Simulation Research on Double Helical Cam Pumping Unit ADAMS

Gongxiang Zhong[1, a], Xiaoan Zhao[1], Guangping Liao[1]

[1]School of Southwest Petroleum University, Chengdu, 610000, China.

[a]Corresponding author e-mail: 1452822902@qq.com

Abstract

At present, the most used pumping unit in China is the beam pumping unit, which has poor balance ability, low transmission efficiency and large inertia load. When mining heavy oil and high water-bearing oil fields, the conventional beam pumping unit can not meet the requirements. The requirements of economical and efficient mining, and the existing beamless pumping unit have problems such as complicated commutation structure and high failure rate. Aiming at some shortcomings of the existing pumping unit using mechanical reversing device, the author proposed a new double-screw cam pumping unit. The theoretical analysis of the new double-screw cam pumping unit is carried out. The kinematics and dynamics simulation of the double-screw cam pumping unit are carried out by using ADAMS software. The large-flex flexible body of steel wire rope and sucker rod column is modeled by discrete method. To verify the correctness and reliability of the model.

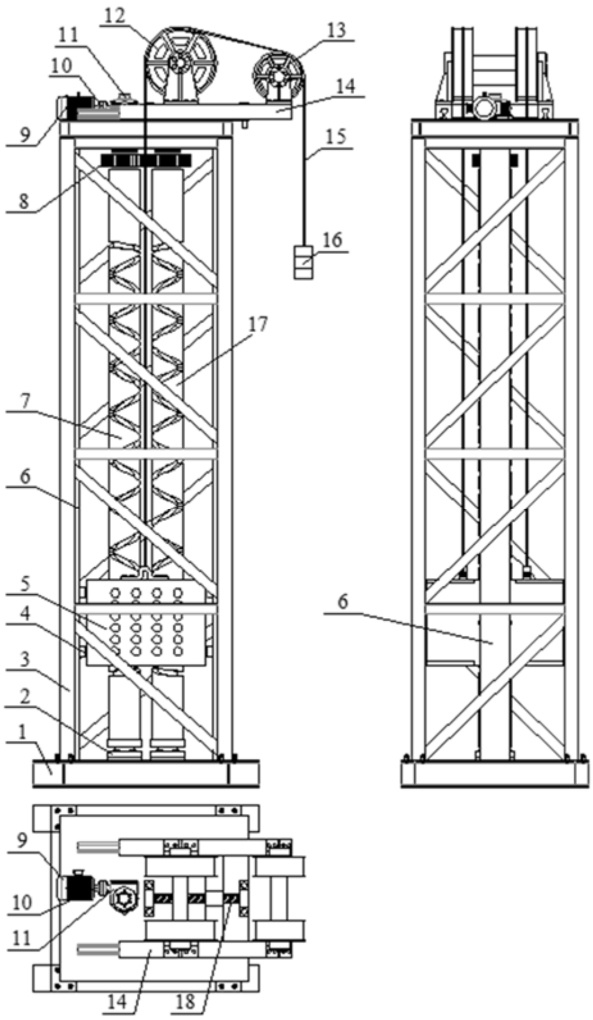
Keywords

ADAMS, double helix cam pumping unit, simulation, suspension load.

1. Introduction

At present, the most used pumping unit in China is the beam pumping unit. The beam pumping unit commonly used in oil fields adopts the principle of connecting rod reversing. Its structure is simple and easy to use, but the efficiency of the whole machine is low. High consumption, when implementing long stroke pumping, it is necessary to increase the structural size and the noise is serious.

The overall scheme of the new double-screw cam pumping unit is shown in Figure 1. The motor with its own brake is driven by the coupling and the reducer to drive the double-helical camshaft to rotate No.1, and the double-helical camshaft No.1 passes the transmission ratio of 1. The spur gear transmits the power to the double-screw camshaft No. 2, the two camshafts are symmetrically mounted, the opposite directions are rotated, and the rotation is synchronous; the counterweight shuttle frame is symmetrically mounted with the reversing device and the guide wheel, and the reversing device is composed of the roller and the slider The composition is matched with the groove of the camshaft spiral groove, and can be moved on the groove of the spiral groove. The guide wheel on the counterweight frame mainly plays a guiding role, and the weight-return frame can only be moved linearly up and down along the guide rail, and the reversing device will After the rotary motion of the double-helical camshaft is converted into the up-and-down reciprocating motion of the counterweight reciprocating frame, the large and small wheels wound around the top by the wire rope are connected with the suspension rope, thereby driving the sucker rod to pump up and down.



1—rack base; 2—camshaft bearing housing; 3—rack; 4—guide wheel; 5—weight-weighted frame; 6—railway;

7—Camshaft No. 1; 8—gear; 9—motor; 10—reducer; 11—coupling; 12—big wheel;13—Small Tianlun Wheel; 14—screw rail; 15—wire rope; 16—suspension point; 17—camshaft No. 2; 18—screw.

Fig 1. Double spiral cam pumping unit overall plan

2. ADAMS Simulation

2.1. Virtual Prototype of Double-Screw Cam Pumping Unit

This paper chooses to model the model in advance in SolidWorks:

(1) Since the whole machine dynamics of the double-screw cam pumping unit is analyzed, bolts, bearings, motors, reducers, couplings, etc., which do not affect the simulation, need to be deleted, and the joints are connected. Simplified to a rotating pair;

(2) Large and small Tianlun bearing brackets and parts such as racks, frames and bases that do not move relative to each other, do not participate in the dynamic analysis of the system, so it is necessary to operate through Boolean operations and make a part, the whole pumping In addition to the sucker rod and wire rope, the oil machine needs to be rigid body treated.

The simplified model only has six components: the frame, the counterweight, the big wheel, the small wheel, the suspension point, and the reversing slider. The simplified model is then shown in Figure 2.

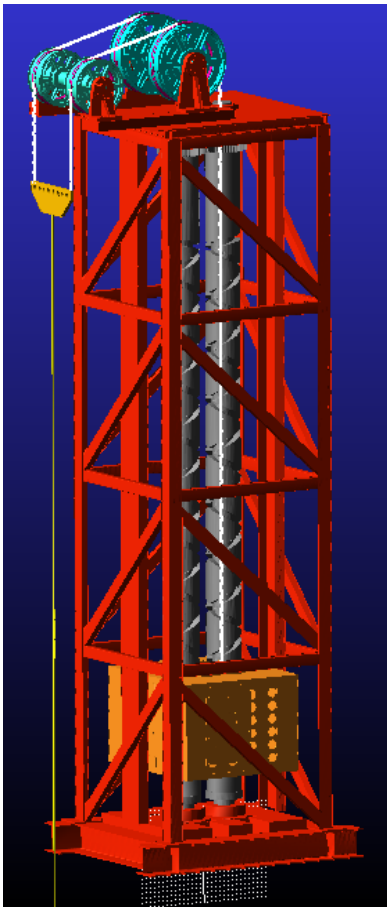


Fig 2. Modeled model

2.2. Solid Modeling of Wire Rope and Sucker Rod Column in ADAMS

Both the wire rope and the sucker rod column are modeled by a discrete method.

(1) Research on wire rope modeling method

Firstly, the corresponding marker points a1, a4 are established on the suspension point and the weight box as the starting point of the rope, and the size of the pulley section is defined, and the depth of the rope groove is set to 20 mm; then, the wheels are selected on the small wheel and the big wheel respectively. The corresponding marker point is used as the hinge of the two pulleys a2, a3, the size and the size of the sky wheel are the same, and the established pulley is fixed on the big and small wheels by the fixed hinge; finally, the winding direction of the wire rope is twisted counterclockwise. :a1—a2—a3—a4 (can also be reverse wound), the diameter of the wire rope is 26mm, and the wire rope model is built).

(2) Research on modeling method of sucker rod

In ADAMS, in order to reflect the dynamic characteristics and flexibility of the sucker rod, this paper adopts the idea of "zeroing out" for the sucker rod modeling. First, the sucker rod is firstly divided into a plurality of equally divided cylindrical segments, and the connecting bushing force is added to the adjacent two cylindrical segments. The bushing force tool is a method applied to the interaction force of the two members by defining three forces. The component and the three moment components exert a flexible force between the two components.

The oil pumping machine and the sucker rod model are established as shown in Figure 3.

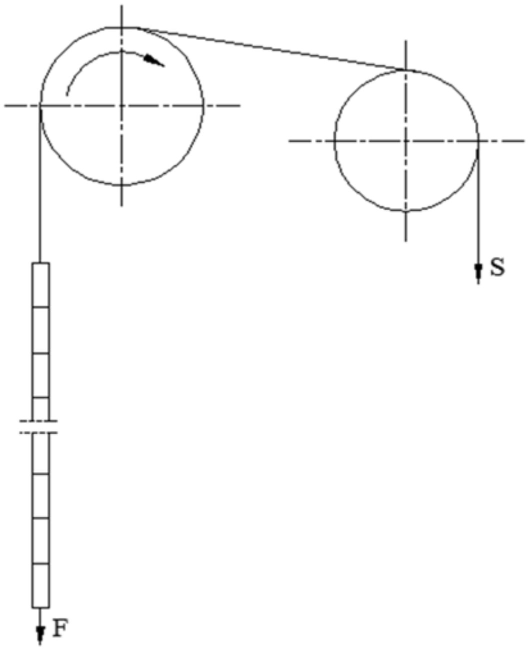


Fig 3. Schematic diagram of ADAMS sucker rod column and wire rope simulation model

2.3. Setting Simulation Constraints

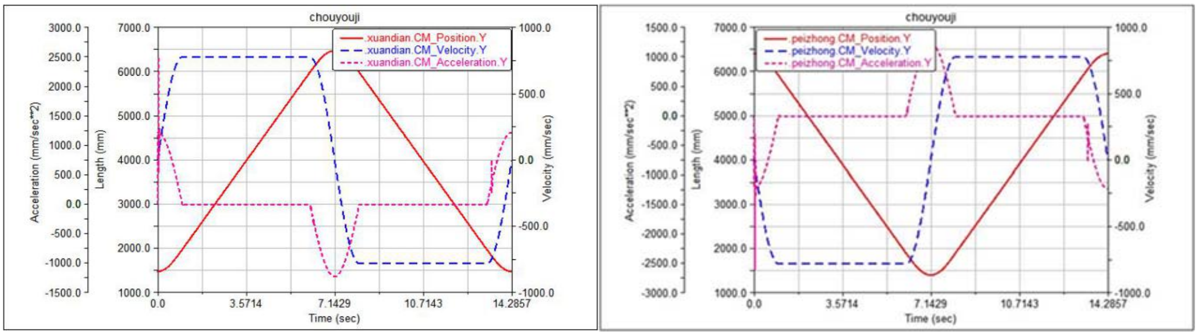
The contact type between the reversing slider and the camshaft is solid to solid, the contact force analysis model uses the IMPACT function contact model, and the contact parameters are the default values of the system for the steel material. . It is worth noting that the Fixed Joint fixing constraint is also required between the first sucker rod and the suspension point and between the wire rope and the suspension point to establish the connection between the two.

After the constraints of each component are set, the drive needs to be added: the rotary drive is defined at the top of the two helical camshafts. The known rotary camshaft speed is 80r/min, which translates into ADAMS medium angular velocity of 480d/s, type selected as displacement, and function set to 480d. *time. The other helical camshaft is -480d*time, that is, the opposite direction of rotation. In addition, it is necessary to apply external load on the bottom of the sucker rod. The double-screw cam pumping unit mainly has gravity and external load, and the external load is a piecewise function about the displacement of the suspension point. It is necessary to write the external part corresponding to each displacement section. For the function of the load, the STEP function is used to apply the external load.

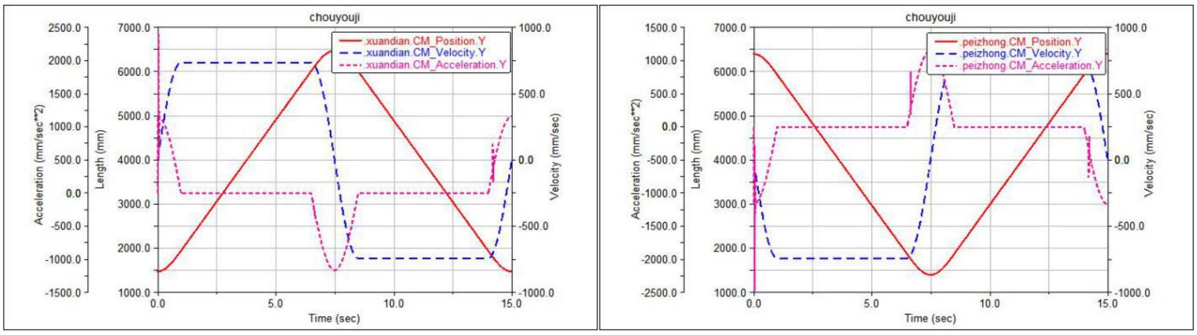
3. ADAMS Simulation Results Analysis

3.1. Analysis of the Law of Suspension Point Motion

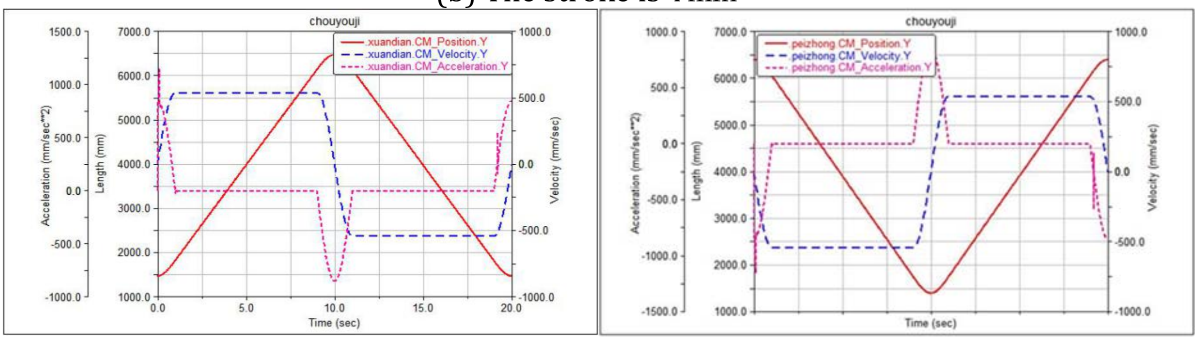
The motion simulation of the suspension point and the counterweight in the case of stroke 5m and strokes of 4.2 $\min^{-1}$, 4 $\min^{-1}$, 3 $\min^{-1}$ is shown in Fig. 4. It can be seen from the figure that with the reduction of the stroke The movement time of the suspension point in one stroke increases, which leads to the decrease of the speed of the suspension point and the decrease of the acceleration. The displacement, velocity and acceleration of the counterweight frame are opposite to the movement of the suspension point



(a) The stroke is 4.2 min^{-1}



(b) The stroke is 4 min^{-1}

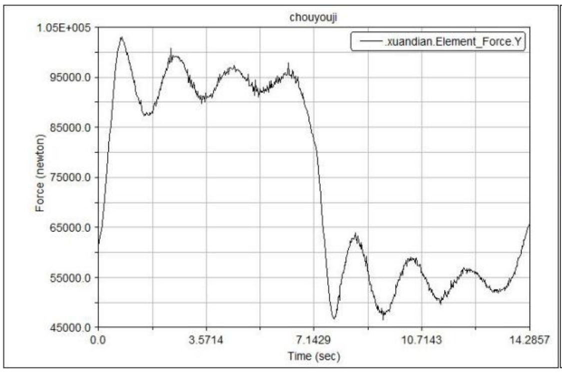


(c) The stroke is 3 min^{-1}

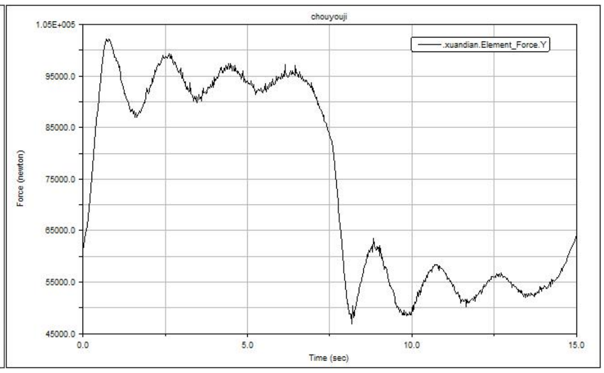
Fig 4. Movement law of the hanging point and counterweight frame under different strokes

3.2. Suspended Point Load Analysis

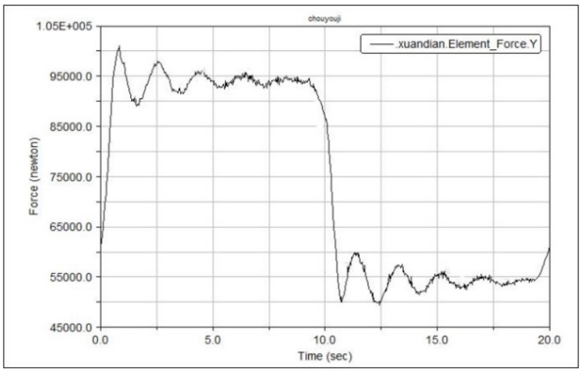
The simulation results of the suspension load under the conditions of 4.2 min^{-1}, 4 min^{-1}, and 3 min^{-1} are shown in Fig. 5. Taking the suspension load variation curve of 4 min^{-1} as an example, it can be seen that the maximum suspended point load of the upper stroke is about 100kN, and the minimum suspension load of the lower stroke is about 46kN, which is basically consistent with the theoretical calculation result. During the stroke, the load fluctuation has a tendency to decrease. This is because the sucker rod dynamic model is an elastic vibration model, and the force is fluctuated, and the sucker rod is affected by various damping forces under the well, resulting in a fluctuating amplitude. The value is reduced. In addition, it can be seen from the figure that as the stroke decreases, the maximum load of the suspension point decreases slightly, and the minimum load of the suspension point slightly increases. This is because the speed and acceleration of the suspension point will follow the stroke. When the pressure is lowered and lowered, the load on the suspension point will also decrease, resulting in an increase in the maximum suspension load of the upper stroke and a decrease in the minimum suspension load on the down stroke.



(a) The stroke is 4.2 min^{-1}



(b) The stroke is 4 min^{-1}



(c) The stroke is 3 min^{-1}

Figure 5. Suspended point load curve under different strokes

4. Conclusion

In this chapter, the ADAMS software is used to analyze the kinematics and dynamics of the double-screw cam pumping unit. The large-flex flexible body such as steel wire rope and sucker rod is modeled by discrete method.

The simulation shows the movement law of the suspension point and the counterweight of the pumping unit when the stroke is 4.2 min^{-1}, 4 min^{-1}, 3 min^{-1}, and finds that the speed of the suspension point in one stroke decreases with the reduction of the stroke. The acceleration is reduced, and the speed and acceleration of the counterweight frame are consistent with the change of the suspension point, but the direction is opposite.

References

[1] Zhao Hui. Simulation study on the winding motion law of glass fiber winding machine. (MS., Nanjing University of Aeronautics and Astronautics, China 2007), p.28.

[2] Jin Minjie, Liu Huawei, Pei Pei et al. Modeling of mine hoist wire rope based on ADAMS macro program. Mining Machinery, 2011, 39(12): 46-49.

[3] MA Xingfu. Modeling and Simulation of Elevator Wire Rope System Based on ADAMS.Journal of Hunan Institute of Engineering(Natural Science Edition),2016,26(03):32-36.

[4] Wang Dingxian, Yin Liang, Li Ying et al. Modeling and Dynamics Simulation Analysis of Steel Wire Rope. Mining Machinery, 2010, 38(08): 20-23.

[5] Zhang Ailian, Chen Shujian. Research on ADAMS Flexible Body Modeling Technology.Coal Mine Machinery,2011,32(06):95-97.

[6] Zhang Yingzhang, Zhang Shunxin, Cui Shaojie et al. Simulation Analysis of Crane Wire Rope Based on ADAMS/Cable.Manufacturing Automation, 2013, 35(13): 10-12.

[7] Li Dongping. Prediction and Computer Simulation of Rod Movement Characteristics of Rod Pumping System. (MS., Xi'an University of Technology, China 2003), p.56.