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 that 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 large 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 driven technology, which can maximize well productivity, good oil economy, especially for the late development of hydraulic pum- ping heavy oil and oil fields are more attractive[1]. Formation of products at home and abroad in the development stage of hydraulic pumping unit are mostly adopts s-ingle well oil production method, using the accumulator as well as the applied load to balance the well up and down stroke. Single-well oil hydraulic pumping unit has be-en well used in foreign countries, and achieved the expected results. But for the limited space, the number of multi-well field, the oil well a hydraulic pumping w-ork must result in equipment footprint, hi-gh equipment purchase cost, low energy ef-ficiency. To solve this problem, this propose put forward a double-well mutual balance hydraulic pumping unit with a hydraulic cylinder unit while pumping wells, wi-th 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 twowells can be made more precise balancing and energy ef-ficiency.

2. Hydraulic pumping unit of hydraulic system design

The double-well mutual balance hydraul-ic pumping unit is main-composed of the power unit, control valve, actuators, hydraulic accessories and hydraulic medium of five parts, the basic structure shown in Figure 1. Power means for the two variable 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 of pressure control valve has pilot-relief valve (5-1, 5-2) and direct acting r-eflux valve (11); the main of flow control valve has 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 hydraulic 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 (S), etc; hydraulicmedium HM antiwear hydraulic oil. According to the flow rate is determined by the speed, the velocity of driving hydraulic cylinder will direct result of the large flow of the system is needed, pumping unit strokerequire adjust, it demand of the system provi-ded by adjustable flow range is adjustable. So choose two adjustable quantitative piston pump as the main pump system (3-1, 3-2), The system required flow is large, 0-pen two hydraulic pumps at the same time, the system needed to little flow, it regulates the hydraulic pump of variable institution or only open a pump. The accumulator is provided at a charge pump (3-4), it use of supplement pressure oil for the accumula-tor 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 guar-teed driving the hydraulic cylinder 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-rsion
valve on the oil supply system will be 1:1 split, the pressure of the hydraulic oil comes from the power source scored 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 the double-well needs workover or encounter other in-measurable factors cannot be recovery oil 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 electrohydraulic valve 7, hydraulic oil conveyed through 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: shuangjing working oil flow schematic](image)

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.

2.2 Analysis of the principle of single well

When single-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 A C, B and D. Limit
switch SQ1 and SQ2 limit switch detecting dri-ver 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 ro-d is located in the lower dead point, the limit switch SQ2 receive electrical signals applied to the electro-hydraulic valve 7, sothat the electro-hydraulic valve 1YA was electric, electro-hydraulic valve fluid com-munication with the left side of the drivecy-linder 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](image)

When the drive cylinder 15-1 piston ro-d is located in the top dead center, the tr-ip switch SQ1 receive electrical sig-nals a-pplied to the electro-hydraulic valve 7, so that the electro-hydraulic valve 2YA was electric, electro-hydraulic valve the right ofcommunication with the fluid driven cy-linder 15-1 to start the next stroke move-ment.

3. Pumping Operation Curve Planning

According to the relevant technical para-meters of the ex-isting hydraulic pumping unit is designed to determine the pumping-stroke of 6m, pumping 4 times. The actualsituation, the pumping speed curve is usu ally designed into sinusoid-al and trapezoidalprofile. Sinusoidal velocity curve used f-or beam pumping unit, trapezoidal veloc-itycurve used for the new multi-linear oil pr-duction equipment, which motion process comprises uniformly accelerated, uniform, uniform deceleration phase and the inverte-d repeat this proce-dure. According to stro-ke, stroke frequency, acceleration-nandspeed requirements, design of hydraulic pumpingunit 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](image)

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

\[
2t_1 + t_2 = 7.5 \\
at_1t_2 = 4.8 \\
\frac{1}{2}at_1^2 = 0.6
\]

Unified the formula (1), (2), (3), calculated value of the ac-ce-leration during accelerate-on and deceleration of 0.768m/s²; maxim-um operating speed of the rod is 0.96m/s.

4. Hydraulic system AMESim simulation

It was established driven hydraulic cyli-nders and load model, balancing hydraulic cylinders model, flow diversion valve mod-el in AMESim [3, 4]. Combining element mo-dule and modeling analysis of some of th-e components, the es-tablishment of double-well mutual balance double-well oil hydra-ulous pumping unit of AMESim model, a model shown in Figure 5, for the entire h-ydraulic system simulation.

![Figure 5: Shua-ningjing mutual balance Shuangjing oil hy-draulic pumping unit of AMESim model](image)

Setting hydraulic pump 01, pump 01_1 displacement of 282ml/r, motor pmover01, pmover01_1 rotational speed of 1480 r/min, in two stages analo-g load signalsignal03_1, signal03_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 hy-draulic cylinder 1 load curve as shown in figure 6, the dis-placement curve as shown in figure 7, speed curve as shown in figure 8.
Driving hydraulic cylinder 2 with the same driving hydraulic cylinder 1 movement in the opposite direction. According to the analysis results, double-well mutual balance hydraulic pumping unit with respect to the beam pumping unit and chain pumping unit has a minimum mandable 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 designs 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-well 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 when two differential pumping Wells, the balancing 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 hydraulic 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 components.

References


Figure 6: driving hydraulic cylinder 1 load curve

Figure 7: displacement curve of driving hydraulic cylinder

Figure 8: driving hydraulic cylinder 1 speed curve
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