

STUDY ON THE OPENING FORCE CHARACTER OF WATER PRESS INLET-VALVE

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ABSTRACT

In this paper, based on the operating principle of water press pull-up inlet valve, we model the mathematical model of inlet-valve and made a simulation on computer. By the method of simulation, get the curve of control pressure (up cavity pressure) and opening force in process of pull-up inlet valve opening. Changing the structural parameter of inlet valve and working pressure of water press, gain the relationship between pull-up inlet valve opening force changing tendency and the structural parameter of inlet valve and working pressure.

KEY WORDS

Water press, Inlet-valve, Opening force, Simulation

NOMENCLATURE

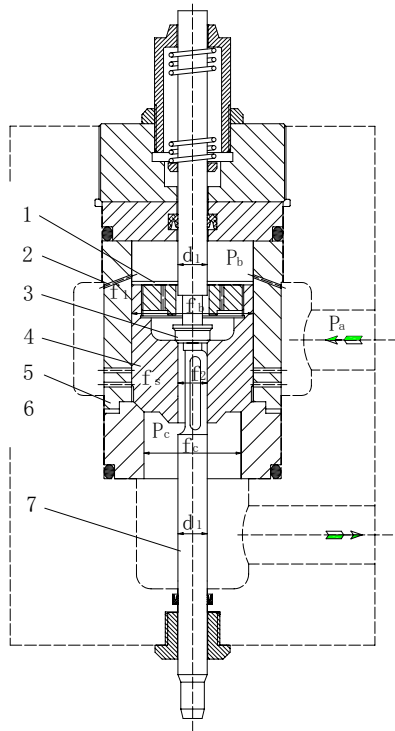
- B :The damp coefficient of main valve spool
 f_b :Cross-sectional area of main valve spool
 f_c :End face area of main valve spool in the down cavity
 f_s :Area of main valve spool circular bead
 F_t :Opening force of main valve
 m :Mass of main valve spool
 P_a :Pressure at main valve inlet
 P_b :Pressure in up cavity
 P_c :Pressure at main valve outlet
 Q_3 :Flow of main valve port
 v_3 :Flow rate at main valve port
 y :Offset of main valve spool
 θ :Cone angle of main valve spool
 ρ :Density of oil water emulsion

INTRODUCTION

The traditional structure of water press' inlet and outlet valve is pull-up valve, this type valve is opened by using external control organ to pull up the valve plug's middle pole. Without external opening force, the valve plug's middle pole will go back by the force of a spring in the valve's up cavity, then the valve plug closed following the middle pole.

The structure of pull-up inlet valve is shown in Figure 1. Its main valve is a cone valve. The pressure relief valve of up cavity pressure is a little cone valve, it is coaxial with main valve and its valve bed is main valve's spool. There are water entrance holes on valve barrel, they can make high pressure water to flow into main valve's up cavity from valve inlet.

The operating principle of water press pull-up inlet valve is so. When pressure relief valve keep shutting, up cavity pressure push main valve spool down on the valve bed. The up cavity pressure begin to drop when pressure relief valve is opened, and when pressure relief valve get its stroke end the main valve spool is pulled up, the inlet valve is opened [1].



1. Spacing screw 2. Water entrance hole
3. Pressure relief valve 4. Main valve
5. valve barrel 6. valve bed 7. Pull-up pole
Figure 1 The structure of pull-up inlet valve

Opening pressure relief valve is by the way of pulling up the pull-up pole which under the pressure relief valve, and the valve is shut by the force of a string in the valve's up cavity. While the pressure relief valve is shutting, the valve port area is reduced and the up cavity pressure is risen. The pressure push main valve spool down on the valve bed solidly.

Mechanical Analysis of the Valve's Opening Process

The opening force of pull-up inlet valve is mainly decided by the resultant force acting on the main valve spool. The force acting on the spool when it is opening include up cavity pressure force, down cavity pressure force, rising force of spool circular bead, hydraulic power at valve port and damping force.

The balanced equation of the main valve spool force:

$$P_b f_b = f_c P_c + f_s P_a - Q_3 \rho v_3 \cos \theta + 0.45 P_a \frac{\pi}{4} (d_1^2 - d_2^2) + F_t - m \frac{dx^2}{dt^2} - B \frac{dx}{dt} \quad (1)$$

The item of $0.45 P_a \frac{\pi}{4} (d_1^2 - d_2^2)$ means the pressure force at cone sealing face of main valve spool. Parameters d_1 and d_2 are outer diameter and inner diameter of the cone sealing face. $0.45 P_a$ means average pressure at cone sealing face of main valve

spool[2].

Simulation of the Valve Opening Process

The MATLAB/Simulink model of the pull-up inlet valve is shown in figure 2.

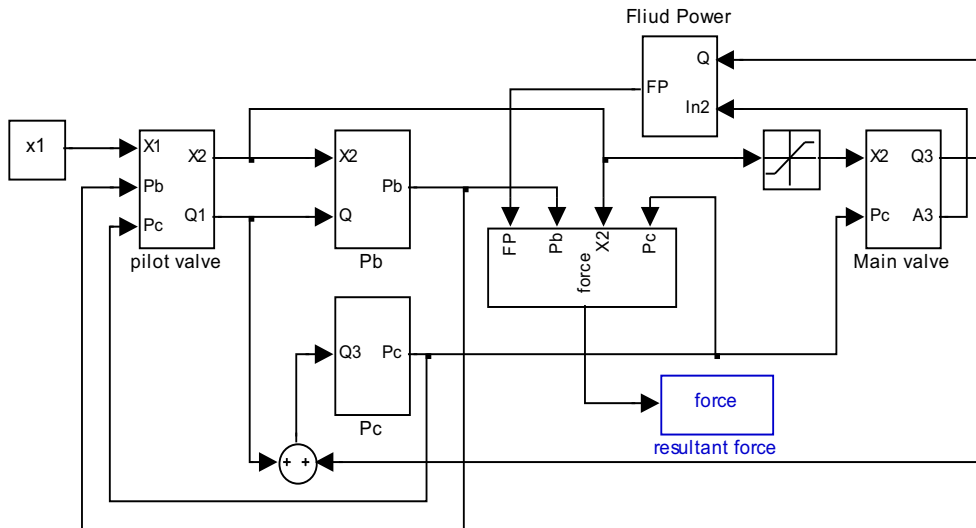


Figure 2 Simulink model of pull-up inlet valve

Changing diameter of water entrance hole and opening stroke of pressure relief valve, we gain the curves of up cavity pressure and main valve spool opening force in

the process of inlet valve opening. These curves are shown in figure 3 and figure 4.

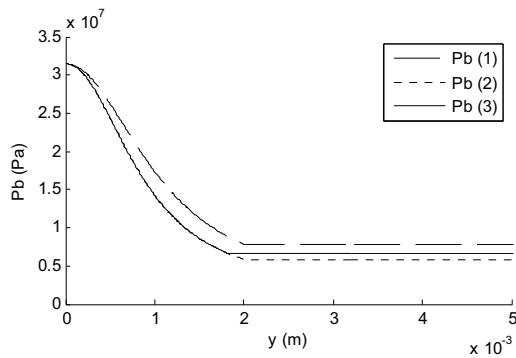


Figure 3 The curves of up cavity pressure

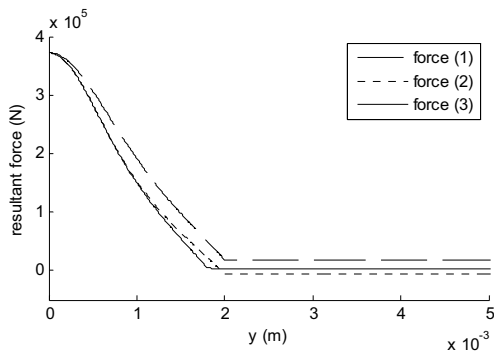


Figure 4 The curves of main valve spool opening force

Structural parameters of curves 1,2,3 in figure 3 is below.

Curve 1: diameter of water entrance hole is 5mm, opening stroke of pressure relief valve is 2mm.

Curve 2: diameter of water entrance hole is 4.5mm, opening stroke of pressure relief valve is 2mm.

Curve 3: diameter of water entrance hole is 6.5mm, opening stroke of pressure relief valve is 1.8mm.

Static acting forces on the inlet valve mainly contain up cavity pressure force ($f_b P_b$), down cavity pressure force ($f_c P_c$), rising force of spool circular bead ($f_s P_d$), and the permeating pressure force at cone sealing face of main valve spool. To make the inlet valve work reliably, need that when pressure relief valve was little opened the main valve spool could be push down on the valve bed solidly, in case of the main valve spool floating with pressure relief valve little opened. The up cavity pressure force is mostly force to keep the main valve spool be push down. Through changing Structural parameters of diameter of water entrance hole and opening stroke of pressure relief valve, we can control the up cavity pressure. The curves in figure 3 and figure 4 show up cavity pressure and opening force of main valve at different structural parameters. The curve 2 in two figures above show the best proper opening force and pressure.

Working pressure of press have an important influence

on the down cavity pressure of inlet valve. So, following, emulate the opening process of inlet valve under different working pressures.

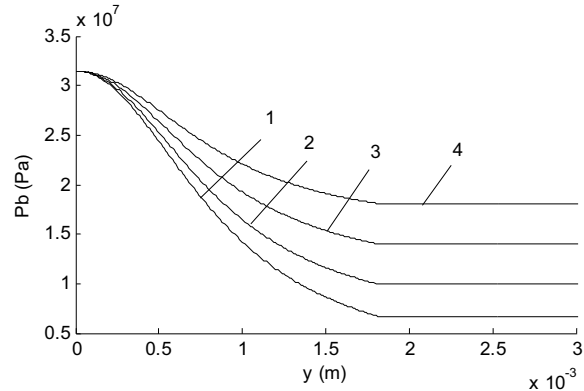


Figure 5 Up cavity pressure under different working pressure

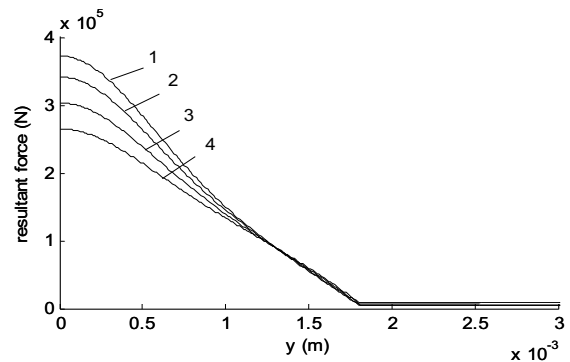


Figure 6 Main valve spool opening force under different working pressure

Curve 1,2,3,4 in figure 5 and figure 6, their working pressure respectively is 1×10^6 Mpa, 5×10^6 Mpa, 10×10^6 Mpa and 15×10^6 Mpa. From figure 5 and figure 6, we can know that rising with working pressure going up, but the opening force is little influenced by the working pressure. The reason is that up cavity pressure is stood off by down cavity pressure, and the permeating pressure force at cone sealing face have a linear relationship with working pressure, it could farther stand off the influence acted by working pressure. Therefore we have the conclusion that the pull-up inlet valve opening force be influenced by working pressure little, and when supply pressure is given the stabilization of the valve opening force is good.

CONCLUSION

1. The structural parameters of pull-up inlet valve have an important influence on the character of the valve's opening force.
2. When supply pressure is given, the valve opening

force is little influenced by working pressure.

REFERENCES

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