]PG Scholar, Dept of Mechanical Engineering, QIS College of Engineering & Technology, Ongole, AP, India.

[2]Associate Professor, Department of Mechanical Engineering, QIS College of Engineering & Technology, Ongole, AP, India.

Abstract: A Jaw Crusher breaks minerals, ores of high strength. The stiffness of swing jaw plate has not been varied with changes in rock strength. Thus stiffness of swing plate is enough to crush taconite with an Unconfined compressive strength (QU) of up to 308 MPa, may be over signed for softer fragmental. Hence the weight of the swing plate is necessary to reduced. In this paper the design of the swing jaw plate using point-load deformation failure (PDF) relationships along with interactive failure of rock particles as a model for such a weight reduction. The design of the corrugated swing jaw plate is carried out by using CAD i.e. jaw crusher plate has been solid modeled by using CatiaV5R15. The calculated dimensions are validated with the drawing of reputed manufacturers. Finite Element Analysis of jaw plates are carried out by using ALGOR V19 software. Computerization of the theoretical design calculations of jaw plates of the jaw crusher has been carried out. The computerized program facilitates for quick design of the plates of the jaw crusher. The different comparisons of corrugated swing jaw plates behavior, calculated with the traditional and the new FEA failure models with stiffeners, shows that some 10-25% savings in plate weight may be possible.

Keywords: Jaw Crusher, Computer Aided Design (CAD), Point-Load Deformations and Failure (PDF), Finite Element Analysis, Solid Modeling, Corrugated Jaw plate, Stiffened-Jaw Plate.

I. INTRODUCTION

Crushing is the process of reducing the size of the lump of ore or over size rock into definite smaller sizes. Based on the mechanism used crushers are of three types namely Cone crusher, Jaw crusher and Impact crusher. The first stage of size reduction of hard and large lumps of run-of-mine (ROM) ore is to crush and reduce their size. The mechanism of crushing is either by applying impact force, pressure or a combination of both. The jaw crusher is primarily a compression crusher while the others operate primarily by the application of impact. The crusher crushes the feed by some moving units against a stationary unit or against another moving unit by the applied pressure, impact, and shearing or combine action on them. The crushers are very much rugged, massive and heavy in design and contact surfaces have replaceable high tensile manganese or other alloy steel sheet having either flat or corrugated surfaces. Many engineering structures consist of stiffened thin plate elements to improve the strength/weight ratio. The stiffened plates subjected to impact or shock loads are of considerable importance to mechanical and structural engineers. The main object of the present work is to propose an efficient use of modeling in the connection between the plate and the stiffener, and as part of it the constraint torsion effect in the stiffener.

II. OBJECTIVE

The objective of this paper is to increase the design and analysis of commercially available swing jaw plates(including stiffening elements),which having 304mm opening at top and 51mm at bottom and 0.9 m wide. And this jaw plate is analyzed by software; Also further study of swing jaw plate with stiffener is done using finite element analysis. The theoretical design calculations of jaw plates have been computerized. The design and modeling jaw plates of crusher is accomplished by using CATIA, by using this package three dimensional model of jaw plates jaw crusher has been developed. Finite Element Analysis of jaw plates are carried out by using ANSYS12 programming. This work is extended to improve the strength/weight ratio of swing jaw plate by adding different number of stiffener elements on the jaw plates.

III. DESIGN OF JAW PLATES

Recently, concern for energy consumption in crushing has led to the consideration of decreasing the weight (and consequently the stiffness) of the swing plate of jaw crushers to match the strength of the rock being crushed. An investigation of the energy saving of plate rock interaction when point load deformability and failure relationships of the rock are employed to calculate plate stresses. In order to conduct this investigation, a model has been created in the modeling software CATIA and then with the help of finite element analysis software ANSYS analysis it. The model is made firstly without stiffeners and analyzed then for further analysis numbers of stiffeners are added in the model and again it analyzed. The factors of importance in designing the size of jaw crusher's plate are:

Height of jaw plate (H)= 4.0 x Gape

Width of jaw plate (W) >1.3 x Gape

< 3.0 x Gape

Throw (T) = 0.0502(Gape) 0.85

Where the crusher gape is in meters. These dimensions vary as individual manufacturers have their own specifications and design of individual makes as shown in Figs.1 and 2. In this case, we have top opening i.e. gape 304 mm (12 in.) and bottom opening 51mm (2 in)

Height of jaw plate (L) = 1200 mm
Width of jaw (W) = 900 mm
Throw (T) = 50 mm

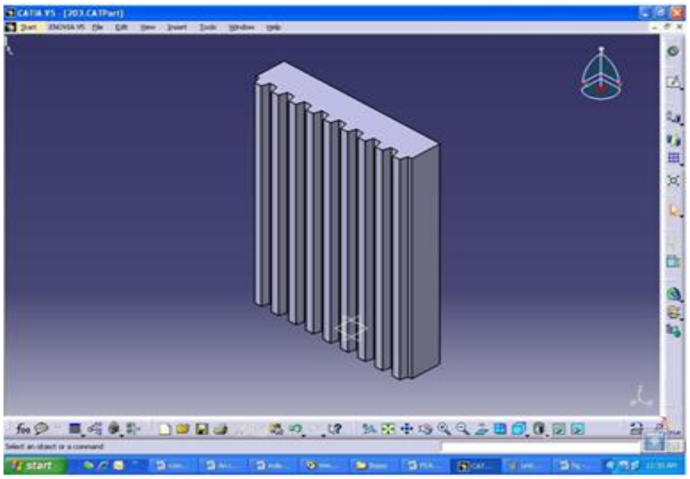

Fig.1. Solid Model of Corrugated Swing Jaw Plate.

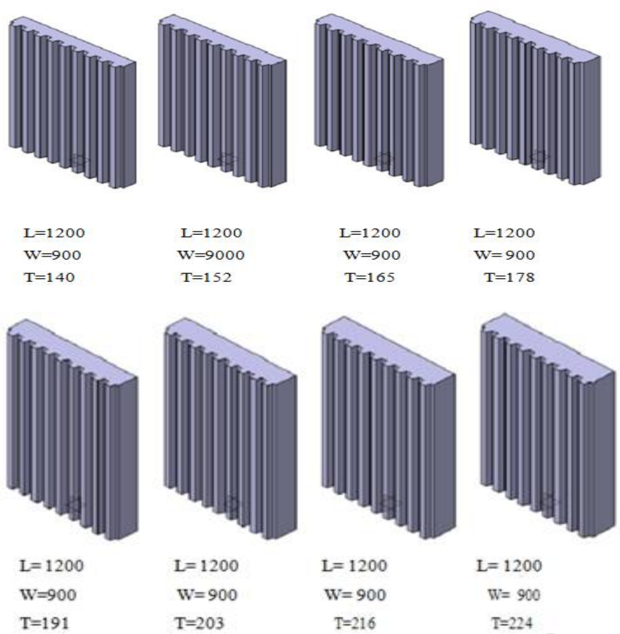

Fig.2. Corrugated Swing Jaw Plate Models having Dimensions in mm.

Assumptions: Analysis was undertaken based on the assumption that the point load strength of the disk and irregularly shaped particles to be equal and tensile point loads of different particle sizes are acting normal to the plate. For the analysis of the of swing jaw plate, the model of the swing jaw plate is converted into IGES file and then this file is called for the analysis.

Applying Material: Before the Structural Analysis module used for the FEA model, it must have material assigned to it. Each material in ANSYS has mechanical properties for computing the analysis for different materials but it has a facility to edits and add some material properties for other parts. For the analysis of plate. Martensitic steel are use, because it is hardenable, which means that it is possible to modify the properties via heat treatment in the same way as for hardenable carbon steels.

TABLE I:

Structure	Material used	Youngs modulus(GPa)	Yield strength(MPa)	Poisions ratio	Density (Kg/m^3)
Swinging jaw plate	Martensitic steel (C-1.1%, Mn-13%)	210	550	0.266	7860

A. Apply Boundary Conditions

Boundary condition for Swing jaw plate is simply supported i.e. the support at bearing location hinge support and at the free end toggle force acting. due to which this plate is acts as a simply supported, figure shows the fixed point of plate. Fig.3 Showing Swing Jaw Plate Model Boundary Condition.

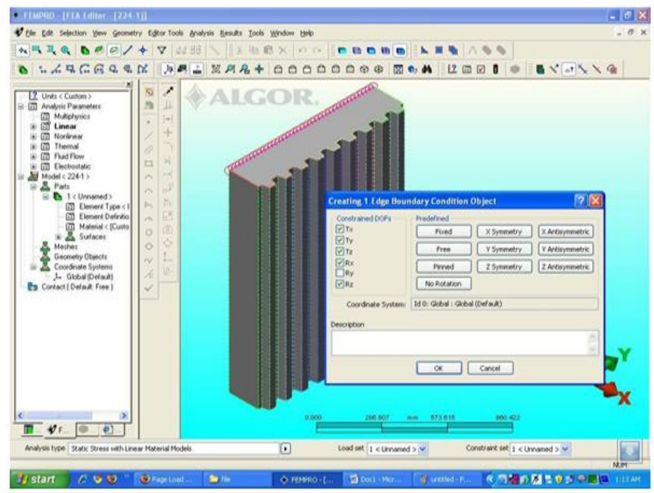

Fig.3. Showing Swing Jaw Plate Model Boundary Condition (Support).

Applying Loads:

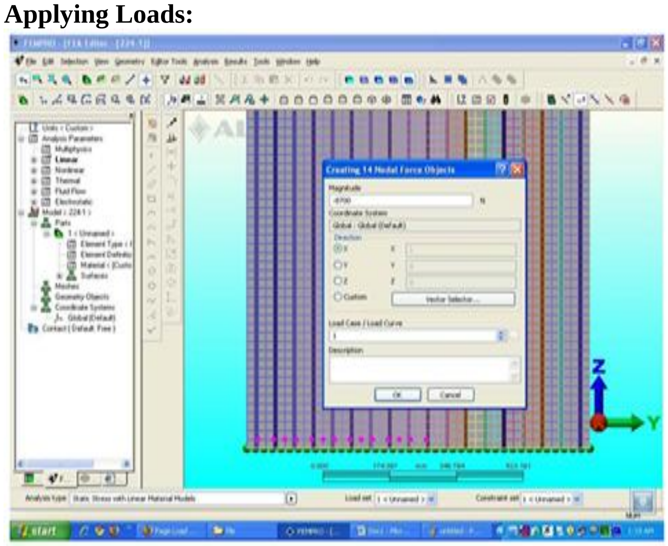

Fig.4. Showing Swing Jaw Plate Model Applying Point Loads.

Showing Swing Jaw Plate Model Applying Point Loads as shown in Fig.4.

B. Linear Static Stress Analysis

Linear Static Stress Analysis as shown in Figs.5 and 6.

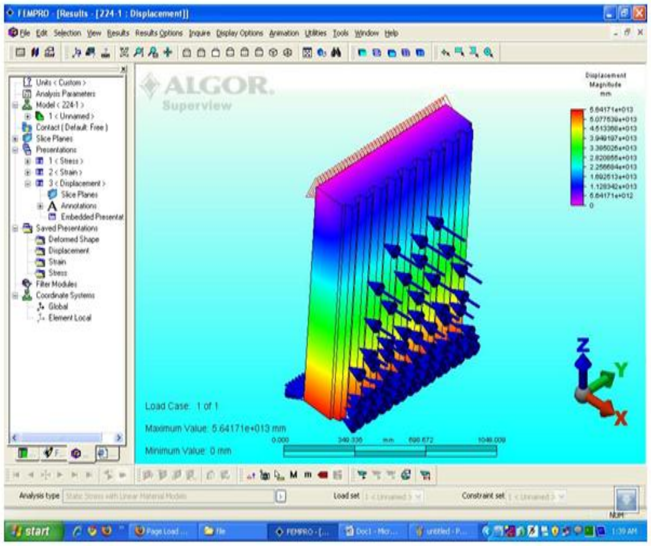

Fig.5. Showing Swing Jaw Plate Displacement.

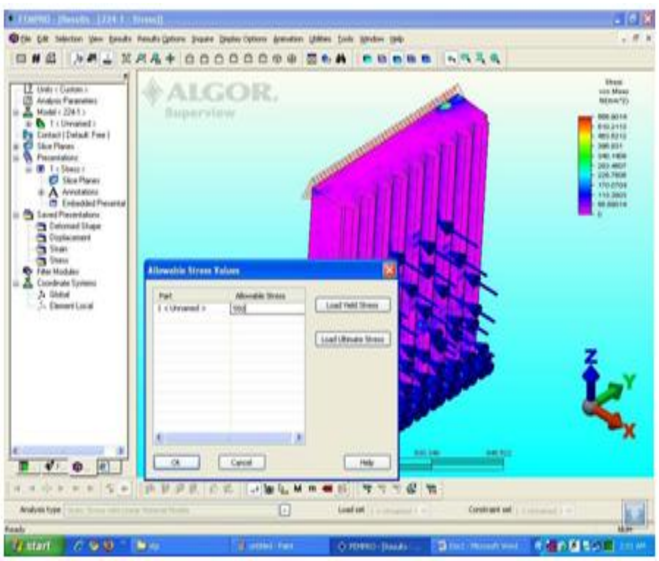

Fig.6. Showing Swing Jaw Plate Allowable Stress Value.

C. Swing Jaw Plates with Stiffeners

Solid Modeling of Swing Jaw Plates with Stiffeners as shown in Figs.7 to 15.

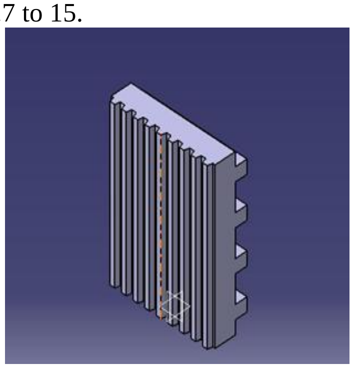

Fig.7. Solid Model of Corrugated Swing Jaw Plate with Stiffeners.

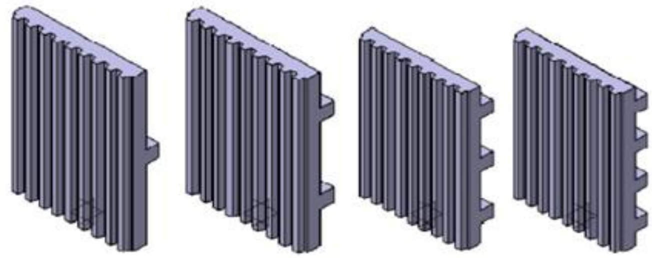

Fig.8. Swing Jaw Plates (1200X900X140) with Stiffeners.

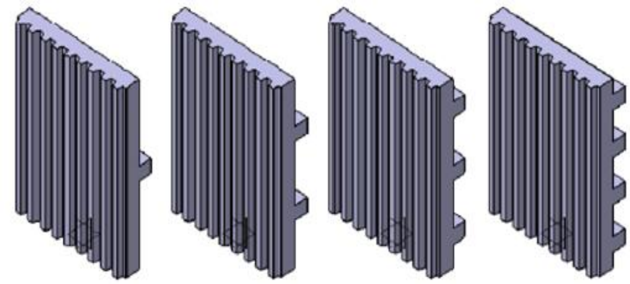

Fig.9. Swing Jaw Plates (1200X900X152) with Stiffeners.

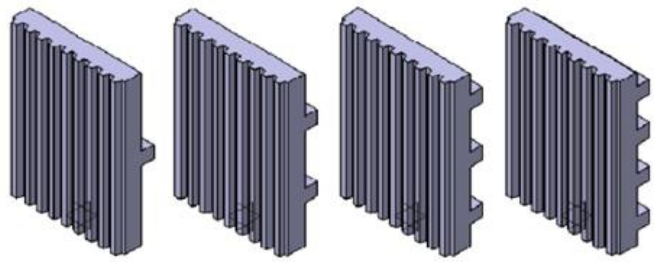

Fig.10. Swing Jaw Plates (1200X900X165) with Stiffeners.

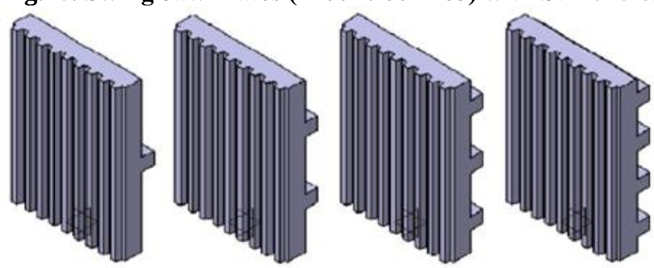

Fig.11. Swing Jaw Plates (1200X900X178) with Stiffeners.

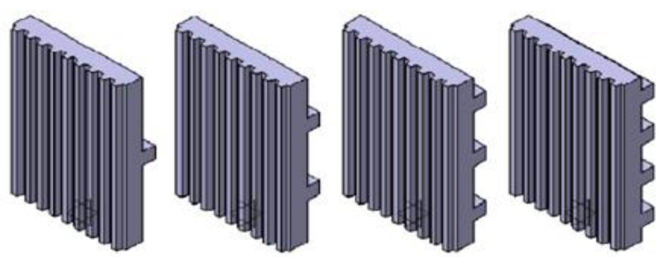

Fig.12. Swing Jaw Plates (1200X900X191) with Stiffeners.

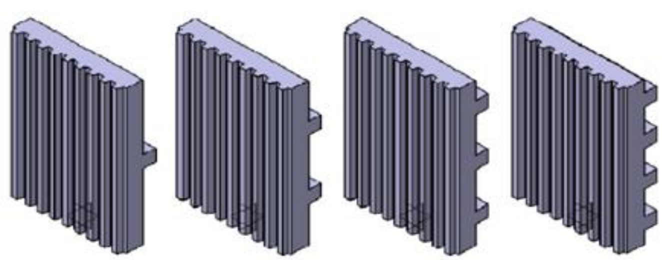

Fig.13. Swing Jaw Plates (1200X900X203) with Stiffeners.

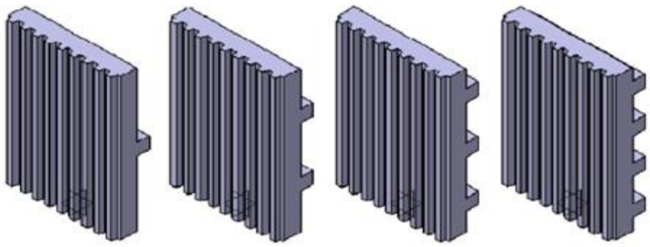

Fig.14. Swing Jaw Plates (1200X900X216) with Stiffeners.

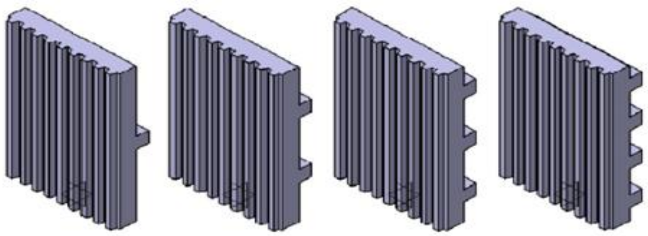

Fig.15. Swing Jaw Plates (1200X900X224) with Stiffeners.

D. Swing Jaw Plates Static Stress Analysis with Stiffeners

Below is a finite element representation of the stiffened plate shown in Figs.16 to 19. The plate is thick, therefore thick plate theory applies. Square beam stiffeners are mounted as shown. The structure is simply supported and point loads at applied to the surface of the plate.

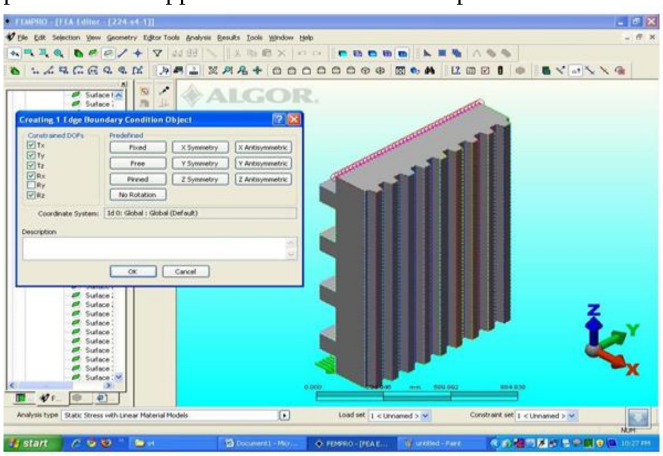

Fig.16. Showing Stiffened Swing Jaw Plate Boundary Condition (Toggle Force).

E. Applying Loads

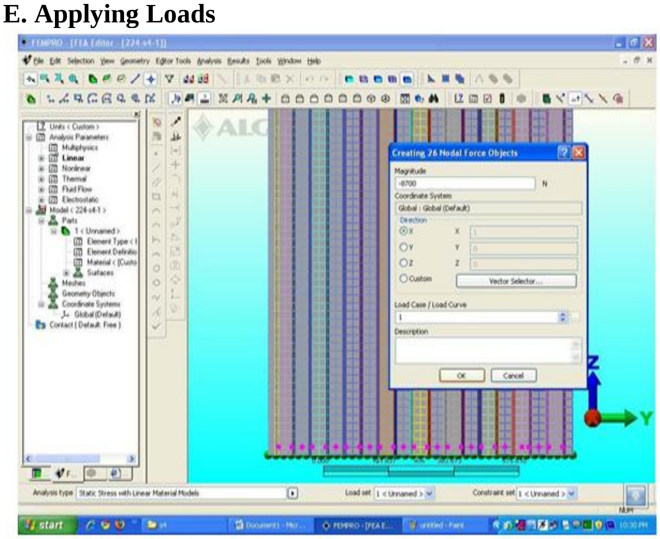

Fig.17. Applying Loads.

F. Linear Static Stress Analysis Results

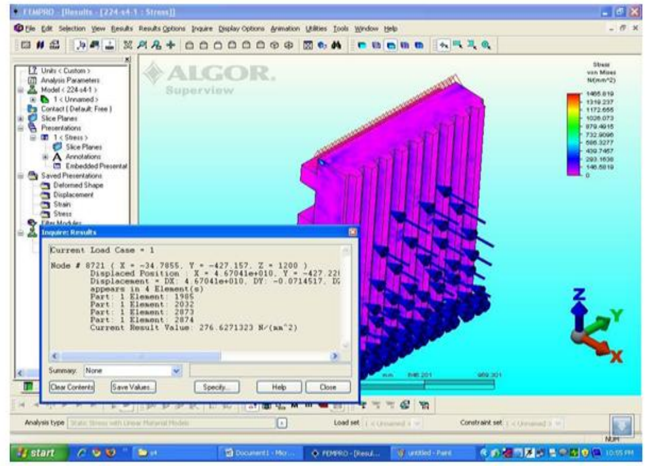

Fig.18. Showing Stiffened Swing Jaw Plate Stress Analysis.

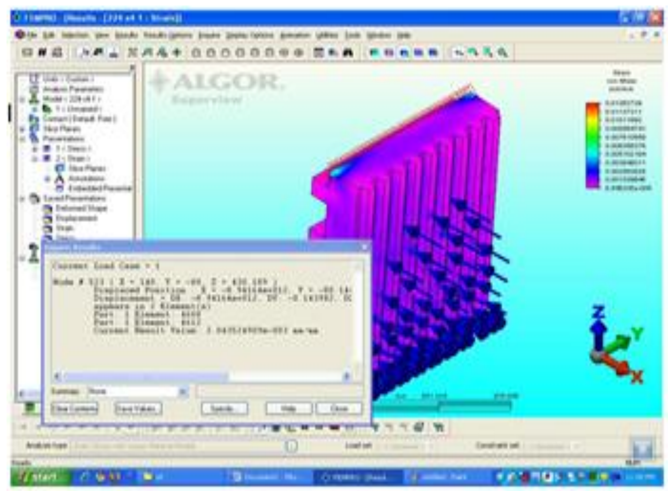

Fig.19. Showing Stiffened Swing Jaw Plate Strain Analysis.

IV. RESULTS AND CONCLUSION

FEA models using ANSYS are employed to calculate maximum tensile stresses for a variety of model plate thicknesses as shown in Fig.20 and 21.

TABLE I: Effect of Thickness on Maximum Response

Jaw Plate Thickness		Stiffness (kN m^2)	Max. Tensile Stress (MPa)		Max Deflection (mm)		Max Driving
(in)	(mm)	(×10^5)	Numerical Analysis	ALGOR Analysis	Numerical Analysis	ALGOR Analysis	Force (T) (MN)
8.8	224	1.74	226.42	228.36	0.071	0.104	1.17
8.5	216	1.60	242.34	245.51	0.079	0.114	1.17
8.0	203	1.33	261.91	262.48	0.094	0.137	1.17
7.5	191	1.10	269.55	273.56	0.112	0.168	1.17
7.0	178	0.90	278.30	281.65	0.137	0.206	1.17
6.5	165	0.73	286.15	289.26	0.178	0.257	1.17
6.0	152	0.55	291.84	293.19	0.226	0.325	1.17
5.5	140	0.44	308.90	309.99	0.292	0.424	1.17

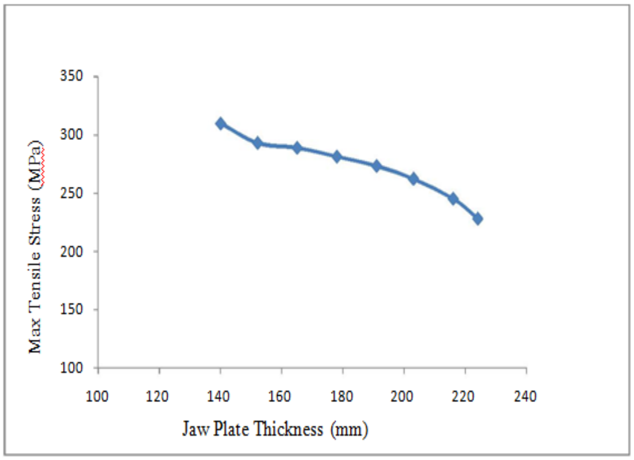

Fig.20. Maximum Tensile Stress Response for Various Jaw Plate Thicknesses.

A. Effect of Stiffeners on Swing Jaw Plates

TABLE II: Effect of Stiffeners on Maximum Response for Various Jaw Plate Thicknesses

Thickness (in)	(mm)	Stiffness(EI) (kNm^2) ($\times 10^5$)	Number of Stiffeners NOS=4	NOS=3	NOS=2	NOS=1	Max Driving Force (MN)
8.8	224	10					
8.5	216	1.60	193.24	209.51	217.41	225.45	1.17
8.0	203	1.33	212.25	218.75	235.89	248.74	1.17
7.5	191	1.10	223.98	239.52	252.78	265.23	1.17
7.0	178	0.90	239.87	246.37	258.60	274.68	1.17
6.5	165	0.73	245.36	257.45	269.63	284.66	1.17
6.0	152	0.55	259.58	267.13	276.53	289.56	1.17
5.5	140	0.44	280.92	283.15	289.91	296.71	1.17

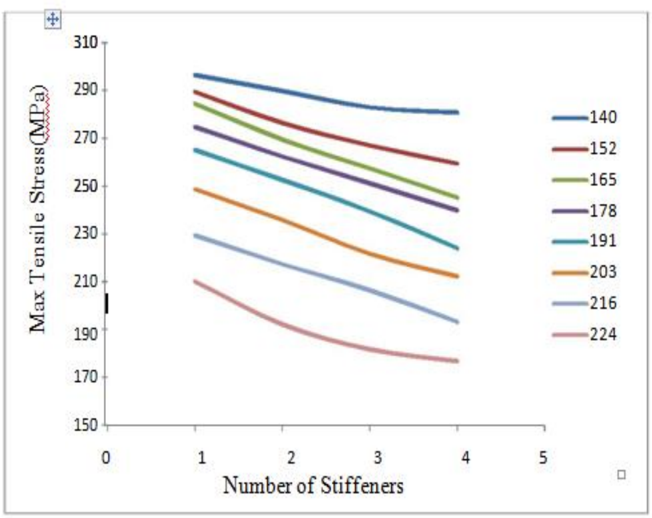

Fig.21. Effect of Stiffeners on Swing Jaw Plates Maximum Stress Response.

B. Approximate Savings in Energy using Stiffeners

If fatigue of the plate is of concern, then the maximum tensile stress is important. The maximum induced tensile stress for the 216 mm thick model plate equals that induced for the 140 mm plate. This difference is found because the particles do not fail simultaneously but fail at different stages, of a single crushing cycle. If the peak acceleration (a) of the 203mm and 152 mm plates is assumed to be equal, then the force reduction resulting from a smaller plate is proportional to the acceleration times the change in plate mass. Since the mass is somewhat proportional to the thickness of the 216 and 140 mm models, the crushing energy absorbed by plate movement is reduced by approximately [(216 – 140)/216] = 35%. Of course this 35% is an estimate, as the model plates which are stiffened and leads to reductions in plate weight and indicates that design of new energy efficient systems should include deformation (PDF) properties of the crushed material.

TABLE III: Comparison of Various Jaw Plates with and Without Stiffeners

Jaw Plate Thickness (in)	(mm)	Max Tensile Stresses(MPa) Number of Stiffeners NOS=0	NOS=4	NOS=3	NOS=2	NOS=1	Approximate Savings in Energy Number of Stiffeners NOS=4	NOS=3	NOS=2	NOS=1
8.8	**224**	**228.36**	176.87	178.71	183.19	210.23				
8.5	**216**	**245.51**	193.24	209.51	217.41	225.45				
8.0	**203**	**262.48**	212.25	218.75	**229.89**	248.74			**10%**	
7.5	**191**	**273.56**	223.98	239.52	252.78	265.23				
7.0	**178**	**281.65**	239.87	**246.37**	258.60	**274.68**		**17%**		**7%**
6.5	**165**	**289.26**	**245.36**	**261.45**	269.63	284.66	**23%**	**19%**		
6.0	**152**	293.19	**261.58**	272.13	276.53	**289.56**	**25%**			**8%**
5.5	**140**	309.99	**280.92**	283.15	**289.91**	296.71	**21%**		**15%**	

V. CONCLUSION

- The stiffened plate models which leads to reductions in plate weight and indicates that Design of new energy efficient systems of the crushed material.
- In case stiffened jaw plates as the number of stiffener increases the strength/weight ratio of the jaw plate increases making it stronger than that of without stiffener.
- The stiffened plate models which leads to 35% saving in energy, of course this 35% is an estimate.

VI. REFERENCES

[1] DeDiemar R.B. “New concepts in Jaw Crusher technology”, Minerals Engineering, Volume 3, Issues 1-2, 1990, Pages 67-74.
[2] Russell A.R., Wood D. M. “Point load tests and strength measurements for brittle Spheres”, International Journal of Rock Mechanics and Mining Sciences, Volume 46, Issue 2, February 2009, Pages 272-280.
[3] Dowding Charles H, Molling R, Ruhl C," Application of point load-deformation relationships and design of jaw crusher plates”, International Journal of Rock Mechanics and Mining Sciences & Geomechanics, Volume 20, Issue 2, April 1983,Pages 277-286.

[4] Gupta Ashok, Yan D.S. “Mineral Processing Design and Operation-An introduction”, Published by Elsevier, 2006, Pages 99-127.
[5] Bharule Ajay Suresh, Computer aided design and Analysis of Swing Jaw Plate of Jaw Crusher, NIT Rourkela, 1-11, 2009.
[6] Computer Aided design of Jaw Crusher” by Sobhan Kumar Garnaik NIT Rourkela, 1-11, 2009-10.
[7] Niles I. L., “MS Thesis -Point Load Strength: Jaw Crusher Design”, August, 1978.
[8] Pollitz H C, “Crusher Jaw Plates” United States Patent, Patent Number 3,140,057, Issued on July, 1982.
[9] Cao Jinxi, Qin Zhiyu, Wang Guopeng, “Investigation on Kinetic Features of Multi- Liners in Coupler Plane of Single Toggle Jaw Crusher”, Journal of Taiyuan Heavy Machinery Institute, July200.Pages 210-219.
[10] Yashima Schimum, “Analysis and Optimization of Crushing Energy of a Compound Swing Jaw Crusher”, Journal of Taiyuan Heavy Machinery Institute, March 1995, Pages 188-192.