Global J. of Mech., Engg. & Comp. Sciences, **2015: 5 (1)**

Review Paper: Ragu and Pandiganesh, 2015: 1-4.

DESIGN AND ANALYSIS OF STRENGTH OF THE SWING JAW PLATES IN JAW CRUSHER MACHINE

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ABSTRACT

Crusher machine mainly used to reduce the irregular shape of metal surface with the help of compress materials mining operation. Commonly crusher machine are classified by the degree to which they fragment the starting material with primary and secondary crushers handling coarse materials and tertiary and quaternary crushers reducing ore particles to finer gradations. Swing jaw plates are takes direct part into this operation. Hence the design and analysis are very important .This paper focuses on review of a work carried out by researchers on analysis of swing jaw plate. Dynamic analyses of the jaw crusher the new design quality of the jaw crusher are improved, but still there is so many area of scope to develop the analysis of swing jaw plate. Jaw crusher is a machine is used to reduce the solid particles of raw materials into smaller particles. Crusher is major size reduction equipment used in metallurgical purpose. There are different types of crusher machines are classified based on the output of the machine from 5 ton/hrs to 50 ton/hrs. They are classified into different types based on the output, based on the Medium of metal is used, and mechanism used. Mainly five types Crusher machine are classified on the basis of usage Jaw Crusher, Mobile crusher, Gyratory crusher, Compound crusher, Cone Crusher. Let us take the movable jaw plate connected directly to the main shaft. Previously they use the shaft mechanism with the help of kinematic arrangement connected by pitman to piston. But this mechanism helps you to move the jaw plates directly connected via CAM connected shaft. Design of lighter weight jaw crushers will requires a more precise accounting of the stresses and deflections in the crushing plates than is available with traditional techniques. Jaw plates are designed in the Pro E V5, and the designed plates are analysis with the help of Ansys Software to find the maximum acting on the Jaw plates.

Keywords: *Computer Aided Design (CAD), ANSYS, PRO E V5 and Force Distribution.*

INTRODUCTION

Recently, concern for energy consumption in crushing has led to the consideration of the decreasing the weight (and consequently the stiffness) of the swing plate of jaw crushers to match the strength of the rock being crushed. An investigation of the energy saving of plate rock interaction when point load deformability and failure relationships of the rock are employed to calculate plate stresses. Non simultaneous failure relationships of the rock particles is incorporated into a beam model of the swing plate to allow stress calculation at various plate positions during one cycle of crushing (Gupta Ashok and Yan, 2006). In order to conduct this investigation, essentially two studies were required. First, point load-deformation relationships have to be determined for differing sizes of a variety of rock type. Even though much has been written about the ultimate strength of rock under point loads, very little has been published about the pre and post failure point load deformation properties. Therefore some unconfined compression tests were conducted to determine typical point load deformation relationships for a variety of rocks types. Secondly a numerical model of the swing plate A as shown in fig has been developed (Fig 1).

ANALYSIS

The swing plate A is idealized as shown in fig 2 as a unit width beam loaded at a number of points by different sized particles. Each row of uniformly sized particles is idealized as one point load on the unit width model of the swing plate (Fig 3). Because of the interactive nature of this model, the failure of any row of particles permits redistribution of stresses within the beam (Jinxi *et al.,* 2006).

Rapidly growing rate of industry crushing machinery, a jaw or toggle crusher consists of a set of vertical jaws, one jaw being fixed and other being mount by pitman mechanism due which the crushing can be done in one stroke due small moment of the jaw plates. These two plates from a tape chute so that material can be crushed, as the plates its wearing rate is high hence high wear resistant material is used generally manganese still are used a heavy flywheels is used. The shaft connected to the flywheel helps us to move the jaw plates with the help of cam rotation. Probably most of the jaw plates are made of cast iron. The plate are helps us to reduce the shape of the blue metals. Before going too analysis first we need to study about the stones strength and yield point of the stone.

In this study point loading of cylinder (or Disc) are undertaken to model behaviour of irregular rock particles. Modelling irregular particle behaviour with that of cylinders can be shown to be appropriate by consideration of work presented by Hiramatsu and Oka. From the photo elastic studies of plate- loaded spheres and point-loaded cubes, prisms, and ellipsoids, they determined that the stresses produced in the plate and point-loaded spheres of identical diameter are equal. Thus the plate idealization may be replaced by the point load shown in fig. (4)

They also showed that point-load failure of a sphere was equal to that of a point –loaded ellipsoid. Therefore, ultimate point loads on spheres will be approximately equal to ultimate point loads on cylinders (or disc). For both the ellipsoids and the cylinders the excess volume outside the spherical dimensions does not change the circular failure surface parallel to the smallest dimension of the body. This circular failure surface for the sphere and cylinder is shown by the jagged lines on the two shapes in fig 4. Blake type jaw crusher, primary crushers in the mineral industry; attains maximum amplitude at the bottom of the crushing jaws as the swinging jaw is hinged at the top of the frame. These crushers are operated by and controlled by a pitman and a toggle. The feed opening is called gape and opening at the discharge end termed as the set (Jinxi *et al.,* 2006).

The Blake crushers may have single or double toggles. The toggle is used to guide the moving jaw. The retrieving motion of the jaw from its furthest end of travel is by springs for small crushers or by a pitman for larger crushers. During the reciprocating action, when the swinging jaw moves away from the fixed jaw the broken rock particles slip down and are again caught at the next movement of the pitman and are crushed again to even smaller size. This process continued till the particle sizes becomes smaller than set; the smallest opening at the bottom. For a smooth movement of the moving jaws, heavy flywheels are used. The size of a jaw crusher is usually expressed as gape x width. The dimension of the largest Blake-type jaw crusher in use is 1600 mm x 2514 mm with motor ratings of 250-300 kW. Crushers of this size are manufactured by Locomo, Nordberg (Metso) and others. The Metso crusher is the C 200 series having dimensions 1600 x 2000 mm. driven by 400 kW motors. Various sizes of jaw crushers are available, even a crusher size of 160 x 2150 mm (1650 mm is the width of the maximum opening at the top and the jaws are 2150 mm in long) are not uncommon. The maximum diameter of the feed is ranged in 80 to 85% of the width of the maximum opening. Such a heavy crusher (16540x 2150mm) crushes rock, mineral or ore varying from 22.5 cm to 30cm with a capacity ranging from 420 to 630 ton per hour. The motor rpm and power are around 90 and 187.5 kW respectively. The jaw and the sides of the unit are lined with replaceable wear resistant plate liners (Gupta Ashok and Yan, 2006).

The fixed jaw face is opposite the pitman face and is statically mounted. It is also covered with a manganese jaw die. Manganese liners which protect the frame from wear; these include the main jaw plates covering the frame opposite the moving jaw, the moving jaw, and the cheek plates which line the sides of the main frame within the crushing chamber. The bottom of the pitman is supported by a reflex-curved piece of metal called the toggle plate. It serves the purpose of allowing the bottom of the pitman to move up and down with 10 | P a g e the motion of the eccentric shaft as well as serve as a safety mechanism for the entire jaw. Should a piece of non-crushable material such as a steel loader tooth (sometimes called "tramp iron") enter the jaw and be larger than the closed side setting it can't be crushed nor pass through the jaw. In this case, the toggle plate will crush and prevent further damage (Khurmi and Gupta. 2005).

Due to its simple structure, easy maintainability jaw crushers are widely used for mining, mechanical and metallurgical industries. A lot of research work is going on over the world to improvise the performance of jaw crusher. The crushing mechanism is composed of series of single particle breakage. Once the particles are squeezed in the cavity and failed in tension stress, the resulting fragments move down before being crushed again. The movement of the swinging jaw is certainly a key factor to jaw crusher performance. In order to study the behaviour of the moving jaw plate; a kinematic analysis of the same is being presented in this chapter. The geometry of moving jaw results in the movement change, which has great effect on the crushing action and the particle breakage. At present, most of the research on the jaw plates wear is carried out from material science perspective on a microscopic level or to predict the jaw plates wear under the fine communition condition. They are limited in helping designing the jaw crusher in use. Now the online monitoring to the wear is difficult.

In this paper the movement of the moving jaw is described in detail and the breakage squeezing process is also analyzed. The breakage force is measured and the test result is analyzed with the particle breakage character taken into consideration. Based on the analysis of the moving jaw movement, the squeezing process and the crushing force distribution, the jaw plates wear on a macroscopic level is studied aiming to effectively predict the wear distribution on the jaw plates. The reciprocating jaw MN driven by the eccentric shaft AB does a kind of periodic plain swing movement. Due to the importance and the complexity of the moving jaw movement, it is necessary to describe it in detail. Jaw crusher can be considered as a four bar mechanism in which, link AN is the crank and OA is the fixed link. MN is the moving jaw and OM is the toggle bar. In the kinematic analysis we are intend to find out the displacement, velocity and acceleration of various points on the swinging jaw plate. We consider the plane of moving jaw as v-axis which makes an angle "α" with the global coordinate "y-axis". Similarly perpendicular to v-axis is u-axis which makes the same angle with x-axis of the global co-ordinate system. From a standard jaw crusher following data is taken: Length of AN =172 cm Length of MN =1085 cm

Length of OM =455 cm Co-ordinates of A (45.3, 815.7) He crank AN rotates from 0 to 360 anticlockwise. By designing the above mechanism in AUTO CAD 2007 for each 30 rotation of the crank we get the following angles made by the moving jaw with the y-axis (Jinxi *et al.,* 2006).

Breakage Analysis: Under compression as the energy intensity increases, there are three types of fracture mechanisms are observed. The particle fracture mechanism in jaw crusher chamber is the mixture of the cleavage and the abrasion. The abrasion fracture is caused with the localized too much energy input to the area directly under the loading points and the friction between the jaw plates and the particle. The induced tensile stress results in the cleavage fracture. The breakage process due to the point contact loading that occurs between the plates of a jaw crusher and a particle.

Crushing Process: The particles were compressed and fail in tensile stress before crushing. During that time the particle was crushed with help of crusher. But in actual practice these particles also undergo slipping motion between the jaw plates. It is due to the vertical movement of the swinging during the working cycle. Sometimes the particles also exhibit rolling motion that depends on the the geometry of the fed material and the crushing zone. As the sliding motion between the jaw plates and the particle has considerable affect on the jaw plates wear, the consequences due to sliding motion is studied here.

Squeezing and sliding are the two principal factors affecting the jaw plates wear? High manganese steel is widely used as the liner for moving jaw as it possesses excellent work hardening character. By scanning the worn jaw plates under the electron microscope, it is found that the sliding is the main factor to the jaw plates wear and the sufficient squeezing can even relieve the jaw plate wear. Squeezing plays the main role at the top of the jaw crusher as the sliding is small at this area, the wear in this zone is small. As we move down the crusher, the probability to slip increases and the wear becomes more serious. While moving along the length, at the middle lower part of the crusher, the ratio of the vertical distance to the horizontal stroke reaches the maximal value resulting maximum wear in this region. Very few particles come in contact with the edge parts, so the ware at the lower parts is considerably small. For the same jaw crusher, the slide between the particle and the moving jaw plate, is more compared to the moving jaw plate wand hence the wear is dominant in fixed jaw relative to its stationary counterpart (Gupta Ashok and Yan, 2006).

The swing jaw plate is type rectangular plate. Solution obtained by the application of classical theory of plate flexure is limited to simple types of plates with simple loading and boundary conditions. With the advent of the finite element method, the plate bending problems have received considerable attention. As a result of which, a large number of different plate bending element formulation have been made. Element types include eight-node hexahedrons, four-node tetrahedrons and ten-node tetrahedrons, but eight-node hexahedrons, which part and die designers call "bricks," lead to more reliable FEA solutions. There are many reasons why the eight-node hexahedral element produces more accurate results than other elements in the finite element analysis of real world models. The eight-node hexahedral element is linear (p = 1), with a linear strain variation displacement mode. Tetrahedral elements are also linear, but can have more discretization error because they have a constant strain. This element is a three dimensional element of the quadrilateral. It is observed that the sides can be considered as straight but its corner nodes take some arbitrary shape in space. As a result, the edges can be warped and hence the shape functions are tri-linear. A widely used 3-D element, 8-node hexahedron is the subject of example that goes with this jaw plate analysis. The element is the analogue of the eight-node hexahedral "brick" element along with coordinate system and node numbering (Gupta Ashok and Yan, 2006).

There is a major logical flaw in this claim: Most parts and products have complex geometries which require fine meshing to accurately resolve the geometry as a solid mesh. The mesh size is so small that the discretization error does not exceed what is required for engineering accuracy. Use of p elements and higher order h elements with mid-side nodes therefore offers no practical engineering benefit over use of eight-node hexahedrons. The physical system describing the design of a typical part or die often has a complex geometry, and building the software model is therefore an intricate process. A number of software programs now exist which automatically or semi-automatically build the mesh, in some cases, directly from the CAD design. Because the engineer typically goes through many design and analysis cycles before determining the optimal design, automatic mesh generators such as Algor's Hypergen and Hexagen have become popular. All other variables being equal, an automatic mesh generator is by definition more accurate, since it minimizes the element of human error in the transformation of a design to a solid finite element mesh. When determining which mesh generation software to use, the engineer must evaluate the type of finite element that will be the basis of the FEA model. Elements differ in many ways, but for analysis, the most significant items are the shape of the element and its "order of interpolation," which refers to the degree of the complete polynomial appearing in the element shape functions. There will be an order of polynomial for the element, termed the p. There is also a size for the element, termed the h. Size h is usually the diameter of the smallest circle (smallest sphere for a three-dimensional element) that encloses the element. Every element has a size h and an order p. FEA, therefore, provides approximate answers to a physical system. If u is the exact solution for the PDE, FEA will produce an approximation uh. The approximation uh will converge to the exact solution u of the mathematical model under certain conditions: when the mesh size (h) decreases to zero or when the element order (p) is increased to infinity. One cannot really compare the discretization error of a single eight-node hexahedral element and a single four-node tetrahedral element, since the solution cost is directly proportional to the number of nodes. A more appropriate comparison is between an eightnode hexahedron comprised of five tetrahedrons and a single eight-node hexahedron, which 46 was generated using Hypergen, Algor's automatic tetrahedral mesh generator. The five tetrahedrons will together have more discretization error than the eight-node "brick" because the five tetrahedrons cannot assume all the displacement fields handled by the eight-node element (http://www.sbmchina.com).

Solid Modelling 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 behoves to discuss the generic design of curves, surfaces and solids in that order. 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 modellers. Other usage of solid modellers 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 (Bharule Ajay Suresh, 2009).

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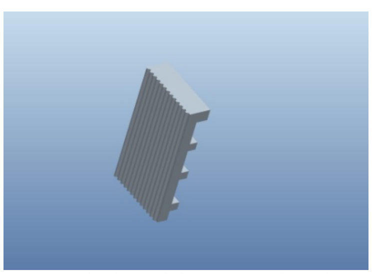

Fig 1. A numerical model of the swing plate

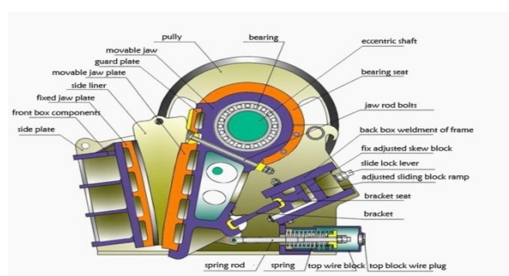

Fig 2. Idealized swing plate with beam loaded at various points.

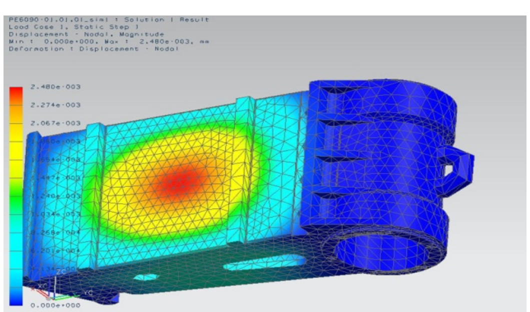

Fig 3. Idealized swing plate with uniform size particles.

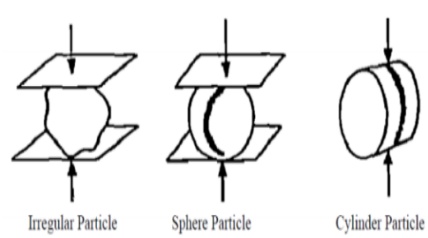

Fig 4. Idealized swing plate modification with point load.

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