Finite Element Analysis of Buffer Device in Large Erecting Hydraulic Cylinder Based on ANSYS

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Abstract: The level exchanging buffer of large erecting hydraulic cylinder is one of the core issues in the process of rapid erecting equipment development. This paper combines the actual, building analysis platform of fluid-structure interaction by using fluent and workbench,researching the effect of the change of flow field and fluid-structure interaction on the structure of buffer throttling when the throttle device in different buffer position. The results show that the hydraulic cylinder buffer zones have obvious pressure gradient.The effect of fluid-structure interaction reflected in the pressure gradient of cylindrical flow field lead to the overall strain values of buffer device coupling surface produce gradient change.

Introduction

In the process of large erecting equipment,the hydraulic cylinder is constantly extended to drive the load to rotate around the hinge point.At each level, the change of level have a limited collision.It is easy to have a big impact on the load,also not conducive to the stability of the vertical process[1].In order to slow down the impact of vibration,buffer device is arranged inside the cylinder body in the buffer stage. With the extension of the cylinder, the throttle gap is gradually reduced .The oil has damping effect,so the speed of the hydraulic cylinder can be reduced at the change stage to achieve the purpose of reducing the impact vibration.In earlier studies,most of them focused on the mathematical model of fluid characteristics in the vicinity of the hydraulic cylinder buffer device with more accurate throttle model to describe the buffering process,without consideration of the fluid-structure interaction effect[2,3].

In this paper, with the flow field simulation software fluent to build fluid-structure interaction analysis platform.Using the method of finite element analysis to study the fluid-structure interaction problem based on the gap throttle buffer structure of large vertical hydraulic cylinder[4,5].Three working conditions were picked to make the analysis of interaction of fluid and solid in different buffer locations to study the internal flow field characteristics with the change of the buffer process and the effect of fluid-structure interaction in different buffer positions .

Principle analysis of buffer structure

There are gap throttle buffer device inside the cylinder in order to prevent the speed of collision between the cylinder and the next cylinder is to fast when each sections of four sections hydraulic cylinder nearly reach the end.The sectional view as follows:

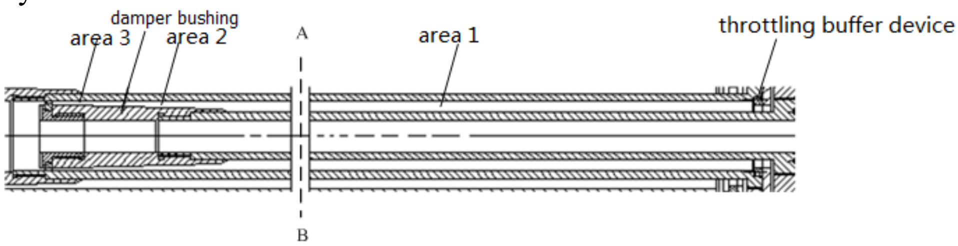


Fig. 1 Schematic diagram of the buffer structure

The end of the buffer chamber have throttling buffer device,the front end is the damper bushing with a slope structure.The throttle buffer device and the damping sleeve have relative movement during buffering.As shown in figure 1,it move to the left relative to damper bushing.The gap between the oil flow becomes small to achieve the purpose of throttling buffer.In order to analyze the effect of gap changing to the flow field and the fluid-structure interaction effect in the buffering process.Choose three working conditions which have representative to study.Considering the whole motion process,three working conditions as shown in table 5.1:

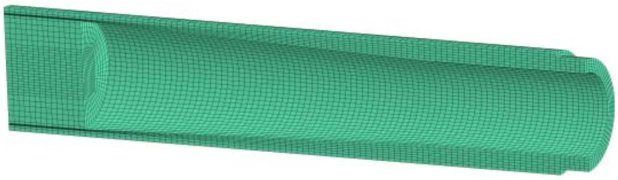
Table 1 Three working conditions of buffering process

working conditions	The position of throttling buffer device
1	First area
2	Second area
3	Third area

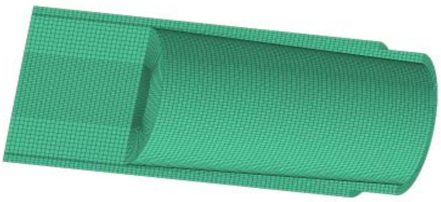
The throttling buffer device has not reached the buffer gap in the first area.It is always be in the middle of the buffer gap in the second area,and it has a smaller distance from the end of the buffer in the third area.The difference of the flowing oil gap is very large in the three working conditions,it can simulate the dynamic process of buffering more really.

Build the fluid and solid model and set the parameters

Fluid modeling and dividing the grid. Using software icem to divide the grid of gap buffer fluid zone,field flows to adopt the hexahedron unit to divide the net.Increase the grid density in central position.



a) The first conditions

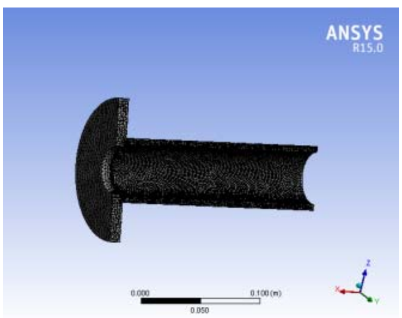


b) The second conditions

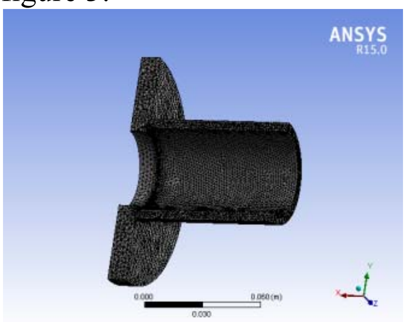
c) The third conditions

Fig. 2 The sectional view of grid in different working conditions

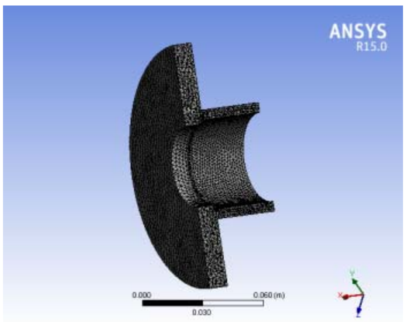
Solid modeling and dividing the grid. Build fluid-structure interaction entity model of solid contacting area with Pro/E in three working conditions to produce the finite element model in three different locations.As shown in figure 3:



a) The first conditions



b) The second conditions



c) The third conditions

Fig. 3 The sectional view of solid grid in different working conditions

Set the fluid boundary conditions and the material parameters. In the process of erecting,the oil pressure and flow rate are known and the pressure inside the cylinder is unknown in the four sections hydraulic cylinder we have studied .So we choice pressure outlet and flow rate inlet as boundary condition.

Table 2 Different buffer position boundary conditions

Boundary position	Boundary condition	Number
inlet	velocity	3.36m/s
outlet	pressure	10.5MPa

Comparative analysis of fluid-structure interaction in different buffer positions

Fluid-structure interaction dynamics mainly studied in the solids corresponding structural changes in the flow field because of the effect of the flow field which Solids in the flow field and the effect to the flow field when solid has produced structural strain,vibration etc.The main feature is the interaction between the two phases.

Comparison and analysis of fluid pressure. The oil is flowing from the gap between the damping sleeve and the upper end sleeve.Set speed inlet to 3.36m/s.The oil flows out from the gap between the throttle buffer device and the lower end bar to the rodless cavity of the hydraulic cylinder.set pressure to 10.5MPa.Using fluent to calculate the pressure field and velocity field in the basin.

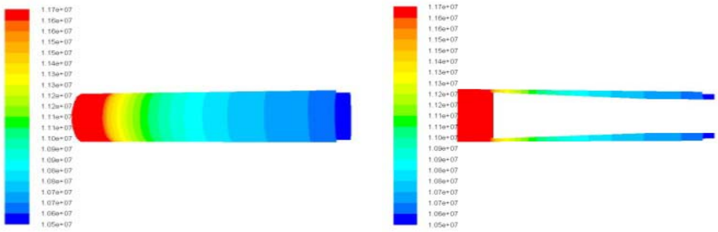


Fig. 4 The first condition pressure distributions

Figure 4 is gap buffer basin pressure distributions.the figure on the left is the 3d view,the right of the figure is cross section diagram.as you can see from the diagram.Oil pressure from inlet to outlet direction has a decreasing trend.The area of the maximum pressure is shown in the diagram as red.the pressure value is about 11.7MPa.the minimum pressure area is the oil outlet.The pressure value is 0.5Mpa.The pressure difference between inlet and outlet is 1.2MPa.We can seen from the figure that it has experienced a gradual process of gradual change.It indicates that there is an obvious pressure gradient in the buffer zone.the pressure gradient of the buffer gap is Obviously faster than other areas.It is proved that the buffer structure has a problem of building the pressure.

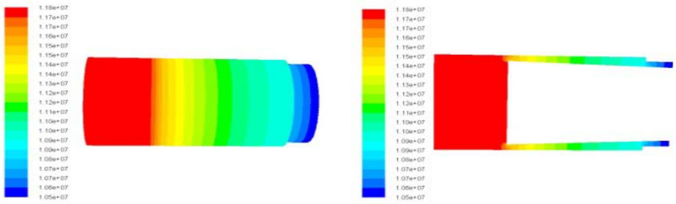


Fig. 5 the second condition pressure distributions

Figure 5 is gap buffer basin pressure distributions.The left pressure of damping sleeve is 11.8MPa.The minimum value for outlet oil pressure is 10.5MPa.The pressure difference up to 1.3MPa.There is still an uneven phenomenon in the pressure gradient of the damping sleeve port area.

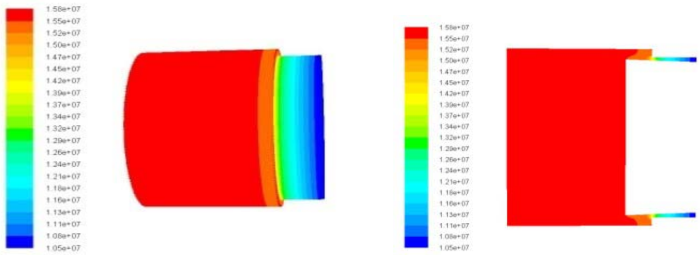
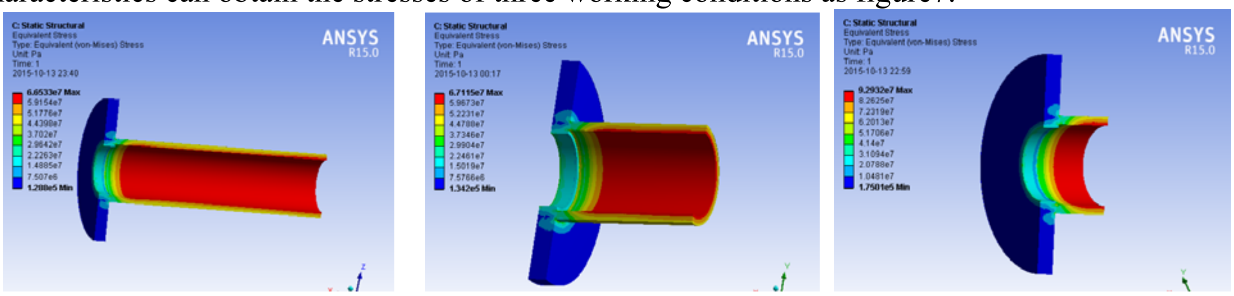


Fig. 6 the third condition pressure distributions

Figure 6 is gap buffer basin pressure distributions.Similarly,the maximum oil pressure at the inlet of the oil is 15.8MPa.The minimum oil pressure at the outlet of the oil is 10.8MPa.The pressure difference up to 5MPa.In this condition,the throttling buffer device is going to run to the end of the buffer.according to the figure,we can found that the pressure is up to 2MPa at a short distance from the cross section.

It can be seen from the pressure figure of the three conditions that the buffer structure build more pressure. Under the premise of setting the outlet pressure is 10.5MPa.The oil inlet pressure can reach 5MPa when it arrived at the terminal buffer.

Calculation,Comparison and analysis of fluid-structure interaction. The fluid-structure interaction surface area of the throttle buffer device during the movement of the working condition one to the working condition three with the buffer gap is decreased continuously,thus the solid finite element model of the fluid-structure interaction is also reduced by importing the flow field characteristics can obtain the stresses of three working conditions as figure7.



a) The first conditions b) The second conditions c) The third conditions

Fig. 7 Sectional drawing of fluid-structure interaction stress distribution

Observe the sectional drawing of fluid-structure interaction stress distribution.The largest stress in the fluid-structure interaction region are found in the oil inlet region in different conditions,and it has been extended to the throttle buffer device.under the three conditions.The maximum stress values are 66.53MPa, 67.16MPa, 92.93MPa. Maximum stress difference is not large between the conditions of the throttling buffer device is not yet moving to the bevel gap of damper bushing and it has reaches the middle position.When moving to the top of the inclined plane, the stress value increases sharply.From this we can know that the effect of fluid solid interaction makes the maximum stress of the buffer solid component in the process of buffering increase constantly as the buffering process going. We can know that there is a large pressure gradient in the flow field in the region where solid strain is relatively large but the difference is not large from the pressure gradient of the flow field in three kinds of working conditions.it will be seen from this that the hydraulic pressure does not determine the fluid-structure interaction stress.

Summary

In this paper, ANSYS software is used to study the influence of flow field and fluid structure interaction on the structure of buffer throttling when the throttle device in different buffer positions. The following conclusions are obtained:

1.Use the fluent to simulate the fluid field,it can describe the distribution of pressure and flow rate in the hydraulic cylinder really.

2.Large vertical equipment hydraulic cylinder buffer zone has a clear pressure gradient,it hold more pressure.In the buffer end pressure it can increased up to 5MPa .

3.The oil pressure of fluid-structure interaction surface does not determine the magnitude of the stress value of the coupling surface of the buffer device.

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