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A Review Study on the Proposed Model for a Multilevel Horizontal Shaft Impact Crusher

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Abstract:

Crushers are one of the major size reduction equipment that is used in metallurgical, mechanical, and other similar industries. They exist in various sizes and capacities which range from 0.1 ton/hr. to 50 ton/hr. They can be classified based on the degree to which they can fragment the starting material and the way they apply forces. Based on the mechanism used crushers are basically of three types namely Cone crusher, Jaw crusher and Impact crusher. Impact crushers involve the use of impact rather than pressure to crush materials. Here the material is held within a cage, with openings of the desired size at the bottom, end or at sides to allow crushed material to escape through them. This type of crusher is generally used with soft materials like coal, seeds or soft metallic ores. The mechanism applied here is of Impact loading where the time of application of force is less than the natural frequency of vibration of the body. Since the hammers/blow bars are rotating at a very high speed, the time for which the particles come in contact with the hammers is very small, hence here impact loading is applied. The shaft is considered to be subjected to torsion and bending. The grinding screen is also designed for optimal output from the crusher A performance model is also considered for the horizontal shaft impact crusher so as to find out the relation between the feed, the crusher parameters and the output parameters.

Keywords **-** *Motor, Blowbars/Hammer, Side Liners, Chain curtain, Rubber Curtain, Rotor, Hydraulic Cylinder, Impact Apron, Bearings, Grizzly Feeder, Conveyor, Vibrating Pan Feeder .*

Introduction

The initial stage of size reduction of hard & large lumps of mine ore is to crush & reduce their size. Generally large scale crushing is done by mechanically operated equipments which are called crushers. The mechanism of crushers can be by applying pressure or impact load or both. On the basis of type of application of load the crushers can be classified. In the case of impact crushers there is an application of impact load through the hammers. A screen is required to get the required grain sized output. Here feed material is inserted through the hopper in the crusher chamber. The impact due to rotation of hammer is applied on the material. Due to the impact force of hammer as well as the crash between the material particles itself the crushing takes place easily & quickly. Crushers can be classified on the basis of the ratio of the reduction of size of the material.

A crusher can be considered as Primary, Secondary or fine crusher relying upon the size decrease variable.

a) Primary crusher – The crude material from mines is handled first in essential crushers. The info of these crushers is generally more extensive and the yield items are coarser in size. Illustration - Jaw crusher, Gyratory crusher, Impact Crushers, and so forth.

b) Secondary crusher- The smashed rocks from essential crusher are sent to these auxiliary crushers for further size lessening. Illustration:- diminishment gyratory crusher, Cone crusher, plate crushers and so forth.

c) Fine crushers- Fine crushers have moderately little openings and are utilized to smash the food material into more uniform and better item. Illustration - Gravity stamp.

Impact Crusher

Impact crushers work on the principle of impact rather than pressure for the crushing of the material. In this the material in kept in the casing with required sixed opening at the bottom or at the sides as per the requirement. The crushed material is allowed to escape the casing through a screen due to which only the required sized particles can move out of the chamber and the rest of the material continued to be crushed again.

Classification of impact crusher

Impact crushers can be classified as Horizontal shaft impact crushers (HSI) & Vertical shaft impact crushers (VSI) depending upon the positioning of the rotor shaft in which hammers are connected.

Horizontal shaft Impact crusher the breakage of the material is done by impact load by the hammers / blow bars placed horizontally which are fixed on the outer edge of the spinning rotor. The food material hits the hammer & due to the sudden force it breaks the material & the material is further broken by throw of it on the anvils/bars. The reduction ration we can achieve from this is 10:1 to 25:1 thus this is useful for extracted materials, sand gravels etc.

Vertical shaft impact crusher in these types of crushers a high speed rotor is used which is situated with its axis vertical. The vertical-shaft impact crusher can be considered a stone pump that can operate like a centrifugal pump. The material is fed Through the center of the rotor, where it is

augmented to high speeds before being cleared through openings in the rotor sideline. The material is crushed as it hits the outer body/ anvils at high speed and also due to the head on head collision action of rocks. It uses the velocity rather than the surface force as the active force to break the material fed. These have a comparative lower reduction ratio of 6:1 to 8:1 and hence are used generally for sand and gravels.

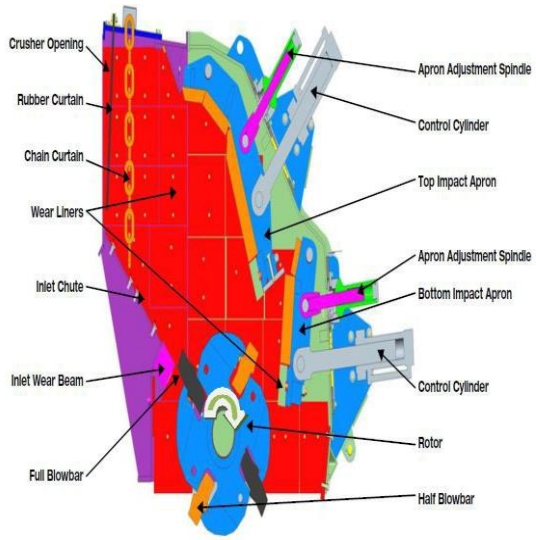
Horizontal Shaft Impact Crusher

The feed material is crushed by high impact of the hammer or blow bars on the material. Also the crushed material before leaving the chamber crashes with the material already available there in the casing. Due to which the particles created will be of fine grained & uniform size.

In an impact crusher the time consumed for the breakage will be less then that of jaw crushers or conical crushers. So here the nature and magnitude of forces as well as the energy dissipated due to impact breakage is different from that of the relative slow breaking that occurs due to compression or shear in other type of crushers.

Working Principle

In the impact crushing machine a rotor revolves in a fixed direction by the connection of it to the motor through v-belt. On this rotor a set of suspended plates is attached. The hammers or blow bars are attached within the slots of the plates in a specific interval. When the material enters into the crushing chamber through the hopper or charging hole, the hammers or blow bars strikes it to the impact apron & then it falls freely from there. During which it get impacted by other material moving from there. Thus material will be moved continuously & repeatedly in the chamber. The crushing chamber consists of rotor, impact plate/ anvils, hammers/ blow bars due to which the continuous impact loads will act & the material will break through its natural cracks & thus will be crushed in bulk in relatively less time. The arrangement of impact plate and hammer/blow bar can be adjusted according to practical requirement by adjusting the angle and distance of the impact anvils. The output easily can be varied by changing rotor speed, input feed rate & the screen configuration.
Any un-crushable material getting into the chamber can relieve the overload cylinders and permit the fabric to pass. The cylinders can then come to the pre-set crushing position. The pre-set gap is adjusted by turning the adjustment spindle while the burden of the apron is continued the cylinder (hydraulic assist).



Internal View of Horizontal shaft Crushing Machine Main Features of

Horizontal Shaft Impact Crusher

Crusher Body: Fabricated from plate and absolutely lined with standardized abrasion resistant liner plates. Hinged side entrance permits access to apron tips and rotor for gap measurements and examination. Complete pivoted segment opens using hydraulic arrangement to allow blow bar evacuation and substitution, apron and liner substitution or significant upkeep.

Rotor: Cast steel and fitted with four reversible and replaceable blow bars.

Orientation: Double line self adjusting circular roller bearing fitted every end of rotor.

Smocks: Cast steel apron with replaceable scraped spot safe wear plate on tip of base cover.

Drive: Direct through wedge belts with tensioning framework on the power pack.

Oil: Rotor orientation are lubed and fitted with internal and external maze seals.

Blowbars: Standard blowbar is of martensitic steel. Options are available in high chrome and ceramic.

Apron Conveyor: This contains overlapping beaded metal apron for carrying non granular hot or abrasive materials, horizontally or at inclinations set by economy and allowed by flowability.

Vibratory feeders: This vibrates at relatively high frequency and small amplitude.

Vibrating screens: Mechanically vibrated moving screens save house and weight, and care for very little power as a result of the screening surface is also motivated by moving, gyrating or rhythmical movement of little amplitude.

Hammer Crusher: In hammer crushers the hammers ar connected to the rotor via pivots thus that they ar deflected once they hit sturdy and significantly massive stones. In most cases the crushing zone is encircled by grate bars so fragments that ar larger than the openings of the grating ar preserved within the crushing zone. These crushers ar less complicated than jaw and cone crushers and units with equivalent turnout ar abundant smaller in size.

Design Parameters:

The most important design parameters included in this design are

1. Compact machine

2. Lesser space requirement

3. Reduction of principal cost

4. Safety concerns

5. Multiple reduction ratios

6. Increased production rate

Some factors which should also be considered for the unaffected performance of the crusher are,

Controlled feed rate

Humidity in the feed material.

Regulated flow of the material inside the chamber.

Extreme hardness of the feed material.

Motor size & configurations.

Capacity of the crusher as well as the conveyer.

Crusher's functioning at less speed of rotation then designed.

Presently the impact crushing machines used in the industries are with single crushing chamber with a big assembly of hammers & rotors, which is connected to a motor as per the requirement for size reduction ratio & capacity. Hammer used in these machines are of manganese steel. The space used for the machine is very large. But if there is not enough space or a small setup is to be done then a small & compact machine is required, also power can used as per the requirement of the output. When

Validating the new concept of multilevel horizontal shaft

Impact crusher two types of analysis are required:

1) Static analysis
2) Dynamic analysis

With the help of above knowledge a guideline for optimized multilevel horizontal crusher can be provided in reference to:

1) Overall space reduction
2) Output size variations can be possible
3) Higher production rate
4) Lesser power can also be used.
5) Higher safety
6) Cost reduction

To understand the working & model of the new concept Autodesk Inventor is used. Also the model is analyzed using stress analysis & dynamic analysis using Autodesk inventor & Altair hyper mesh.

Advantages:

1. Hammers have four crushing positions to maintain a more const. gradation and greater top size control.
2. Less capital outlay.
3. High degree of product size control.
4. Long life of wear components.
5. Reducing loading and unloading time
6. Improved handling efficiency
7. Improved operative safety

Presently running machines require large ground area for installation also the power consumption for conveying the material for loading & unloading is very high as well as they need to give a particular reduction ratio in a single stage. This further reduces the life of the components. In this case if a different sized output is required then another setup is needed to be introduced. This involves high cost & bigger area for installation. Conveyers are also required to convey the output of one machine to the other machine as an input. These facts if are combine together generates a new idea of compacting the three different size reduction machines together into one, which can be used for small plants. In this the output of first chamber is directly fed as an input of the second chamber. So the conveyer will not be needed. As well as if large sized output is required, it can be obtained using first chamber working only. Rest of the two can be kept idle. In this type of machine higher reduction rate can be achieved in three stages which reduces load on single hammer. So the life of the hammer increases considerably.

OBJECTIVES AND METHODOLOGY

Observe the natural phenomena in question as they occur and if possible quantify the observations:

Primary crushing equipment used in the aggregate industry is inefficient and over-designed. The proper selection and optimization of primary crushing equipment should be based on the energy required for rock breakage, the desired product size, and the desired production capacity, all of which are dependent upon a proper physical characterization of the rock being crushed.

Objectives:-

The objective here is to design various components of an Impact crusher like multi-level drive mechanism, shaft, rotor, multi-level hammers, casing, and various shape sieve at discharge level and discharge mechanism which will be useful in minimizing weight, cost and maximizing the capacity and also analyze the equipment for proper and required output.

Methodology:-

For designing & visualizing the machine Autodesk Inventor V-2014 and for Stress/Impact Analysis Altair hyper mesh is used as a tool.

Autodesk Inventor
Autodesk Inventor is a CAD modeling software, in which individual parts of any assembly, can be designed & visualized. Further these parts can be assembled together y and Manufacturing Drawing/Production Ready Drawing can be generated. Mechanical or Physical behavior of any component or assembly by applying material and by doing dynamic simulation can be checked. Here Autodesk Inventor Professional 2014 is used to design Multi Level Horizontal Shaft Impact Crusher.

Altair
Altair is a CAE software in which Pre and Post Analysis can be done. In this a mesh is to be generated then there are options for creating element (1d, 2d and 3d) as per requirement, connectors are also required to be added. Different user profiles and options for exporting any analysis to any other analysis software are present in this software. Altair is the user friendly CAE Software and it is easy to use/learn. Altair Hypermesh V11.0 is used here for Meshing and optimization

Terminology

Von Mises Stress:
The von Mises yield basis proposes that the yielding of materials starts when the second deviatoric stress invariant achieves a critical value. It is part of a plasticity theory that applies best to flexible materials, for example, metals. Preceding yield, material reaction is assumed to be elastic.

1st Principal Stress:
The 1st principal stress gives the estimation of stress that is normal to the plane in which the shear stress is zero. The first principal stress offers you some assistance with understanding the most extreme elastic stress affected in the part because of the stacking conditions

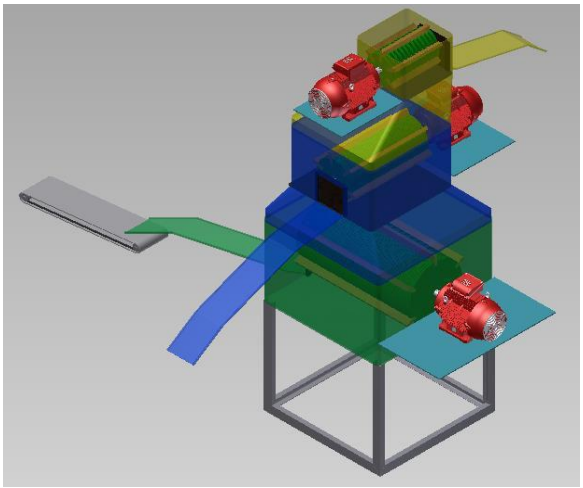
3rd Principal Stress:
The 3rd principal stress acts normal to the plane in which shear stress is zero. It offers you some assistance with understanding the most extreme compressive stress actuated in the part because of the loading conditions." In substance for one point there is a plane where the shear stress is zero. The 3 principal stresses define the stress in this point respect the plane and his 3 direction

Displacement:
Displacement is the contrast between the last and beginning position of a point. The genuine way secured to achieve the last position is unimportant. It can essentially be characterized as the length of the most brief way between the last point and beginning purpose of a body.

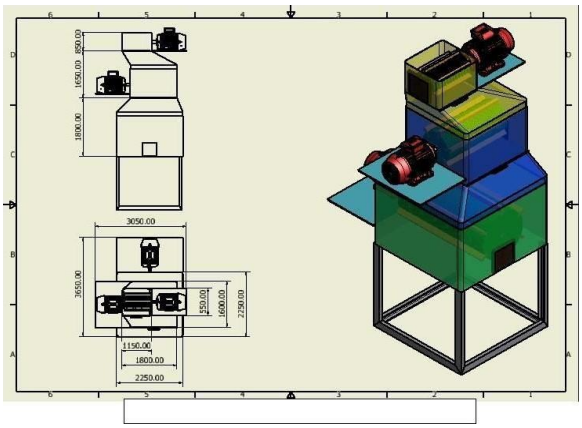
Factor of Safety:
Factor of safety (FoS), also known as (and used

interchangeably with) safety factor (SF), is a term describing the capacity of a system beyond the expected loads or actual loads. Essentially, the factor of safety is how much stronger the system is than it usually needs to be for an intended load. Safety factors are often calculated using detailed analysis because comprehensive testing is impractical on many projects, such as bridges and buildings, but the structure's ability to carry load must be determined to a reasonable accuracy.

Proposed Model:-



Proposed Model View

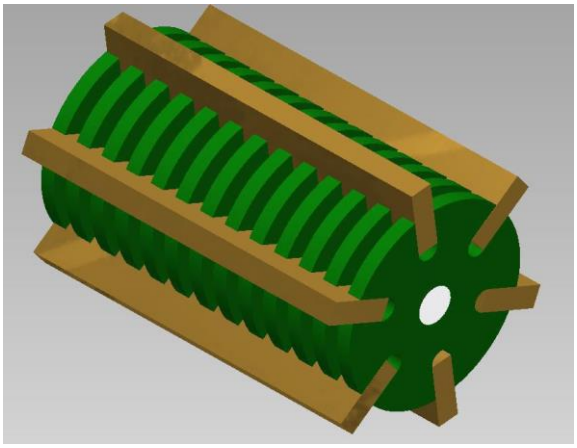


DESIGN

Hammer / Blow bars:
Design of Hammer / Blow bars the hammers or the blow bars area unit subject to shear force at the purpose of fixation, centrifugal force because of rotation, bending force as a result of putting of the fabric. once a sudden impact force is applied by the blow bars which moves the input feed placing further.

The result of the impact loading differs from the static loading because in case of static load the stress developed are less and distributed but in case of impact loading a sudden load is applied on a small area which produces more stresses.

Hammers or blow bars is created exploitation totally different sections like, I section, T section, S section, cylindrical bars, rectangular bars etc.. The shape of the hammers decides the impacting capacity as well as the strength of the crusher. Hammers are mounted of the rotor plates or rotor drum using lock pin mechanism.

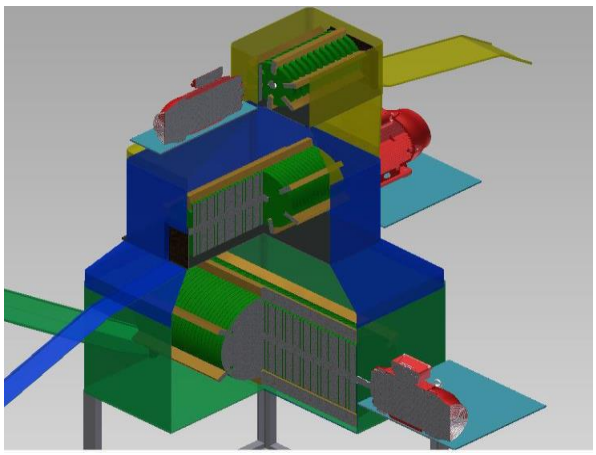


Proposed Model Hammer Assembly View

Let us consider a hammer or the blow bar made of Manganese steel and having a rectangular cross section.

Casing:

The crusher case can be made up of welded steel construction and built in three or more sections. The lower half is made up of one piece and upper half is made up of two sections. sustain consumption area is in the upper half and is darted to the lower half bringing about an enduring dust sort association between the food and crusher admission. Whatever is left of the top segment is pivoted for access to inside of the crusher for evolving hammers, hammer sticks and screens. All the mating surfaces are developed for an exact, clean tight fit.

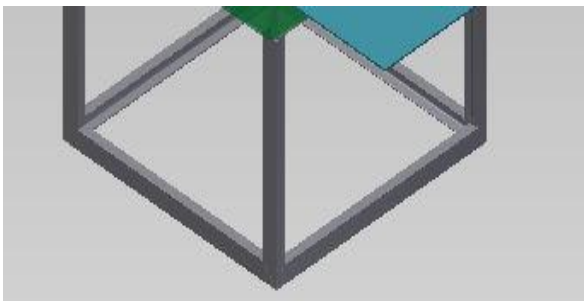


Proposed Model Cross Sectional View

Single hook entryway is accommodated simple upkeep and cleaning and a Gasket entryway is accommodated tidy tight operation. The packaging of the crusher does not encounters and bigger powers but rather still they ought to have the capacity to endure grating powers following up on it. The effect bars are connected to the packaging through a system which might help in changing the point of effect on the bar , by moving or tilting the bar.

Frame & structure:
The legs of the complete machine are made by the hollow pipe of rectangular cross section & the other parts

are made by angles. The pipes are joined such that the structure should be supported thoroughly. This further distributes the weight of the machine uniformly. Also the vibrations are reduced considerably by this type of support.



Proposed Model support frame view

Motor:
Motors are chosen as per the feed rate required. At the primary level crushing less force is needed as the feed size is bigger considerably. But for the second & third stages comparatively higher force & speed is required. The selection of motors is done taking this fact into consideration. The motor for the first stage is taken of less speed & power. The other two motors are of relatively higher power & speed. The placement of the motor for the first & second stage is also taken into consideration. Because installation of motor should be done properly for the efficient working of it & the base should also be strong enough to sustain the weight of the motor with the vibrations during crushing. Another fact which should be taken care of is the direction of the outflow of the material should not interfere with the motor working & placement. Space utilization should be maximum & without any inference of parts placement & working. Motor is connected to the rotor through the v-belt for power transmission.

The reference taken here are from the company Trio Mineral Processing Private Limited. TRIO offers two configurations of impact crushers: the APP Series for high-production primary and recycling applications, and the APS Series for high production secondary or recycling applications. All models are available as bare units, and as stationary and portable

Configurations. The machines are all equipped with solid rotors in either 2 , 3 or 4 row blow bar configurations. These extra-heavy duty solid rotor units provide the mass and strength necessary to crush feed material up to 36**”**. Comparisons with other brands will show that TRIO crushers are among the most heavy-duty machines available.

RESULT

This model is able to predict the product size distribution with reasonable accuracy even when important variations in both the rotor velocity and feed were imposed.

As a preliminary investigation to model the performance of the Breaking for a number of cases of particular interest. The results of one of these tests were plotted in Figures They show the relative speed and acceleration of the feed material and the normal and frictional forces acting on a particle of units mass, as distributed along the wear part length. Also given are the absolute exit speed, the impeller power and the anvil angle required for normal impact.

Three factors were discussed to confirm the accuracy of the mechanism indicated. Firstly, no downstream depression was formed on the wear part when, as for certain feed materials and earlier impeller designs, the upstream depression was similar in profile to a full sine wave. The prediction is that
separation and detachment do not occur for such an upstream depression. Secondly, each downstream depression had a steeper downstream face than upstream face. Such a depression would be formed if material were to impact the surface at a shallow angle. Thirdly, smooth, ripple-like surface profiles, similar to those of the worn wear parts, have been observed on exit chutes of screens clearly carrying only non-airborne material.

CONCLUSION AND FUTURE WORK

This section sums up the results and highlights the realizations of the follow a line of investigation work carried out in this thesis . This is pursued by few plans for future work. The results offered in this thesis have been published by the author in different international journals and conferences

Conclusion
In this work, the Rotor hammers were checked for their bending and shear stress and were found within the allowable limits in the maximum load condition. The rotor plates were also checked for shear stress and were found safe. The anvils were checked for bending and shearing strengths and were found under the limits of failures. The rotor shafts was checked for torsion and bending and was found safe. The Driving mechanism of rotors was designed in such a way that the V belt was safe and was able to transmit required

speed to the rotors from the motor. An appropriate

Casing structure is also proposed for **housing the crushers’ assembly.**

The conclusions are as follows:

It saves lot of space for installation.

It will reduce the installation capital.

Only one labor needed to work in this machine, so it will reduce labor energy and salary also.

Suggestions for Future Work

The following are some of the prospects for future work:
The moveable and more compact machine can be designed.
New techniques can be employed in future to increase the production.
By changing some material or by using some alloys we can easily reduce the manufacturing cost.
More feasible design can be made of Blowbars for crushing material in different shapes .
M.B.D., Drop, N.V.H. analysis can be employed to development new designs.

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