Research on the characteristics of baffled demister based on Computational Fluid Dynamics

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Abstract. In order to study the influence of the design parameters of baffled demister, the efficiency and the pressure drop of the inlet and outlet of the blade with different structure parameters and operating conditions were calculated by using the discrete phase model of Fluent. The results show that the parameters such as the spacing of blade, the velocity of the flue gas and the droplet size have a certain effect on the efficiency and pressure drop, which can provide a direction for the optimization design of the demister.

1. Introduction

With the development of science and technology, people pay more attention to SO2 emission in power plant. While the demister is the key equipment to control of SO2 emissions[1], which is installed at the outlet of the flue gas, to capture flue gas entrained droplets, reducing acid droplets of gas, at last to prevent the formation of acid rain.

Demister takes use of centrifugal force working for droplet. Demisting efficiency and pressure drop are key index. but the fog flow state is very complex, demister is influenced by many factors, it is difficult to obtain theoretically analytical model accurately, so this paper use CFD method. By controlling the variables to calculate various parameters' influence to demister characteristics, then analysis and give guidance parameters for the demister design.

Due to the simple process and stable demisting efficiency, the baffled demister is widely used in engineering. Therefore, this paper have a research on the characteristics of baffled demister based on software FLUENT[2].

2. Evaluation indicator

Demister performance measure has two important indicators, one is a demisting efficiency, the ability to capture the fog. Another is the pressure drop, pressure drop of the system shows how much the blower to replenish their energy, pressure drop is directly proportional to energy consumption. There are some influencing indicator :

(1) Gas velocity

Gas velocity affects the pressure drop and demisting efficiency. when the velocity is too large, it will make the removed droplets away again by airflow, reducing the demisting efficiency. When the gas velocity is too small, centrifugal force is too small to capture droplets.

(2) Droplet size

The larger the particle size is, the more easily it is separated. If the droplet size is too small, you'll need to gather droplet to increase diameter again separated.

(3) Blade spacing

As the distance between the blades increased, the droplet in the flow passage area becomes larger, while varying the direction of gas flow rate leveling off, causing demisting efficiency is reduced. When the distance between the blades is reduced, demisting efficiency will improve, but it will increase the pressure drop .it is represented by D in Fig.1.

(4)Other factors

Blade inclination angle α , Straight height H1,Bending heightH2.

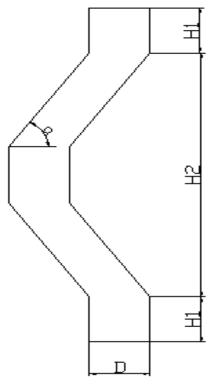

Fig.1 Structure parameters of demister

3. Numerical calculation

3.1 Assumptions

In order to improve the calculation speed, we use some assumptions as follows:

(1)The height width ratio of the demister l is very large, and the flow field can be simplified to two-dimensional plane flow;

(2) The gas velocity is not large enough, it can be regarded as an incompressible gas.;

(3) The gas is an ideal gas, and the flow is steady flow;

(4) the droplet particles are homogeneous spheres (the assumption can be accepted when the droplet diameter is at the UM level);

(5)There is no interaction between droplets and particles, and the single particles are only affected by the gas;

(6)The droplet was captured as soon as it encouraged the wall.

3.2 Mathematical model

For the gas phase,we use the two dimensional incompressible viscous flow equation. Then we choose RNG k-ε turbulence model to Solving the equation group.

Near wall surface, discrete phase is calculated by DPM method based on Euler-Lagrange. At the same time, considering interaction with continuous phase and Discrete phase.

3.3 Computing method[3]

For continuous phase, the SIMPLE algorithm is used to for the pressure-velocity coupling. Momentum, turbulent kinetic energy and turbulent dissipation rate are Second Order Upwind.

For discrete phase, because the liquid phase volume fraction is less than 12%, a random particle tracking model is used to simulate the movement of particles.

3.4 Boundary condition

Gas boundary condition:

(1) Import conditions: distribution of velocity is uniform in import section, the velocity inlet is set to 1m/s~6m/s;

(2) Export conditions: outflow;

(3)Wall condition: wall is set into trap wall.

Droplet boundary condition:

(1) Physical properties: the droplet is desulfurization slurry, its density is approximately $\rho = 1000 kg/m^3$;

(2) Import condition: The concentration of particles in the inlet area is uniform distribution, and with the same velocity of the gas is injected into the demister.

4. Calculation result

4.1 Analysis of the flow field in a single working condition

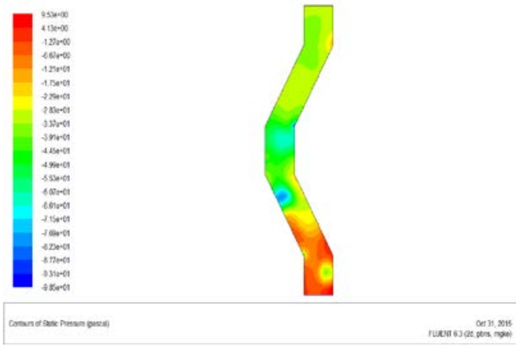

Fig.2 Pressure distributions

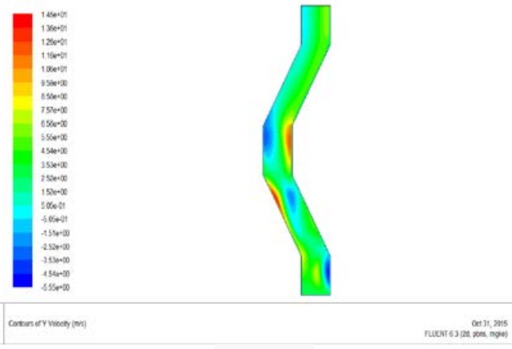

Fig.3 Velocity distributions

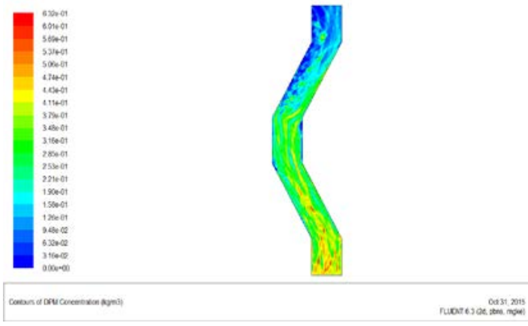

Fig.4 Concentration distributions

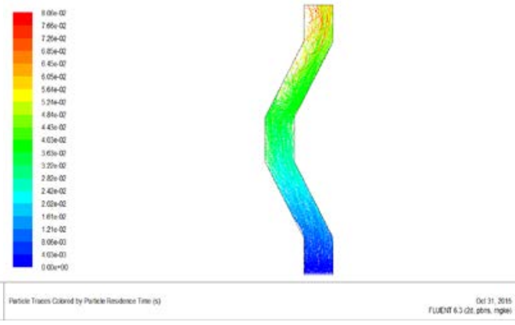

Fig.5 Path of particle

As diagram shows, the pressure in demister pipeline has been declining. After the gas goes through the corner, the intensity of turbulence increases and the local velocity is increased obviously. The place of maximum concentration gradient is located in corner of the demister and most demisting work is done here too. Due to the corner , the droplet has a lager turbulence intensity. It is in favor of gas-liquid separation.

4.2 Analysis of the flow field in a multi working condition

According to a certain type of fog removing device， the design parameters is α, H_1, H_2 =(90,30,120).

(1) Set velocity v=5m/s, with the change of the particle diameter and blade spacing, the influence of the pressure drop as .Fig.6

(2)Set blade spacing D=35 mm, with the variations of particle diameter and gas velocity, the effect on the demisting efficiency, as shown in Fig.7

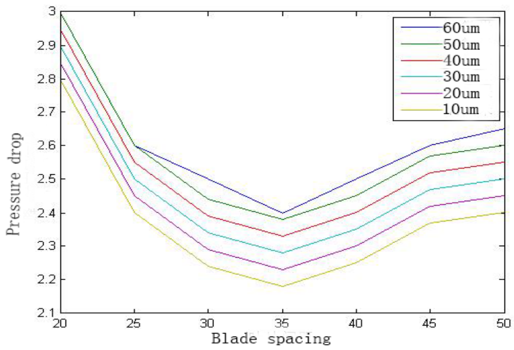

Fig.6 blade spacing and pressure drop

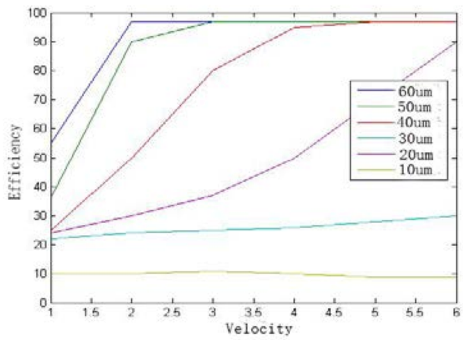

Fig.7 velocity and demisting efficiency

5. Summary

When the particle diameter is certain, with the increase of the blade spacing, pressure drop is decreased first and then increased, when the blade spacing is 35um, pressure drop is reduced to a minimum, that shows the energy consumption get least, and when the blade spacing is increased, pressure drop will continue to increase, the energy consumption will be more and more.

And with increasing speed , demisting efficiency with different droplets diameter (10, 20, 30, 40 um) of is gradually increased, but the increase amplitude becomes smaller and smaller, and all can achieve maximum efficiency in a certain velocity value. But the diameter of 60, 50 um droplets efficiency does not increase with the increase of speed, even 60um in diameter get reduced oppositely.

References

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