The numerical simulation of the gas phase flow field of a Super Vortex Quick Separation System

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Abstract

Super Vortex Quick Separation System（SVQS） is an important device to realize the efficient Separation of oil and gas and strip catalytic cracking catalyst after Separation and rapidly lead oil and gas out after the reaction in time. In This article, the total height of SVQS is 7.2 m and the diameter is 0.6 m, the Fluent software and RNG k - epsilon turbulence model will be used to numerically simulate the gas phase flow field in vortex quick subsystem and analyze the change laws of velocity and pressure.

Keywords

Turbulent flow model, Super Vortex Quick Separation System, numerical simulation ,flow field.

1. Introduction

FCC riser outlet super vortex quick separation is an important apparatus to achieve the efficient separation of oil and catalyst and rapid exporting of oil gases, this principle is to make use of centrifugal force field generated by high-speed rotational flow of riser outlet oil gases to achieve gas-solid separation. Chun-xi lu, etc. has developed a riser Vortex Quick Separation System (SVQS)with a isolate cylinder and isolating cover plate. Turbulence is a highly complex nonlinear fluid motion of irregular and temporal order in space. In the numerical simulation calculation of turbulence for engineering, the main current model of turbulence models include standard k - epsilon model, RN G k - epsilon model, RSM, etc. In multiphase flow calculation, the Lagrangian-eulerian model and eulerian-eulerian model have been widely applied to describe a variety of complex characteristics of gas-solid flow in the reactor and separator and many researchers have done a lot of work in this field[1]. These two models can be used in different turbulence models when calculating, and the accuracy of description of the spiral flow in the vortex quick subsystem with a variety of strong turbulence model has some differences. At the same time, the amount of calculation of various models needed are different. The RNG k - epsilon model turbulence model is successfully and widely used in scientific research and engineering practice[2] [3]. The diameter of the cylinder and the diameter of the riser are 0.6 m and 0.1m respectively. In the study, the center of the circular flow of the vortex fast subsystem is the starting point, and the vertical direction is positive. The axial height of the five planes are 3.5m,5m,6m,6.5m, and 6.7 m, respectively, which are to reflect the velocity and pressure change of the ejection section and the separation section. In the calculation process, the control equation is separated by the control volume integral method and the Quadratic upwind interpolation of connective kinematics difference scheme. The Inlet velocity of Super Vortex Quick Separation System is 18m/s, the outlet is considered as the pressure outlet and the other parts are the wall boundary conditions.

2. Numerical simulation results and analysis

2.1 The tangential velocity.

The maximum velocity in the three velocity components is the speed of the rotational speed, which is the driven force of the centrifugal force[4].As the figure 1 shows, tangential velocity decreases from spewing down section along the axial and in turn analysis show that the axial height does have a significant impact on the tangential velocity, and the tangential velocity has a mutation in the septum

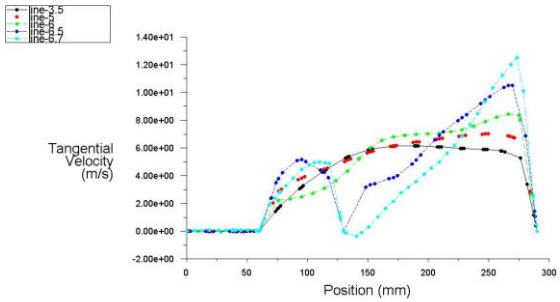

Fig 1

2.2 The axial velocity.

(1) As the figure 2 shows ,the axial velocity of the ejection segment is mainly the downward flow, and the downward velocity is larger, which is beneficial for downward movement of fluid.(2) Separation section of the cross section axial velocity distribution is made up by near the riser wall upward flow and downward flow near the closed hood lining, and as the axial height descends , cut-off point of the upstream and downstream streamlines moves outward gradually, in short, the upstream flow area increases and the downstream flow area decreases.

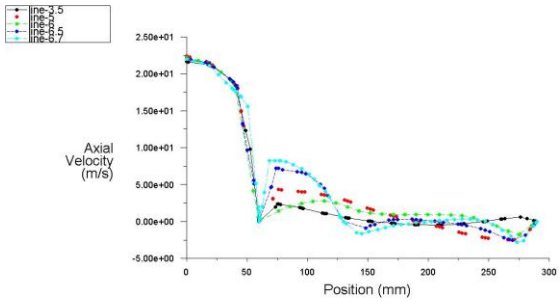

Fig 2

2.3 The radial velocity.

As the figure 3 shows ,the radial velocity distribution is composed of the centrifugal flow near the wall of the riser and the inward flow near the inner wall of the enclosed cover. In addition to transition points of the jet exit and isolating cylinder bottom section centrifugal and centripetal flow on separated flow in cylinder radial location, the transition points of the other sections move outward to the closed hood in the radial position.

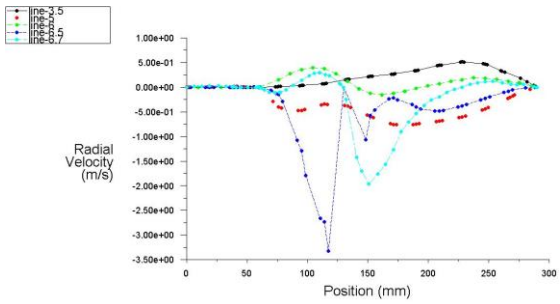

Fig 3

2.4 The static pressure.

As the figure 4 and 5 shows , there are step-up and step-down area along the radial area of the Static pressure distribution, namely static pressure along the axial down gradually rises near the edge of the riser wall, static pressure reduces along the axial height gradually near the side wall of the closed hood. this kind of change is closely related to vortex distribution the inside and outside of the gas flow field.

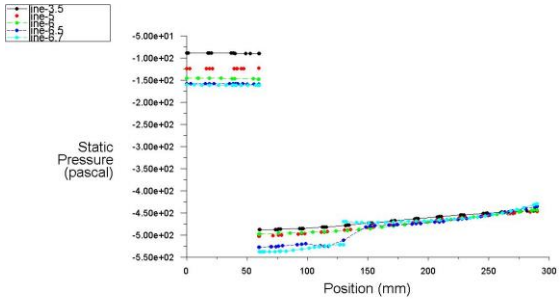

Fig 4

The distribution of five sections of static pressure is shown below:

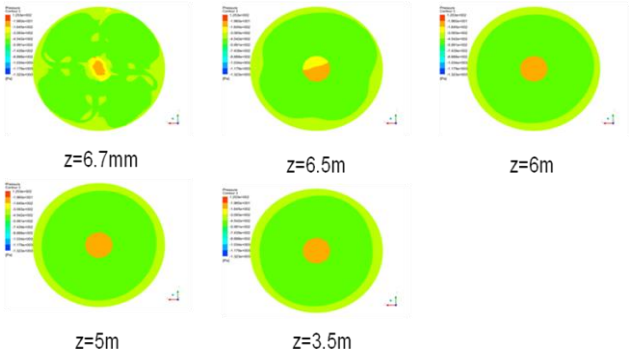

Fig 5

3. The Conclusion

In this paper, the RNG k - epsilon turbulence model is used to simulate the gas phase flow field in SVQS vortex quick separating system, the conclusions are as follows:

(1) The flow field in Super Vortex Quick Separation System is a three-dimensional turbulent field, and there is a short-circuit flow phenomenon in the vicinity of the swirl head.

(2) Near the edge of the riser, the static pressure is gradually increasing along the axial direction, and the static pressure is gradually decreasing along the axial direction near the wall of the closure

(3) The maximum value of the velocity in the three velocity components is the rotational velocity of the cyclone, which is the driving force for the centrifugal force of the particle.

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