Research On Nozzle Structure Selection Of Cementing Ground Anchor

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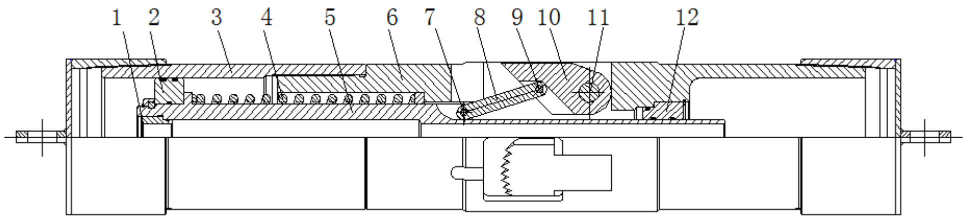
Abstract. By using fluid dynamics calculation, we start a numerical simulation research on flow fields of cylindrical and conical nozzle in order to choose a better structure of cementing ground anchor, at the same time, we also do hydraulic cycle experiments on cylindrical nozzle with different bore diameter. According to the result: cylindrical nozzle has an obvious throttling effect so that cylindrical nozzle is the better choice for cementing ground anchor; the theoretical differential pressures of nozzles with different diameters are very close to experimental date; the flow coefficient of the nozzle doesn't trend to a constant, when Reynolds number of the nozzle is 25000~35000, the nozzle has more flow coefficient; as the Reynolds number increases or decreases, the flow coefficient decreases and the damping of the flow increases. The result does a great contribution to the thermal recovery of heavy oil and pre-pressure cementing.

1 . GENERAL INSTRUCTIONS

In recent years, national thermal recovery of heavy oil is mainly on land, the thermal recovery is widely used [1]. In thermal recovery, casing pipes would endure huge range of temperature and it will cause damages like plastic deformation, rupture, shifting up of well head and so on, so it needs cementing ground anchor for pre-pressure cementing [3]. Nozzle is the direct power unit of cementing ground anchor. Its capability determines the capability of whole cementing ground anchor system, at the same time it also restrains other parts of the cementing system. Nozzle as an energy conversion mechanical element, flow coefficient is the key coefficient that should be taken into consideration, at the same time the variation law of hydraulic performance parameters has an effect on ground anchor cementing.

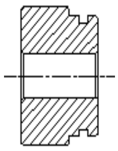
2. STRUCTURE OF THE GROUND ANCHOR

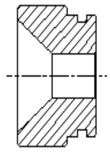
Cementing ground anchor uses throttle nozzle to form differential pressure and the pressure acts on plunger, the pressure will push plunger and central tube downside, and then the central tube and the linkage help the fluke to touch the wall of well, with the help of upside well hole casing tube, the fluke will plant into the ground and pre-pressure cementing work would be done. The structure of the cementing ground anchor is shown in Figure 1.



1—throttle nozzle 2—plunger 3—upper short circuit 4—reset spring 5—central tube 6—body 7,9—melt 8—linkage 10—fluke 11—melt of the fluke 12—guide sleeve Figure 1 structure of ground anchor

Nozzle as the main power element of the cementing ground anchor, its hydraulic performance parameters affect the efficiency of the whole cementing ground anchor system directly. According to the plan, we choose cylindrical and conical structure as the preliminary scheme, and the structures are shown in Figure 2





(a) cylindrical structure (b) conical structure

Figure 2 structures of the nozzles

3. THEORETICAL ARITHMETIC

3.1 Hydraulic power calculation

The flow field inside the cementing ground anchor includes throttle nozzle, central tube and so on. Central tube is made up of two parts, one's length is 0.4m core diameter is 5.2cm the other's length is 0.4m core diameter is 3.5cm. Nozzle changes structure size to let the flow change to form local damping which can form pressure drop, it can realize the energy transformation. When liquid flow goes through the central tube, not only the different parts would cause pressure drop, but also the change of core diameter would cause local damping and form pressure drop.

Nozzle pressure drop calculation formula: $\Delta P = \dfrac{0.05\rho v^2}{u^2 A^2}$

ΔP is nozzle pressure drop,MPa; ρ is the density of circulation liquid, g/cm^3; v is the flow of the circulation liquid, L/s; μ is coefficient of flow, take 0.97; A is area of section of nozzle hole, cm^2.

As usual, the pressure drop caused by nozzle is larger than central tube, so the hydraulic parameters of nozzle determines the efficiency of whole ground anchor system. For calculate cementing ground anchor's nozzle hydraulic power, we use 0.97 as flow coefficient and can get the whole hydraulic pressure drop of the whole anchor system. The choice of flow coefficient of nozzle is very important for ground anchor nozzle structure design, at present there isn't confirmed formula for getting nozzle flow coefficient. There are many factors affecting the flow coefficient such as status of the flow in nozzle, nozzle structure, flow characteristic, nozzle machining roughness In engineering studies, the combination of theoretical calculation, simulation and experiments is used for make sure the flow coefficient.

3.2 Simulation analysis

Two kinds of nozzle structure 3D models were established for researching the hydraulic performances of cylindrical and conical nozzles. The outlet holes of these two nozzles are both 37mm, ground anchor entrance flow path diameter is Φ155mm, export flow path diameter is Φ145mm and then insert these data into FLUENT software to do hydraulic power simulation. Turbulence model is chosen to simulate flow field inside the nozzle and standard $k-\varepsilon$ formula is chosen for control equation. Pure water is chosen for liquid medium and set boundary condition chose 20L/s as circulation displacement, set the entrance absolute velocity and direction and export static pressure boundary conditions, chose non-slip wall boundary. Calculate the pressure drop of the flow through the entrance and export of the nozzle.

According to hydraulic power simulation, under the same entrance velocity, the pressure drop of cylindrical nozzle is larger than conical nozzle; conical nozzle has a larger export velocity and it has a longer range. Conical nozzle's flow path decreases gradually and its pressure drop is caused by local damping; cylindrical nozzle's flow path decreases in a sudden and has an obvious throttle effect. According to theoretical calculation and CFD simulation analysis, cylindrical nozzle is the better choice for cementing ground anchor.

4 . EXPERIMENTS AND RESEARCHES

4.1 Research purpose

Verify the stability of cementing ground anchor. When reach the certain flow, the fluke can open successfully; when flow decreases, the fluke can close unfailingly. Measure the holding pressure characters of nozzles with different diameters in different flow to offer basis for cementing ground anchor system structure design; measure pressure drop of nozzles with different diameters in different flow, make sure the flow coefficient.

4.2 Experiment method

1) Experiment bench is made up of cast iron platform, holding mechanism and circulation system. Flow sensor and digital display are set in entrance pipe line to measure circulation flow; 10MPa pressure transmitter and digital display are set in flow path entrance of ground anchor; 1MPa pressure transmitter and digital display are set at the export.

3) Gradually increase the entrance flow, then gradually decrease the entrance flow. wait till the flow is stable, record ground anchor entrance flow and pressure, export flow and pressure Repeat the experiment twice and take the average number to minimize the error.

4.3 Experiment results

1) According to φ178mm cementing ground anchor hydraulic power circulation experiment, we can get Ø25mm、Ø30mm、Ø37mm diameter cylindrical nozzles pressure drop—flow graphs, they are shown in Figure 3,4and 5.

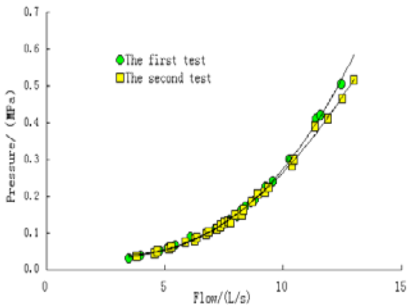


Figure 3 Ø25mm pressure drop—flow graph

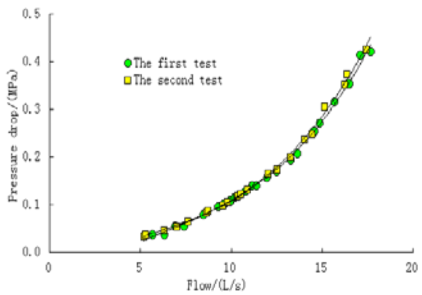


Figure 4 Ø30mm pressure drop—flow graph

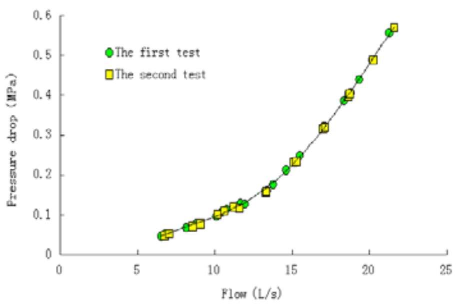


Figure5 Ø37mm pressure drop—flow graph

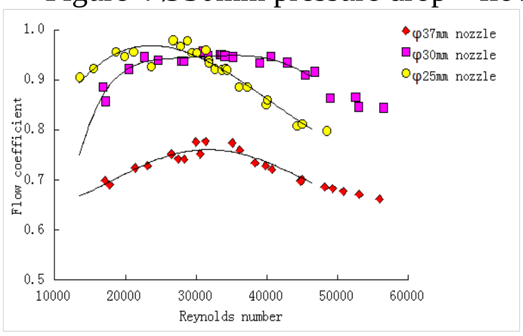


Figure6 Reynolds number—flow coefficient graph

1)According to the results, under the certain flow, cylindrical nozzle with different diameters all can make the fluke open and close; under the same circulation displacement with the diameter increases, the throttle pressure decreases. So, in working progress, we can choose different diameter nozzle according to locale situation. Flow coefficient reflects the throttling capability. The coefficient is little that means throttle capability is little or the damping is huge.

As usual, flow coefficient depends on nozzle structure mainly and the number trends to a constant . According to theoretical calculation, CFD simulation and circulation experiments, when nozzle inner diameter is smaller than central tube inner diameter 35mm, flow coefficient is 0.8~1.0;

when nozzle diameter is bigger than central tube inner diameter 35mm, flow coefficient is 0.65~0.9.

2) According to hydraulic power circulation experiments and continuous linear equation we can get cylindrical velocity and Reynolds number at export. Ø25mm、Ø30mm、Ø37mm diameter cylindrical nozzles Reynolds number—flow coefficient graph is shown in Figure 6. According to Figure 6, the flow coefficient of cylindrical nozzle doesn't trend to a constant and it has relationship with Reynolds number. When Reynolds number is 25000~35000, the flow coefficient is larger; with the decrease or increase of Reynolds number, flow coefficient and damping changes.

5 . CONCLUSION

[1] Research on cylindrical and conical nozzle and do numerical simulation, discuss and analyze the structure of the nozzle that affects cementing ground anchor working efficiency.

[2] By φ178mm ground anchor hydraulic power circulation experiments, analyze and compare 3 different-diameter cylindrical nozzle hydraulic performance. Under the same circulation displacement, with the diameter increases the throttling pressure drop decreases. In working progress, we can choose different diameter nozzle according to locale situation.

[3] Flow coefficient of nozzle directly determines the hydraulic performance, suitable nozzle flow coefficient is so important for ground anchor structure design.

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