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Research on VR Simulation Technology of Round Chemical Stacker

Chen Hu

Quanzhou Huaguang College, Fujian, 362001 China
54367667@qq.com

In order to apply the virtual prototyping technology to the research and development of the stacking machine simulation system, the stacking device of the stacker is taken as the research object, and the virtual prototype model of the main components of the stacker is established. The structure of the overall scheme of the stacker is determined. The stacking device is modeled and the virtual prototype model of the stacker is established. On the basis of mixing theory of material yard, the mathematical model of material pile is set up. The mathematic model is combined with the stacking process parameters to determine the motion of the stacker. Through the dynamic simulation of the typical working conditions of the stacking device, the key technical parameters such as the variation range of the thrust of the pitch cylinder and the force of the relevant hinge are obtained. It provides a reference for the selection of relevant parts. The results show that the virtual prototype simulation model of the stacking device is correct, and the reclaiming device is stable in the working process. Therefore, the virtual prototype technology is applied in the research and development of circular material stacker reclaimer, and the data processing results are more intuitive. The processability is improved and costs are reduced.

1. Introduction

At present, stacker reclaimer is widely used in basic industries, such as power plants, ports, cement plants and so on (Zhang et al., 2014). As a high productivity equipment for bulk material treatment, it has attracted more and more attention all over the world. There are two kinds of closed yard at home and abroad (Jing et al., 2014): circle and rectangle. However, under the same conditions, the circular stacker reclaimer has a relatively small footprint (Xianghua et, al., 2013) while meeting the requirements of material storage. Therefore, it has been widely used in practical production. The circular material stacker reclaimer is a stacker and Reclaimer equipment, which is composed of stacker and reclaimer for the round material field. Both stacker and reclaimer can move at 360° on a circular orbit with the column as the center (Paul and Chunliang, 2012). It is the structure of totally enclosed spherical grid steel. The research and development of traditional mechanical products generally need to design samples, establish physical prototype and test procedures, which often waste a lot of manpower, material and financial resources (Peng et al., 2013). The application of computer aided design technology provides great help to the development and design of circular stacker reclaimer. Virtual prototype technology has also shown a series of advantages in the development of circular material stacker reclaimer (Kwangseok et al., 2015). For example, convenient and efficient product development reduces the cost of research and development, and the data processing results are more intuitive and vivid. By simulating the manufacturing process, the machining performance is improved, and the cost is reduced (Nilsson et al., 2015).

2. Establishment of virtual prototype for stacker reclaimer

2.1 Data exchange between Pro/ENGINEER and ADAMS

ADAMS is a software developed by MSC company, which can be used to analyze virtual prototype of mechanical system in interactive graphic environment (Park et al., 2014). The data transmission mode between Pro/ENGINEER and ADAMS is as follows. The seamless connection between Pro/ENGINEER and

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ADAMS is realized by using MECHANISM/Pro special module. The data of the two software can be shared directly. The use of the module allows users to directly design and impose constraints in a familiar Pro/ENGINEER environment, and then directly import ADAMS for dynamic analysis of CAD (Yu et al., 2016). This method is to import the built 3D model directly. The data transmission is fast and the model precision is high, which improves the efficiency of design and analysis (Yang et al., 2014). The data exchange between Pro / ENGINEER and ADAMS is shown in Figure 1.

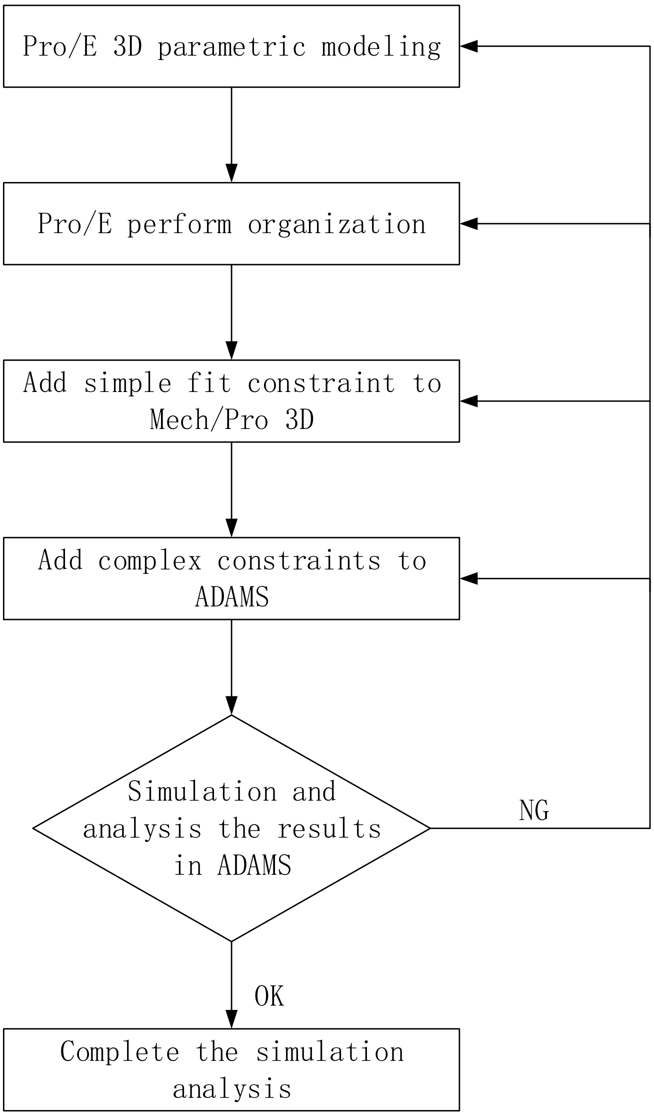
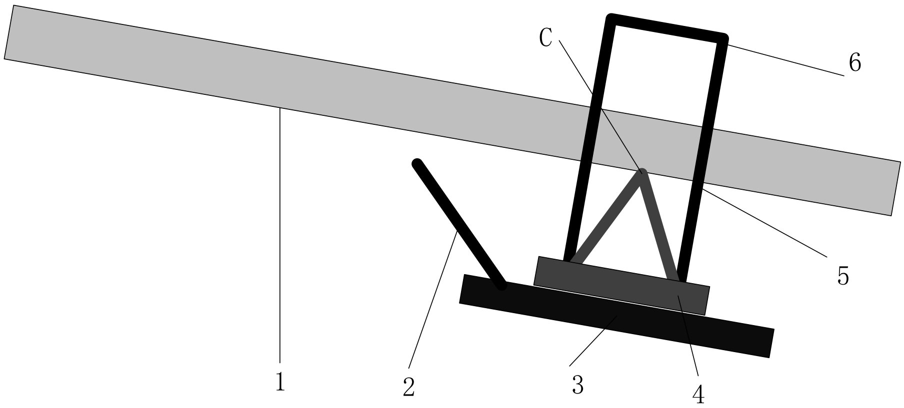


Figure 1: Pro/ENGINEER and ADAMS collaborative simulation steps

2.2 Establishment of virtual prototype for stacker

The establishment of virtual prototyping model needs to simplify the model and reduce the number of model building under the condition of meeting the requirements (Vianen et al., 2016). In the initial simulation analysis, the details of the geometry of the component do not have to be consistent with the actual situation. The stacking device is mainly composed of stacking arm, slewing support platform, rotary mechanism and pitching mechanism (Gongbo et al., 2014). The composition of the various parts is very complex. The detailed structural model of the stacking device is not only time-consuming, but also makes it difficult to analyze. In order to analyze the motion characteristics of the stacker, it is necessary to model the stacking device with conditions permitting and to retain the main moving members (Jean et al., 2013). All components are rigid, and all friction is zero. The cantilever beam is connected with the support frame by the hinge at the C point, and the rotary pair is used. The default slewing bearing is fixed on the ground. The rotary pair is used between the oil cylinder and the cantilever beam and the lower slewing support. The cylinder piston rod is connected with the cylinder by cylinder pairs (Xiu-Qin et al., 2012). The rotary pinion is connected with the lower slewing bearing through the gear pair (Badr et al., 2016). The virtual prototyping of stacking device is shown in Figure 2.



1. Pile arms, 2. Pitching cylinder, 3. Below rotation support, 4. Rotary pinion, 5. Column, 6. Up rotation support

Figure 2: Virtual prototyping of stacking device

2.3 Kinematical analysis of stacker

The stacking operation is accomplished by the boom on the belt conveyor. It runs around the center of a stacker. The stacking interval formed by the stacking operation is approximately an arc with the length of L. The arc is located on the stack centerline (Oliver et al., 2017). Once the stacking arm is operated back and forth, the number of stacks will be increased by two layers. When the stacking boom completes a round trip operation, it advances a length △L. The above is a cycle of operations. By repeating this cycle, a single-shaped pile is formed in the yard. In case of stacking operation, the cloth operation cannot be interrupted and must be kept stable. The rotational speed of the stacker arm cannot be changed, and the stacking arm reaches zero at the end of the stacker (Teusvan et al., 2014). After theoretical calculation, the stacking speed Vd and the pitch line velocity Vf are expressed by formula (1) and formula (2):

$$V_d = \frac{nQ_d}{15\gamma(R_o - R_i)^2 tg\rho} \tag{1}$$

$$\begin{aligned} X &\in \left[-\frac{(R_O - R_i)^2}{16L}, \frac{(R_O - R_i)^2}{16L}\right], V_f = V_d tg\rho \\ X &\in \left[\frac{(R_O - R_i)^2}{16L}, L\right], V_f = \frac{(R_O - R_i)tg\rho}{4\sqrt{LX}} V_d \end{aligned} \tag{2}$$

Among them, n is the number of stacking layers. Qd is the stacking capacity, and the unit is t/h. γ is the volume density, and the unit is t/m³. ρ is the stacking area of pile bottom half tail cone. L is the turning arc length in the stacking area. X is the stacking point.

3. Dynamic simulation of stacking device

3.1 Setting of simulation parameters

Suppose that the stacking layer is 500, and 800 tons of material can be piled up every hour. The density of the accumulated material is 1.5 tons per cubic meter, and the natural repose angle is 38°. After calculation, the speed of return point of the discharge point is 17.931m / min. The length of the stacking center of the stacking device to the blanking point is 21.15 m. Thus, the rotational angular velocity of the stacker is Vstack=0.59rad/min. Function(time)=0.5925d, time is the rotational displacement of the Displacement function. The graph is the graph of the function (Tomas et al., 2014). Assuming that the value of the stack area is 100, the value of the arc length L of the stacking zone is 40.1 m, and the time for completing a downhill operation is 150 s. The values of the pitch velocity of the unloading arm of the unloading point can be obtained by substituting the above-mentioned values into the formula (2). STEP (time, 0,0,15,6,123.21) + STEP (time, 15,6,0,150,1127.77) is the cylinder piston motion drive function (Kwangseok et al., 2016). The motion control of the pitch cylinder piston rod is realized by STEP function.

3.2 Simulation results analysis

Figure 3 is the no-load conditions under the pitch cylinder thrust curve and the cylinder pitch angle curve. Through the analysis of the curve, when the stacker arm is at the highest point, the cylinder is not stressed. When the stacker arm starts to move downward, the force of the cylinder has a direct relationship with pitch angle. The greater the angle, the greater the pressure on the cylinder. When the pitch angle reaches the minimum, the thrust of the cylinder reaches a maximum of 1.4×105N.

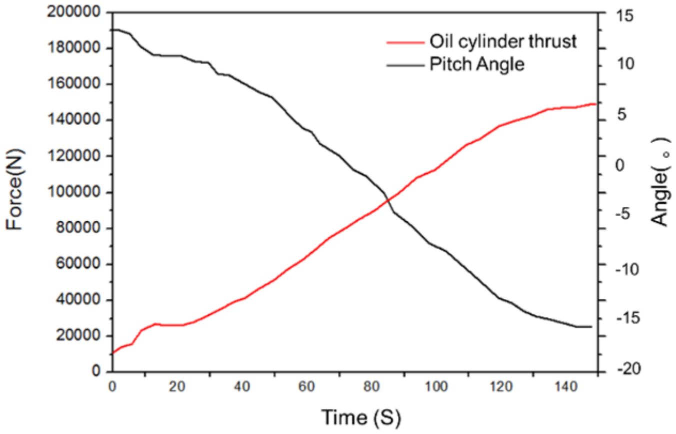


Figure 3: Pressure curve and angle of pitch cylinder under no - load condition

In the absence of external load, the load condition of the hinge position on the rotary support platform and the change of the pitch angle during the operation of the cylinder are shown in Figure 4. Through the analysis of the curve, it can be seen that the load of each part of the device is not maximized when the load of all the parts is changed during the movement of the stacker. In the C hinge position, the vertical force is much greater than the horizontal force, so the stacking device in the horizontal direction by the impact is relatively small.

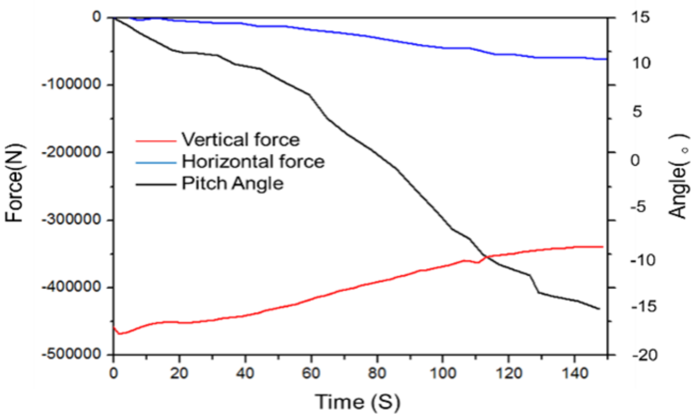


Figure 4: Load curve and pitch angle variation curve of hinge C of rotary support platform under no - load condition

By changing the centroid position of the stacking arm model and modifying the relevant parameters, a simulated simulation analysis is carried out by applying a load corresponding to the actual stacking device.

The simulation curve is shown in Figure 5. By analyzing the curve, it can be concluded that when the stacker starts running, the pressure of the cylinder is 80000N. It is much larger than the no-load conditions of the cylinder force. However, during the movement of the stacking arm, the change trend of the cylinder force is consistent with that under no load. The maximum thrust is achieved when the stacker reaches the lowest point. The maximum value is 2.2x105N. When designing the cylinder, this value is very helpful in the selection of the cylinder.

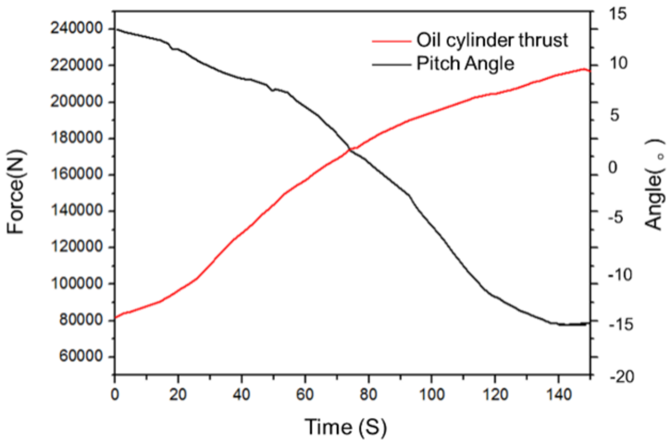


Figure 5: Pressure curve and pitch angle curve of pitch cylinder under load condition

Under the load condition, the force on the turning point of the slewing supporting platform and the pitching angle change of the cylinder during operation are shown in Figure 6. According to the analysis of the simulation curve, it can be seen that under the load, the difference between the force at the hinge point of the slewing bearing platform and the no-load value is in line with the actual work. During the downward movement of the stacker, the force change of the C hinge point is the same, and the stacker arm is stable.

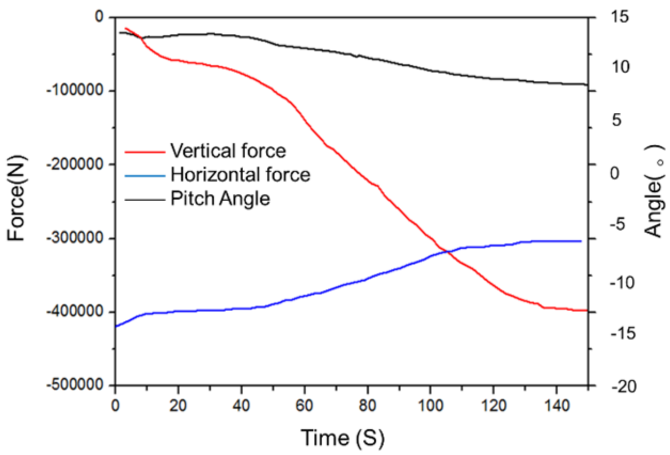


Figure 6: Load curve and pitch angle curve of hinge C of rotary support platform under load condition

4. Conclusions

In this paper, according to the structural design requirements of the circular material field stacker reclaimer, the parameters are designed. Three-dimensional modeling of the important components of the circular yard stacker is carried out by using Pro / ENGINEER parametric design software. ADAMS analysis software is combined with Pro / ENGINEER design software. The virtual prototype of the important parts of the circular material stacker reclaimer is established. Through the analysis of the stacking process of the pre-stacking yard of the round chemical stacker reclaimer, the mathematical model of the stacking area is established. Combined with the mathematical model of the stacker area and the stacking process parameters, the movement of the stacker is analyzed. According to the simulation analysis of the virtual prototype, the change of the oil cylinder in the pitching process of the stacker and the change trend of the force on the hinge point of the slewing supporting platform are obtained respectively under the two conditions of no-load and load. In addition, the specific values are also obtained. As a reference for the selection of pitch cylinder and slewing bearing, it has certain value.

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