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Numerical Simulation of Flow Field in Spiral Separator

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Abstract

Using the method of numerical simulation for PHOENICS, the paper gives a quantitative analysis about the distribution of flow field and pressure field for different viscosity and flow rate. The results show that: In the spiral flow, its tangential velocity is much larger than other velocity; with the increasing of the flow rate and polymer concentration, the speed for pressure drop is increasing; the change of internal pressure within the separator is not uniform. The simulation result scan supply reference for future research about spiral flow field within the piral separator.

Key words: Spiral separator; Spiral flow; PHOENICS; Power-law fluid

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INTRODUCTION

For the gas bearing pump with high gas content, the oil gas separator and gas anchor are generally connected to the bottom of the pump. The separation of the centrifugal force generated by the oil gas mixture by the spiral slice of the down hole oil gas separator of the screw separator[1]. In recent years, the spiral gas-liquid separator due to the advantages of low manufacturing cost, light weight, accuracy, high degree of automation, good stability and so forth, at home and abroad start is widely used in the petroleum and petrochemical industry. But because of limitations in addition to the complexity of internal flow in spiral separator[2-7], for inside the helical structure of spiral flow research is always explicitly rarely reported, the spiral flow is involved in this paper is by mounting screw mounting structure form a rotary flow generated, and by PHOENICS numerical simulation of laminar helical flow field and pressure field were quantitatively analyzed, to the spiral flow to further research and application.

1. PHOENICS

PHOENICS is in the world the first put on the market of computational fluid dynamics (CFD) and heat transfer commercial software, it is the abbreviation of parabolic hyperbolic or elliptic numerical integration code series, the software can be of one-dimensional, two-dimensional or three-dimensional, often or unsteady, compressible or in compressible flow numerical simulation, for a particular direction flow phenomena have corresponding “parabolic” calculation module; and there are some accessories, such as used for cooling electronic components calculated HOTBOX, for thermal and ventilation of flair, and for chemical vapor phase deposition (chemical vapor deposition) simulation of VCD module. PHOENICS is one of the widely used computational fluid mechanics software for engineering personnel who have no specific numerical analysis and computational program knowledge.

2. SIMULATION PROCESS

2.1 Establishment of Calculation Model

(a) The selection of the coordinate system: A calculation model is established in Cartesian coordinates. Due to the complexity of the spiral structure, it is difficult to realize the direct model in PHOENICS. Therefore, the spiral structure model (CAD model to STL format) is constructed in CAD, and then transferred to the PHOENICS, the internal spiral structure as shown in Figure 1.

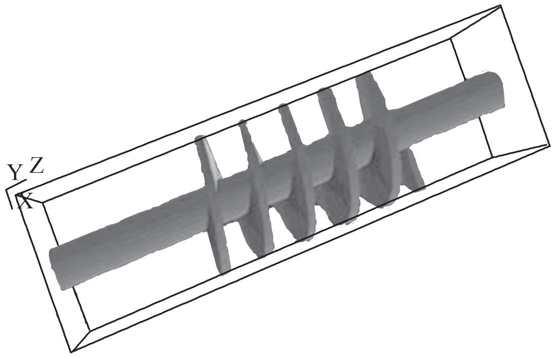

Figure 1
Geometric Model in PHOENICS

(b) Simulation area: Delta X = 0.052 m, Delta Y = 0.052 m, Delta Z = 0.24 m, at the same time, set screw outer tube wall thickness of 0.001 m.

2.2 Boundary Conditions

(a) The flow inlet boundary: A speed inlet, the inlet velocity, and the vertical in the inlet section of the inlet cross section;

(b) The boundary of the flow exports: Set free exports, that is, not set any boundary conditions, at the same time, at the same time that the flow state of the outlet is fully developed;

(c) The wall boundary: The flow boundary is used for the solid wall condition without slip, and the flow near the solid wall is determined by the standard wall function method.

2.3 Physical Model

The physical model of CFD software should also include information of solid wall and fluid space[8]. At the same time, the following hypothesis is made for the fluid properties:

(a) Fluid motion can be regarded as an incomprehensible fluid of a continuous and uniform motion;

(b) When the fluid is at rest, the total pressure is hydrostatic pressure;

(c) The assumption that the inlet is an infinite distance is uniform, that is, the inlet velocity end is uniformly distributed;

(d) It is assumed that the velocity of the fluid in the body is independent of the time, the steady flow.

Under the assumption of the above, the physical model is established[9,10]:

(a) The selection of turbulence model: KEMODEL (two equation model);

(b) The determination of the quality of the workers: The concentration of the paper is 200 mg/L, 400 mg/L, 600 mg/L, and the water of the polysyllabic aqueous solution as the research object.

In PHOENICS, the physical properties of the fluid are added to its own, and are set to a power law fluid (LAW POWER). In the PHOENICS, the consistency coefficient K of the power-law fluid is defined as the value of A and the flow exponent n is defined as the value of B;

(c) The selection of iteration number: Iteration = 10,000.

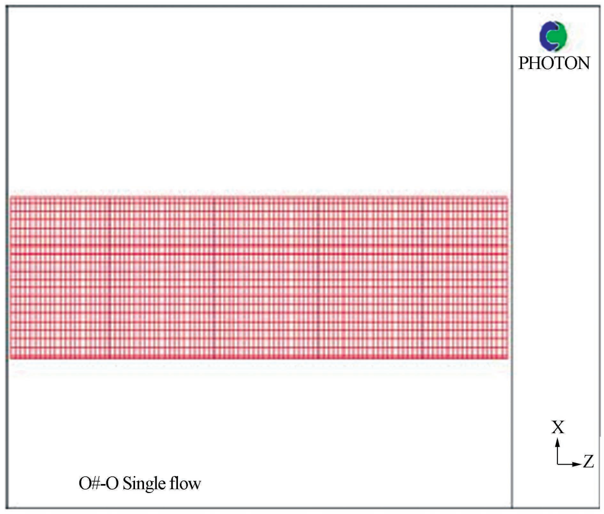

Figure 2
X-Z Surface of the Outer Grid

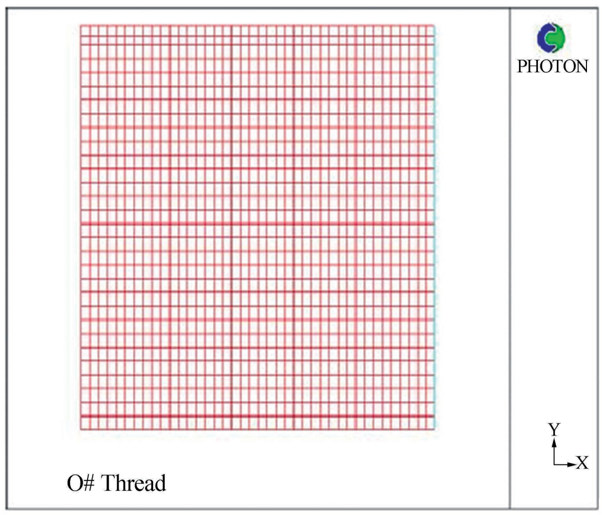

Figure 3
X-Y Surface of the Outer Grid

2.4 Computational Grid

Take the whole drainage area of the screw separator as the area, and use the structure grid (Cartesian grid) to divide the basin. Computational grid is about 200,000. The advantage of structured mesh is that it is more advantageous to convergence than non-uniform mesh, but the disadvantage is that the number of mesh is more than the surface of complex rough structure.. In view of the disadvantages of structure grid, PHOENICS software comes with PARSOL (solids treatment Partial) processing technology. At the same time, the regional local encryption is carried out for the area of the change, which is not encrypted on the whole grid structure, which greatly improves the efficiency.

3. SIMULATION RESULTS

3.1 Flow Field Analysis

There are 3 velocity components in the spiral flow, that is tangential velocity, radial velocity and axial velocity. From the speed curve 5, 4, we can see that the speed of its tangential speed advantage. By comparing the velocity curve can be seen that the radial velocity value was less than the axial velocity and tangential velocity and radial turbulence in the core region in less than in the tangential direction of the turbulent core region, therefore, in the usual calculation can fail to take into account the influence of radial velocity.

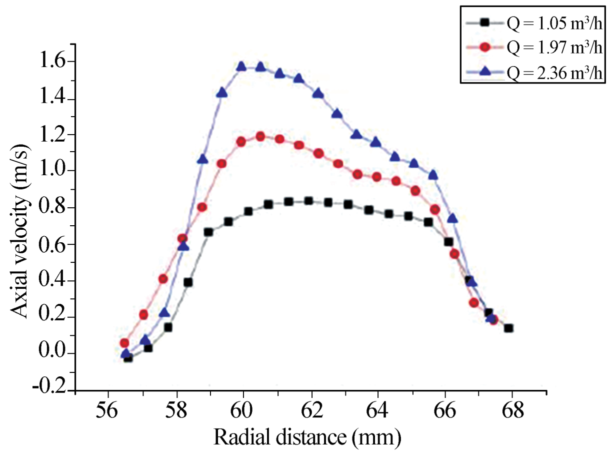

Figure 4
400 mg/L - Axial Velocity Distribution Curve

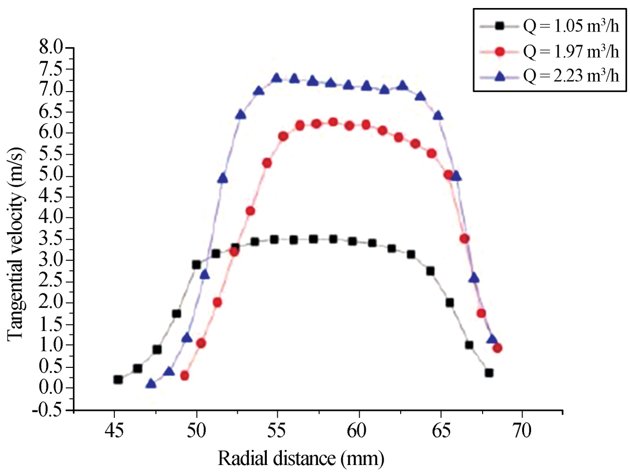

Figure 5
400 mg/L - Tangential Velocity Distribution Curve

From the Figures 6 and 7 can be seen in the separator internal, the flow of the inner spiral section of the separator is a strong swirl. Separator, role in the spiral structure in the fluid along the inner wall of the separator is spiral flow, spiral flow axial velocity from the inlet to the outlet is obviously weaker trend and in axial cross section, into helical blade speed is greater than the left spiral blade speed. Figures 6 and 7 show that the flow of the screw is obviously weakened in the inner helical separator. Therefore, to maintain a certain helical flow intensity should be considered to increase the appropriate starting screw device.

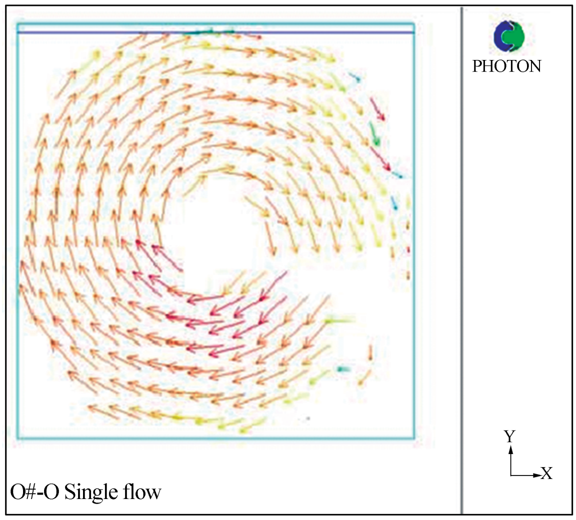

Figure 6
X-Y Section Velocity Vector Diagram

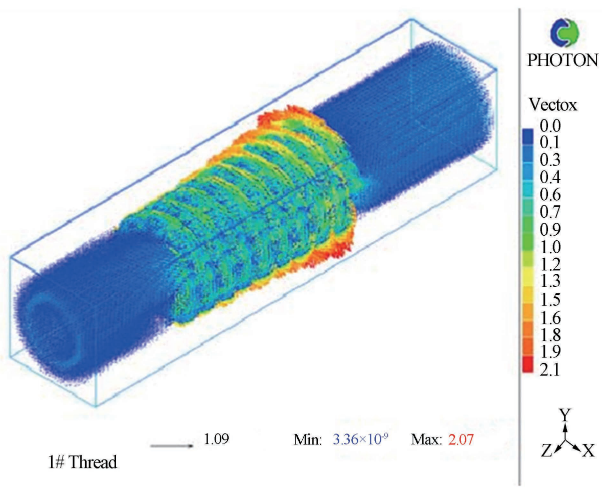

Figure 7
Velocity Vector Diagram

3.2 Pressure Field Analysis

The screw separator is the price of the pressure loss, so the study of the pressure field is important for the screw separator. A polymer solution with the concentration of Q = 2.4 m^3/h and 200 mg/L was calculated as the prototype. Get the following pressure: From the color of the left pressure image shown in Figure 8, we can see the trend of the pressure of the pressure In the pressure cloud image, red represents the maximum of the pressure, blue means the minimum pressure, other colors are the intermediate value of the pressure. As can be seen in the separator, fluid before did not enter the helical segments, pressure did not change, when into helical segments, in each layer of thread in the blade channel flowing pressure ladder was dropped. Through the visualization of the cloud image, the pressure value of different rotating channels is found.

By Figure 8 on the right side of the pressure drop curve can be seen in the different position of the helical blade rotating flow within this kind of change is not uniform, the interface of the ladder is helical blade, near the pressure change of the helical inlet end less than that close to the outlet end of the spiral pressure changes, which are also reflects the spiral separator spiral flow to form a weak trend.

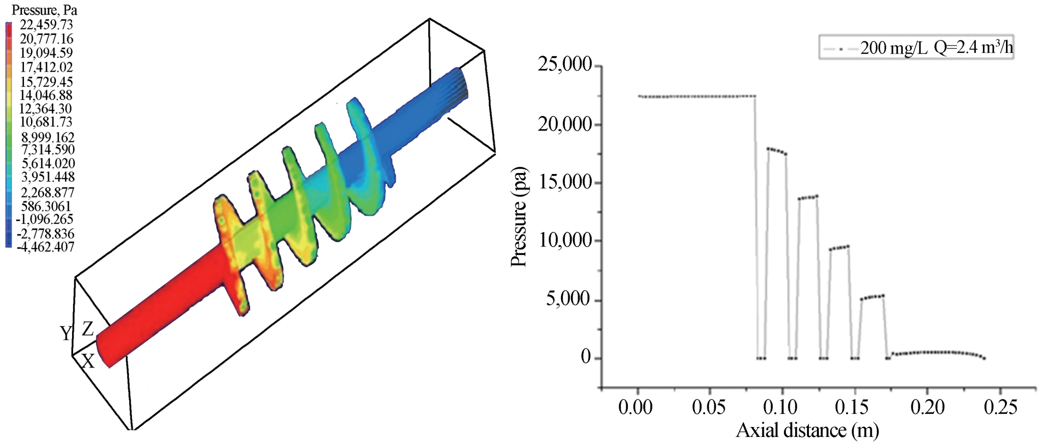

Figure 8
Pressure Distribution and Pressure Drop Curve of Q = 2.4 m^3/h, 200 mg/L

Under different working conditions, the pressure drop of the screw separator is different. The related conditions, respectively, for the following conditions: Case 1 - case 3 as working medium is water, flow rates were 1.05 m^3/h, 1.97 m^3/h, 2.36 m^3/h; Case 4 - case 6 working medium is 200 mg/L polymer solution, flow rates were 1.15 m^3/h, 1.53 m^3/h, 2.4 m^3/h; Case 7 - case 9 working medium is 400 mg/L polymer solution, flow rates were 0.97 m^3/h, 1.5 m^3/h, 1.8 m^3/h; Case 10 - case 12 working medium is 600 mg/L polymer solution, flow respectively for 1.2 m^3/h, 1.64 m^3/h, 2.71 m^3/h.

The pressure drop value of each working condition is shown in Table 1. From Table 1, it can be seen that with the increase of flow rate, polymer concentration, pressure drop rate also increased. In spiral separator internal non Newtonian fluid pressure changes greater than Newtonian fluid pressure changes, and non Newtonian more strongly, pressure change more. Under all working conditions, the energy consumption of the screw separator is generally lower, which belongs to the low energy consumption equipment, and has good generalization.

CONCLUSION

(a) There are 3 velocity components in the spiral flow, that is, radial velocity, tangential velocity and axial velocity. Its tangential velocity is the speed advantage, and it is far more than the axial velocity and radial velocity, and the radial velocity is small, and can neglect its effect.

(b) In the inner of the separator spiral flow, the velocity from the entrance of spiral to the exit of the spiral have obvious weak trend and in the axial section and helical blade speed to enter more than leave the speed of the helical blade, spiral flow cyclone have decreased trend.

(c) With the increase of the flow rate and the concentration of polymer, the pressure drop is also increasing. The pressure of Newton fluid (water) is less than the pressure change of non Newton fluid (polymer solution), and the stronger the non Newton is, the greater the loss of the pressure.

(d) In the internal pressure of the separator is the ladder to drop and the pressure change is not uniform, near spiral separator inlet pressure changes less than that close to the spiral separator at the outlet end of the pressure change.

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