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A Design & Analysis of Swing Jaw Plates of Jaw Crusher

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Abstract: A jaw crusher break 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 (Q_U) of up to 308 MPa, may be oversigned for softer fragmental. Hence the weight of the swing plate is necessary to reduced. In this paper work can be done with help of Point-Load Deformation Failure (PDF) relationship Along with interactive failure of rock particles. Design of a plate is carried by using CATIA .And finite element analysis will be carried out by using ANSYS. The different comparisons of a corrugated swing jaw plates behavior calculated with the traditional and new FEA, failure models with stiffeners.

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

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.

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.

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.

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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) = $0.0502(\text{Gape})^{0.85}$
where the crusher gape is in meters

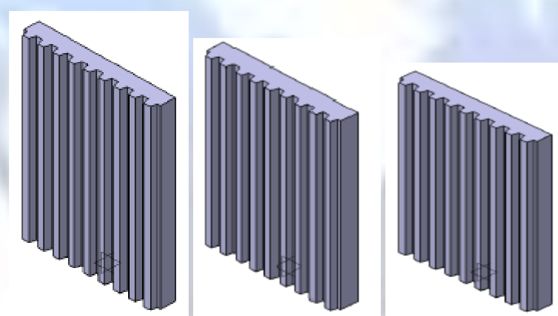
These dimensions vary as individual manufacturers have their own specifications and design of individual makes. In this case, we have top opening i.e. gape 304 mm (12 in.) and bottom opening 51mm (2 in)

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

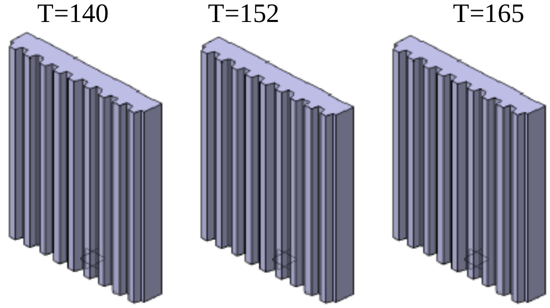
Solid Modeling of Swing Jaw Plates using CATIA without stifeners

The modeling of swing jaw plate is done with CATIA, here different thickness are taken and then this plates are analyzed

Fig. Solid Model of Corrugated Swing Jaw Plate



L=1200 W=900 T=140 L=1200 W=900 T=152 L=1200 W=900 T=165



L=1200 W=900 T=178 L=1200 W=900 T=191 L=1200 W=900 T=203

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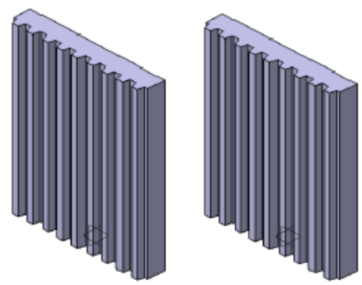


L=1200 W=900 T=216   L=1200 W=900 T=224

Fig. Corrugated Swing Jaw Plate Models having Dimensions in mm

Swing Jaw Plates Static Stress Analysis Using ANSYS

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.

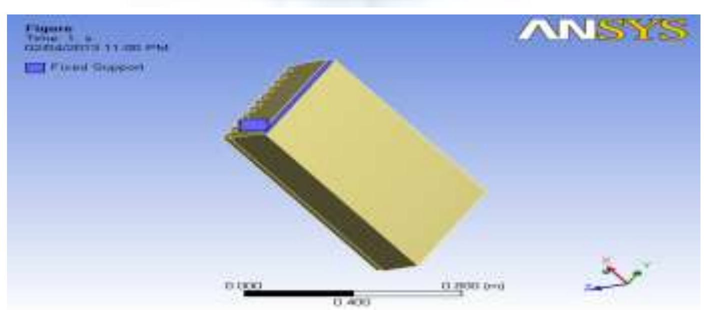
Applying material:

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.

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

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. Showing Swing Jaw Plate Model Boundary Condition.



Applying Loads:

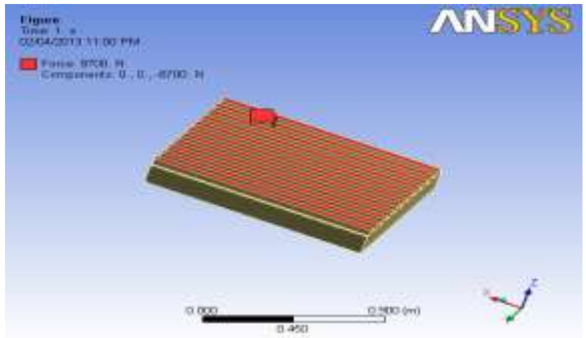


Fig. Showing loading condition on Swing Jaw Plate

Linear Static Stress Analysis

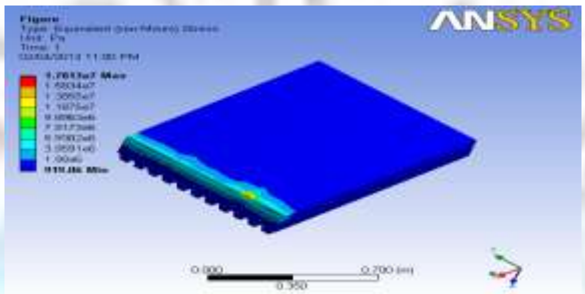


Fig. Showing Swing Jaw Plate Stress Analysis

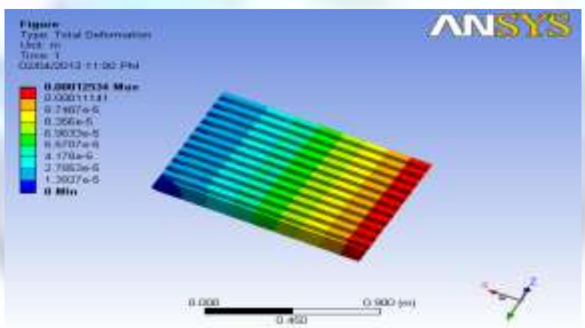


Fig. Showing Swing Jaw Plate Displacement

Swing Jaw Plates with Stiffeners:

Solid Modeling of Swing Jaw Plates with Stiffeners

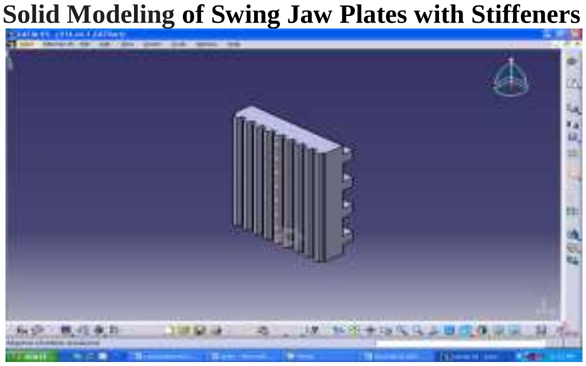


Fig . Solid Model of Corrugated Swing Jaw Plate with Stiffeners.

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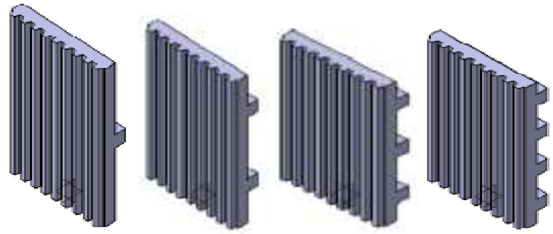

Fig. Swing Jaw Plates(1200X900X140) with Stiffeners

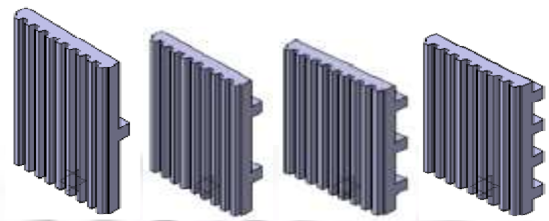

Fig. Swing Jaw Plates(1200X900X152) with Stiffeners

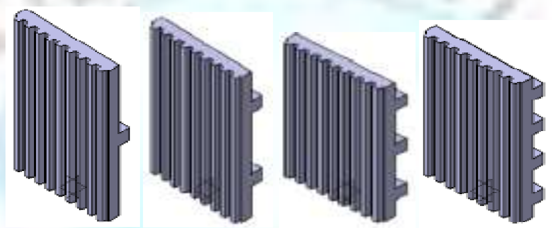

Fig. Swing Jaw Plates(1200X900X165) with Stiffeners

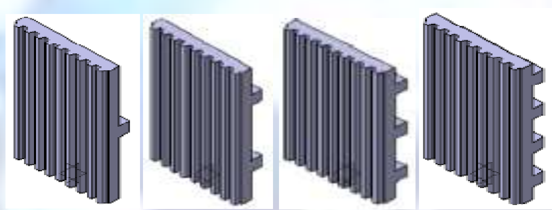

Fig. Swing Jaw Plates(1200X900X178) with Stiffeners

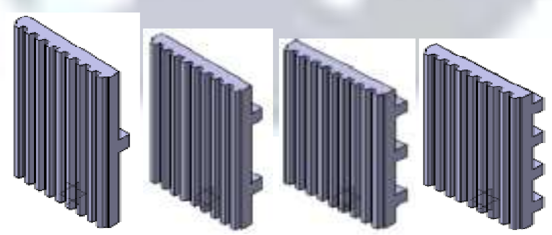

Fig. Swing Jaw Plates(1200X900X191) with Stiffeners

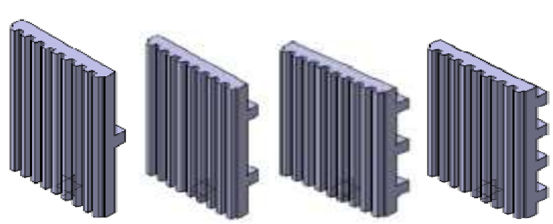

Fig. Swing Jaw Plates(1200X900X203) with Stiffeners

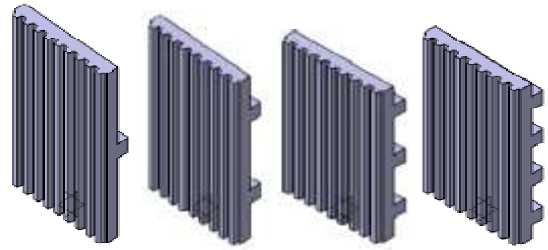

Fig. Swing Jaw Plates(1200X900X216) with Stiffeners

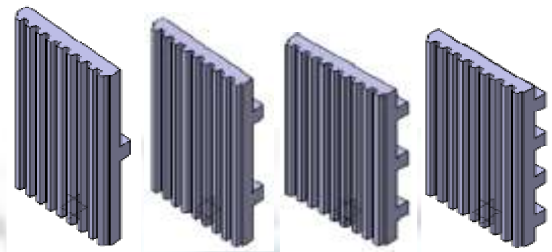

Fig. Swing Jaw Plates(1200X900X224) with Stiffeners.

Swing Jaw Plates Static Stress Analysis with Stiffeners

Below is a finite element representation of the stiffened plate shown above. 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

Apply Boundary Conditions

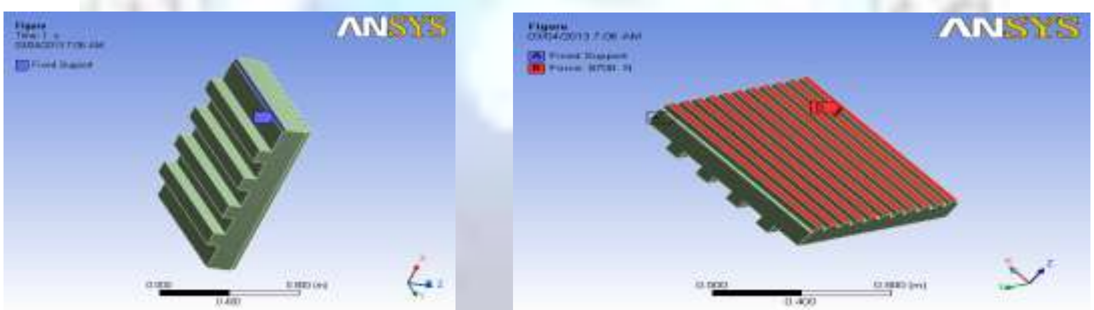

Fig. Showing Stiffened Swing Jaw Plate Boundary Condition

Applying Load:
Linear Static Stress Analysis Results

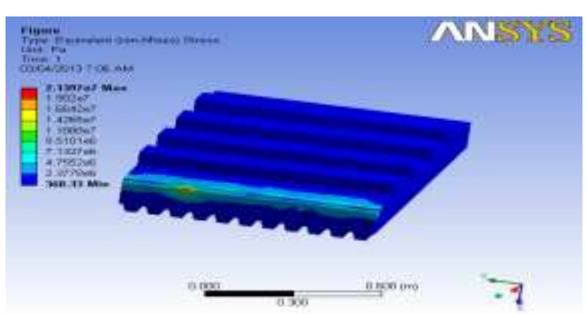

Fig. Showing Stiffened Swing Jaw Plate Stress Analysis

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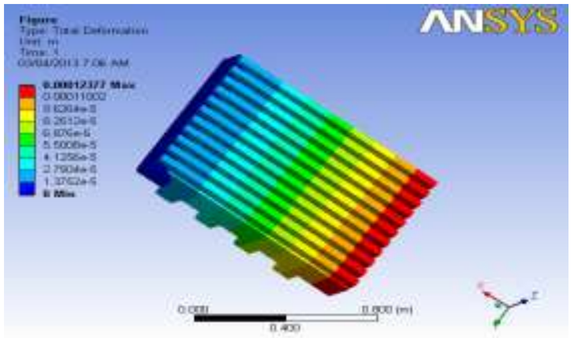

Fig. Showing Stiffened Displacement Swing Jaw Plate.

RESULTS AND CONCLUSION

FEA models using ANSYS are employed to calculate maximum tensile stresses for a variety of model plate thicknesses, Table. Effect of thickness on maximum response

Jaw Plate thickness in mm		Max tensile stress(Mpa) ANSYS Analysis	Max Deflection mm ANSYS Analysis	Driving Force (T) (N)
8.8	224	16.9	0.10399	8700
8.5	216	18.9	0.1112	8700
8	203	18.538	0.1149	8700
7.5	191	19.967	0.1195	8700
7	178	19.412	0.121	8700
6.5	165	20.23	0.1242	8700
6	152	21.397	0.1344	8700
5.5	140	20.063	0.1375	8700

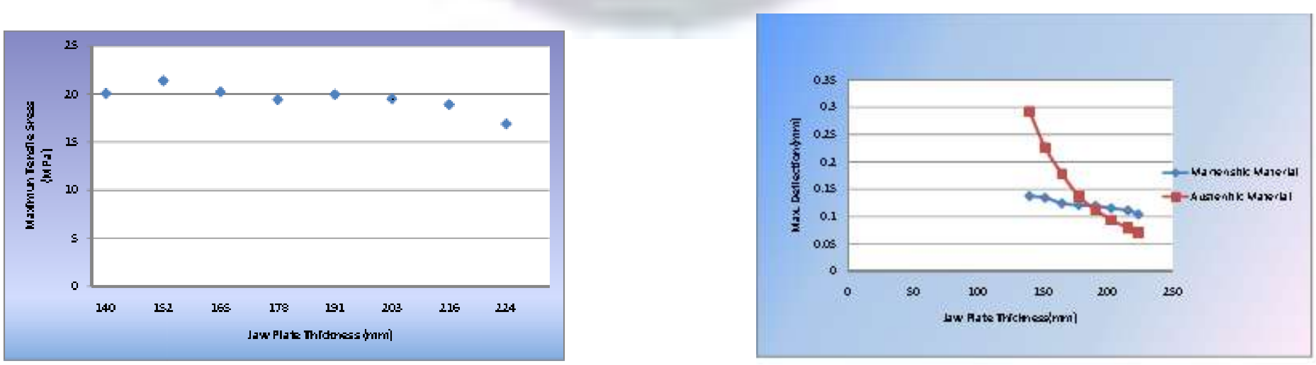

Fig. Maximum Tensile Stress Response for Various Jaw Plate Thicknesses

Effect of Stiffeners on Swing Jaw Plates

Table. Effect of stiffeners on maximum response for various jaw plate thicknesses

Thickness		Number of Stiffeners				
(in)	(mm)	NOS=4	NOS=3	NOS=2	NOS=1	NOS=0
8.8	224	15.217	16.891	13.454	13.454	15.85
8.5	216	18.892	18.427	15.056	16.425	18.795
8	203	19.547	18.5015	15.775	17.71	17.067
7.5	191	19.967	18.593	16.23	17.967	16.203
7	178	17.999	16.782	19.412	17.055	16.417
6.5	165	8.9625	20.237	17.745	8.392	16.402
6	152	21.397	10.226	20.517	10.994	17.813
5.5	140	16.629	20.063	20.57	9.1001	9.0704

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. Comparison of Various Jaw Plates with and without stiffeners

Jaw Plate Thickness(mm)		Max Tensile Stresses (MPa) Number of Stiffeners					Approximate Savings in Energy Number of Stiffeners				
		NOS=4	NOS=3	NOS=2	NOS=1	NOS=0	NOS= 4	NOS= 3	NOS= 2	NOS= 1	NOS= 0
8.8	224	15.217	**16.891**	13.454	13.454	15.85					
8.5	216	**18.892**	18.427	15.056	16.425	18.795					
8	203	**19.547**	18.5015	15.775	17.718	17.0673					
7.5	191	**19.967**	18.593	16.23	17.967	16.203		5.911			
7	178	17.999	16.782	**19.412**	17.055	16.417	17.59		12.31	12.315	
6.5	165	8.9625	**20.237**	17.745	8.392	16.402			18.71		7.303
6	152	**21.397**	10.226	20.517	11	17.813					
5.5	140	16.7	**20.063**	20.57	9.1001	9.1	35.18	26.70			

Conclusion

1) The stiffened plate models which leads to reductions in plate weight and indicates that Design of new energy-efficient systems of the crushed material.
2) 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.
3) The stiffened plate models which leads to 35% saving in energy, of course this 35% is an estimate.

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