DYNAMIC AND STATIC BEHAVIOR OF JAW CRUNCHER USING UG AND ANSYS APPLICATION

BIJIGIRI RAGHU [1], A.VENKATA VISHNU [2]

[1]PG Student, Dept. of Mechanical (machine design), *nalla narasimha reddy education society's group of insistutions, Hyderabad,TS, India.*

[2]*Asst.professor,* Dept. of Mechanical *engineering nalla narasimha reddy education society's group of insistutions,Hyderabad, TS, India.*

ABSTRACT:

Jaw Cruncher is a machine designed to reduce large solid particles of raw material into smaller particles. Crunchers are major size reduction equipment used in mechanical, metallurgical and allied industries. They are available in various sizes and capacities ranging from 0.2 ton/hr to 50 ton/hr. They are classified based on different factors like product size and mechanism used. Based on the mechanism used Crunchers are of three types namely Cone Cruncher, Jaw Cruncher and Impact Cruncher. The mechanism of crushing is either by applying impact force, pressure or a combination of both. The jaw Cruncher is primarily a compression Cruncher while the others operate primarily by the application of impact.

The present project is aimed at design and analysis of swing jaw plate of a jaw Cruncher. A number studies have been carried out earlier on the design and analysis of swing jaw plate of jaw Cruncher. But all of them have been restricted to static loading only. As the jaw Cruncher has lot of moving components, it is subjected to a lot of linear and random vibrations as well. In this present project the design and analysis has been extended to dynamic loading to meet the industry requirement. Since the rock strength also vary depending on the different quarry, the Crunchers cannot be selectively designed with low factors of safety. Considering this design and analysis has been carried out by increasing the loading by 25 % in this project.

During the part of project a static and dynamic analysis of swing jaw plate was carried out using finite element analysis package. The 3 dimensional model of the swing jaw plate shall be designed using NX-CAD. Then the 3-D model shall be imported into ANSYS using the parasolid format. The analysis shall be performed in both static and dynamic condition. From the analysis results mode shapes and frequencies are documented by using FEA software. Harmonic analysis is also carried out to plot the frequency Vs amplitude graphs. Finally design optimization of the swing jaw plate shall be done to increase the factor of safety of the jaw Cruncher. NX-CAD software shall be used for 3D modeling of the jaw Cruncher and ANSYS software shall be used to do the finite element analysis of the jaw Cruncher.

I. INTRODUCTION

Jaw Cruncher is a machine designed to reduce large solid particles of raw material into smaller particles. Crunchers are significant size diminishment hardware utilized as a part of mechanical, metallurgical and united enterprises. They are accessible in different sizes and limits running from 0.2 ton/hr to 50 ton/hr. They are ordered in light of various variables like item size and component utilized. In view of the component utilized Crunchers are of three kinds in particular Cone Cruncher, Jaw Cruncher and Impact Cruncher.

Introduction to jaw cruncher

The principal phase of size decrease of hard and vast pieces of run-of-mine (ROM) mineral is to pound and lessen their size. Gentler metals, similar to placer stores of tin, gold, mineral sands and so on don't require such treatment. Vast scale pulverizing operations are for the most part performed by mechanically worked hardware like jaw Crunchers, gyratory Cruncher and move Crunchers. For substantial metal pieces that are too huge for accepting containers of mechanically determined Crunchers, percussion shake breakers or comparative instruments are utilized to separate them to measure. The component of squashing is either by applying sway power, weight or a mix of both. The jaw Cruncher is essentially a pressure Cruncher while the others work fundamentally by the utilization of effect.

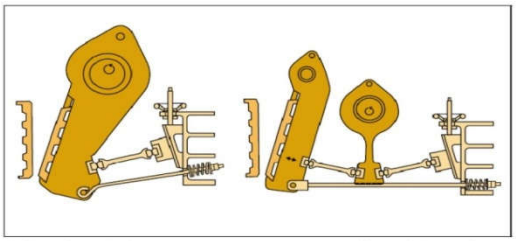
Different Types of Jaw Cruncher

Jaw Cruncher can be divided into two according to the amplitude of motion of the moving face. The different types of Jaw Crunchers are Blake Type Jaw Cruncher and Dodge Type Jaw Cruncher.

In this present project the work has been carried out on the Blake Type Jaw Cruncher.

Different Types of Jaw Cruncher:

Jaw cruncher can be divided into two according to the amplitude of motion of the moving face. The different types of Jaw Crunchers are **Blake Type Jaw Cruncher** and **Dodge Type Jaw Cruncher**.



Single-Toggle Jaw Crusher Double-Toggle Jaw Crusher

II. LITERATURE REVIEW

Shyam Sundar.V has published a paper on "OPTIMUM DESIGN AND ANALYSIS OF SINGLE TOGGLE JAW CRUNCHER". The exceptional of the paper says A jaw Cruncher is a kind of size abatement machine which is extensively used as a piece of mineral, aggregates and metallurgy fields. The execution of jaw Cruncher is generally controlled by the kinematic features of the swing jaw in the midst of the staggering technique. The convenient kinematic typical for the concentrations arranged along the swing jaw plate are handled and inspected. In light of the examination of the liner improvement and the overwhelming parameters, compel course along the swing jaw plate is obtained. The action is helpful for an arrangement of new model of this kind of machine on enhancing the edge, arranging the chamber and seeing the staggering character. The correspondence between jaw plates and material particles passes on the unpreventable and certifiable wear to the jaw plates in the midst of the jaw Cruncher task, which lessens the efficiency, and constructs the cost and the imperativeness use of the jaw Cruncher. Gotten comes to fruition due to the kinematic examination of the moving jaw and the overwhelming force allotment examination, the jaw plates wear is destitute out on an evidently obvious level. It is valuable to plot the Cruncher for improved execution. Attempts to reduce imperativeness consumed in squashing have incite thought of lessening the greatness of the swing plate of jaw Crunchers. Blueprint of lighter weight jaw Cruncher will require a more correct accounting of the nervousness and redirections in the staggering plates than is available with standard method. The framework of swing jaw plate is finished by using CAD i.e., jaw plate has been solid shown by using CATIAV5R20. FEA is associated with gathered structure of swinging jaw plate and lever to streamline the width and territory of the flip plate along the swinging lever. The particular relationships of swing jaw plates lead, processed with the ordinary and the new FEA dissatisfaction models with stiffeners, shows that 24% hold supports in plate weight may be possible.

Deepak Gupta has published paper on "DESIGN AND ANALYSIS OF A HORIZONTAL SHAFT IMPACT CRUNCHER". The dynamic of the paper is Crunchers are one of the noteworthy size diminishment equipment that is used as a piece of metallurgical, mechanical, and other tantamount endeavors. They exist in various sizes and cutoff points which reach out from 0.1 ton/hr. to 50 ton/hr. They can be masterminded in light of the amount they can part the starting material and the way they apply powers. In light of the framework used Crunchers are basically of three sorts specifically Cone Cruncher, Jaw Cruncher and Impact Cruncher. We will likely diagram distinctive parts of an Impact Cruncher like drive segment, shaft, rotor, sledges, bundling, and discharge framework which will be profitable in constraining weight, cost and intensifying the utmost and besides do their examination. Impact Crunchers incorporate the use of impact rather than strain to squash materials. Here the material is held inside a fenced in area, with openings of the pined for estimate at the base, end or at sides to empower pummeled material to escape through them. This sort of Cruncher is all things considered used with fragile materials like coal, seeds or sensitive metallic minerals. The framework associated here is of Impact stacking where the period of utilization of energy isn't as much as the typical repeat of vibration of the body. Since the sledges/blow bars are turning at a quick, the perfect open door for which the particles associate with the hammers is pretty much nothing, from now on here impact stacking is associated. The post is believed to be subjected to torsion and bowing. The pulverizing screen is in like manner expected for perfect yield from the Cruncher An execution show is furthermore considered for the even shaft influence Cruncher keeping in mind the end goal to find the association between the support, the Cruncher parameters and the yield parameters.

III. PROBLEM DEFINITION AND METHODOLOGY

The present task is gone for outline and examination of swing jaw plate of a jaw Cruncher. As the jaw Cruncher has parcel of moving parts, it is subjected to a great deal of direct and irregular vibrations. In this present venture the outline and investigation has been reached out to dynamic stacking to meet the business necessity. Since the stone quality additionally change contingent upon the distinctive quarry, the Crunchers can't be specifically outlined with low factors of wellbeing. Thinking about this, plan and examination has been done by expanding the stacking by 25 % in this task.

METHODOLOGY

1. The 3D model of the Jaw Cruncher is demonstrated utilizing NX-CAD programming from the measurements got from the writing overview and rumored producers.
2. The 3D display is changed over into parasolid design and imported into Ansys to perform limited component investigation.
3. Basic static examination is performed on the swing jaw plate by applying the devastating parameters and power dispersion along the swing jaw plate.
4. Modular examination is performed on the swing jaw plate to figure characteristic frequencies and mode shapes.

IV. 3D MODEL OF SWINGING JAW PLATE WITH STIFFENER

The CAD model of the jaw plate with stiffener is shown below:

Isometric view of Jaw plate with stiffener:

Figure 5 Shows the Isometric view of Jaw plate with stiffener

V. FINITE ELEMENT ANALYSIS OF SWINGING JAW PLATE OF JAW CRUNCHER

FINITE ELEMENT METHOD.

The FEM is numerical examination system for getting evaluated answers for wide course of action of building issues. The framework began in the plane business as an instrument to consider worries in convoluted airframe structures. It wound up evidently out of what known as the cross segment examination framework was utilized as a bit of flying machine outline. The system has gotten notoriety among the two specialists and specialists and after such huge amounts of degrees of progress codes are made for wide mix of issues.

STRENGTH OF MATERIALS APPROACH (CLASSICAL METHODS)

The least difficult of the three techniques here talked about, the mechanics of materials strategy is accessible for basic auxiliary individuals subject to particular loadings, for example, pivotally stacked bars, kaleidoscopic bars in a condition of unadulterated bowing, and round shafts subject to torsion. The arrangements can under specific conditions be superimposed utilizing the superposition guideline to break down a part experiencing joined stacking. Answers for uncommon cases exist for basic structures, for example, thin-walled weight vessels. The arrangements depend on direct isotropic minute versatility and Euler-Bernoulli shaft hypothesis.

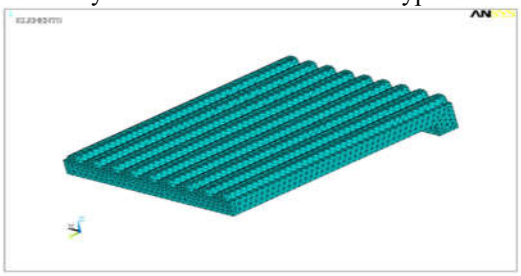


Fig: shows the meshed model of Swinging jaw plate with stiffener

MATERIAL PROPERTIES:

Material used for Swinging jaw plate with stiffener is steel:

Young's Modulus: 200GPa

Poisson's Ratio: 0.3

Density: 7850 Kg/m3

Yield strength: 240MPa

Element Types used:

Name of the Element: SOLID 92

Number of Nodes: 10

DOF: UX, UY & UZ

BOUNDARY CONDITIONS:

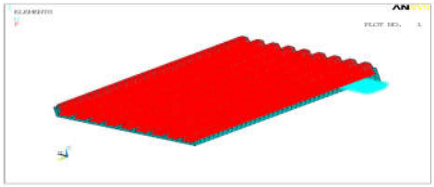


Figure: shows the applied boundary and loading conditions of Swinging jaw plate with stiffener

RESULTS:

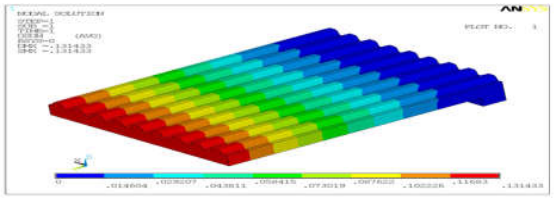


Figure Shows the Displacement vector sum of Swinging jaw plate with stiffener

The Von Misses Stress observed 6.08MPa on Swinging jaw plate with stiffener.

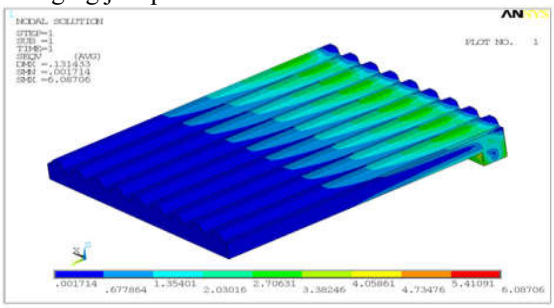


Figure shows the Von Mises stress of Swinging jaw plate with stiffener

MODAL ANALYSIS OF SWINGING JAW PLATE WITH STIFFENER

MODAL ANALYSIS

Swinging jaw plate with stiffener is subjected to modal analysis to determine the first 5 natural frequencies and mode shapes.

Boundary Conditions:

- The bottom of stiffener of jaw plate is fixed in all Dof.

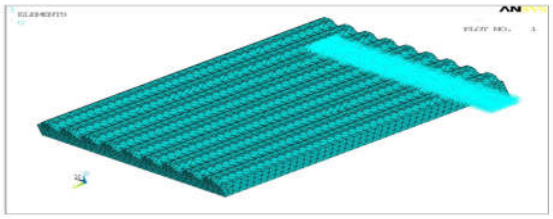


Figure shows Applied Boundary conditions on Swinging jaw plate with stiffener.

Table shows first 5 natural Frequencies of jaw plate with stiffener.

MODE	FREQUENCY	PARTIC.FACTOR			EFFECTIVE MASS		
		X	Y	Z	X	Y	Z
1	59.2883	-5.10E-5	-4.63E-02	0.75767	2.61E-09	2.15E-03	0.574071
2	159.015	-0.14259	-3.31E-05	4.80E-05	2.03E-02	1.09E-09	2.30E-09
3	253.759	0.73529	7.19E-06	-7.81E-05	0.540648	5.18E-11	6.09E-09
4	368.555	-1.57E-4	0.26883	-0.37749	2.47E-08	7.23E-02	0.142499
5	588.862	-0.14541	1.23E-03	-1.62E-04	2.11E-02	1.52E-06	2.63E-08

Results –Model @ 59.2Hz

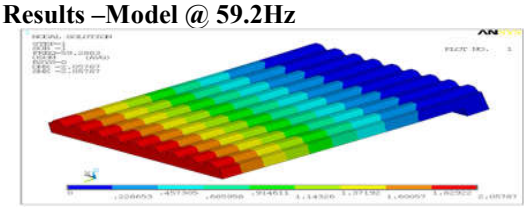


Figure Shows Mode shape 1@59.2Hz for Swinging jaw plate with stiffener:

Results –Model @ 368.5 Hz

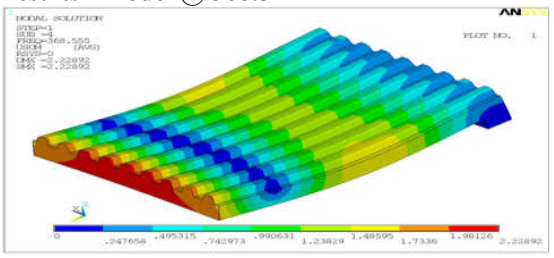


Figure Shows Mode shape 4@368.5Hz for Swinging jaw plate with stiffener

Results –Model @ 588.8Hz

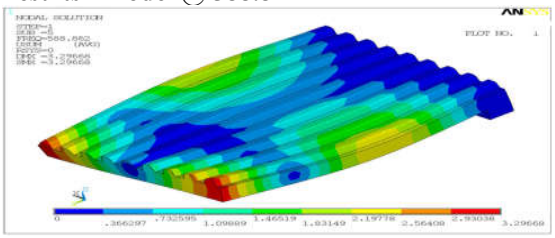


Figure Shows Mode shape 5@ 588.8Hz for Swinging jaw plate with stiffener

From the modal analysis,

The total weight of the Swinging jaw plate with stiffener is 0.96Tone.

- It is observed that the maximum mass participation of 0.54Tone in X-dir (i.e. 56% of its total weight) for the frequency of 253.7Hz.
- It is observed that the maximum mass participation of 0.072Tone in Y-dir (i.e. 7.5%

of its total weight) for the frequency of 368.5Hz.

- It is observed that the maximum mass participation of 0.574Tone in Z-dir (i.e. 59.3% of its total weight) for the frequency of 59.2Hz.

HARMONIC ANALYSIS OF SWINGING JAW PLATE WITH STIFFENER:

Table shows natural frequencies of jaw plate with stiffener

MODE	FREQUENCY	PARTIC.FACTOR			EFFECTIVE MASS		
		X	Y	Z	X	Y	Z
1	59.2883	-5.10E-5	-4.63E-02	0.75767	2.61E-09	2.15E-03	0.574071
2	159.015	-0.14259	-3.31E-05	4.80E-05	2.03E-02	1.09E-09	2.30E-09
3	253.759	0.73529	7.19E-06	-7.81E-05	0.540648	5.18E-11	6.09E-09
4	368.555	-1.57E-4	0.26883	-0.37749	2.47E-08	7.23E-02	0.142499
5	588.862	-0.14541	1.23E-03	-1.62E-04	2.11E-02	1.52E-06	2.63E-08

This is done to check, the structure behavior for resonance condition. Because, resonance occurs when natural frequency coincides with operating frequency.

HARMONIC ANALYSIS:

- The bottom of stiffener of jaw plate is constrained in all Dof.
- A force of 10.875KN is applied on top surface of the jaw plate.

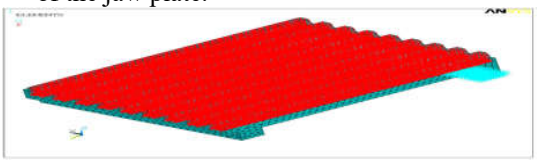


Figure shows Boundary conditions and loading of Swinging jaw plate with stiffener

The deflections and stresses nearest to the above frequencies are plotted below

Max. Deflection and stress of frequency @ 59.2Hz:

VonMises stress:

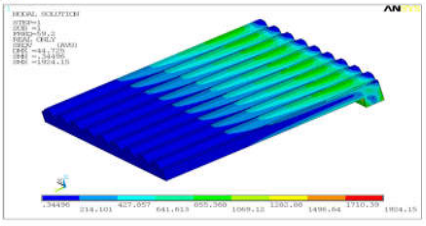


Figure 28 shows the VonMises stress of Swinging jaw plate with stiffener

Max. Deflection and stress of frequency @ 253.7Hz:

VonMises stress:

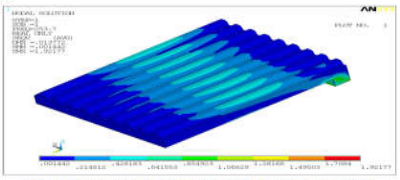


Figure 8Shows the VonMises stress of Swinging jaw plate with stiffener

Max. Deflection and stress of frequency @ 368.5Hz.

VonMises stress:

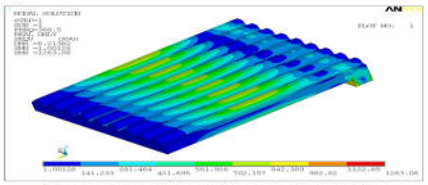


Figure shows the VonMises stress of Swinging jaw plate with stiffener

Table shows Deflections and von misses stress for critical frequencies

S.NO	FREQUENCY(Hz)	DEFLECTIONS (mm)	VON MISES STRESS (MPa)
1	59.2	44.7	1924.1
2	253.7	0.01	1.92
3	368.5	6.21	1263

MODEL OF SWINGING JAW PLATE WITH TWO STIFFENERS

The CAD model of the jaw plate with two stiffeners is shown below:

2D drawing:

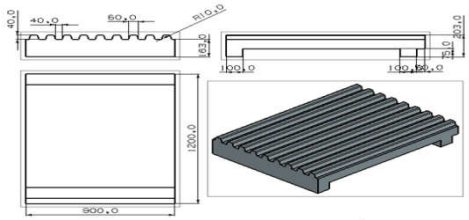


Figure shows the drafting of jaw plate with two stiffeners

Isometric view of Jaw plate with two stiffeners:

Figure Shows the Isometric view of Jaw plate with two stiffeners

STRUCTURAL ANALYSIS OF SWINGING JAW PLATE WITH TWO STIFFENERS

Figure shows the geometric model of the Swinging jaw plate with two stiffeners

BOUNDARY CONDITIONS:

- The bottom of first stiffener of jaw plate is constrained in all Dof.
- A force of 10.875KN is applied on top surface of the jaw plate.

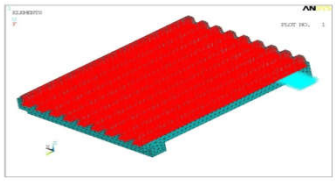


Figure shows the applied boundary and loading conditions of Swinging jaw plate with two stiffeners

The Maximum Displacement vector sum observed 0.10 mm on Swinging jaw plate with two stiffeners

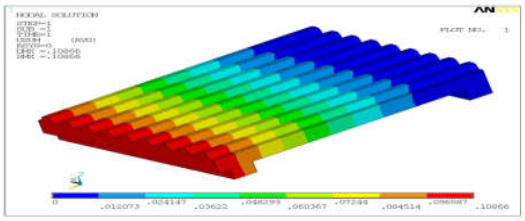


Figure shows the Max. Displacement of Swinging jaw plate with two stiffeners

From the above analysis:

- The Maximum Deflection and Von Mises Stress observed on the Swinging jaw plate with two stiffeners is 0.10mm and 7.77MPa with respectively. And the Yield strength of the material steel is 240MPa.
- Hence according to the Maximum Yield Stress Theory, the Von Mises stress is less than the yield strength of the material. The design of Swinging jaw plate with two stiffeners is safe for the above operating loads.

MODAL ANALYSIS OF SWINGING JAW PLATE WITH TWO STIFFENERS

MODAL ANALYSIS

Boundary Conditions:

The bottom of the first stiffener of jaw plate is fixed in all Dof.

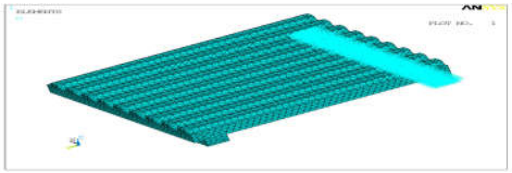


Figure shows Applied Boundary conditions on Swinging jaw plate with two stiffeners.

Table shows first 5 natural Frequencies of jaw plate with two stiffeners.

MODE	FREQUENCY	PARTIC.FACTOR			EFFECTIVE MASS		
		X	Y	Z	X	Y	Z
1	54.6634	1.89E-05	-3.44E-02	0.78626	3.58E-10	1.18E-03	0.618204
2	149.279	-0.19503	2.71E-05	1.84E-05	3.80E-02	7.36E-10	3.39E-10
3	239.79	0.75371	-1.00E-04	1.58E-05	0.568076	9.99E-09	2.49E-10
4	349.045	1.01E-04	0.31499	-0.38272	1.03E-08	9.92E-02	0.146475
5	585.322	-0.14767	1.77E-04	-1.16E-05	2.18E-02	3.13E-08	1.34E-10

The mode shapes for the above frequencies are plotted below

Results –Mode @ 349.0Hz.

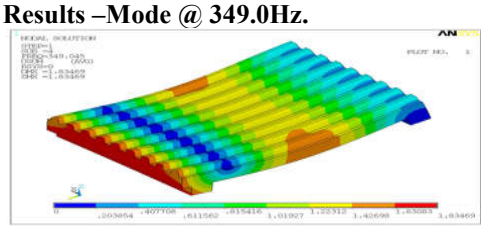


Figure Shows Mode shape 4@349.0Hz for Swinging jaw plate with two stiffeners

Results –Mode5 @ 585.3Hz

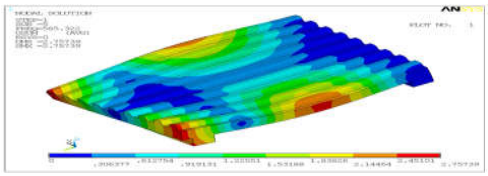


Figure 1 Shows Mode shape 5@ 585.3Hz for Swinging jaw plate with two stiffeners

From the modal analysis,

- The total weight of the Swinging jaw plate with two stiffeners is 1.01Tones.
- It is observed that the maximum mass participation of 0.56Tones in X-dir (i.e.55.4% of its total weight) for the frequency of 239.7Hz.
- It is observed that the maximum mass participation of 0.099Tones in Y-dir (i.e.55.4% of its total weight) for frequency of 349.0Hz.

HARMONIC ANALYSIS OF SWINGING JAW PLATE WITH TWO STIFFENERS.

Table shows natural frequencies of jaw plate with two stiffeners

MODE	FREQUENCY	PARTIC.FACTOR			EFFECTIVE MASS		
		X	Y	Z	X	Y	Z
1	54.6	1.89E-05	-3.44E-02	0.78626	3.58E-10	1.18E-03	0.618204
2	149.2	-0.19503	2.71E-05	1.84E-05	3.80E-02	7.36E-10	3.39E-10
3	239.7	0.75371	-1.00E-04	1.58E-05	0.568076	9.99E-09	2.49E-10
4	349.0	1.01E-04	0.31499	-0.38272	1.03E-08	9.92E-02	0.146475
5	585.3	-0.14767	1.77E-04	-1.16E-05	2.18E-02	3.13E-08	1.34E-10

Table shows Deflections and von misses stress for critical frequencies

S.NO	FREQUENCY(Hz)	DEFLECTIONS (mm)	VON MISES STRESS (MPa)
1	54.6	57.4	2561.1
2	239.7	0.01	1.97
3	349.0	7.58	1791.5

3D MODEL OF SWINGING JAW PLATE WITH THREE STIFFENERS:

The CAD model of the jaw plate with three stiffeners is shown below:

2D drawing:

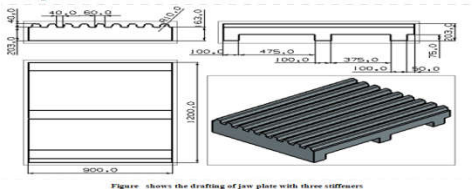


Figure shows the drafting of jaw plate with three stiffeners

Isometric view of Jaw plate with three stiffeners:

Figure Shows the Isometric view of Jaw plate with three stiffeners

STRUCTURAL ANALYSIS OF SWINGING JAW PLATE WITH THREE STIFFENERS

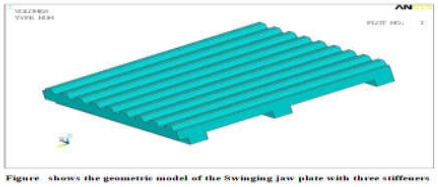


Figure shows the geometric model of the Swinging jaw plate with three stiffeners

RESULTS

The Maximum Displacement vector sum observed 0.087mm on Swinging jaw plate with three stiffeners.

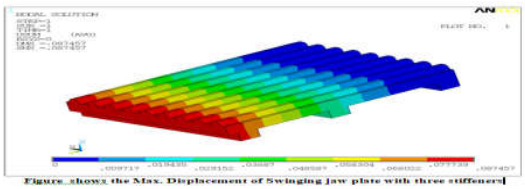


Figure shows the Max. Displacement of Swinging jaw plate with three stiffeners

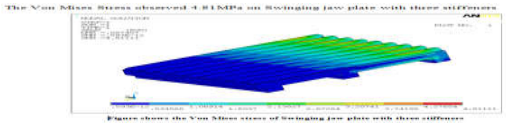


Figure shows the Von Mises stress of Swinging jaw plate with three stiffeners

From the above analysis:

- The Maximum Deflection and the Von Mises Stress observed on the Swinging jaw plate with three stiffeners is 0.08mm and 4.81MPa with respectively. And the Yield strength of the material steel is 240MPa.
- Hence according to the Maximum Yield Stress Theory, the Von Mises stress is less than the yield strength of the material. The design of Swinging jaw plate with three stiffeners is safe for the above operating loads.

MODAL ANALYSIS OF SWINGING JAW PLATE WITH THREE STIFFENERS

Table shows first 5 natural Frequencies of jaw plate with three stiffeners.

MODE	FREQUENCY	PARTIC.FACTOR			EFFECTIVE MASS		
		X	Y	Z	X	Y	Z
1	54.1145	2.16E-05	-2.85E-02	0.81478	4.65E-10	8.13E-04	0.663864
2	152.241	0.23677	-2.42E-05	1.41E-06	5.61E-02	5.87E-10	2.00E-12
3	236.438	0.77026	-1.36E-04	5.12E-05	0.593299	1.85E-08	2.62E-09
4	341.359	1.58E-04	0.32028	-0.3932	2.51E-08	0.10258	0.154607
5	568.232	0.13635	-7.93E-05	1.01E-05	1.86E-02	6.28E-09	1.01E-10

Results –Mode5 @ 568.2Hz

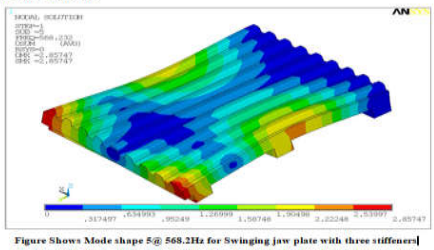


Figure Shows Mode shape 5@ 568.2Hz for Swinging jaw plate with three stiffeners

The total weight of the Swinging jaw plate with three stiffeners is 1.07Tones.

- It is observed that the maximum mass participation of 0.59Tones in X-dir (i.e.55% of its total weight) for the frequency of 236.4Hz.
- It is observed that the maximum mass participation of 0.102Tones in Y-dir (i.e.9.5% of its total weight) for the frequency of 341.3Hz.
- It is observed that the maximum mass participation of 0.66Tones in Z-dir (i.e.61.6% of its total weight) for the frequency of 54.11Hz.

To check the structure response at the mentioned frequency due to the operating loads, Swinging jaw plate with three stiffeners is also subjected to harmonic analysis.

HARMONIC ANALYSIS OF SWINGING JAW PLATE WITH THREE STIFFENERS

Table shows natural frequencies of jaw plate with three stiffeners

MODE	FREQUENCY	PARTIC.FACTOR			EFFECTIVE MASS		
		X	Y	Z	X	Y	Z
1	54.1145	2.16E-05	-2.85E-02	0.81478	4.65E-10	8.13E-04	0.663864
2	152.241	0.23677	-2.42E-05	1.41E-06	5.61E-02	5.87E-10	2.00E-12
3	236.438	0.77026	-1.36E-04	5.12E-05	0.593299	1.85E-08	2.62E-09
4	341.359	1.58E-04	0.32028	-0.3932	2.51E-08	0.10258	0.154607
5	568.232	0.13635	-7.93E-05	1.01E-05	1.86E-02	6.28E-09	1.01E-10

HARMONIC ANALYSIS:

- The bottom of first stiffener of jaw plate is constrained in all Dof.
- A force of 10.875KN is applied on top surface of the jaw plate.

The deflections and stresses nearest to the above frequencies are plotted below

VonMises stress:

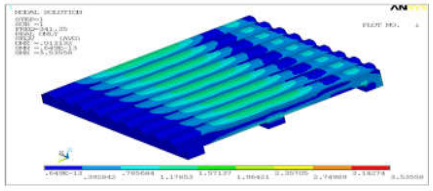


Figure shows the VonMises stress of Swinging jaw plate with three stiffeners

Table shows Deflections and von misses stress for critical frequencies

S.NO	FREQUENCY(Hz)	DEFLECTIONS (mm)	VON MISES STRESS (MPa)
1	54.1	0.624	39.75
2	236.4	0.009	0.78
3	341.3	0.013	3.53

From the above results it is observed that the critical frequencies 54.1Hz, 236.4Hz, and 341.3Hz are having stresses of 39.75MPa, 0.78MPa and 3.5MPa respectively.

Hence according to the Maximum Yield Stress Theory, the Von Misses stress is less than the yield strength of the material. The design of Swinging jaw plate with three stiffeners is safe for the above operating loads.

VI. RESULTS AND CONCLUSION

Swinging jaw plate with was modeled in NX-CAD software. Structural analysis was done on Swinging jaw plate for following number of stiffeners. Each model of Jaw plate was analyzed

for Static analysis, modal analysis and harmonic analysis.

- **Jaw plate with one stiffener**
- **Jaw plate with two stiffeners**
- **Jaw plate with three stiffeners**

Each model of Jaw plate was analyzed for three analyses. They are

- **Static analysis**
- **Modal analysis and**
- **Harmonic analysis.**

1. Results of Jaw plate with one stiffener:
Static analysis:

From the results, The Max Deflection and the Max Avg. Von Mises Stress observed on the Swinging jaw plate with stiffener is 0.0004mm and 1.973MPa with respectively. And the Yield strength of the material steel is 240Mpa and the Von Mises stress is less than the yield strength of the material.

Modal analysis:

The total weight of the Swinging jaw plate with stiffener is 0.96Tone.

- It is observed that the maximum mass participation of 0.54Tone in X-dir (i.e. 56% of its total weight) for the frequency of 253.7Hz.
- It is observed that the maximum mass participation of 0.072Tone in Y-dir (i.e. 7.5% of its total weight) for the frequency of 368.5Hz.
- It is observed that the maximum mass participation of 0.574Tone in Z-dir (i.e. 59.3% of its total weight) for the frequency of 59.2Hz.

Harmonic analysis:

From the above results, it was observed that the critical frequencies 59.2Hz, 253.7Hz, and 368.5Hz are having stresses of 1924.1MPa, 1.92MPa, 1263Mpa respectively. Hence according to the Maximum Yield Stress Theory, the Von Misses stress is greater than the yield strength of the material. The design of Swinging jaw plate with stiffener is not safe for the above operating loads.

2. Results of Jaw plate with two stiffeners:
Static analysis:

The Maximum Deflection and Von Mises Stress observed on the Swinging jaw plate with two stiffeners is 0.10mm and 7.77MPa with respectively. And the Yield strength of the material steel is 240Mpa and the Von Mises stress is less than the yield strength of the material.

Modal analysis:

The total weight of the Swinging jaw plate with two stiffeners is 1.01Tones.

- It is observed that the maximum mass participation of 0.56Tones in X-dir (i.e.55.4% of its total weight) for the frequency of 239.7Hz.
- It is observed that the maximum mass participation of 0.099Tones in Y-dir (i.e.55.4% of its total weight) for frequency of 349.0Hz.
- It is observed that the maximum mass participation of 0.61Tones in Z-dir (i.e.55.4% of its total weight) for the frequency of 54.6Hz.

Harmonic analysis:

From the above results it is observed that the critical frequencies 54.6Hz, 239.7Hz, and 349.0Hz are having stresses of 2561.1MPa, 1.97MPa, and 1791.5MPa respectively. Hence according to the Maximum Yield Stress Theory, the Von Misses stress is greater than the yield strength of the material. The design of Swinging jaw plate with two stiffeners is not safe for the above operating loads.

3. Results of Jaw plate with three stiffeners:
Static analysis:

The Maximum Deflection and the Von Mises Stress observed on the Swinging jaw plate with three stiffeners is 0.08mm and 4.81MPa with respectively. And the Yield strength of the material steel is 240Mpa and, the Von Mises stress is less than the yield strength of the material.

Modal analysis:

The total weight of the Swinging jaw plate with three stiffeners is 1.07Tones.

- It is observed that the maximum mass participation of 0.59Tones in X-dir (i.e.55% of its total weight) for the frequency of 236.4Hz.
- It is observed that the maximum mass participation of 0.102Tones in Y-dir (i.e.9.5% of its total weight) for the frequency of 341.3Hz.
- It is observed that the maximum mass participation of 0.66Tones in Z-dir (i.e.61.6% of its total weight) for the frequency of 54.11Hz.

Harmonic analysis:

From the above results it is observed that the critical frequencies 54.1Hz, 236.4Hz, and

341.3Hz are having stresses of 39.75MPa, 0.78MPa and 3.5MPa respectively. Hence according to the Maximum Yield Stress Theory, the Von Misses stress is less than the yield strength of the material. The design of Swinging jaw plate with three stiffeners is safe for the above operating loads.

Conclusion:

Swinging jaw plate was modelled in NX-CAD software and jaw plate was analyzed for structural analysis in ANSYS software. At first, jaw plate with one stiffener was considered. Structural analysis was performed on jaw plate and results of jaw plate with one stiffener were within design limits of material used for static analysis, but in case of harmonic analysis, the results were not in limits of the material. So, jaw plate with two stiffeners was modelled to obtain the results of harmonic analysis within limits of material used. But the results of jaw plate with two stiffeners were not within limits for harmonic analysis. So, jaw plate with three stiffeners was modelled and analysed for structural analysis. The results of both static and harmonic analysis were within the limits of material used (i.e. steel). Hence, model of jaw plate with three stiffeners was better compare to jaw plate with one stiffener and two stiffeners.

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