Effect of the length of cylindrical section of Hydrocyclone on Separation Efficiency

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Abstract

Numerical simulations of different cylindrical length models based on Martin Thew hydrocyclone by using Fluent software. The influence of the length of the cylindrical section on the separation performance of the hydrocyclone was studied. As the length of the cylindrical section increases from 50mm to 70mm, the separation efficiency of the hydrocyclone separator increases first and then decreases. If the length of the cylindrical section is too long, the swirling speed is attenuated more severely, and thus there is not enough centrifugal force, which leads to a gradual decrease in separation efficiency. When the cylindrical section is too short, the mixed liquid enters the hydrocyclone without effective buffering, and the stability is poor, so that the mixed liquid flows out from the overflow port and the bottom flow port without effective separation, and the hydrocyclone separation efficiency is low.

Keywords

Hydrocyclone, Numerical simulations, Length of Cylindrical Section, Separation Efficiency.

1. Introduction

As a high-efficiency, stable, simple structure and small footprint, the cyclone is widely used in various oil fields in China, and has achieved good separation effect. The oil and water are separated by the difference in density between two mutually incompatible substances such as oil-water and the centrifugal force generated by the strong swirling flow inside the hydrocyclone[1].Due to the small difference in density between liquids, liquid-liquid separation is more difficult than solid-liquid separation. Therefore, the study of the structure of liquid-liquid cyclone is particularly important. In recent years, many scholars have studied the structure of the separator, and improved the separation efficiency of the oil-water hydrocyclone by optimizing the inlet form[2], cone angle[3] and overflow port[4], but the research on the cylindrical segment structure is relatively rare. In this paper, the length of the cylinder segment is taken as the starting point, and the influence of the length of the cylinder segment on the performance of the cyclone separator is studied by numerical simulation.

2. Geometry of the Simulated Hydrocyclone

Fig.1 shows the physical model of the cyclone. The model is a symmetric double inlet form, so it has good flow field stability and symmetry.

The cyclone treatment capacity is $4m^3/s$,the inlet cross-section size is 19mm×6mm,and the overflow pipe split ratio is 20%. The remaining structural parameters are shown in Table 1.

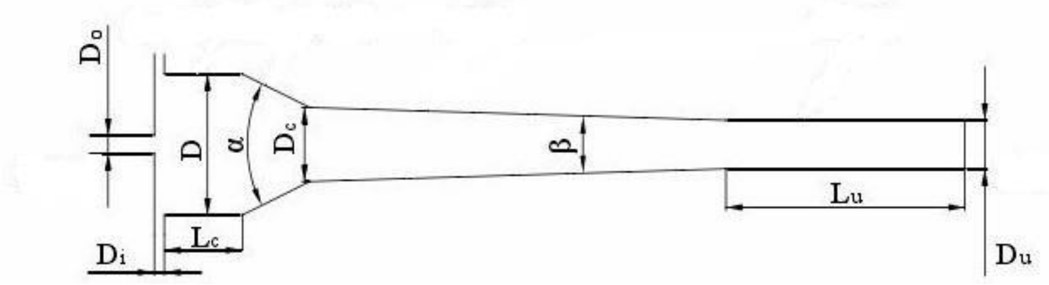

Fig.1 The model of hydrocyclone

Table 1 hydrocyclone structure parameters

D	L_c	D_c	D_o	α	β	D_u	L_u
56mm	60mm	28mm	10mm	20°	1.5°	14mm	280mm

3. Simulation

In this paper, the blocking of the solid model of the cyclone separator is performed by Blocking in the meshing software ICEM-CFD. The overall 3D solid model grid pattern has a total of approximately 340,000 tetrahedral grid cells, as shown in Fig.2.

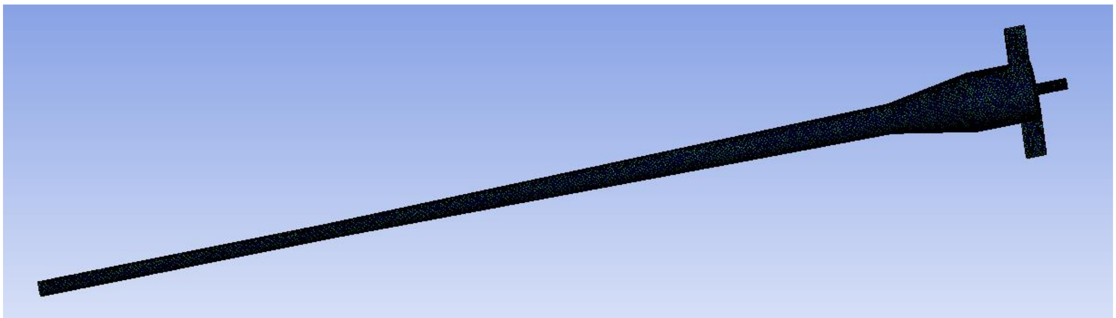

Fig.2 hydrocyclone overall mesh

The inlet of the cyclone is defined as a velocity inlet with an inlet velocity of 5 m/s. Both the flow port and the bottom flow port are free to flow, and the overflow port split ratio is set to 0.2. The physical properties of the oil and water treated by the cyclone are shown in Table 2, and the volume fraction of the oil phase of the aqueous mixture is 5%.

Table 2 Oil and water physical parameters (normal temperature)

materials	density（kg/m^3）	dynamic viscosity（$kg/m \cdot s^{-1}$）
oil	852.75	0.33
water	998.2	0.001003

4. Results and Discussion

In order to study the influence of the length of the cylindrical section on the separation performance of the cyclone, the numerical simulation was carried out separately by changing the length of the cylindrical section to 50 mm, 55 mm, 60 mm, 65 mm and 70 mm while keeping the other parameters constant.

As the cylindrical section grows, the overall size of the cyclone becomes longer, and as the swirling cavity of the cylindrical section lengthens, the oil phase concentration at the overflow increases first and then decreases. The simulation results are analyzed to obtain the length of the cylindrical section—the separation efficiency line graph as Fig.3.

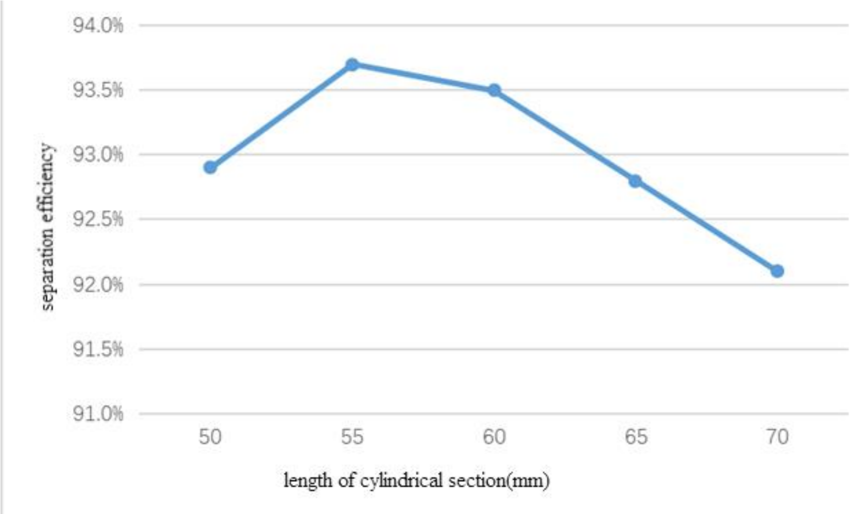

Fig.3 Length of cylindrical section - separation efficiency line graph

It can be seen from the separation efficiency diagram that as the length of the cylindrical section increases from 50 mm to 70 mm, the separation efficiency of the cyclone separator first increases and then decreases. When the length of the cylindrical section swirling chamber is 55 mm, the separation efficiency of the cyclone separator is up to 93.7%. This phenomenon occurs because the cylindrical section has no taper angle, and the swirling velocity of the liquid in the cavity is attenuated. The longer the length of the cylindrical section, the more severe the swirling velocity is attenuated, and thus there is not enough centrifugal force, resulting in a gradual decrease in separation efficiency. When the cylindrical section is too short, the mixed liquid enters the cyclone without effective buffering, and the stability is poor, so that the mixed liquid flows out from the overflow port and the bottom flow port without effective separation, and the cyclone separation efficiency not tall.

5. Conclusion

In concordance with the numerical results, we can conclude in general that:

a. As the length of the cylindrical section increases, the separation efficiency increases first and then decreases.

b. If the length of the cylindrical section is too long, the swirling speed is attenuated more severely, and thus there is not enough centrifugal force, which leads to a gradual decrease in separation efficiency.

c. When the cylindrical section is too short, the mixed liquid enters the cyclone without effective buffering, and the stability is poor, so that the mixed liquid does not effectively separate from the overflow port and the bottom flow port, and the cyclone separation efficiency is not high.

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