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COMPUTER AIDED DESIGN AND ANALYSIS OF SWING JAW PLATE OF JAW CRUSHER

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Abstract: - Traditionally, stiffness of swing plates has not been varied with changes in rock strength. Rock strength has only been of interest because of the need to know the maximum force exerted by the toggle for energy considerations. Thus a swing plate, stiff enough to crush taconite with an unconfined compressive strength (q) of up to 308 MPa, may be overdesigned (and, most importantly, overweight) for crushing a softer fragmental limestone, amphibolites. Design of lighter weight jaw crushers will require a more precise accounting of the stresses and deflections in the crushing plates than is available with traditional techniques. Efforts to decrease energy consumed in crushing have lead to consideration of decreasing the weight of the swing plate of jaw crushers for easily crushed material. In the present work the design of the swing jaw plate using point-load deformation failure (PDF) relationships along with interactive failure of rock particles as a model for such a weight reduction. The design of the corrugated swing jaw plate is carried out by using CAD i.e. jaw crusher plate has been solid modeled by using CatiaV5R15. The calculated dimensions are validated with the drawing of reputed manufacturers. Finite Element Analysis of jaw plates are carried out by using ALGOR V19 software. Computerization of the theoretical design calculations of jaw plates of the jaw crusher has been carried out. The computerized program facilitates for quick design of the plates of the jaw crusher. The different comparisons of corrugated swing jaw plates behavior, calculated with the traditional and the new FEA failure models with stiffeners, shows that some 10-25% savings in plate weight may be possible.

Keywords: Swing Plates, Crusher, V19 Software

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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..

2.0 OBJECTIVE

The objective of the present work is to strive for a design and analysis of commercially available swing jaw plates (including stiffening elements), that is 0.9 m (36 in.) wide with304 mm and 51 mm (12 in. and 2 in.) top and bottom openings of jaw crusher. The finite element method is applied to the analysis of the swing jaw plate. 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 CAD i.e. parametric design package (CATIAP3V5R15). 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 ALGOR V19 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.

3.0 LITERATURE REVIEW

Jaw crushers are used to crush material such as ores, coals, stone and slag to particle sizes. Jaw crushers operate slowly applying a large force to the material to be granulated. Generally this is accomplished by pressing it between jaws or rollers that move or turn together with proper alignment and directional force. The jaw crusher squeezes rock between two surfaces, one of which opens and closes like a jaw. Rock enters the jaw crusher from the top. Pieces of rock those are larger than the opening at the bottom of the jaw lodge between the two metal plates of the jaw. The opening and closing action of the movable jaw against the fixed jaw continues to reduce the size of lodged pieces of rock until the pieces are small enough to fall through the opening at the bottom of the jaw. It has a very powerful motion. Reduction in size is generally accomplished in several stages, as there are practical limitations on the ratio of size reduction through a single stage.

The jaw crushers are used commercially to crush material at first in 1616 as cited by

Anon [1].It is used to simplify the complex engineering. Problem those were prevailing in Mining and Construction sector. An important experimental contribution was made in1913 when Taggart [2] showed that if the hourly tonnage to be crushed divided by Square of the gape expressed in inches yields a quotient less than 0.115 uses a jaw crusher.

Lindqvist M. and Evertsson C. M. [3] worked on the wear in rock of crushers which causes great costs in the mining and aggregates industry. Change of the geometry of the crusher liners is a major reason for these costs. Being able to predict the geometry of a worn crusher will help designing the crusher liners for improved performance. Tests have been conducted to determine the wear coefficient. Using a small jaw crusher, the wear of the crusher liners has been studied for different settings of the crusher. The experiments have been carried out using quartzite, known for being very abrasive. Crushing forces have been measured, and the motion of the crusher has been tracked along with the wear on the crusher liners. The test results show that the wear mechanisms are different for the fixed and moving liner. If there were no relative sliding distance between rock and liner, would yield no wear. This is not true for rock crushing applications where wear is observed even though there is no macroscopic sliding between the rock material and the liners. For this reason has been modified to account for the wear induced by the local sliding of particles being crushed. The predicted worn geometry is similar to the real crusher. A jaw crusher is a machine 15 commonly used in the mining and aggregates industry. The objective of this work, where wear was studied in a jaw crusher, is to implement a model to predict the geometry of a worn jaw crusher.

4.0 COMPUTER AIDED ASPECTS OF DESIGN

Computers can be efficiently in several aspects of the design process. the capabilities of the computers in terms of storing vast amount of data, the astonishing speed with which it can retrieve the required information buried in its knowledge base ,and also the speed with which it can perform routine and repetitive computations with accuracy for the required analysis and optimization of the design ,the graphics capabilities which enables visual representation of the design at every stage in design, convenience with which design information can be transmitted to the production shop in the form of computer drafted drawings or directly to CNC machines, industrial robots etc make it very useful tool for the designer. Design is an activity that facilitates the realization of new products and processes through which technology satisfies the needs and aspirations of the society. Engineering design of a product may be conceived and evolved in four steps:

1. Problem definition: Extracting a coherent appreciation of need or function of an engineering part from a fuzzy mix of facts and myths that result from an initial ill-posed problem. The data collection can be done via observation and/or a detailed survey.

2. Creative process: Synthesizing form, a design solution to satisfy the need. Multiple solutions may result (and are sought) as the creative thought process is aided by the designers' vast experience and knowledge base. Brainstorming is usually done in groups to arrive at various forms which are then evaluated and selected into a set of a few workable solutions.

3. Analytical process: Sizing the components of the designed forms. Requisite functionality, strength and reliability analysis, feasible manufacturing, cost determination 54 and environmental impact may be some design goals that could be improved optimally by altering the components' dimensions and/or material. This is an iterative process requiring design

changes if the analysis shows inadequacy, or scope for further improvement of a particular design. Multiple solutions may be evaluated simultaneously or separately and the best design satisfying most or all functional needs may be chosen.

4. Prototype development and testing: Providing the ultimate check through physical evaluation under, say, an actual loading condition before the design goes for production. Design changes are needed in the step above in case the prototype fails to satisfy a set of needs in step 1. This stage forms an interface between design and manufacture. Many groups encourage prototype failure as many times as possible to quickly arrive at a successful design. [35]

4.1 SOLID MODELING OF SWING JAW PLATES

Engineering components can be of various forms (sizes and shapes) in three dimensions.

A Solid can be thought of as composed of a simple closed connected surface that encloses a finite volume. The closed surface may be conceived as an interweaved arrangement of constituent surface patches, which in turn, can be individually considered as composed of a group of curves. It then behooves to discuss the generic design of curves, surfaces and solids in that order. Even before, it may be essential to understand how three dimensional objects or geometrical entities are represented on a two-dimensional display screen, and how such entities can be positioned with respect to each other for assembly purposes or construction operations. Engineers have converged to numerous standard ways of perceiving a three-dimensional component by way of engineering drawings depicted on a two-dimensional plane (conventionally blue prints, but for CAD's purpose, a display screen). Solids represent a large variety of objects we see and handle. Curves and surfaces are intended to form the basis for solid or volumetric modeling. Solid modeling techniques have been developed since early 1970's using wireframe, surface models, boundary representation (b-rep), constructive solid geometry (CSG), spatial occupancy and enumeration. A solid model not only requires surface and boundary geometry definition, but it also requires topological information such as, interior, connectivity, holes and pockets. Wire-frame and surface models cannot describe these properties adequately. Further, in 55 design, one needs to combine and connect solids to create composite models for which spatial addressability of every point on and in the solid is required. This needs to be done in a manner that it does not become computationally intractable. Manufacturing and Rapid Prototyping (RP) both require computationally efficient and robust solid modelers. Other usage of solid modelers is in Finite Element Analyses (as pre- and post processing), mass property calculations, computer aided process planning (CAPP), interference analysis for robotics and automation, tool path generation for NC machine tools, shading and rendering

for realism and many others.[33]

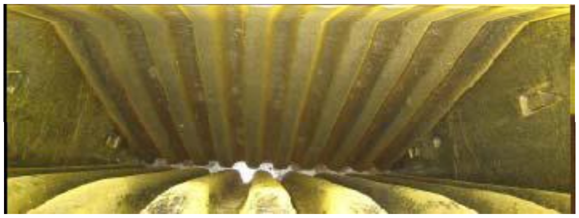


Fig.4.1 Picture Showing Corrugated Cast Steel Jaw Plates [36]

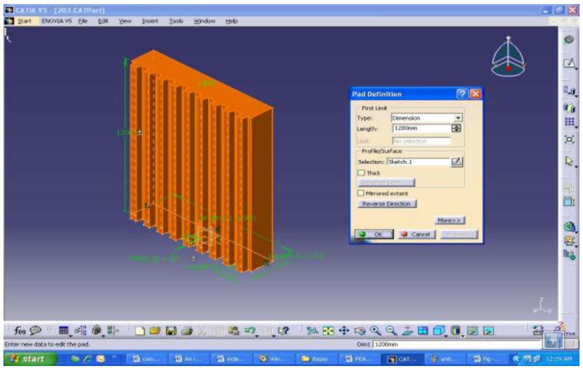


Fig.4.3 Extruding Sketch of Swing Jaw Plates Using Pad Tool

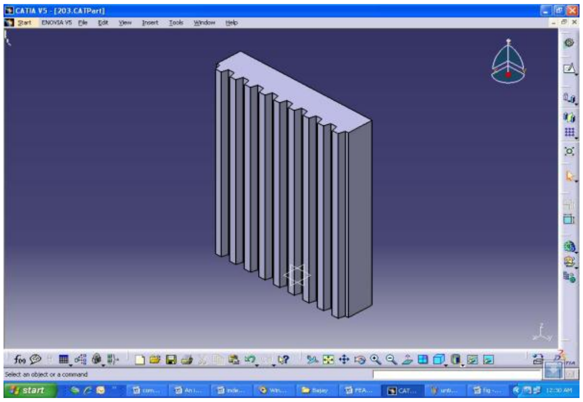
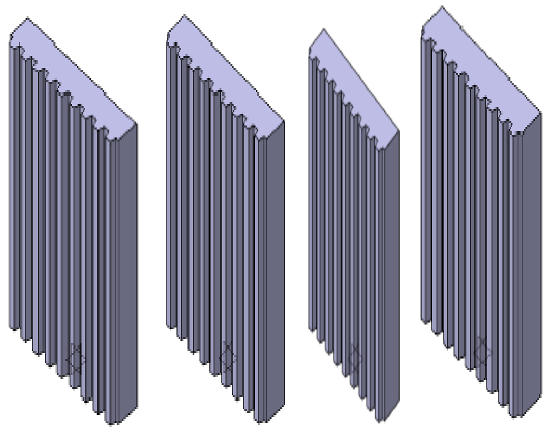


Fig.4.4 Solid Model of Corrugated Swing Jaw Plate



L= 1200	L= 1200	L= 1200	L= 1200
W=900	W= 900	W= 900	W= 900
T=191	T=203	T=216	T=224

Fig.4.5 Corrugated Swing Jaw Plate Models having Dimensions in mm

5.0 STATIC STRESS ANALYSIS RESULTS

Since the PDF data were most complete for the amphibolites, these load-deformation relations were employed in the model. Laboratory data were extrapolated for the larger sizes according to the dotted line in the strength-deformation size relationships in Figs. 3.7 and 3.9. To obtain a comparison for the interactive model, the same beam model (same EI) was loaded with the same sized particles which were all assumed to fail simultaneously. The load distribution found with simultaneous failure as shown and compared with the load distribution curve assumed by Molling [6]. The stepwise pressure distribution was found by distributing the ultimate point load for that size particle over the distance midway between each of the two adjacent loads. The similarity of the two distributions further substantiates the size-strength relations and particle size distribution employed in this study.

6.0 CONCLUSION

(1) Finite element analysis of swing jaw plates is carried out, using eight- noded brick element to predict the behavior when it is subjected to point loading under simply supported boundary conditions.

(2) The accuracy of results obtained using the present formulation is demonstrated by comparing the results with theoretical analysis solution. Moreover, the results of stresses are calculated at points and they are expected to differ from the analytical solutions.82

(3) The present jaw plate models accurately predict the various stresses for plates. As the present models are developed using a non-conforming element, the results can be further improved using a conforming element with improved mesh size thereby increased no of elements. Infact, FEM results approach the true solutions, with the increase in the number of elements.

(4) The stiffened plate models which leads to reductions in plate weight and indicates that design of new energy-efficient systems of the crushed material.

(5) 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.

(6) The stiffened plate models which leads to 25% saving in energy, of course this 25% is an estimate.

(7) The packing arrangement of particles used for the jaw plate analysis shows maximum particles which the plate can accommodate in one crushing cycle.

(8) Consideration of the two particles between the crusher plates reveals the importance of the point-load failure mechanism. Thus, any design based upon both deformation and strength must begin with a point-load idealization.

(9) Design of lighter weight jaw crushers will require a more precise accounting of the stresses and deflections in the crushing plates than is available with traditional techniques.

(10) Rock strength has only been of interest because of the need to know the maximum force exerted by the toggle for energy considerations. Thus a swing plate, stiff enough to crush taconite, may be overdesigned for crushing a softer fragmental limestone.

(11) Design of crushers for specific rock types must consider the variability of point load strength and deformability implicit in any rock type name and quarry sized sampling region.

7.0 FURTHER SCOPE FOR STUDY

Further work is needed to apply the basic, non-simultaneous failure and rock-machine interaction theory with the following modifications and extensions.

(1) Varying packing arrangements from the simplified row assumption to random distributions found in actual operation can be applied to get more accurate results.

(2) Extend the size-peak crushing force and stiffness relationships to account for larger sized feed stock and the effects of jointing and blast-induced micro fissures.

(3) All the Rock names are given on the basis of composition and texture, not strength or deformability. Thus limestone, as shown by the comparison of fragmental and dolomitic limestone, can have widely varying strengths. Therefore crushers cannot be selectively designed with low factors of safety without testing the exact rock to be crushed.

(4) Rock strength will vary even within a specific quarry. Other work has shown that coefficients of variation of rock strength can be as much as 20 - 50% of the mean for are stricted sampling region.

(5) Line loading also produces deformation hardening behavior. Such loading conditions may be applicable for modeling the behavior of slabby material when loaded with ridged plates.

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