Available online at www.sciencedirect.com

SciVerse ScienceDirect

Physics Procedia 25 (2012) 2268 – 2275

Physics Procedia

2012 International Conference on Solid State Devices and Materials Science

# Simulation Analysis of Certain Hydraulic Lifting Appliance under Different Working Conditions

Huang Lei[1,2],Yuan Genfu[1],Chen Xuehui[1]

[1]*Anhui University of Architecture,Hefei,230022,China;Hefei University of Technology,Hefei,230022,China*

**Abstract**

Being typical of mechanical and electronic hydraulics appliance, hydraulic lifting appliance has many working conditions due to its particularities. Properties of hydraulic system decide high efficiency, security as well as stability under different working conditions. Beginning with simulation analysis on hydraulic system of hydraulic lifting appliance under different working conditions, the essay analyzes a certain hydraulic system through which design references can be offered for optimizing hydraulic system properties via hydraulic system force and changes of torque. And then properties of hydraulic system can be improved and a hydraulic system with stable performance can be obtained.



*Keywords:* Hydraulic, Pressure, Lifting, Property, Analysis

## 1. Introductions

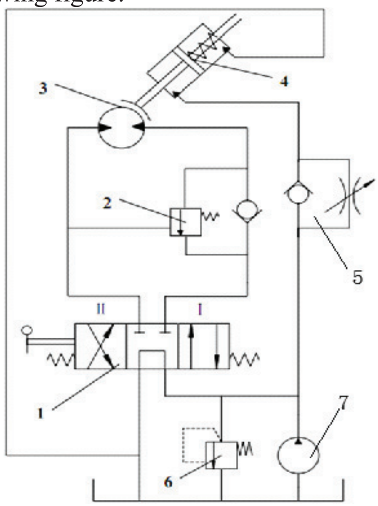
With favorable properties over lifting, braking and property control, hydraulic lifting appliance plays an important role in modernization drive. Being a symbol of social advance, hydraulic lifting appliance is indispensible to civilization development. Much attention has been paid by lifting industry to the efficiency, security and stability of hydraulic lifting appliance. With ceaseless development of science and technology, more and more new technologies are applied to lifting appliance design. At the same time, the once exist hydraulic oil leakage phenomenon is overcame gradually by the perfection of hydraulic transmission technology and improvement of domestic hydraulic elements quality. As a result, wide application of hydraulic transmission technology on lifting appliance is becoming an inevitable trend. Beginning with the analysis on hydraulic system of the current hydraulic appliance, the essay conducts analysis on hydraulic system with the purpose of improving properties of hydraulic system and finally establishing a stable hydraulic system[1-3].

## 2. Working Principle of Jacking Hydraulic System

As commonly used in vertical transportation appliances, hydraulic crane plays a significant part. During the process of lifting, commodities are lifted by drum propelled by rotation of hydraulic motor.

 doi:10.1016/j.phpro.2012.03.381

Different in lifting hydraulic system of various types, the basic design idea of different factories is the same. Lifting hydraulic system generally consists of electrical machine, oil pump, safety valve, change valve, pressure gage, balanced valve, motor or hydraulic cylinder, pipeline and some other components. Electrical energy can be transferred into hydraulic pressure energy by motor drive hydraulic pump and then into mechanical energy drive load by motor or hydraulic cylinder propelled by control valve. With general adoption of bidirectional meter out regulative system, hydraulic system can control commodity ascension and descension speed effectively. Hydraulic lock or speed limit lock is launched within the oil way so as to guarantee that hydraulic cylinder can stay in any position at any time during operation in avoidance of the danger of commodities' self-descension due to instantaneous power cut or the tripping of air switch. Security settings of overload protection and hydraulic pressure should be launched in hydraulic system[4-5]. The setting pressure of relief valve should be no greater than 110%of working pressure the system specified and the pressure specified by the system should be no greater than the setting pressure specified by hydraulic pump. Working pressure of relief valve should be adjusted before lifting operation and should be restricted within the maximum allowable working pressure. A Hydraulic lifting system is shown in the following figure.




1-Change Valve 2-Balanced Valve 3-Hydraulic Motor 4-Brake Hydro-Cylinder
5-One-Way Throttle Valve 6-Pressure-Control Valve 7- Hydraulic Pump

Figure1 Principle on Hydraulic Lifting System

## 3. Systematic Modeling of Hydraulic Jacking Appliance

### *3.1 Simulation Modeling Method of Hydraulic System*

The prerequisite for conducting systematic simulation is to establish accurate systematic and dynamic math model and obtain accurate parameter data of the system and components. Continuous steady lumped parameter model is commonly used for studying hydraulic system or machinery and hydraulic system. And the relevant frequently-used math models are differential equation form, transfer function form, block diagram, signal flow graph, state variable math model and so on[26]. The frequently-used methods for modeling are analysis, state space, power bond graph and 'grey-box' modeling.

### *3.2 The Establishment of Simulation Model on the basis of AMESim*

Jacking system model of hydraulic crane mainly consists of establishing model, selecting model types and setting up model parameters.

Hydraulic pressure principles of hydraulic crane's lifting mechanism are shown in figure1. When establishing model, partial hydraulic components are missed in AMESim software, therefore it is necessary to conduct equivalent treatment and the relevant treatments are as follows:

(1)Three Figured Four-Way Valve

Three figured four-way valve doesn't exist in AMESim software, therefore three-figured four-way solenoid valve is used in simulation software and direct signal loading method is substituted for manual operation.

(2)Brake

In the figure, made up of brake cylinder and returning spring, the brake accomplishes hydraulic motor braking and normal operating through spring contraction when conducting oil-taking. Due to the fact that no brake exists in AMESim software, motor connection pin for the stall of the variable friction torque model is adopted. In order to realize the start, normal operation and brake of the lifting mechanism, friction torque model parameters should be adjusted.

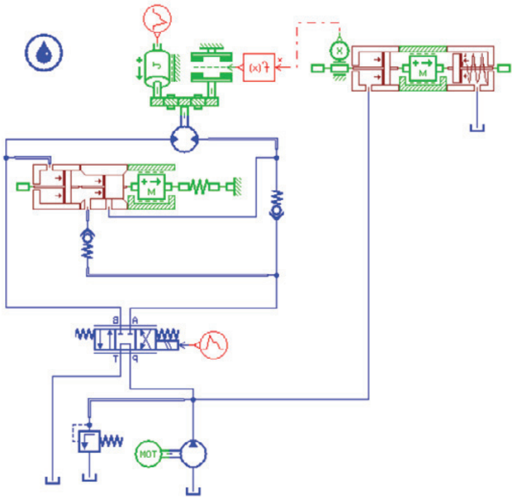


Figure2 Lifting System of the Simulation Model

## 4 Analyses on Simulation Results of Lifting Hydraulic System

Suppose that torque of systematic load is 20Nm. The movement of the lifting structure is analyzed under six working conditions. The six conditions are sudden ascension after systematic stop, descension after stop, sudden stop after ascension, sudden stop after descension, sudden descension after ascension and sudden ascension during descension.

Analyses conducted under each condition are as follows:

### *4.1 Sudden Ascension after Systematic Stop*

When change valve is on the left side, it is the lifting loop that offers motive power. The relevant simulation figure is shown as follows.

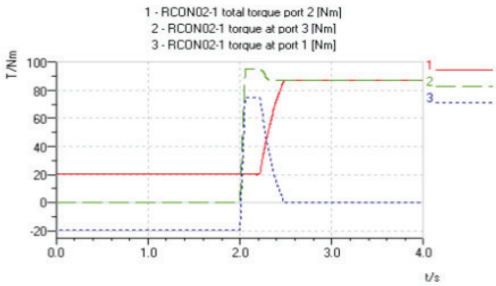



Figure3a Changes on Lifting Brake, Load and Motor Torque under the Conditon that System Ascends after Stopping

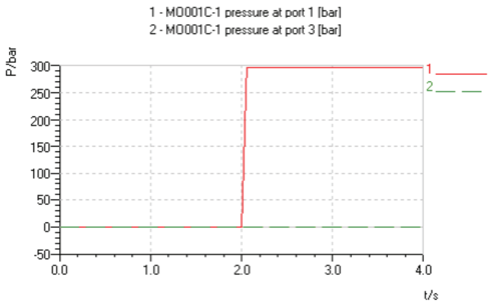



Figure3b Pressure Changes of Port1 and Port3 in the Motor

Simulation results demonstrate that between 0~2 seconds, change valve locates in the meso-position. In this case, the motor is in off-working state, load torque equals with brake torque and differential pressure on the two sides are zero. Between 2~4 seconds, change valve turns left and the system offers lifting power. In this case, load torque equals to motor output torque. After loosened for a while, the brake stops working so that the system can conduct normal operation. Pressures on the two ports of the original lifting motor are the same. Pressure values vary according to different working situation. Pressure on port1 is larger than that of port3. System offers lifting power when the motor is contrarotating.

*4.2 Sudden Descension after Systematic Stop*

When change valve turns right, load is in a falling state. The simulation figure in this case is shown as follows:

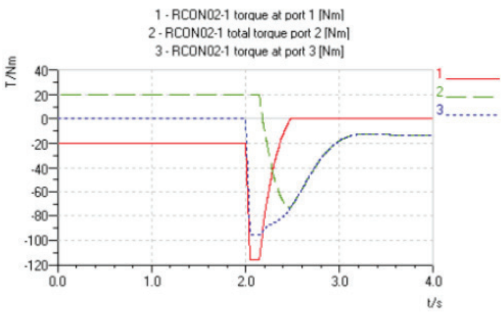



Figure4a Changes on Brake, Load and Motor Torque under the Condition that System Desends after Stopping

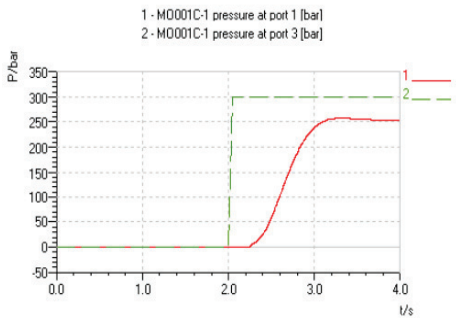



Figure4b Pressure Changes of Port1 and Port3 in the Motor

Simulation results demonstrate that between 2~4seconds, change valve changes from the meso-position to that of the right and the integrated system is descending. After a while, motor output torque balances with load torque. In this case, the brake stops working after a short time's response. The fact that load torque is far less than 20Nm demonstrates that weights are working when descending and the motor is under the influence of block load.

Under normal circumstance, pressure on port3 is larger than that of port3. But in such case, the situation turns to be different due to rightward displacement of spool and the returning of motor output flow back to the tank via balanced valve under the influence of pressure so that over-quick falling speed of load can be prevented.

*4.3 Sudden Stop during Systematic Load Ascension*

When change valve turns from the left position to meso-position, load stops suddenly during lifting movement. The simulation figure is shown as follows.

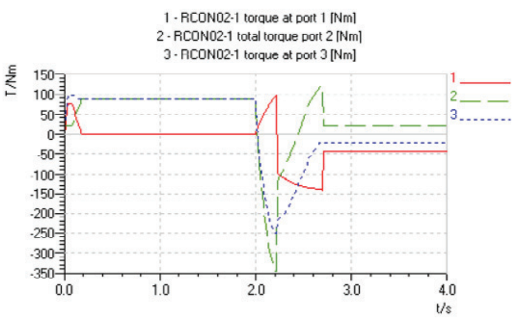



Figure5a Changes on Suspend Brake, Load and Motor Torque under the Condition that System Stops during Ascension

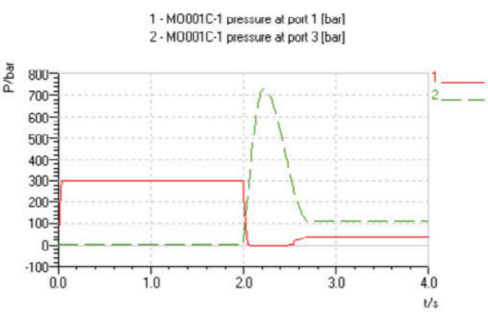



Figure5b Pressure Changes of Port1 and Port3 in the Motor

Simulation results in figure5 demonstrate that after change valve changes into meso-position, brake that doesn't work can return to work again. Loss of components can be reduced after forceful suspend of torque fluctuation of load and motor. After a period time's of cushioning, the system stops. At this moment, being supportive to load and motor, the brake offers the power to loading moment and surplus motor torque.

Pressures on both ports of the motor vary due to interference from the brake. Pressure on port3 is larger than that of port1 due to sudden brake working and the consequent inertia effect of hydraulic oil. Pressures on the two ports are no longer balanced.

*4.4 Sudden Stop during Systematic Descension*

When change valve changes from the right position to meso-position, load stops suddenly during descension. The simulation figure is shown as follows.

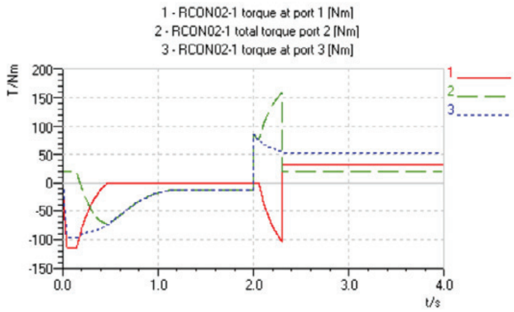



Figure6a Changes on Brake,Load and Motor Torque under the Consition that System Stops during Descension

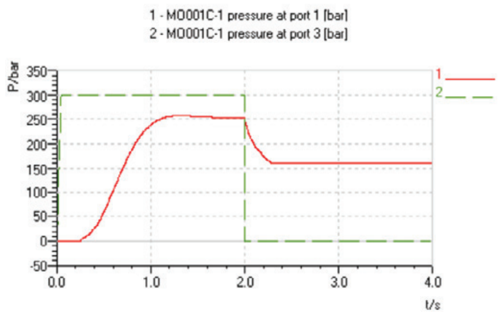



Figure6b Pressure Changes of Port1 and Port3 in the Motor

Simulation results demonstrate that when change valve changes from the right position to the meso-position, load descension is stopped forcibly. Brake previously in the loosened state begins working and terminates torque change fluctuation of load and motor. At this moment, motor torque equals to the sum of brake torque and load torque. Pressure on port3 becomes zero suddenly due to brake working.

*4.5 Sudden Descension during Systematic Ascension*

When change valve changes directly from the left position to the right, the system changes working direction. The simulation figure is shown as follows.

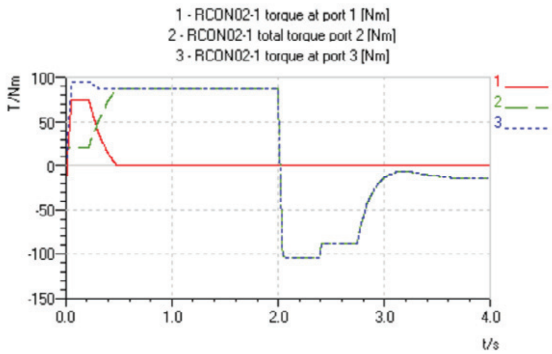



Figure7a Changes on Brake, Load and Motor Torque under the Condition that Syetem Descends Suddenly during Ascension

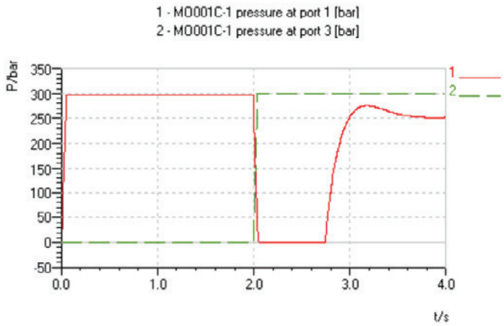



Figure7b Pressure Changes of Port1 and Port3 in the Motor

Simulation results demonstrate that when change valve changes directly from left to the right, the system descends rather than ascends. The system has already changed movement direction and it is too late for brake to work due to instant change. At this moment, the brake stops working and load torque equals to motor torque consistently. This suggests that it is the motor that completely offers load torque. Big fluctuation would emerge during the process. Therefore the system should avoid the occurrence of such working condition as far as possible.

*4.6 Sudden Ascension during Systematic Descension*

When change valve changes directly from the right to the left, the system would change working direction. The simulation figure is shown as follows.

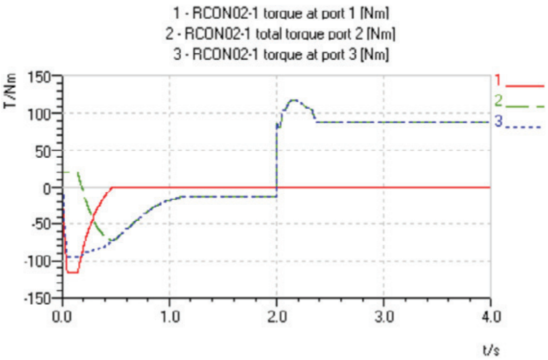



Figure8a Changes on Brake, Load and Motor Torque under the Condition that System Ascends Suddenly during Descension

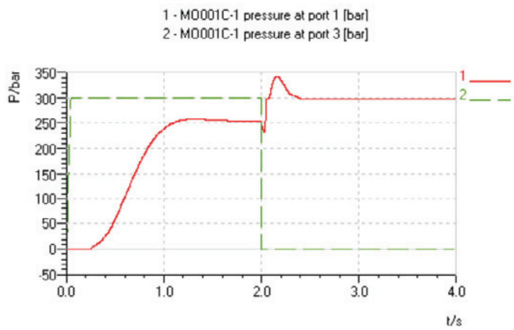



Figure8b Pressure Changes of Port1 and Port3 in the Motor

Similar to the condition that system descends suddenly during ascension, in this case it is too late for the brake to make responses before the system enters the next motion due to rapid reversing change. At this moment, the brake doesn't work as usual and load torque equals to motor torque. A huge step change that is generated during torque change process would jeopardize severely service life of mechanism components. Therefore, such working condition should be avoided.

## 5. Conclusions

In the essay, on the basis of AMESim software, the braking and change characteristics of hydraulic system under each working condition are worked out by taking advantage of simulation analysis conducted under each working condition of a certain kind of lifting appliance in hydraulic system. The author's own opinions are put forward on correctly use and improve the hydraulic system.

## References

[1] Yang Erzhuang, *Analyses on the Status Quo and Future Trends in Construction Crane* [J], *Transpo World*, page: 42-44, 11th issue, 2006.

[2]Xu Lei, *the Characteristics and Future Trends of Modern Crane*[J], *Lifting the Transport Machinery,* page: 3-7, 10th issue, 1997.

[3] Xie Yingjun, Xu Li and Chen Ying, *Discussion on the Mode of Secondary Lift Phenomenon of Cranes*[J],*Construction Machinery and Equipment* page: 14-16, 4th issue, 1997.

[4] Liu Nenghong and Tian Shujun, *Dynamic Digital Simulation of Hydraulic System* [M], Dalian: Dalian University of Technology Press, 1993.

[5]Zhu Xinglong, Chen Jian and Zhou Jiping, *Development of Strategy and Current Situation of the Domestic Hydraulic Control Technology* [J], *Mechanical Science and Technology,* page: 10-12, 3rd issue, 1997.

[6]Cheng Anning, *the Application and Development of Hydraulic Simulation Technology* [J], *Machine Tool and Hydraulics*, page: 9-10, 5th issue, 2004.

[7]Liu NengHong and Liu Qiyun, *Digital Simulation on Dynamic Characteristics of Complex Nonlinear Hydraulic System* [J], *Hydraulics and Pneumatics*, page: 1-5, 4th issue, 1982.

[8]Wang Yong, Zhang Yong and Li Congxin, *Research Progress in Hydraulic Simulation Software* [J], *Journal of System Simulation*, page: 54-57, 10th issue, 1998.

[9]Wang Bangfeng, Zhang Guozhong, Zhang Ruifang, *A Simulation Study in the Lifting Process of the Hydraulic Lifting Mechanism of Cranes*[J], *Construction and Machinery*, page: 9-10, 10th issue, 1998.

[10] M Lizell. Dynamic Leveling a Low Power Active Suspension With Adaptative Control, Vehicle System Dynamics,1991(3).

[11]Leonhard E, Benold. Simulation of Nonsteady Construction Processes. ASCE.115(2):163-178.