Hydraulic synchronizing lifting steel template based on AMESim modeling simulation technology research

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Abstract: Steel formwork is used for concrete casting and forming, and plays a key role in the construction of high-rise buildings with asymmetrical large loads. In order to make the inner and outer formwork can be lifted synchronously, the difficult problem of unbalanced inner and outer formwork must also be overcome. According to the synchronization principle of the hydraulic lifting system and the performance parameters of its main components, AMESim model was created and the simulation was done for two hydraulic cylinders bearing the same heavy load and different weight load respectively. Therefore, the synchronization scheme of shunt valve is proposed.

1.Introduction

Hydraulic synchronous lifting technology is a novel building construction installation technology, its load-bearing material is flexible steel strand, and constitute a cluster of lifters, and then computer to control the hydraulic synchronous lifting. The construction background of literature [1] is a project in Changsha, using hydraulic synchronous lifting technology to lift two adjacent brackets synchronously with high stability and reliability, this study takes steel formwork as the research object, using AMESim software, designed a double-cylinder hydraulic synchronous lifting model, made simulation analysis for the two working conditions of double-cylinder bearing the same load and different load respectively, and got the simulation curve, and used the diverter valve to improve the system to overcome the difficulty of non-equilibrium and large load [2-5].

2. Steel formwork hydraulic synchronizing lifting system performance parameters of main components

According to the actual demand of the project, the total load mass is 10 tons, the lifting speed of steel formwork is not more than 1m/h, and the synchronization error is 30mm.

Because the assumed load is 10 tons, according to experience, set the lifting working pressure is 4Mpa. according to the formula to obtain the force of steel formwork is:

\[ F = m \times a = 10000 \times 9.8 = 98000N \]  \hspace{1cm} (1)

m: the quality of the steel template
a: acceleration of gravity, from 9.8 m/s

The stress of the cylinder covers an area of:
Because there are two oil cylinders, so the area of each cylinder is respectively:

$$A_1 = \frac{A}{2} = \frac{24500}{2} = 12250\, \text{mm}^2$$

(3)

Each cylinder corresponding diameter:

$$D = \sqrt{\frac{4A_1}{\pi}} = \sqrt{\frac{4 \times 12250}{3.14}} = 124.888\, \text{mm}$$

(4)

Rounded to 126 mm. Because of the oil cylinder speed is not more than 1 m/h, take oil cylinder speed 0.8 m/h.

The oil cylinder for ascension requires the flow:

$$Q = A \times V = \left(\frac{\pi D^2}{4} \times V\right) = 0.166\, \text{L/min}$$

(5)

So the two cylinder corresponding flow for $2q = 0.332\, \text{L/min}$.

3. The hydraulic synchronizing lifting technology of steel template AMEsim modeling and simulation

3.1 under the uniform load modeling of hydraulic system

The state of the steel formwork hydraulic synchronous lifting load is ideally uniform, the load borne by both hydraulic cylinders is the same, the simulation model is established in AMESim platform and the parameters are set as shown in Table 1.

| Table 1 Parameter setting table |
|---------------------------------|
| element                          | parameter                  | The values |
| Hydraulic pump                  | displacement/cc \cdot r\,^{-1}| 1          |
| The motor                       | speed/\, r \cdot \, min\,^{-1}| 1000       |
| The overflow valve              | opening pressure /Mpa       | 6          |
| Hydraulic controlled check valve| opening pressure /Mpa       | 0.01       |
| The hydraulic cylinder          | cylinder bore /mm           | 126        |
|                                 | The piston rod diameter /mm | 90         |
|                                 | trip /mm                    | 1000       |
| The quality of block            | The weight of the /kg       | 10000      |

The AMEsim model was built. The simulation run time is 10 s. Take the hydraulic cylinder rising speed, cylinder displacement for analysis; Figure 1 indicates the hydraulic cylinder rising speed curve, it can be seen that when the hydraulic cylinder is stable rising speed are 0.000225 m/s; Figure 2 is the hydraulic cylinder rising displacement curve, as the figure can be seen, the two hydraulic cylinders rise synchronously. In summary, it can be seen that the hydraulic cylinder operating state meets the actual needs of the hydraulic lifting project of steel formwork.
3.2 under non-uniform load modeling and simulation of hydraulic system

In the previous section, we discussed the case where the two hydraulic cylinders bear the external load evenly, the two hydraulic cylinders feed equal amounts of oil, and the speed is kept consistent. However, during the actual operation of the equipment, the physical characteristics such as the structure and quality of the inner and outer formwork are not the same, and the building exterior safety net, internal auxiliary facilities, etc. also need to be lifted simultaneously, so the load borne by the two cylinders will not be the same. Suppose the left cylinder bears 6 tons and the right cylinder bears 4 tons.

In this case, the built AMEsim model is unchanged. The mass parameter is set to change and the simulation time is 10s, and the curves of flow rate, displacement and velocity are obtained. From Figure 3, we can see that the design flow rate is 0.33L/min, and the actual simulated flow rate is 0.337L/min, which matches with the requirement. However, because of the load mismatch between the two ends, the flow distribution is unbalanced, the flow rate of the 6 ton load on the left is
0.021L/min and the flow rate of the 4 ton load on the right is 0.3157L/min, so the flow rate basically goes from the 4 ton cylinder. So even if the load deviation is not very big, the relative flow difference seems especially big because of the small flow rate. From Fig. 4 and Fig. 5 it can be seen that the speed and displacement difference between the two cylinders is large and does not meet the requirements. So a diverter valve needs to be designed to achieve a synchronous diversion of the rise.

Fig. 3 Non-uniform load flow distribution

Fig. 4 Non-uniform load displacement

Fig. 5 Non-uniform load velocity
4. Research on hydraulic system synchronization steel template

In the case of non-uniform load, the double-cylinder hydraulic lifting system appears asynchronous, in order to solve the problem, it was decided to add a shunt collector valve at the inlet pipe of the two hydraulic cylinders in the original hydraulic system to adjust the feedback of the inlet (outlet) oil flow of the two hydraulic cylinders, so as to achieve the synchronization of the shrinkage (extension) speed of the double hydraulic cylinders.

Diverter valve model is set up as shown in figure 6. As seen in Figure 7, after the system enters the stable ascent state, the running speed of the mass blocks on both sides is very close, and by taking the value, the system speed difference is about 5.9679e-06m/s at 2 seconds.

Comparing the graphs with and without adding the diverter valve, it can be seen that since the addition of the diverter valve does not prolong the time from acceleration to speed stabilization of the system, the synchronization error is calculated to be 0.08mm at 10 seconds of piston operation and 5.04mm at one minute of synchronization according to the simulation results obtained from Figure 8, which is less than the specified value of 30mm and meets the requirements.

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**Fig. 6 Diverter valve model**

**Fig. 7 Non-uniform load velocity**
5. Conclusion
In this study, according to the operation principle of hydraulic synchronous lifting of steel formwork, a hydraulic synchronous lifting system model is established, the same load on both sides and different load cases are simulated respectively, and a two-cylinder hydraulic synchronous lifting scheme based on shunt collector valve is proposed for non-uniform large load cases.

The simulation results show that after adding the diverter valve, even if the two sides bear different loads of heavy loads, they can basically achieve synchronous rise, and the error meets the actual engineering needs.

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References
[1] Zhang M, Chen Y, Zhou P, Zhuang Z. (2018)Application of integral lifting technology in construction of long-span steel truss [J]. Steel Structure, 33(07):94-98.
[2] Li J, Hu Z, Guo Y. (2017)Simulation study of shunt and collector valve based on AMESim [J]. Mechanical Engineer, (08):63-64.
[3] Wang W, Li J, Lv Z, Zhang P, He Zhenghao. (2019) Modeling and synchronization research of hydraulic lifting system of frog jump based on AMESim [J]. Hydraulics and Pneumatic, (12):95-100.
[4] Cao Y, Dai L, Deng Ri, Lu H. (2019) Modeling and Simulation of Hydraulic Brake System of Mine Hoist [J]. Chinese Hydraulics & Pneumatics, (06):69-74.
[5] Tong Z, Zhang X, Wu Y, Chen X, Hou (2020)Chaopeng. Research on Hydraulic System Design and Simulation of Tobacco Cultivator Based on AMESim [J]. Chinese Hydraulics & Pneumatics, (08):139-144.