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

<table>
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<tr>
<th>Symbol</th>
<th>Definition</th>
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<tr>
<td>$B$</td>
<td>The damp coefficient of main valve spool</td>
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<tr>
<td>$f_b$</td>
<td>Cross-sectional area of main valve spool</td>
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<tr>
<td>$f_c$</td>
<td>End face area of main valve spool in the down cavity</td>
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<tr>
<td>$f_s$</td>
<td>Area of main valve spool circular bead</td>
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<td>$F_t$</td>
<td>Opening force of main valve</td>
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<td>$m$</td>
<td>Mass of main valve spool</td>
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<td>$P_a$</td>
<td>Pressure at main valve inlet</td>
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<tr>
<td>$P_b$</td>
<td>Pressure in up cavity</td>
</tr>
<tr>
<td>$P_c$</td>
<td>Pressure at main valve outlet</td>
</tr>
<tr>
<td>$Q_v$</td>
<td>Flow of main valve port</td>
</tr>
<tr>
<td>$v_3$</td>
<td>Flow rate at main valve port</td>
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<td>$y$</td>
<td>Offset of main valve spool</td>
</tr>
<tr>
<td>$\theta$</td>
<td>Cone angle of main valve spool</td>
</tr>
<tr>
<td>$\rho$</td>
<td>Density of oil water emulsion</td>
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</table>

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 Figure1. 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].
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 raised. The pressure pushes 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:

\[
P_b f_b = f_x P_x + f_z P_z - Q_i \rho v_i \cos \theta + 0.45P_a \frac{\pi}{4}(d_1^2 - d_2^2) + F_r - m \frac{dx^2}{dt^2} - B \frac{dx}{dt} \tag{1}
\]

The item of \(0.45P_a \frac{\pi}{4}(d_1^2 - d_2^2)\) 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. \(0.45P_a\) 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.

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

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

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

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

Static acting forces on the inlet valve mainly contain up cavity pressure force \( f_1 P_b \), down cavity pressure force \( f_2 P_b \), rising force of spool circular bead \( f_3 P_c \), 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.

Curve 1, 2, 3, 4 in figure 5 and figure 6, their working pressure respectively is \( 1 \times 10^6 \text{MPa} \), \( 5 \times 10^6 \text{MPa} \), \( 10 \times 10^6 \text{MPa} \) and \( 15 \times 10^6 \text{MPa} \). 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 standoff 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