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Dynamic Analysis of Double Toggle Jaw Crusher Using Pro-Mechanica

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ABSTRACT

Pro/Engineer is a parametric feature-based design of 3D software and capable to solve the motion dynamics of the motion, and the reactions at the constraints of the mechanisms can be used as the inputs for any Finite element program to understand the behaviour of stresses and deformations of the individual component of the machine to estimate the working life of the machine elements designed for the application. Parametric modeling functions. To reduce the development cycle and improve the design quality of jaw crusher, this paper takes full advantage of the Function module of the Pro/Engineer platform to make model simulation and dynamic analysis on the actual jaw crusher mechanism, and provided the updated path for the design and manufacture of Jaw Crusher.

Keywords: **Jaw Crusher, Pro/Engineer, Model Simulation, Dynamic Analysis**

I. INTRODUCTION

Jaw Crusher is important detritus equipment in the production processing, because of its simple structure, reliability, easy to manufacture and maintenance, adaptability, etc., which are widely used in the crushing work of variety of ores and bulk materials in mining, smelting, building material, highway, railway, water conservancy and chemical and other industries.
The schematic diagram of jaw crusher is shown in Fig. 1

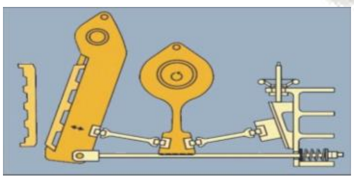

Figure 1 Double Toggle Jaw Crusher Schematic Diagram

In the traditional design process of mechanical products, hand drawing or computer drawing 2D graphical is often used to express the mechanical parts and assembly relationships, this approach is difficult to directly reflect the motion relations and the relative position of the various components during the operation, and also can not directly determine its motion is reasonable, whether there is interference between the various parts and other issues. In this paper, the 3D design software Pro/E is used to carry out virtual assembly, motion simulation and dynamic analysis for the jaw crusher mechanism.

II.ESTABLISHMENTS OF 3D MODEL JAW CRUSHERS

According to the actual shapes and sizes of jaw crusher it should firstly abstract the movement vice between the components and define 3D solid model before the simulation. Pro/E platform which contains some auxiliary Datum plane, stretching chamfering, constraints and other characteristics, is widely used to build the models, such as static jaw box, connecting rods, pins, crank and crank frame and other parts, which are abstracted in accordance with the actual parameters. The paintings of these parts are simple, so they are no longer specifically introduced.

A. Modeling of Eccentric shaft, Swing Jaw and Pitman assembly

The Phenomenon of Crushing is done due to the force produced due to eccentricity of the shaft providing the oscillating motion of the swing jaw. The modeling of the frame with the eccentric shaft of 10 mm eccentricity is modeled along with the swing jaw to produce the desired motion of the machine in Pro-e as shown in the Fig. 2 below.

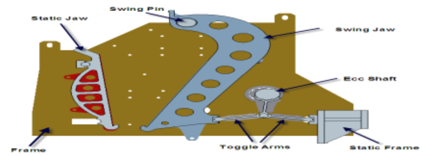

Figure 2 Jaw Crusher Model Assemblies

As per the Principle, the stone is crushed in between the static jaw and the swinging jaw. The swing jaw swings on the swing pin assembled with bush while the motion of swing is provided by the eccentric shaft rotating in bearings assembled on the frame. The eccentric shaft provides the downward motion to the toggle arm pin and since one side toggle arm is fixed with the static frame the other side toggle arm pushes the swing jaw to create the swinging motion required for crushing.

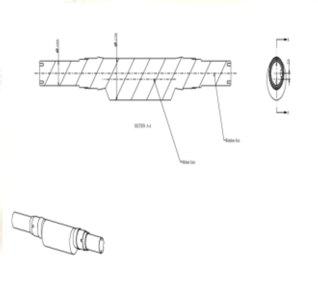

Figure 3 Eccentric Shaft drawing

The Fig. 3 above shows the eccentricity value of 25 mm, for the shaft to provide the eccentric motion to the swing Jaw. The 3D image of the flywheel is given in the Fig. 4 below, which is rotated via belt connected to the pulley of the motor shaft. The mass of the flywheel is directly proportional to the inertia developed for the machine.

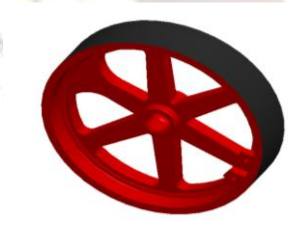

Figure 4 3D Model of Flywheel Used in Crusher

B. Development of Mechanism for the Machine

To develop the mechanism to get the results of the forces acting on the swing jaw to crush the stone we make an assembly with joints to study the motion of the machine. We will assemble the parts one by one with the joints to simulate the mechanism. Fig. 5 shows the assembly constraint of Pin joint of eccentric shaft with the ground part.

Figure 5 Eccentric Shaft Pin Joint Assembly

The axis defines the rotation about the axis while the plane defines the restriction of translation for the joints. Machine pulley is attached to the flywheel. Along with Cam and follower the axis of the Eccentric shaft is made cylindrical connection to the axis of the eccentric shaft. But since the bottom of the pitman arm has to be moved only in single plane which is the plane of ground so the planner connection is placed along with the ground to the pitman shaft to accomplish the desired motion of the pitman arm in Pro-e mechanism module. The Fig. 6 below shows the assembly of toggle pin, the toggle pin is assembled with the planer constraint of the ground part and along the axis constraint of the pitman arm, so that the toggle pin follows the motion of the pitman arm and remains static at its plane also as is assembled with the ground plane.

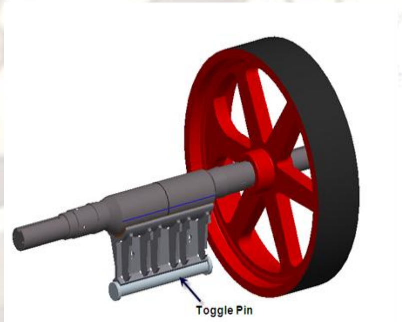

Figure 6 Toggle Pin Assembly

If shaft rotates by say 40 deg the flywheel assembled to the shaft will rotate the same rotation angle i.e. of 40 deg.

This is further can be understood by the parent child relationship in mechanisms similar to that in the standard mode of proe.The reaction of the toggle pin is transferred at an inclination to the Swing Jaw. Solving statics we will be able to get the results of force in the direction of swing jaw based on which we will analyse the swing jaw steel casting strength. This spring is taken with the consideration to get the results of dynamic forces acting on the spring. The maximum of these dynamic forces will then be taken to simulate the strength of the swing jaw in any of the FEM software. All the connections are shown in the mechanism window which is taken to define the mechanism along with the application of spring which is done in mechanism itself and not in standard module of pro-e.

The definition window of compression spring is shown in the next Fig. 7 below.

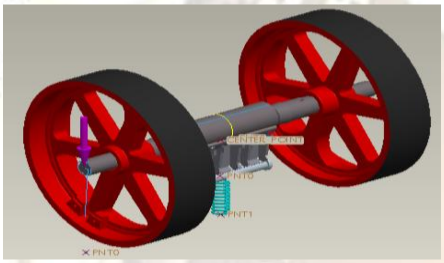

Figure 7 Spring & Toggle Pin Attachment

The stiffness and the Diameter of the spring is what are required to be given as the input parameter to analyse the system. Since the motion is defined and stiffness of the spring is known, the displacement of the spring will result in the force which can be broken down into forces in different directions to analyse the swing jaw. The motion of the system i.e. the kinematic study of the system is completed at this stage, with the definition of joints working in the correct form, as desired.

C. Dynamics Analysis:

Dynamic analysis is a time dependent analysis, which is done for the forces which are time based like the cyclic forces. Each time cyclic forces are heard off, the dependence of the Modified Goodman theory is brought into picture to define the term fatigue failure of the machine component of the system under analysis. To get the results of the maximum instant force which is acting on the system the dynamic analysis of the system is done here the machine flywheels are run on 325 rpm. The velocity as the input criteria in our case the Inertia forces play's the most important role in the working principle of the machine. The Point graph is plotted to study the nature of motion while the dynamic analysis is performed to study the nature of forces resulting from the system which might be directly affecting the system key role here it is crushing of the stone. The properties which affect the dynamic analysis can be best understood by the window shown below for the input parameters of the system .The first input which we have from the running of the machine is the rpm of the machine for performing the dynamic analysis. The Input velocity in deg/sec is specified as 1950.

Calculated as follows.

325 M of a machine results in 325*360 deg per minute of velocity resulting in 1950 deg/sec of velocity for the machine.

III.DYNAMIC RESULTS FOR POSITION &VELOCITY

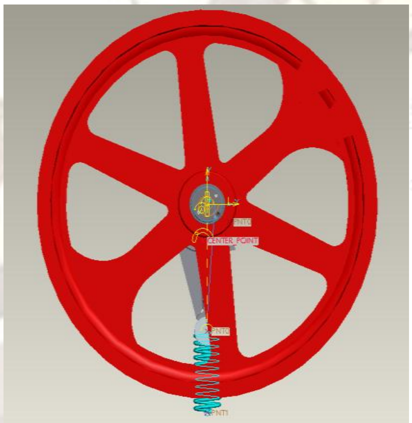

Figure 8 Positional Analysis Assembly

In order to facilitate the analysis, as shown in above Fig. 8 ''O'' that on the flywheel center point is selected as an analysis point. Click the menu command "analysis /measurement" and define the position and velocity of point ''O'' is as the output images are shown in Fig. 9 and Fig. 10 analysis object. The position of highlighted centre point is plotted as the first result for the dynamic system given below Fig. 9

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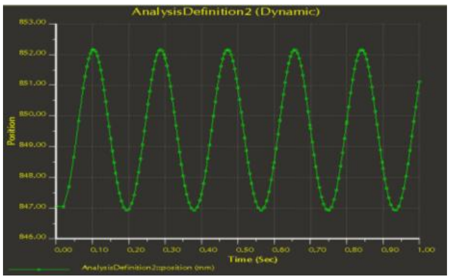

Figure 9 The output image of the location of the point 'O'

The position of the center point varies from 847 mm to 852 mm, which is the total displacement which is achieved by the compression of the spring.

Velocity plot at each time second for the motion is plotted as the second curve for the analysis given Fig. 10

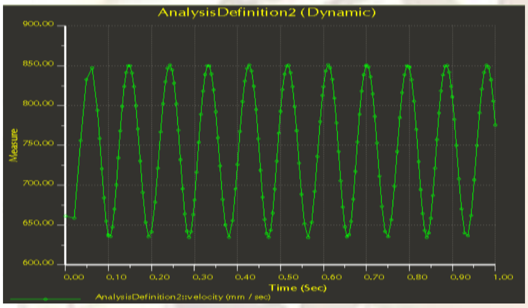

Fig. 10 The output image of the velocity of the point 'O'

In addition, in this module, many types, such as the reaction force, impulse, and static load of different positions can also be defined to carry out static analysis, kinematics analysis and dynamic analysis. It has very important significance for the life of the specific parts. Specific process will be no longer introduced.

IV. CONCLUSION

Through the application Pro/E platform on the jaw crusher, not only the result of the assembly can be expressed in the form of animation, but also can be output in the form of parameters. Thus, it is easy to know that whether to produce interference between the parts. It makes the original motion relationships in the 2D view are difficult to be expressed become intuitive and easy to modify. At the same time, the development cycle of the jaw Crusher can be shortened and the design process of the mechanism can be simplified. And it is an important means of the modern product design.

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