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Design and Analysis of Swing Jaw Plates of Jaw Crusher

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Abstract: **In this project, static and Model analysis is a process to determine the stress, strain and deformation. Vibration characteristics (natural frequencies and mode shapes) of a structure or a machine component while it is being designed. It has become a major alternative to provide a helpful contribution in understanding control of many vibration phenomena which encountered in practice. Fatigue analysis is a process to determine estimate the life of swing jaw plates. In this work we compared the stress and natural frequency for different material (MARTENSTIC steel and EN31 steel) having Swing Jaw Plates. The swing jaw plates material martensitic steel but here we replace and compare the EN31 steel. The EN 31 steel material has more strength. The Swing Jaw Plates is designed IN PRO-ENGINEER and analyzed in ANSYS. The swing jaw plates have no stiffeners, but in this project we are adding the stiffeners of the swing jaw plates. The Swing Jaw Plates which is fixed at BOTTOM SURFACE OF THE Swing Jaw Plate is vibrated to obtain the natural frequency, mode shapes and deflection with different geometries and materials.**

Keywords: **Finite Element Analysis; Swing Jaw Plates; Jaw Crusher;**

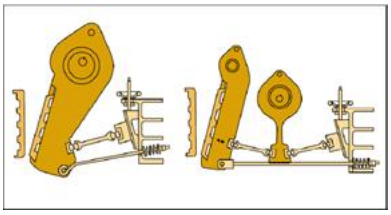
I. INTRODUCTION

Jaw crusher is one of the main types of primary crushers in a mine or ore processing plant. The size of a jaw crusher is designated by the rectangular or square opening at the top of the jaws (feed opening). Primary jaw crushers are typically of the square opening design, and secondary jaw crushers are of the rectangular opening design. However, there are many exceptions to this general rule. Jaw crusher is a primary type of crusher which has two jaws, out of which one is stationary attached rigidly with the crusher frame whereas the other moves between a small throw forward and retarded back successively to crush the ore or rock boulders Jaw crushers are typically used as primary crushers, or the first step in the process of reducing rock. They typically crush using compression. The rock is dropped between two rigid pieces of metal, one of which then move inwards towards the rock, and the rock is crushed because it has a lower breaking point than the opposing metal piece.

Jaw Crusher Working Principle

The working principal of Jaw Crusher is based on modern design "CRUCHING WITHOUT RUBBING" The machine consists, two Jaws, one fixed and the other moving. The opening between them is smaller at the bottom and wider at the top. The pitman moving on an eccentric shaft on bearing, swing lever (Moving Jaw) swing on center pin. The Rock held in between two Jaws and crushed by mechanical pressure.

The motor drives the belt pulley and the belt pulley drives the eccentric shaft to rotate, and make the moving jaw approach and leave the fixed jaw periodically shaft rotation, to crush, rub and grind the material sand slower and gradually fall down and finally discharge from the discharge opening desired dimension of the crushed product stationary breaking surface with stationary plate. The ore or rock is fed to the crusher where the jaws are further apart, i.e. at the maximum opening or gape. When the jaws come together the ore is crushed and slip down in the crushing chamber experienced and the ore moves down further. The process is repeated till particles having size less than the bottom opening or set pass through as move the pivoted jaw. The retrieving action of the jaw from its furthest end of travel is by springs for small crushers or by a pitman for larger crushers. For a smooth reciprocating action of the moving jaws, heavy flywheels are used in both types of crushers &the eccentric shaft.



Single toggle jaw crusher, Double toggle jaw crusher

The characteristics of this type of crusher are as following

1. Larger, rough, blocky as well as sticky rock or ore lumps can be crushed.

2. Reinforcement of the crusher is possible with the help of high strength crusher frame to crush very hard rock or ore lumps.

3. It is very simple to adjust to prevent much of wear and also very easy to repair.

4. Maintenance of the crusher is very easy.

II. LITERATURE REVIEW

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.

III. PROBLEM DESCRIPTION

The objective of this project is to make a 3D model of the swing jaw plates of jaw crusher and study the static and modal analysis behavior of the swing jaw plates of jaw crusher by performing the finite element analysis.3D modeling software (PRO-Engineer) was used for designing and analysis software (ANSYS).

MODELS

With ribs and without ribs	**Case: 1**	130mm(thickness)
	Case: 2	140mm(thickness)
	Case: 3	150mm(thickness)
	Case: 4	160mm(thickness)

The methodology followed in the project is as follows:

- Create a 3D model of the swing jaw plates of jaw crusher assembly using parametric software pro-engineer.
- Convert the surface model into Para solid file and import the model into ANSYS to do analysis.
- Perform static analysis on the swing jaw plates of jaw crusher assembly for static loads.

IV. INTRODUCTION TO CAD/CAE

Computer-aided design (**CAD**), also known as **computer-aided design and drafting** (**CADD**), is the use of computer technology for the process of design and design-documentation.

INTRODUCTION TO PRO-ENGINEER

Pro/ENGINEER Wildfire is the standard in 3D product design, featuring industry-leading productivity tools that promote best practices in design while ensuring compliance with your industry and company standards. Integrated Pro/ENGINEER CAD/CAM/CAE solutions allow you to design faster than ever, while maximizing innovation and quality to ultimately create exceptional products.

Different modules in pro/engineer

Part design, Assembly, Drawing& Sheet metal.

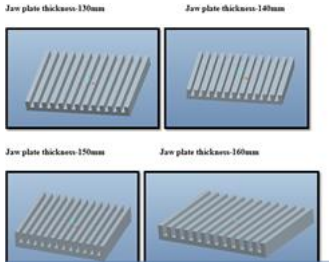
INTRODUCTION TO FINITE ELEMENT METHOD:

Finite Element Method (FEM) is also called as Finite Element Analysis (FEA). Finite Element Method is a basic analysis technique for resolving and substituting complicated problems by simpler ones, obtaining approximate solutions Finite element method being a flexible tool is used in various industries to solve several practical engineering problems. In finite element method it is feasible to generate the relative results.

V. RESULTS AND DISCUSSIONS

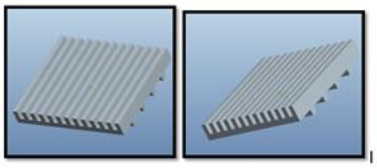
Models of swing jaw plates of jaw crusher using pro-e wildfire 5.0: The swing jaw plates of jaw crushers modeled using the given specifications and design formula from data book. The isometric view of swing jaw plates shown in below figure. The swing jaw plates of jaw crusher outer casing body profile is sketched in sketcher and then it is sweep option and tubes are designed and assemble to in swing jaw plates of jaw crusher using extrude option.

Without stiffeners

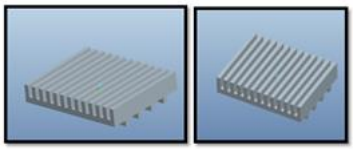


WITH STIFFENERS

Jaw plate thickness-130mm Jaw plate thickness-140mm



Jaw plate thickness-150mm Jaw plate thickness-160mm



STRATURAL ANALYSIS OF CRUSHER JAW PLATE

CASE 1:-WITHOUT STIFFENERS

Jaw plate thickness-130mm

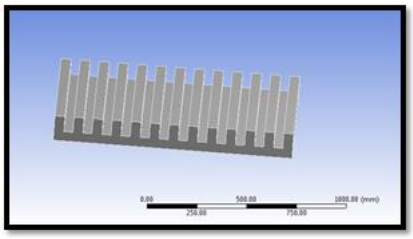
MATERIAL – MARTENSTIC STEEL

Save Pro-E Model as .iges format

→→Ansys → Workbench→ Select analysis system → static structural → double click

→→Select geometry → right click → import geometry → select browse →open part → ok

→→ select mesh on work bench → right click →edit

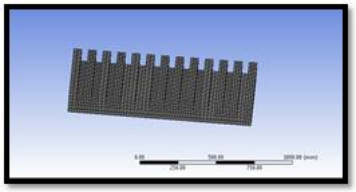


Double click on geometry → select MSBR → edit material →

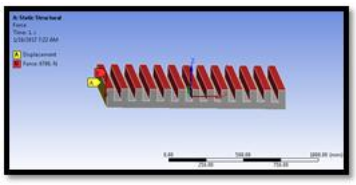
MATERIAL PROPERTIES OF STAINLESS STEEL

Density	:	0.000007860kg/mm^3
Young's modulus	:	210000Mpa
passions ratio	:	0.26

Select mesh on left side part tree → right click → generate mesh →



Select static structural right click → insert → select pressure and displacement →



Select displacement → select required area → click on apply → put X, Y, Z component zero →

Select pressure → select required area → click on apply → enter pressure value 10.868Mpa →

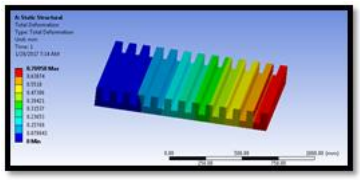
Select solution right click → solve →

Solution right click → insert → deformation → total → Solution right click → insert → strain → equivant (von-mises) →

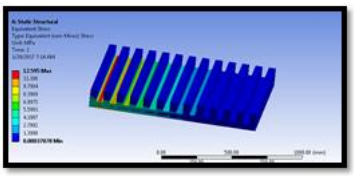
Solution right click → insert → stress → equivant (von-mises) →

Right click on deformation → evaluate all result

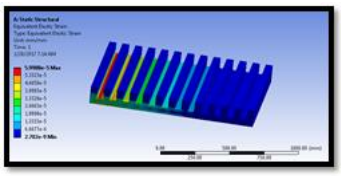
TOTAL DEFORMATION



VON-MISES STRESS

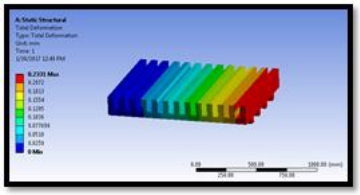


VON-MISES STRAIN

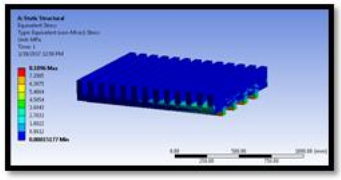


Jaw plate thickness-160mm (with stiffeners)

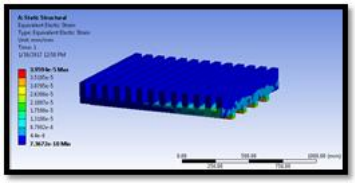
TOTAL DEFORMATION



VON-MISES STRESS



VON-MISES STRAIN

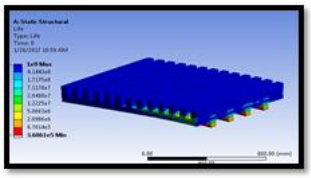


FATIUGE ANALYSIS OF CRUSHER JAW PLATE

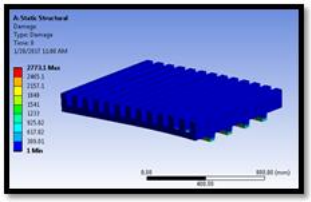
MATERIAL – MARTENSTIC STEEL

Jaw plate thickness-130mm

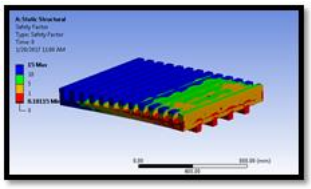
LIFE



DAMAGE

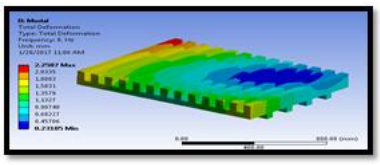


SAFTEY FACTOR

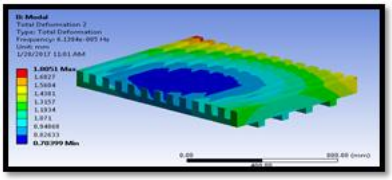


MODAL ANALYSIS OF CRUSHER JAW PLATE

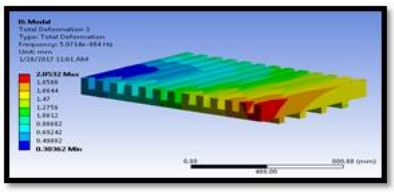
TOTAL DEFORMATION 1



TOTAL DEFORMATION 2



TOTAL DEFORMATION 3



STATIC ANALYSIS

Without stiffener

Crusher jaw plate thickness(mm)	Martenstic steel			En 31 steel		
	Displacement (mm)	Stress ($N/m m^2$)	Strain	Displacement (mm)	Stress ($N/m m^2$)	Strain
130	0.70958	12.595	5.998e-5	0.71192	12.59	6.113e-5
140	0.7097	12.563	0.0005983	0.70192	12.555	6.0956e-5
150	0.7092	12.548	0.0005976 4	0.71147	12.537	6.089e-5
160	0.71122	12.954	6.1752e-5	0.71335	12.953	6.2988e-5

With stiffeners

Crusher jaw plate thickness(mm)	Martenstic steel			En 31 steel		
	Displacement (mm)	Stress (N/mm^2)	Strain	Displacement (mm)	Stress (N/mm^2)	Strain
130	0.24672	8.5218	4.0587e-5	0.25084	8.5235	4.1837e-5
140	0.23908	8.2762	3.9417e-5	0.24306	8.2574	4.0535e-5
150	0.22876	8.1127	3.8635e-5	0.24013	8.1696	3.9661e-5
160	0.23042	8.1219	3.8693e-5	0.2331	8.1016	3.9594e-5

Fatigue analysis results

Without stiffener

Crusher jaw plate thickness(mm)	Martenstic steel			En 31 steel		
	Life	Damage	Safety Factor	Life	Damage	Safety Factor
130	$1e^{10}$	751.51	0.109	$1e^{10}$	750.81	0.10961
140	$1e^{10}$	746.76	0.1098	$1e^{10}$	745.51	0.10922
150	$1e^{10}$	744.56	0.1099	$1e^{10}$	742.94	0.11007
160	$1e^{10}$	805.66	0.10654	$1e^{10}$	805.63	0.10654

With stiffeners

Crusher jaw plate thickness (mm)	Martenstic steel			En 31 steel		
	Life	Damage	Safety Factor	Life	Damage	Safety Factor
130	$1e^{9}$	2773.1	0.10115	$1e^{9}$	2774.5	0.10113
140	$1e^{9}$	2570	0.10415	$1e^{9}$	2554.8	0.10439
150	$1e^{9}$	2446	0.10625	$1e^{10}$	2488.48	0.16892
160	$1e^{10}$	2449	0.16985	$1e^{10}$	2437	0.17017

VI. CONCLUSION

Crushers are major size reduction equipment used in mechanical, metallurgical and allied industries which crushes different types of soft and hard materials. swing jaw plates are takes direct part into these operations. hence the design and analysis are very important.

In this work we compared the stress and natural frequency for different material (martensitic steel and en31 steel) having swing jaw plates. the swing jaw plates is designed in pro-engineer and analyzed

in Ansys. the swing jaw plates which is fixed at bottom surface of the swing jaw plate is vibrated to obtain the natural frequency, mode shapes and deflection with different geometries and materials.

By observing the static analysis, the stress values are more for martensitic steel than en 31 steel. when we compare the models of swing jaw plates jaw crusher, the stress values are less for swing jaw plates of jaw crushes at plate thickness 160mm.

By observing the fatigue analysis, the life, damage and safety factor values are better for en 31 steel. by observing the modal analysis, the deformation more for en31 steel.

So it can be concluded the en 31 steel is better for swing jaw plates of jaw crushes at plate thickness 160mm.

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