DESIGN OPTIMIZATION OF SWING JAW PLATE OF A JAW CRUSHER USING FINITE ELEMENT ANALYSIS

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***ABSTRACT:** Jaw crusher is a machine designed to reduce large solid particles of raw material into smaller particles. Crushers 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 crushers are of three types namely Cone crusher, Jaw crusher and Impact crusher. 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 present project is aimed at design and analysis of swing jaw plate of a jaw crusher. A number studies have been carried out earlier on the design and analysis of swing jaw plate of jaw crusher. But all of them have been restricted to static loading only. As the jaw crusher 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 crushers 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 crusher. NX-CAD software shall be used for 3D modeling of the jaw crusher and ANSYS software shall be used to do the finite element analysis of the jaw crusher.

I. INTRODUCTION

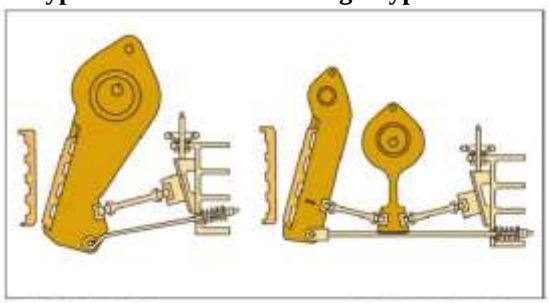
Jaw crusher is a machine designed to reduce large solid particles of raw material into smaller particles. Crushers are major size reduction equipment used in mechanical, metallurgical and allied industries. They are available in various sizes and capacities ranging from 0.2 ton/hr to 50 ton/hr. They are classified based on different factors like product size and mechanism used. Based on the mechanism used 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. Large scale crushing operations are generally performed by mechanically operated equipment like jaw crushers, gyratory crusher and roll crushers. For very large ore pieces that are too big for receiving hoppers of mechanically driven crushers, percussion rock breakers or similar tools are used to break them down to 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.

Crushing is the process of reducing the size of the lump of ore or over size rock into definite smaller sizes. 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 strain in the feed material due to sufficiently applied pressure, impact forces, or shearing effect when exceeds the elastic limit of the feed material, the fracturing will occur 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. To guard against shock and over load the crushers are provided with shearing pins or nest in heavy coiled springs. 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.

Different Types of Jaw Crusher:

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



II. LITERATURE REVIEW

Shyam Sundar.V has published a paper on **"OPTIMUM DESIGN AND ANALYSIS OF SINGLE TOGGLE JAW CRUSHER".** The unique of the paper says A jaw crusher is a sort of size decrease machine which is broadly utilized as a part of mineral, totals and metallurgy fields. The execution of jaw crusher is for the most part controlled by the kinematic highlights of the swing jaw amid the devastating procedure. The handy kinematic normal for the focuses situated along the swing jaw

plate are processed and examined. In light of the examination of the liner development and the devastating parameters, constrain circulation along the swing jaw plate is acquired. The activity is useful for a plan of new model of this sort of machine on improving the edge, planning the chamber and perceiving the devastating character. The communication between jaw plates and material particles conveys the inescapable and genuine wear to the jaw plates amid the jaw crusher operation, which diminishes the productivity, as well as builds the cost and the vitality utilization of the jaw crusher. Gotten comes about because of the kinematic examination of the moving jaw and the devastating power appropriation investigation, the jaw plates wear is broke down on a plainly visible level. It is useful to outline the crusher for enhanced execution. Endeavors to diminish vitality expended in squashing have prompt thought of diminishing the heaviness of the swing plate of jaw crushers. Outline of lighter weight jaw crusher will require a more exact bookkeeping of the anxiety and redirections in the devastating plates than is accessible with customary procedure. The outline of swing jaw plate is done by utilizing CAD i.e., jaw plate has been strong displayed by utilizing CATIAV5R20. FEA is connected to collected structure of swinging jaw plate and lever to streamline the width and area of the flip plate along the swinging lever. The distinctive correlations of swing jaw plates conduct, computed with the conventional and the new FEA disappointment models with stiffeners, demonstrates that 24% reserve funds in plate weight might be conceivable.

Bharule Ajay Suresh has published a paper on **"Computer Aided Design and Analysis of Swing Jaw Plate of Jaw Crusher".** The outline of the paper is Traditionally, firmness of swing plates has not been fluctuated with changes in shake quality. Shake quality has just been of intrigue on account of the need to know the most extreme power applied by the flip for vitality contemplation. Along these lines a swing plate, sufficiently solid to pound taconite with an unconfined compression quality (q□) of up to 308 MPa, might be over designed (and, above all, overweight) for squashing a milder frag mental limestone, metabolites. Plan of lighter weight jaw crushers will require a more exact bookkeeping of the anxieties and diversions in the devastating plates than is accessible with conventional systems. Endeavors to diminish vitality expended in pulverizing have prompt thought of diminishing the heaviness of the swing plate of jaw crushers for effortlessly smashed material. In the present work the plan of the swing jaw plate utilizing point-stack misshapening disappointment (PDF) connections alongside intelligent disappointment of shake particles as a model for such a weight decrease. The outline of the ridged swing jaw plate is done by utilizing CAD i.e. jaw crusher plate has been strong demonstrated by utilizing CatiaV5R15. The figured measurements are approved with the illustration of rumored makers. Limited Element Analysis of jaw plates are completed by utilizing ALGOR V19 programming. Computerization of the hypothetical outline figurings of jaw plates of the jaw crusher has been completed. The automated program encourages for snappy plan of the plates of the jaw crusher. The distinctive correlations of folded swing jaw plates conduct, figured with the customary and the new FEA disappointment models with stiffeners, demonstrates that some 10-25% reserve funds in plate weight might be conceivable.

Ashish Kumar Shrivastava and **Avadesh K. Sharma** have published a paper on " **Dynamic Analysis of Double Toggle Jaw Crusher Using Pro-Mechanica".** The conceptual of the paper clarifies Pro/Engineer is a parametric element based plan of 3D programming and skilled to explain the movement flow of the movement, and the responses at the limitations of the instruments can be utilized as the contributions for any Finite component program to comprehend the conduct of stresses and distortions of the individual segment of the machine to appraise the working existence of the machine components intended for the application. Parametric displaying capacities. To decrease the advancement cycle and enhance the plan nature of jaw crusher, this paper takes full favourable position of the Function module of the Pro/Engineer stage to make demonstrate re-enactment and dynamic examination on the genuine jaw crusher system, and gave the refreshed way to the outline and make of Jaw Crusher.

Ashish Kumar Shrivastava and **Avadesh K. Sharma** have published one more paper on " **A REVIEW ON STUDY OF JAW CRUSHER".** The unique of the paper clarifies Crushers are machines which utilize a metal surface to break or pack materials mining operations utilize crushers, normally grouped by how much they section the beginning material with essential and auxiliary crushers taking care of coarse materials and tertiary and quaternary crushers decreasing metal particles to better degrees. This paper concentrates on survey of a work did by specialists in the field of kinematic and dynamic examination of the jaw crusher connection. Kinematic and Dynamic investigation is useful for understanding and enhancing the plan nature of jaw crusher. There are numerous specialist work done by analyst in a similar field yet at the same time there is an extension to create Kinematic and dynamic investigation to jaw crusher connection.

Sobhan Kumar Garnaik has published a paper on **"Computer Aided Design of Jaw crusher".** The rundown of the task is Due to their straightforward plan and simple practicality jaw crushers are generally utilized as essential size diminishment types of gear in mechanical and mining businesses. As jaw crushers break minerals and metals of high quality and the economy of numerous enterprises relies upon its execution; it is fundamental to enhance the effectiveness of the present plan. The kinematic investigation of single flip jaw crusher demonstrates that the powers on the moving jaw plate at various wrench edge are unique and henceforth control produced differs with wrench point. One approach to expand the effectiveness is to store the vitality in a flywheel when the supply is more than the rate of utilization and to use a similar when the supply tumbles down. Consequently endeavors are made to plan a flywheel to limit the wastage of energy and to extemporize the execution parameters of single flip jaw crusher. Jaw plate wear has significant effect on the life of jaw Crusher which is caused by the slipping movement between the fed material and the jaws. This wear is overwhelmingly genuine in the settled plate and consequently the liners of the settled jaw ought to be legitimately picked. Notwithstanding this the flip bar which goes about as a wellbeing lever must be definitely planned. The outline parts of flywheel, spring of strain bar and flip bar are examined in this paper.

III. PROBLEM DEFINITION AND METHODOLOGY

The present project is aimed at design and analysis of swing jaw plate of a jaw crusher. As the jaw crusher has lot of moving components, it is subjected to a lot of linear and random vibrations. 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 crushers 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 crusher. NX-CAD software shall be used for 3D

modeling of the jaw crusher and ANSYS software shall be used to do the finite element analysis of the jaw crusher.

IV. 3D MODEL OF SWINGING JAW PLATE WITH STIFFENER

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

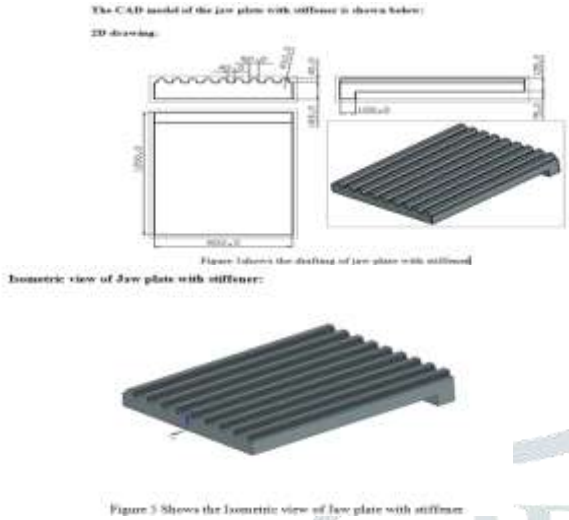


Figure 3 Shows the Isometric view of Jaw plate with stiffener

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

STRUCTURAL ANALYSIS OF SWINGING JAW PLATE

Finite Element Modeling (FEM) and Finite Element Analysis (FEA) are two most popular mechanical engineering applications offered by existing CAE systems. This is attributed to the fact that the FEM is perhaps the most popular numerical technique for solving engineering problems. The method is general enough to handle any complex shape of geometry (problem domain), any material properties, any boundary conditions and any loading conditions. The generality of the FEM fits the analysis requirements of today's complex engineering systems and designs where closed form solutions are governing equilibrium equations are not available. In addition it is an efficient design tool by which designers can perform parametric design studying various cases (different shapes, material loads etc.) analyzing them and choosing the optimum design.

STATIC ANALYSIS OF SWINGING JAW PLATE WITH STIFFENER:

A static investigation can however incorporate consistent idleness loads and time fluctuating burdens that can be approximated as static equal burdens. The 3d model of the swinging jaw plate with stiffener is made in NX-CAD and changed over into parasolid. The parasolid document is transported in into ANSYS and limited component investigation is done utilizing ANSYS programming.

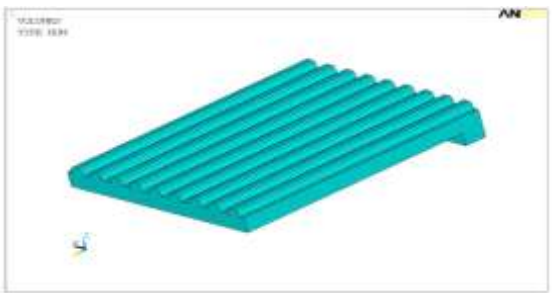


Fig: Shows the geometric model of the Swinging jaw plate with stiffener

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:

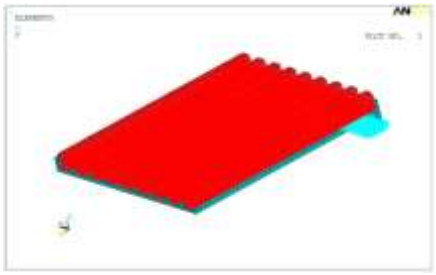


Figure: shows the applied boundary and loading conditions of Swinging jaw plate with stiffener

RESULTS:

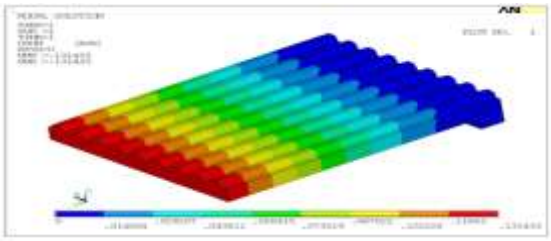


Figure Shows the Displacement vector sum of Swinging jaw plate with stiffener

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

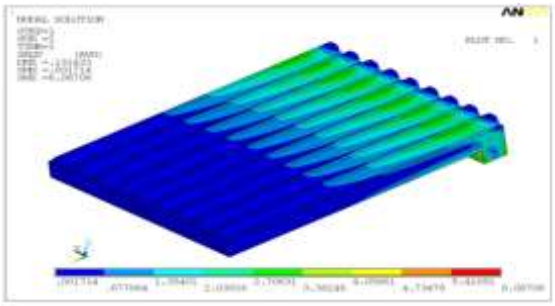


Figure shows the Von Mises stress of Swinging jaw plate with stiffener

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.
-

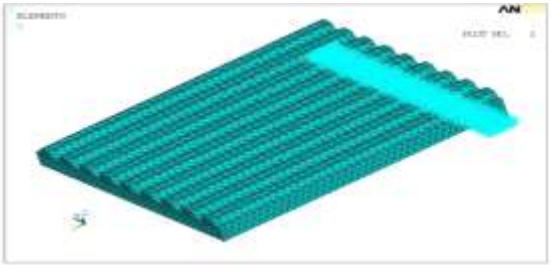


Figure shows Applied Boundary conditions on Swinging jaw plate with stiffener.

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

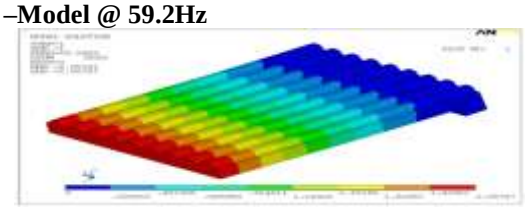


Figure Shows Mode shape 1@59.2Hz for Swinging jaw plate with stiffener:

Results –Model @ 368.5 Hz

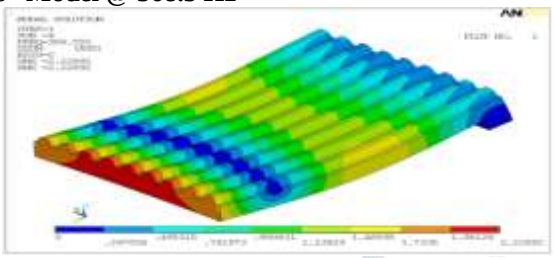


Figure Shows Mode shape 4@368.5Hz for Swinging jaw plate with stiffener

Results –Model @ 588.8Hz

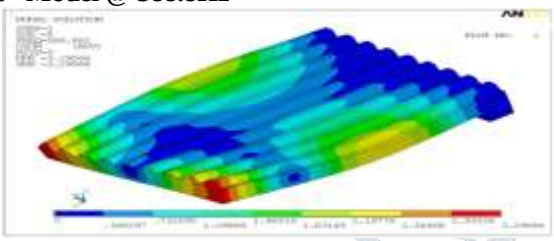
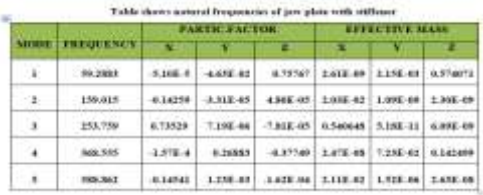


Figure Shows Mode shape 5@ 588.8Hz for Swinging jaw plate with stiffener

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:



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.

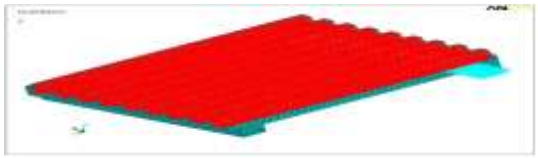


Figure shows Boundary conditions and loading of Swinging jaw plate with stiffener

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

Max. Deflection and stress of frequency @ 59.2Hz:

VonMises stress:

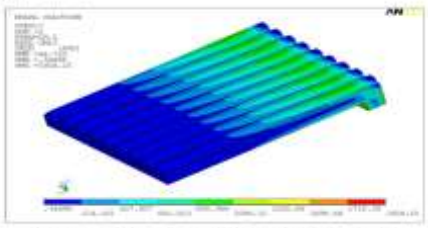


Figure 20 shows the VonMises stress of Swinging jaw plate with stiffener

Max. Deflection and stress of frequency @ 253.7Hz:

VonMises stress:

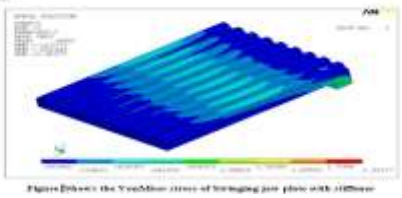


Figure 21shows the VonMises stress of Swinging jaw plate with stiffener

Max. Deflection and stress of frequency @ 368.5Hz.

VonMises stress:

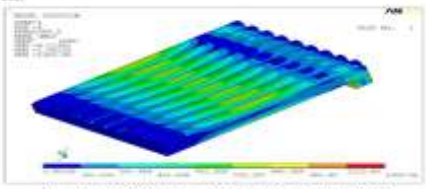


Figure shows the VonMises stress of Swinging jaw plate with stiffener

Table shows Deflections and von mises 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:
3D drawing:

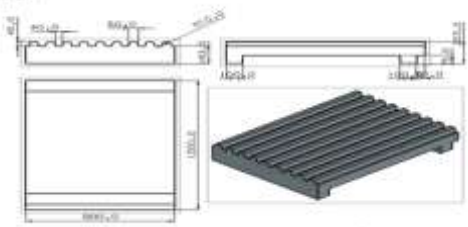


Figure shows the drafting of jaw plate with two stiffened

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

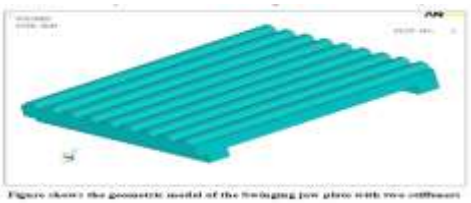


Figure shows the geometric model of the Swinging jaw plate with two stiffeners

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 0.10mm on Swinging jaw plate with two stiffeners

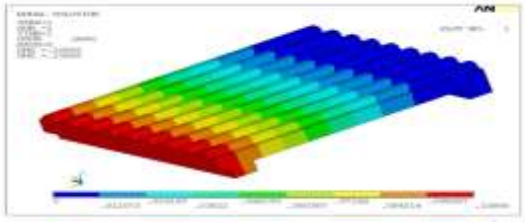


Figure shows the Max. Displacement of Swinging jaw plate with two stiffeners

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.

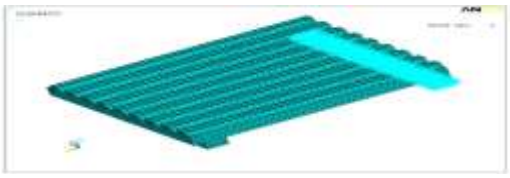


Figure shows Applied Boundary conditions on Swinging jaw plate with two stiffeners.

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	-1.08E-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.

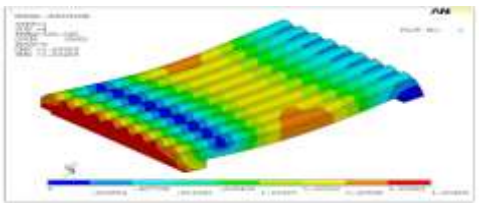


Figure Shows Mode shape 4@349.0Hz for Swinging jaw plate with two stiffeners

Results –Mode5 @ 585.3Hz

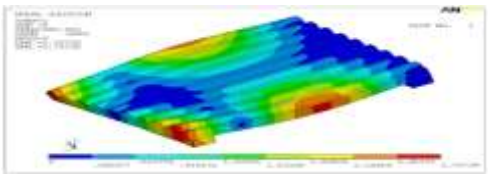


Figure 1 Shows Mode shape 5@ 585.3Hz for Swinging jaw plate with two stiffeners

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.

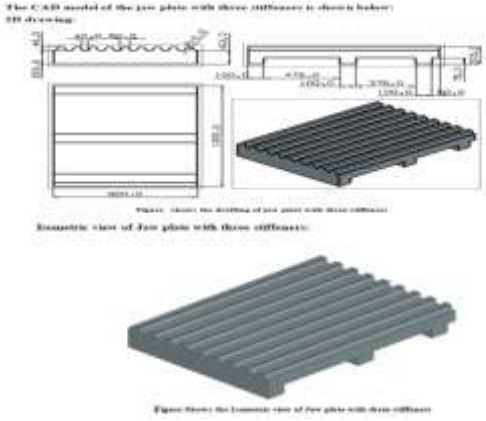
Table shows natural frequencies of jaw plate with two stiffeners

MODE	FREQUENCY	PARTIC.FACTOR			EFFECTIVE MASS		
		X	Y	Z	X	Y	Z
1	54.6	1.58E-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	-1.08E-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 mises 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:

3D drawing:

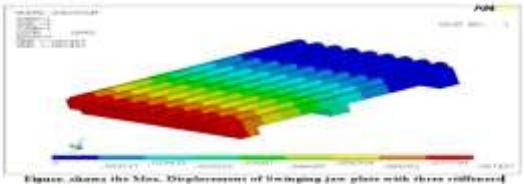
Isometric view of jaw plate with three stiffeners:

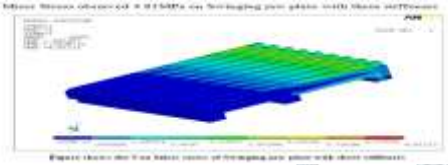
Figure shows the isometric view of jaw plate with three stiffeners

STRUCTURAL ANALYSIS OF SWINGING JAW PLATE WITH THREE STIFFENERS

RESULTS

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





From the above analysis:

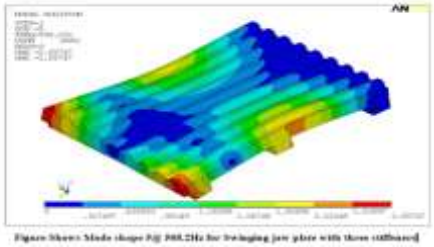
- The Maximum Deflection and the Von Mises Stress observed on the Swinging jaw plate with three stiffeners is 0.08mm and 4.81MPa with respectively. And the Yield strength of the material steel is 240MPa.
- Hence according to the Maximum Yield Stress Theory, the Von Mises stress is less than the yield 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 @ 568.23Hz



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:

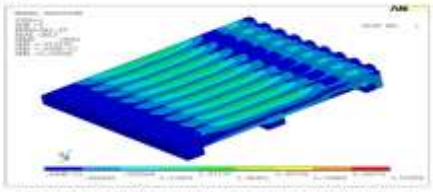


Table shows Deflections and von misses stress for critical frequencies

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 7.77 MPa 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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