Design and Analysis of a Double-well Mutual Balance Hydraulic Pumping Unit

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Abstract: According to the characteristics of the small spacing of cluster wells, this paper designs a double-well mutual balance hydraulic pumping unit. One pumping unit is used for two wells, and it achieves interactive balance pumping through two balanced hydraulic cylinders. The hydraulic system is simulated by AMESim software. The simulation results are in good agreement with the design curve, which proves the designed pumping unit has excellent working performance.

Keywords: double wells; hydraulic system design; AMESim analysis; system simulation; hydraulic components

1. Introduction

From the point of view of the development process of pumping, pumpingthe general trend of technological development towards long stroke, large load, precision balance, save energy, adaptability and other aspects of development. Hydraulic fluid is ess-ential for modern industrial energy-intensive transmission mode, it can minimize equipment size and weight. The hydraulic pumping unit character is use for hydraulic drive technology, which can maximize well productivity, good oil economy, especially for the late development of hydraulic pumping heavy oil and oil fields are more attractive [1]. Formation of a product at home and abroad in the development stage of hyla-rid pumping unit are mostly adopts a single well oil production method, using the accumulator as well as the applied load to balance the well up and down stroke. Single-well oil hy-draulic pumping unit has been well used in foreign countries, and achieved expected results. But for the limited space, the number of multiwell oil field, the oil well is a hydraulic pumping work or must result in equipment footprint, high equipment purchase cost, low energy ef-ficiency. To solve this problem, this paper proposes to use a double-well mutual balance hydraulic pumping unit with a hydraulic pump while pumping wells, with better economic benefits. Two different-al oil pump work, it use of two wells up and downstroke difference balancing. By adjusting the depth, sucker rod pump com-binations and pump diameter size at two wells pump, so that the load balance each other two wells can be made more precisely balancing and energy efficiency.

2. Hydraulic pumping unit of hydraulic system design

The double-well mutual balance hydraulic-ic pumping unit hydraulic system is mainly composed of the power unit, control valve-s, actuators, hydraulic accessories and hydraulic medium of five parts, the basic structure shown in Figure 1. The two variables piston pump as the main pump system (3-1, 3-2), is provided at the accumulator charge pump (3-4), in addition to the system set a manual pump (8). The main oil pressure control valve has pilotrelief valve (5-1, 5-2) and directacting relief valve (11); the main oil flow control valve veins flow diversion valve (10-1, 10-2, 10-3, 10-4, 10-5, 10-6); the main of directional. 1. Tank; 2 suction filter; 3 hydraulic pump; 4 motor; 5. Pilot Relief Valve (with relief); 6-way valve; 7 electro-hydraulic valve; 8 manually change 9 manual shut-off valve; the valve 10 bypass flow valve; 11 directly Operated; 12 pressure switch; 13 cooler; 14 gauge; 15 drive the hydraulic cylinder; hydraulic balance 16. cylinder; 17 accumulator; 18 heater; SQ limit switch; A, B, C, D, E, F quick connector.

Figure 1 Double-well Mutual Balance Hydraulic Pumping Unit hydraulic system diagram

Control valve with a check valve (6-1, 6-2, 6-3, 6-4), electro-hydraulic valve 7, manual valve 8; actuator consists of balancing hy-draulic cylinders (16-1, 16-2) and a drive cy-linder (15-1, 15-2). Hydraulic accessories-including tank (1), fittings, filters (2), a heat exchanger (13, 18), the accumulator (17), indicating instrument (14), pressure switch (12), limit switch (SQ), etc; hydraulicsmedium HM antiwear hydraulic oil. According to the flow rate is determined by sp-eed, the velocity of driving hydraulic cylinder will direct result of the large flow system is needed, pumping unit strokereq-uire adjust, it demand of the system provi-ded by adjustable flow range is adjustable. So choose two adjustable quantitative pist-on pump as the main pump system (3-1, 3-2). The system required flow is large, open two hydraulic pumps at the same time, the system needed to little flow, it regulate the hydraulic pump of variable institution or only open a pump. The accumulator is provided at a charge pump (3-4), it uses supplement pressure oil for the accumulator for the first time to use, when the bal-ance cylinder system leaks to supplement oil for its pipeline. In addition the system setup manual pump (8), is used in the ca-se of the main system is not work, it gua-mente driving the hydraulicyc-inder position. Two flow diversion valve are comm-unicated with a balanced hydraulic cylinder (16-1, 16-2) in the front chamber and the other balancing hydraulic cylinders (1-6-1, 16-2) of the rear chamber. Flow dive-CISION
valve on the oil supply system will be 1:1 split, the pressure of the hydraulic oil comes from the power source score divided into two parts, transported to the balancing hydraulic cylinders to achieve drive the two hydraulic cylinders synchronous phase operation.

Hydraulic System Works Analysis

Double-well mutual balance hydraulic pumping unit is mainly used in the oil double-well conditions, but also have a single-well oil production capabilities. When one well needs workover or encounter other immesurably factors cannot be recovered in a short time, it can take advantage of features of single well oil. When the double-well work, each element work condition of the hydraulic system as follows:

2.1 Analysis of the principle double-well

Limit switch SQ1, SQ2 detected piston-stroke of the driving hydraulic cylinder 1-5-1, limit switch SQ1 is located at the top dead center, limit switch SQ2 is located at the down dead center of the piston stroke. When the drive cylinder 15-1 piston rod is located in the lower dead point, the limit switch SQ2 receive electrical signals applied to the electro-hydraulic valve 7, so that the electro-hydraulic valve 1YA was electric, electro-hydraulic valve fluid communication with the left. At this time, the power plant sent out from the high pressure fluid through the check valve 6-1 and 6-2 to reach the left side of the electro-hydraulic valve 7, hydraulic oil conveyed by the electro-hydraulic valve in the bypass flow valve 10-1, 10-2, 10-3 is at 1:1 split, the split oil respectively reach balance cylinder 16-1 lower chamber and 16-2 up chamber. Balancing hydraulic cylinders 16-1 oil pressure chamber pressure is increased to promote the drive cylinder 15-1 on the trip. Balance hydraulic cylinder 16-2 up chamber pressure oil and drive hydraulic cylinder 15-2 load both to promote balance hydraulic cylinders 16-2 oil return, thus promoting driving the hydraulic cylinders 15-2 down stroke. Balancing hydraulic cylinders 1-6-1 oil return through the upper chamber and flow diversion valve 10-4, 10-5, 10-6 back to the tank. Its passage schematic diagram shown in Figure 2.

![Figure 2: shuangjiing working oil flow schematic](image)

2.2 Analysis of the principle of single well

Whensingle well work, driving the hydraulic cylinders 15-1 or 15-2 drive the hydraulic cylinders working separately, each element in the work of this particular analysis of the hydraulic cylinder drive system 15-1 work alone. Close manual shut-off valve 9-1, 9-2, 9-3, 9-4 and 9-8, with hydraulic hoses and quick connectors AC, B and D. Limit
switch SQ1 and SQ2 limit switch detecting drive hydraulic cylinder 15-1 piston stroke, limit switch SQ1 15-1 is located at the t-op dead center of the piston stroke, limit switch SQ1 15-2 is located at the under dead center of the piston stroke.

When the drive cylinder 15-1 piston rod is located in the lower dead point, the limit switch SQ2 receive electrical signals applied to the electro-hydraulic valve 7, so that the electro-hydraulic valve 1YA was electric, electro-hydraulic valve fluid communication with the left side of the drive cylinder 15-1 start on the stroke movement. Its passage schematic diagram shown in Figure 3.

Figure 3: a schematic view of a single well working oil flow

When the drive cylinder 15-1 piston rod is located in the top dead center, the trip switch SQ1 receive electrical signals applied to the electro-hydraulic valve 7, so that the electro-hydraulic valve 2YA was electric, electro-hydraulic valve the right of communication with the fluid driven cylinder 15-1 to start the next stroke movement.

3. Pumping Operation Curve Planning

According to the relevant technical parameters of the existing hydraulic pumping unit is designed to determine the pumping-stroke of 6m, pumping 4 times. The actual situation, the pumping speed curve is usually designed into sinusoidal and trapezoidal profile. Sinusoidal velocity curve used for beam pumping unit, trapezoidal velocity curve used for the new multi-linear oil production equipment, which motion process comprises uniformly accelerated, uniform, uniform deceleration phase and the inverted repeat this procedure. According to stroke, stroke frequency, acceleration, and speed requirements, design of hydraulic pumping unit suspension point velocity trapezoidal speed profile [4], as shown in Figure 4. t1- acceleration time, deceleration time; t2- uniform time.

Figure 4: trapezoidal velocity curve design

Within a cycle of run light pole run 12m, where the up stroke 6m, the lower stroke 6m. Early light rod running from the bottom dead center begins to move, after time t1, 0.6m of uniformly accelerated t-he campaign began uniform motion, after uniform motion time t2, 4.8m started deceleration, deceleration time is t1, deceleration distance is 0.6m. According to Figure 4 lists the following formula.

\[2t_1 + t_2 = 7.5\]  \hspace{1cm} (1)
\[at_1t_2 = 4.8\]  \hspace{1cm} (2)
\[\frac{1}{2}at_1^2 = 0.6\]  \hspace{1cm} (3)

United the formula (1), (2), (3), calculated value of the acceleration during accelerate-on and deceleration of 0.768m/s²; maximum operating speed of the rod is 0.96m/s.

4. Hydraulic system AMESim simulation

It was established driven hydraulic cylinders and load model, balancing hydraulic cylinders model, flow diversion valve module in AMESim. Combining element module and modeling analysis of some of the components, the establishment of double-well mutual balance double-well oil hydraulic pumping unit of AMESim model, a model shown in Figure 5, for the entire hydraulic system simulation.

Figure 5: Shuangjing mutual balance Shuangjing oil hydraulic pumping unit of AMESim model

Setting hydraulic pump 01, pump 01_1 displacement of 282ml, motor pmover01, pmover01_1 rotational speed of 1480 r/min, in two stages analog load signal 03_1, 03_2 of signal value, namely the up stroke 160kN and lower stroke stroke 65 kN. Setting simulation time is 60 seconds, graphic printing interval of 1 seconds, for the double-well mutual balance double-well oil hydraulic pumping unit of AMESim modelsimulation.

The results of simulation after processing by driving hydraulic cylinder 1 load curve as shown in figure 6, the displacement curve as shown in figure 7, speed curve as shown in figure 8.
values have been changed, the maximum speed of 1.3 m/s[5]. The same specifications LDCJ16-6type chain pumping unit calculated maxiumum acceleration 1.85m/s², the maximum speed of 0.8 m/s[6]. Designed a double-we-Il mutual balance hydraulic pumping unit with respect to the beam pumping unit and chain pumping unit has a minimumstandable acceleration and a suitable speed. In the pump suction process, changes in acceleration and greater acceleration is not good for the suction pump, and when the oil stability absorption stability, greater operating speed can increase the value of the oil pump speed. Therefore, this paper designed a double-well mutual balance hydraulic pumping unit in terms of stability and change in acceleration rate advantage over the same type of beam pumping unit and chain pumping unit.

5. Conclusion

This paper designs a kind of double-we-Il balanced hydraulic pumping unit, can realize double production at the same time compatible with single well oil production. The hydraulic pumping unit adopts the hydraulic cylinder reciprocating drive rod, easy to realize long stroke pumping unit requirements; double oil well production w-hen two different pumping Wells, the bal-ancing oil cylinder stroke up and down; a accumulator balance when single oil well production accumulator up and down stroke, facilitate the well maintenance. AMES-im software using the hydraulic system simulation resulting motion characteristic curve is consistent with the design requirements. The simulation results show that the designed double-well mutual balancing hy-draulic pumping unit has a longer uniform motion stage and a shorter variable motion stage, its acceleration is less than the same size of the beam pumping unit and chain drive pumping unit, improve the working conditions of pumping and extending the life of the pumping unit and its comp-onents.

References

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