Study on Modeling and Simulation of X-Swing-type Leg Hydraulic System of Concrete Pump

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ABSTRACT

It is of importance for a truck mounted concrete pump to analyze its dynamic characteristics of X-Swing-type leg hydraulic system. According to the working principle of X-Swing-type leg hydraulic system of a truck mounted concrete pump, the simulation model of X-Swing-type leg hydraulic system is established based on AMESim, and the dynamic characteristics of X-Swing-type leg hydraulic system is analyzed. The research result provides some reference for design and improvement of X-Swing-type leg hydraulic system of a truck mounted concrete pump.

INTRODUCTION

Truck mounted concrete pump mainly consists of boom mechanism, pumping unit, rotation system, and leg hydraulic system. By the cooperation of boom mechanism, pumping unit and rotation system, the concrete can be transported to appropriate target position [1]. X-Swing-type leg hydraulic system of a truck mounted concrete pump is used to make all tires leave the ground and ensure it can be exempted the influence of dynamic construction load. Therefore, the X-Swing-type leg hydraulic system plays an essential role in concrete pumping process, and it is important to analysis the dynamic characteristics of the X-Swing-type leg hydraulic system.

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Zhang Yanwei et al. [2] discussed the calculate method and general calculation formula of leg counter force. Kang Huimei [3] analyzed the leg counter force and lift displacement and gave corresponding calculation method. Tang Yongzhi et al. [4] introduced the design procedure of the bear range of front legs. Chen Guoan et al. [5] proposed the calculation method for solving the max possible leg counter force. AMESim, an advanced modeling and simulation environment for multi fields including mechanical, hydraulic, control, etc. [6], has been widely applied in many engineering fields such as renewable energy, hybrid system, et al.

This paper built the model of the X-Swing-Type leg hydraulic system of truck mounted concrete pump based on AMESim according to the working principle of the X-Swing-Type leg hydraulic system, and analyzed the dynamic characteristics.

**WORKING PRINCIPLE OF X-SWING-TYPE LEG HYDRAULIC SYSTEM**

The X-Swing-type leg hydraulic system mainly consists of 4 legs, 4 leg vertical cylinders and 4 leg swing cylinders, etc., as shown in Fig. 1. The swinging of 4 legs is controlled by corresponding leg swinging cylinders. When the rods of the 4 leg swinging cylinders extend to a certain position, then under the action of the 4 leg vertical cylinders, all tires of a truck mounted concrete pump leave the ground, and guarantees it has sufficient safety and stability during pumping process.

As shown in Fig. 2, the X-Swing-type leg hydraulic system includes engine, pump, pressure relief valve, bi-directional hydraulic lock, 4 leg vertical cylinders and 4 leg swing cylinders. When the X-Swing-type leg hydraulic system is working, firstly the 4 legs should be swung to the right position by means of the 4 leg swing cylinders, secondly the rods of 4 leg vertical cylinders extend to make all tires leave the ground thoroughly. The bi-directional hydraulic locks are used in each leg vertical cylinders and leg swing cylinders to ensure the safety and stability of a truck mounted concrete pump.

![Figure 1](image1.png)  
**Figure 1** Structure of X-Swing-type leg

![Figure 2](image2.png)  
**Figure 2** X-Swing-type leg hydraulic system

1-engine, 2-pump, 3-pressure relief valve, 4-directional control valve, 5-bi-directional hydraulic lock, 6-leg vertical cylinders, 7-tank, 8-leg swing cylinders
SIMULATION MODEL OF X-SWING-TYPE LEG HYDRAULIC SYSTEM

On the base of working principle of X-Swing-type leg hydraulic system, by selecting appropriate components of engine, directional control valve, bi-directional hydraulic lock, and cylinders in AMESim, the simulation model of X-Swing-type leg hydraulic system is established, as shown in Fig. 3.

Figure 3. AMESim simulation model of X-Swing-type leg hydraulic system.

SIMULATION RESULTS AND ANALYSIS

The simulation parameters for X-Swing-type leg hydraulic system are as follows: For a certain truck mounted concrete pump, weight is 32000kg, transverse span of front and rear legs are 6200mm and 7160mm respectively, and longitudinal spans is 7600mm. The rotational speeds of engine and pump are both 1450 rev/min, and the displacement of pump is 75cc/rev, the setting pressure of pressure relief valve is 250bar, the open pressure and control pressure of bi-directional hydraulic locks is 0.5bar and 20bar respectively. The mass of each front leg and rear leg are 800kg. The cylinder diameter, rod diameter and stroke of front leg swing cylinders are 125mm, 90mm and 1200mm. The cylinder diameter, rod diameter and stroke of rear leg swinging cylinders are 125mm, 90mm and 600mm. The cylinder diameter, rod diameter and stroke of leg vertical cylinders is 180mm, 125mm and 0.8m. The simulation results are shown in Fig. 4-Fig. 9.
As shown in Fig. 4, when all piston rods of leg vertical cylinders are extending all leg vertical cylinders reach 0.8m using 22.5s, and the piston rods of rear leg vertical cylinders extend 22.5s earlier than the piston rods of front leg vertical cylinders. After the displacement of all leg vertical cylinders reach 0.8m and making all tires leave the ground, all leg vertical cylinders are locked by bi-directional hydraulic locks until the pumping work is finished. The piston rods of rear leg vertical cylinders withdraw with the piston rods of front leg vertical cylinders using same time 23.3s. As shown in Fig. 5, all piston rods of leg swing cylinders extend simultaneously, and rear leg swinging cylinders reach their setting stroke 0.6m in 16.25s, while front leg swinging cylinders reach their setting stroke 1.2m in 24.4s. After the displacement of front leg swing cylinders reach 1.2m and rear leg swinging cylinders reach 0.6m, all horizontal cylinders are locked respectively by bi-directional hydraulic locks until the pumping work is finished.

As shown in Fig. 6, that when extending the velocity of rear leg vertical cylinders is 0.0355m/s from the time of 50s and remains this value 22.5s, then turns to 0m/s at the time of 72.5s, meanwhile the velocity of front leg vertical cylinders is 0.0355m/s and remains this value 22.5s, then turns to 0m/s at the time of 95s. When withdrawing all leg vertical cylinders withdraw in the same velocity of 0.0343m/s at the time of 200s. As shown in Fig. 7, when extending the velocity of front leg swing cylinders and rear leg swinging cylinders is 0.037m/s. After 16.25s the velocity of rear leg swinging cylinders turns to 0m/s but the velocity of front leg swinging cylinders is 0.0738m/s and lasts 8.13s. When withdrawing the velocity of front leg swing cylinders and rear leg swinging cylinders is the same velocity of 0.0765m/s at the time of 250s and the velocity of rear leg swinging cylinders turns to 0m/s in 7.8s, meanwhile the velocity of front leg swing cylinders turns to 0.153m/s and remains this value 3.95s, then turns to 0m/s at the time of 261.75s.
As shown in Fig. 8, when extending the pressure of rear and front leg vertical cylinders is 16bar and 49.5bar from the time of 50s and remains this value 22.5s, then turns to 37.2bar and 52.4bar at the time of 72.5s respectively. When withdrawing the pressure of all leg vertical cylinders is 18.9bar, then turns to 2.41bar and 8.16bar at the time of 223.5s respectively since the action of hydraulic locks. As shown in Fig. 9, when extending the pressure of rear and front leg swing cylinders is 1.46bar and lasts 16.2s, then the pressure of rear leg swinging cylinders and front leg swing cylinders turns to 6.74bar and 1.85bar respectively. It can be seen in Fig. 9 that when withdrawing the pressure of rear and front leg vertical cylinders is 5.17bar, then turns to 1.22bar and 20.63bar at the time of 257.8s respectively, then turns to 1.22bar and 8.16bar at 262s respectively since the action of hydraulic locks.

CONCLUSION

The simulation model of X-Swing-type leg hydraulic system of a concrete pump is established based on AMESim according to the working principle of X-Swing-type leg hydraulic system, and the dynamic characteristics of X-Swing-type leg hydraulic system is analyzed. The research result provides some reference for design and improvement of X-Swing-type leg hydraulic system of concrete pump.
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