Study on Dynamic Characteristics of X-Type Leg Hydraulic System of Truck Mounted Concrete Pump

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

Introduction

Truck mounted concrete pump consists mainly of pumping unit, boom, convey pipes, leg system, etc, which is a construction machinery used to pumping concrete by convey pipes depending on pressure. Due to it has some merits including high construction efficiency, high mechanization degree, et al., it has been widely applied in some construction engineering, i.e. bridges, hydropower [1]. It is required for truck mounted concrete pump that it must have the ability of anti overturning, adequate safety and stability. The X-type leg hydraulic system of truck mounted concrete pump can make all tires leave the ground so as to keep it from the effect of pumping construction load, and let a truck mounted concrete pump have adequate safety and stability when working. Therefore, it is of importance to study the dynamic characteristics of X-type leg hydraulic system of a truck mounted concrete pump. A method for calculating the maximum possible counterforce of leg is proposed in [2]. The design process of the bearing extent of X-type front leg was introduced in [3]. The calculation method and general calculation formulation for counterforce of leg was expounded in [4] and [5]. AMESim is an advanced modeling environment for establishing engineering system including mechanical, hydraulic, and control, etc., and it has been applied successfully in some fields of construction, hydraulic component, and energy system[6].

This paper establishes the simulation model of X-type leg hydraulic system of a truck mounted concrete pump according to its working principle, and study the dynamic characteristics of X-type leg hydraulic system.

Working principle of X-type leg hydraulic system

The X-type leg hydraulic system of a truck mounted concrete pump mainly consists of legs, leg vertical cylinders, leg expanding and contracting cylinders, and leg swinging cylinders, etc. as shown in Fig. 1. The swinging of legs are controlled by leg swinging cylinders respectively, and the expanding and contracting of legs are controlled by leg expanding and contracting cylinders respectively. When the piston rods of leg expanding and contracting cylinders and leg swinging cylinders extend to a certain position, the legs look like X-type, then under the action of the leg vertical cylinders to make all tires of a truck mounted concrete pump leave the ground, and guarantees it has sufficient safety and stability, as shown in Fig. 2.

Fig.1 Structure diagram of X-type leg

Fig.2 X-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 expanding and contracting cylinders, 9-leg swinging cylinders

AMESim simulation model of X-type leg hydraulic system

By selecting suitable models of motor, pressure relief valve, directional control valve, bi-directional hydraulic lock, and cylinders in AMESim, the simulation model of X-type leg hydraulic system is established, as shown in Fig. 3.

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

Simulation results and analysis

The simulation parameters for X-type leg hydraulic system are as follows: For a certain truck mounted concrete pump, weight is 56000kg, transverse span of front and rear legs are 6600mm and 7800mm respectively, and longitudinal spans is 8200mm. 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 1050kg and 850kg. The cylinder diameter, rod diameter and stroke of front leg expanding and contracting cylinders is

140mm, 100mm and 3.5m. The cylinder diameter, rod diameter and stroke of rear leg swinging cylinders is 125mm, 90mm and 0.45m. The cylinder diameter, rod diameter and stroke of leg vertical cylinders is 180mm, 125mm and 0.6m. The simulation results are shown in Fig. 4-Fig. 9.

Fig. 4 Displacement of leg vertical cylinders

Fig. 5 Displacement of leg horizontal cylinders

It can be seen in Fig. 4 that when all piston rods of leg vertical cylinders are extending all leg vertical cylinders reach 0.6m using 17s, and the piston rods of rear leg vertical cylinders extend 17s earlier than the piston rods of front leg vertical cylinders. After the displacement of all leg vertical cylinders reach 0.6m 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 17.5s. It can be seen in Fig. 5 that all piston rods of horizontal cylinders extend simultaneously, and rear leg swinging cylinders reach their setting stroke 0.45m in 12.2s, while front leg expanding and contracting cylinders reach their setting stroke 3.5m in 65.6s. After the displacement of front leg expanding and contracting cylinders reach 3.5m and rear leg swinging cylinders reach 0.45m, all horizontal cylinders are locked respectively by bi-directional hydraulic locks until the pumping work is finished. During withdrawing, front leg expanding and contracting cylinders withdraw 20s earlier than rear leg swinging cylinders.

Fig. 6 Velocity of leg vertical cylinders

Fig. 7 Velocity of leg horizontal cylinders

It can be seen in Fig. 6 that when extending the velocity of rear leg vertical cylinders is 0.0355m/s from the time of 70s and remains this value 17s, then turns to 0m/s at the time of 87s, meanwhile the velocity of front leg vertical cylinders is 0.0355m/s and remains this value 17s, then turns to 0m/s at the time of 104s. When withdrawing all leg vertical cylinders withdraw in the same velocity of 0.0343m/s at the time of 370s. It can be seen in Fig. 7 that when extending the velocity of front leg expanding and contracting cylinders is 0.0295m/s while the velocity of rear leg swinging cylinders is 0.037m/s. After 12s the velocity of front leg expanding and contracting cylinders turns to 0m/s but the velocity of rear leg swinging cylinders is 0.059m/s and lasts 53s.

When withdrawing the velocity of front leg expanding and contracting cylinders is 0.12m/s and lasts 29s then turns to 0m/s, and after 20s the velocity of rear leg swinging cylinders is 0.15m/s and lasts 2.9s then turns to 0m/s.

Fig. 8 Pressure in leg vertical cylinders

Fig. 9 Pressure in leg horizontal cylinders

It can be seen in Fig. 8 that when extending the pressure of rear and front leg vertical cylinders is 37.7bar and 75bar from the time of 70s and remains this value 17s, then turns to 95.6bar and 78bar respectively, then turns 250bar at the time of 104s. When withdrawing the pressure of all leg vertical cylinders is 18.9bar. It can be seen in Fig. 9 that when extending the pressure of rear and front leg horizontal cylinders is 1.5bar and lasts 12s, then the pressure of rear leg swinging cylinders and front leg expanding and contracting cylinders turns to 6.7bar and 2bar respectively and lasts 53s. It can be seen in Fig. 9 that when withdrawing the pressure of rear and front leg vertical cylinders is 20bar.

Conclusion

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

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