

Multi-Physical Field Study of Polymerization Reaction

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Abstract

PVC as the main material of industrial plastics, has good chemical stability, but in the polymerization of PVC often faced with difficult to control the mixing time, stirring temperature conditions are difficult to control, low degree of material mixing difficulties. In this paper, under the joint action of multiple physical fields such as gravity field, temperature field and fluid field, the double Euler fluid model is used to analyze the particle diffusion degree in the double-suction turbine polymerizer flow field under different cover inner diameter and thickness combination, and the particle size distribution under different cover combination and mixing spacing is studied. The results show that the thickness of the cover plate has little effect on the solid-liquid characteristics in the polymerizer. The liquid velocity is distributed regularly along the value direction of the polymerizer, the peak velocity is constant, and the liquid velocity at the center height of the agitator is positively correlated with the inner diameter of the cover plate. With the increase of the inner diameter of the cover plate, the axial turbulence ability in the polymerization kettle is enhanced, the stirring power is higher, the material in the kettle is more fully mixed, the stirring dead zone is reduced by 22.04%, the axial motion component of the center fluid of the agitator is increased, the local accumulation of particles is significantly weakened, the proportion of medium particle size particles increases, and the proportion of large particle size particles decreases. With the decreasing of stirring interval, the proportion of medium particle size decreases, the proportion of large particle increases, and the polymerization rate increases.

Keywords

Polyvinyl Chloride; Solid-Liquid Stirring; Double Suction Turbine; Multiple Physical Fields; Suspension Polymerization.

1. Introduction

Polymerization reaction refers to the process of converting low molecular weight monomers into high molecular weight polymers through polymerization, and polymerization products are diverse and accompanied by complex rheological properties^[1]. Zhao Yang^[2] pointed out that in the polymerization process, the mismatch of blade matching leads to weak areas in the flow field and uneven distribution of solid content, which leads to the phenomenon of implosion and agglomeration. With the continuous development of science and technology, the application of polymer is more and more extensive, and the performance of polymer depends on the continuous stirring control in the

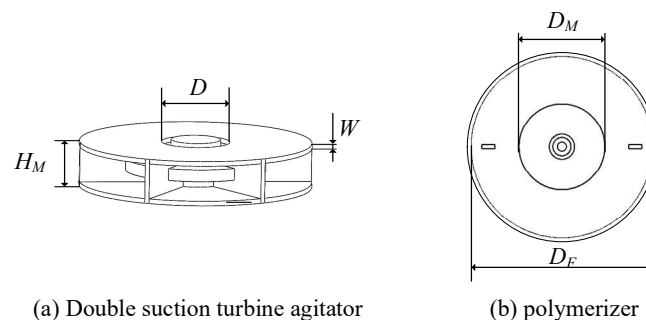
synthesis process^[3]. Different polymers have different viscosity, the best polymerization time and the mixing structure, which lead to the uneven efficiency of polymerization products.

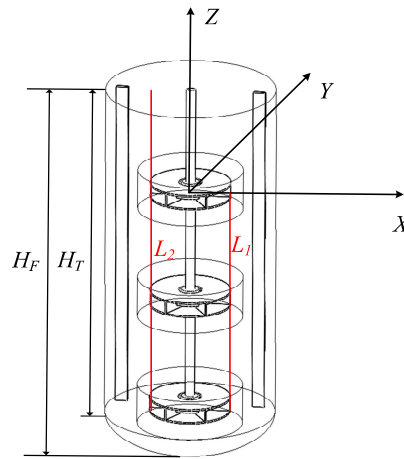
Agitator is the core component of mixing, and the structure of agitator directly affects the mixing efficiency. Liu Hao^[4] prepared monobutyric glyceride using stirred kettle reactor, conducted a study on the effects of reaction temperature, reaction time and amount of catalyst on the stirring process, and found that the chemical equilibrium constant of synthetic monobutyric glyceride increased with the increase of temperature. In order to improve the numerical simulation prediction accuracy of stirring power in stirring tank, Zhang Linwei^[5] verified the conclusion that the viscosity model of solid-liquid two-phase system based on particle dynamics theory, which is widely used at present, reduces the stirring power predicted by CFD with the increase of solid holdup through experiments and CFD simulation results. Based on CFD-PBM numerical simulation, Xie Nannan^[6] obtained the optimal blade combination in gas-liquid stirring kettle, which increased the stirring efficiency. Wang C^[7] applied Open FOAM to the simulation of gas-liquid stirred tanks and developed a comprehensive CFD-PBE calculation framework to achieve efficient and stable simulation of such systems.

Double suction turbine agitator is a flat blade agitator with two annular cover plates. When the mixing blade diffuses the fluid radially, the annular surface of the cover plate prevents part of the fluid from flowing from below the agitator to the center of the agitator, resulting in further expansion of the negative pressure in the center of the agitator compared with the former, which greatly enhances the axial flow ability of the agitator and further improves the mixing efficiency. PVC is the world's third largest synthetic polymer plastic^[8], with low cost, strong chemical resistance, high mechanical strength advantages, widely used all over the world. In the industry, most PVC particles are formed by free radical suspension polymerization of VCM monomer in polymerization kettle. It is difficult to measure the spatial distribution of component media and temperature in the reactor through the construction of the reaction device^[9]. Based on the coupling of temperature field, gravity field and fluid field, the flow field and particle state in double-suction turbine polymerizer are simulated and analyzed in this paper, which is of practical significance to the industrial polymerization process.

2. Model Building

Multiple Reference Frame (MRF) was used to divide the entire region in the kettle into dynamic region and static region, and different regions were calculated using independent equations. This method can adapt to complex multi-rotating parts scenarios^[10]. The three-layer double-suction turbine PY polymerization kettle model is established based on the MRF model. Many structures of the polymerization kettle have no impact on agitation during the stirring reaction process, but a lot of resources will be occupied in the model establishment and solution. In order to better simulate and analyze, the three-layer turbine PY polymerization kettle is simplified^[11]. The simplified model basically does not affect the simulation results, and greatly reduces the computing resources required. The blade shape is consistent with the actual structure. The simplified model structure diagram is shown in Fig. 1, and the structural parameters are shown in Table 1.





(c) Coordinate diagram of polymerization kettle

Fig. 1 Schematic diagram of simplified model structure of polymerization kettle

Table 1. Polymerization kettle model parameters

Parameter name	Representative symbol	Parameter size
Caldron diameter	D_F	4000mm
Bugao	H_F	8900mm
Barrel height	H_T	8000mm
Baffle quantity	N_{DB}	2
Agitator diameter	D_M	1800mm
Agitator height	H_M	450mm
Cover plate thickness	W	40mm
Cover bore	D	584mm

In order to meet the needs of the suspension production process of PVC, the stirring system of the polymerization kettle is configured in three aspects, including stirring speed, stirring blade form and internal part setting^[12]. This simulation study aims to explore the influence of double-suction turbine agitator on the suspension polymerization of PVC particles under different structural parameters, so the stirring speed is set at 100rpm according to the actual industrial processing and production^[13].

3. Meshing

The polymerization kettle model was meshed and the agitator was encrypted. A total of 5 groups of grid division schemes were obtained by setting different partition sizes, and the number of grid cells were 660,000 (I), 800,000 (II), 1.01 million (III), 1.25 million (IV), and 1.88 million (V). Line segment L1 along the vertical direction of the polymerization kettle, $X=1270\text{mm}$ from the central axis in the ZX coordinate section, as shown in Figure 1. The average distribution of 15 observation points on the line segment was set up, and the change rate of PVC particle volume fraction on the 15 observation points under different mesh division schemes was compared to determine the final mesh division scheme. Set the speed of the polymerization kettle to 100rpm, the initial inlet PVC particle size to $100\mu\text{m}$, the volume fraction content to 30%. The simulation results are shown in Fig. 2, and the calculation results are shown in Table 2. The results show that when the number of grids increases from 1.03 million to 1.66 million, the average relative change measure is less than 3%, which proves that when the number of grids reaches 1.03 million, the grid has little effect on the simulation and is

within the error range. In this simulation, grid scheme IV (1.25 million) is used as the final calculation division scheme.

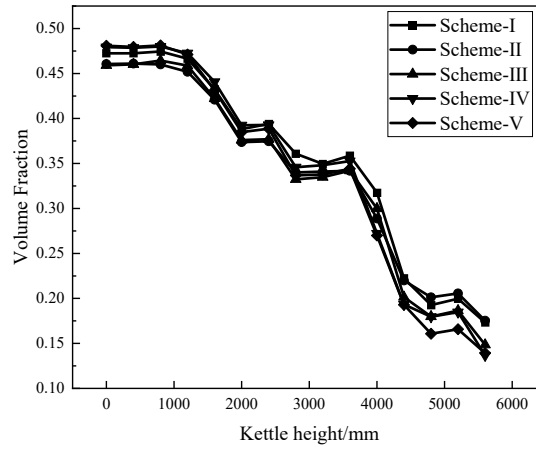


Fig. 2 Volume fraction of PVC particles on line segment L_1

Table 2. Change rate of PVC particle volume fraction on the lower line segment L_1 of different mesh division schemes

Comparison scheme	$\bar{\Delta}$
SchemeI - SchemeII	5.78
SchemeII - SchemeIII	5.14
SchemeIII - SchemeIV	4.08
SchemeIV - SchemeV	2.53

4. Mathematical Model

4.1 Multiphase Flow Model

This simulation selects a double Euler fluid model, which follows the three laws of conservation of mass, conservation of momentum and conservation of energy, and regards both solid particles and fluid as continuous media with mutual penetration and interaction^[14]. The turbulence model is the standard model, which assumes that the fluid is completely in a turbulent state^[15] and can be used for calculation in a flow field with a large Reynolds number^[16].

4.2 Drag Function Model

There are many interphase forces such as drag force, lift force and additional mass force in the solid-liquid stirring system, among which drag force is the main force to describe the movement of solid particles in the fluid during the stirring process, and its effect is far greater than other interphase forces. In this simulation, Wen-Yu drag force is chosen to describe the interphase drag force. In this model, momentum exchange coefficient is used to measure the momentum exchange between phases to realize the interaction between the two phases^[17].

The drag equation under the Wen-Yu model is shown in equation (1):

$$F_D = \frac{1}{2} C_D \rho_l A_p |U_l - U_p|^2 \quad (1)$$

The drag coefficient under the Wen-Yu model is usually determined by equation (2):

$$C_D = \begin{cases} \frac{24}{Re} (1 + 0.15 Re^{0.687}), & Re < 1000 \\ 0.44 & , Re \geq 1000 \end{cases} \quad (2)$$

F_D is drag force, N; C_D is drag coefficient; ρ_l is the liquid density; A_p is the projected area of the particle; U_l is liquid velocity; U_p is particle velocity; Re is the particle Reynolds number.

4.3 Population balance model

Population Balance Model (PBM) can be used to describe the phenomena of particle fragmentation and agglomeration. For the suspension polymerization process of PVC production, this model can accurately describe the phenomena in the kettle. The basic equation is shown in equation (3):

$$\begin{aligned} \frac{\partial n(V,t)}{\partial t} + \nabla \cdot [\bar{u}n(V,t)] &= \int_{\Omega_V} pg(V')\beta(V|V')n(V',t)dV' \\ - \int_0^\infty \alpha(V,V')n(V,t)n(V',t)dV &- g(V)n(V,t) \\ + \frac{1}{2} \int_0^V \alpha(V-V',V')n(V-V',t)n(V',t)dV' & \end{aligned} \quad (3)$$

V is the volume of PVC particles; V' is the volume of PVC particles before the change; α is the collision frequency between particles; $\nabla \cdot [\bar{u}n(V,t)]$ is the convection of particle distribution function with space; $g(V)$ is the loss rate; $\beta(V|V')$ is a conditional probability density function.

5. Boundary Condition

The simulated boundary conditions were set according to the actual conditions of industrial production of PVC particles. The pressure in the polymerization process is set to 1.13MPa and the ambient temperature is 328K. Set the stirring speed to 100rpm, and set the top surface of the kettle as the Symmetry boundary. The SIMPLE algorithm is used to calculate the pressure-velocity coupling. The second order upwind scheme is chosen to discretize the control equation. PVC particles are divided into 9 sub-zones Bin-0 to Bin-8 according to the particle size range of 60-220 μ m. In the initial state, the volume fraction of PVC particles with the size of 100 μ m is set to 1, and the phase volume fraction is 30%. The PVC particles are evenly distributed in 50% of the volume below the kettle, and set as the initial region.

6. Computational Analysis

6.1 Particle Characteristics Analysis under Different Plate Combinations

6.1.1 Particle Diffusion Degree Analysis

The inner diameter of the cover plate determines the flow rate of the axial moving fluid into the center of the agitator, and also affects the negative pressure when the negative pressure space is formed. When the wave encounters a single gap formed by two obstacles, the wave will propagate through the single gap, and the diffraction phenomenon will occur at the edge of the gap. However, when the size of the obstacle is much larger than the wave length, the wave propagation begins to tend to linear propagation. As the obstacle for water waves to enter the center of the agitator, the thickness of the annular cover plate has certain research value. In this design, the inner diameter of different cover plates is 420mm, 484mm, 534mm, 584mm; The thickness of different cover plates is 20mm, 30mm, 40mm, 50mm. The diffusion of PVC particles in polymerization kettle under 16 different inner diameter and thickness of cover plate was analyzed. According to the law of conservation of mass, there is no material input or outflow during the stirring process. After the simulation is completed, the diffusion of PVC particles in the entire polymerization kettle can be further obtained by observing

the remaining average volume fraction content of PVC particles in the initial area of the polymerization kettle, and the results are shown in Table 3.

Table 3. The average remaining volume fraction of PVC particles in the initial area under different inner diameter and thickness of the cover plate

Cover plate thickness	Cover bore			
	420mm	484mm	534mm	584mm
20mm	0.421	0.403	0.399	0.395
30mm	0.422	0.407	0.401	0.390
40mm	0.418	0.400	0.398	0.392
50mm	0.416	0.406	0.402	0.395

The results in Table 3 show that the thickness of the cover plate has no significant effect on the diffusion degree of PVC particles within the study range. With the thickness of the cover plate increasing, the average volume fraction of the remaining PVC particles in the agitator under different inner diameters of the cover plate changes in a different trend and shows a fluctuation. The inner diameter of the cover plate continues to increase, and the average volume fraction in the area where the PVC particles initially exist decreases significantly. According to the principle of conservation of mass, more PVC particles diffuse to the area above the agitator to achieve full mixing with the fluid. This is because with the increase of the inner diameter of the cover plate, the amount of axial fluid that can enter the center of the agitator increases, and the axial turbulence ability is further enhanced, making the two-phase mixing in the entire mixing system more adequate.

6.1.2 Power Comparison

The agitator power can be calculated by the power number or directly by simulating the torque on the agitator. Compared with the former, the latter does not rely on the empirical correlation formula, and can be directly solved in the simulation calculation process to obtain the torque and further solve the power. The formula is as follows:

$$P = \frac{2\pi nM}{60} \quad (4)$$

P is power, W; n is the stirring speed, rpm; M is torque, N·m.

The power of the agitator is further calculated by simulating the torque on the agitator under different plate combinations as shown in Table 4.

Table 4. Agitator power under different inner diameter and thickness of the cover plate

Cover plate thickness	Cover bore			
	420mm	484mm	534mm	584mm
20mm	1004.63	2331.88	3263.68	3944.00
30mm	1004.51	2391.05	3300.47	4067.50
40mm	1031.51	2328.37	3297.73	3888.60
50mm	994.76	2337.85	3348.03	4100.99

According to the results in Table 4, when the cover plate thickness is changed, the power on the agitator shows a certain fluctuation, but the change is relatively gentle, indicating that the inner diameter of the cover plate has almost no influence on the power of the agitator. The agitator power increased with the increase of the inner diameter of the cover plate, and there was a positive correlation. This is because the inner diameter of the cover plate increases, the axial turbulence ability of the flow field continues to increase, and the stirring effect continues to improve, resulting in an increase in the power consumption required for the agitator to maintain the state.

6.1.3 Particle Volume Fraction Cloud Image Comparison

Take ZX coordinate cross section as analysis cross section for cloud image analysis. It can be seen from Table 3 that when 534mm and 584mm are taken from the cover plate, the volume fraction of PVC particles in the initial area changes gently with the thickness of the cover plate. However, when the cover plate inner diameter is 584mm, the diffusion degree of PVC particles in the kettle is much greater than that when the cover plate inner diameter is 534mm. Therefore, this analysis takes the cover plate inner diameter of 584mm and thickness of 40mm as the basis for volume fraction cloud image analysis. FIG. 3 shows the cloud map of PVC particle volume fraction distribution under different cover thickness when 584mm is taken inside the cover plate. FIG. 4 shows the cloud map of PVC particle volume fraction distribution under different cover inner diameter when the cover thickness is 40mm. With the increasing thickness of the cover plate, the volume distribution cloud map of PVC particles hardly changed. Combined with the data in Table 3, it can be concluded that the thickness has almost no influence on the diffusion of PVC particles in the entire polymerization kettle within the study range, and the wavelength of the fluid entering the center of the agitator is much larger than the thickness of the cover plate under the current study. As the inner diameter of the cover plate increased, the volume fraction of PVC particles above the polymerization kettle increased, and the particles spread more evenly in the whole kettle. When the inner diameter of the cover plate increased from 420mm to 484mm, the low particles in the kettle decreased significantly. It can be concluded that the axial turbulence ability of the fluid increased due to the increase of the inner diameter of the cover plate, the phenomenon of the material mixing degree increased is real. According to the legend, the stirring dead zone is set as the stirring dead zone with the volume fraction less than 0.13. Further calculation of the stirring dead zone area under the two working conditions, as shown in Table 5 and 6, shows that with the change of cover plate thickness, the dead zone ratio changes in a fluctuating way, with the maximum difference of 3.13%; while with the increase of inner diameter, the dead zone ratio decreases significantly, with the maximum difference of 22.04%.

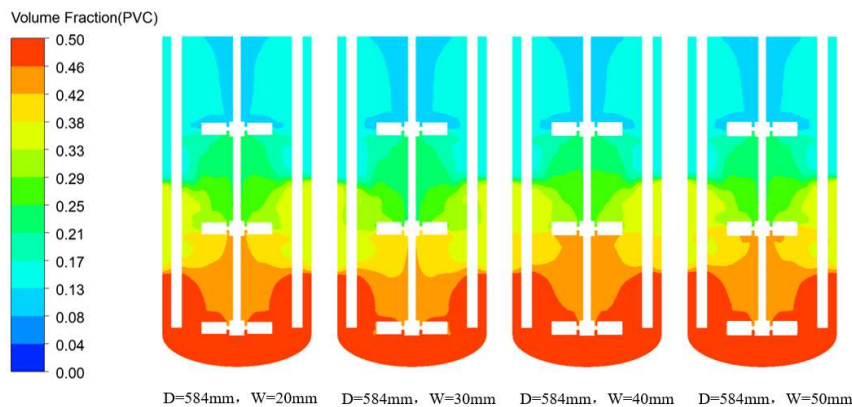


Fig. 3 Cloud image of PVC particle volume distribution under different cover thickness

Table 5. Mixing dead zone area ratio of different cover thickness

D=584mm	W=20mm	W=30mm	W=40mm	W=50mm
Area proportion	8.23%	11.36%	9.90%	10.50%

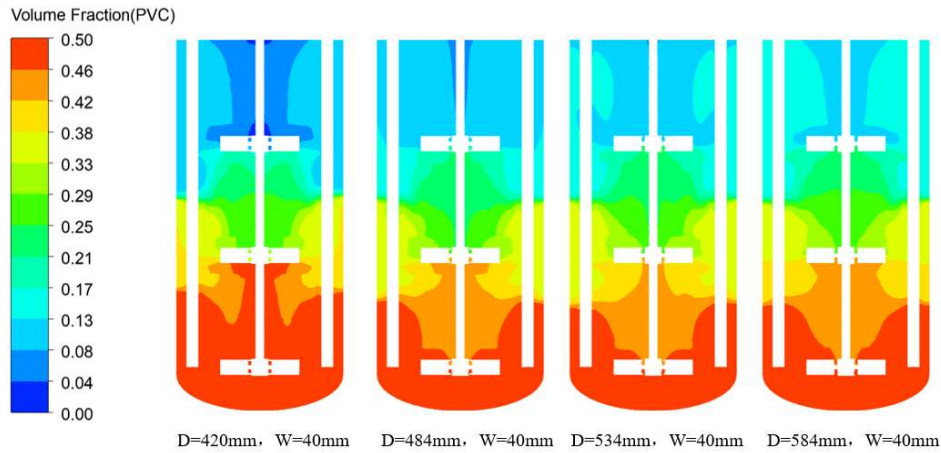


Fig. 4 Volume distribution of PVC particles under different inner diameters

Table 6. Mixing dead zone area ratio of different inner diameter of cover plate

W=40mm	D=420mm	D=484mm	D=534mm	D=584mm
Area proportion	31.94%	28.69%	19.51%	9.90%

6.1.4 Particle Velocity Comparison

The velocity vector analysis of PVC particles is also carried out by taking the ZX coordinate section as the analysis section. Fig. 5 shows the velocity vector distribution of PVC particles under different cover thickness. Fig. 6 shows the velocity vector distribution of PVC particles under different inner diameters of cover plates. It can be seen from FIG. 5 and FIG. 6 that PVC particles enter the center of the agitator from the inner diameter of the cover plate to the center of the agitator and then diffuse around through the action of rotating blades, which greatly enhances the axial turbulence ability of the polymerization kettle. In Fig. 6(a), when 420mm is taken from the cover plate, the inner diameter of the cover plate is connected to the connecting shaft of the agitator, and the fluid cannot flow from the inner diameter hole of the cover plate to the center of the agitator. In the figure, there are no PVC particles above and below the center of the agitator to the center of the agitator, and the axial turbulence ability of the fluid is far less than that of the polymerization kettle with the other three inner diameter schemes. When the inner diameter of the cover plate continues to increase, it can be seen from Fig. 6(a-d) that the axial movement of the fluid in the polymerization kettle continues to increase, the local accumulation of PVC particles is weakened, the mixing with the fluid is more uniform, and the axial movement component of the fluid in the center of the agitator increases, because the strengthening of the axial flow causes more PVC particles to spread to every place in the kettle. Mix well with the fluid.

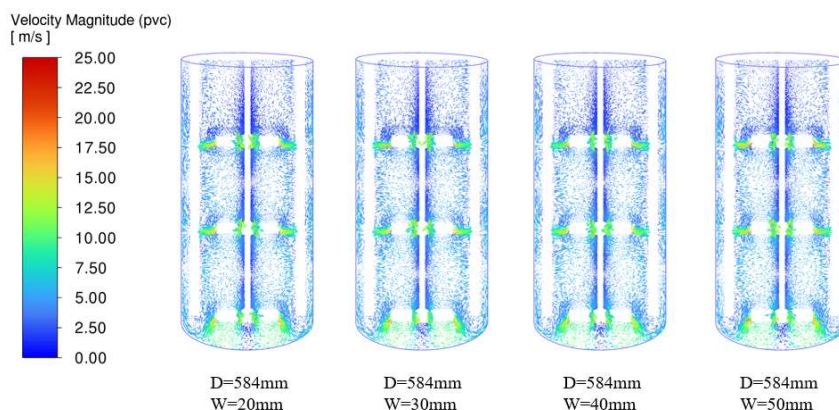


Fig. 5 Velocity vector distribution of PVC particles under different cover thickness

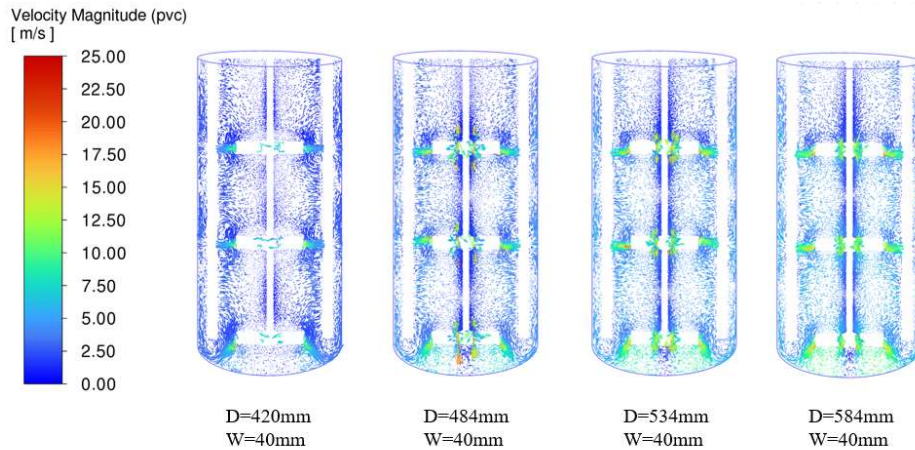


Fig. 6 Velocity vector distribution of PVC particles under different inner diameters

6.1.5 Fluid Velocity Analysis

In the rotating process of agitators, the fluid is driven to diffuse around. Different forms of double-suction turbine agitators have different axial turbulence abilities, so that the liquid diffuses around at different speeds. In order to explore the influence of different agitators on the liquid phase velocity, the two working conditions of single-phase flow and multiphase flow are discussed. The liquid phase velocity distribution in the polymerization kettle was analyzed by taking the line segment L_2 on the section of ZX coordinates as the analysis line segment. The line segment $X=-1270\text{mm}$ from the central axis is parallel to the Z axis, and its height is from the center of the agitator at the very bottom to the top of the kettle, passing through the dynamic and static regions at the same time, as shown in Fig. 1. The large difference of velocity distribution on line segment is of reference significance.

The liquid velocity distribution on line L_2 was simulated in the double suction turbine polymerizer with different combinations without adding PVC particles, and the other simulation conditions were the same as above. When the inner diameter of the cover plate is 584mm, the liquid velocity on the lower line segment L_2 with different cover plate thickness varies with the line segment height, as shown in FIG. 7. The thickness of the cover plate is 40mm. The liquid velocity on the line segment L_2 under different cover plate inner diameter varies with the line segment height, as shown in FIG. 8. The results show that the liquid velocity changes regularly along L_2 in the vertical direction of the polymerizer when multiple phases exist simultaneously in the polymerizer. When the height is in the center of the agitator, the liquid speed increases, and when the height is in the upper and lower sides of the agitator, the liquid speed reaches the maximum. When the thickness or inner diameter of the cover plate is changed, the peak liquid speed will not be affected; Changing the inner diameter will affect the liquid velocity at the center height of the agitator, but changing the thickness of the cover plate will not, and the change of the speed at this position is positively correlated with the inner diameter of the cover plate.

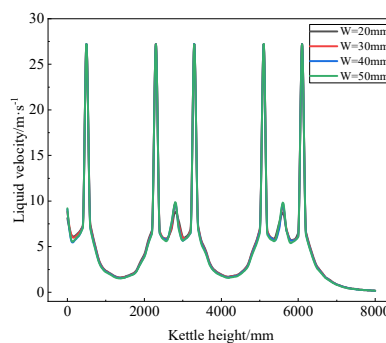


Fig. 7 L_2 liquid velocity distribution under different plate thickness under single phase flow

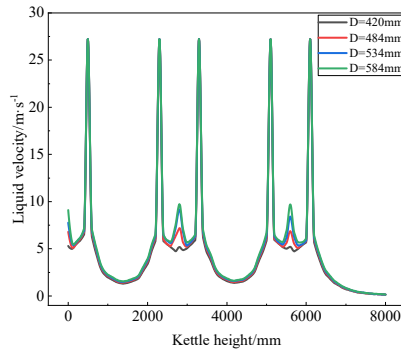


Fig. 8 L_2 liquid velocity distribution under different inner diameters in single phase flow

The liquid velocity distribution on the observation line L_2 of a double-suction turbine polymerizer with different combinations was simulated in the initial state with two phases of water and PVC particles. The simulation conditions were the same as above. When the inner diameter of the cover plate is 584mm, the liquid velocity on the lower line segment L_2 with different cover plate thickness varies with the line segment height, as shown in FIG. 9. The thickness of the cover plate is 40mm, and the liquid velocity on the line segment L_2 with different inner diameters of the cover plate varies with the height of the line segment, as shown in Fig. 10. The results show that the liquid velocity changes along L_2 in the vertical direction of the polymerizer are consistent with that of single-phase liquid stirring.

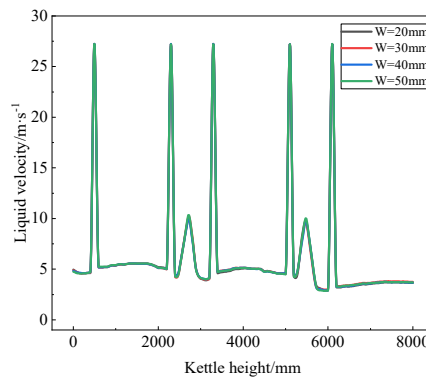


Fig. 9 L_2 liquid velocity distribution under different plate thicknesses under multiphase flow

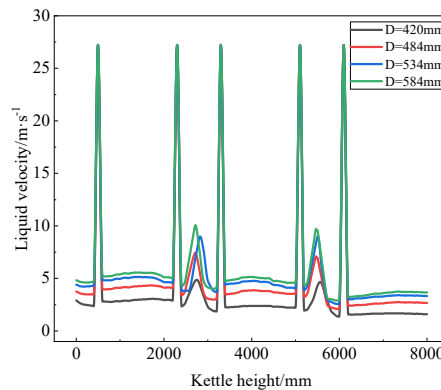


Fig. 10 L_2 liquid velocity distribution under different inner diameters in multiphase flow

6.1.6 Comparison of Particle Size under Different Plate Combinations

The change of the cover plate combination will lead to different diffusion degrees of PVC particles and affect the polymerization effect. Fig. 11 shows the distribution diagram of the average volume

fraction of particles with different particle sizes under different cover plate thickths when the cover plate inner diameter is 584mm, and Fig.12 shows the distribution diagram of the average volume fraction of particles with different particle sizes under different cover plate inner diameter when the cover plate thickness is 40mm. After polymerization, the particle size distribution in the two figures showed that large and small particle size accounted for a small proportion, while medium particle size accounted for a large proportion. The calculation was consistent with the experimental results in literature[13], and the results were reliable. In the figure, the thickness of the cover plate has almost no effect on the particle size distribution, and the proportion of small and medium particle size particles is almost unchanged during the process of the increase of the inner diameter of the cover plate, while the proportion of medium particle size particles increases and the proportion of large particles decreases.

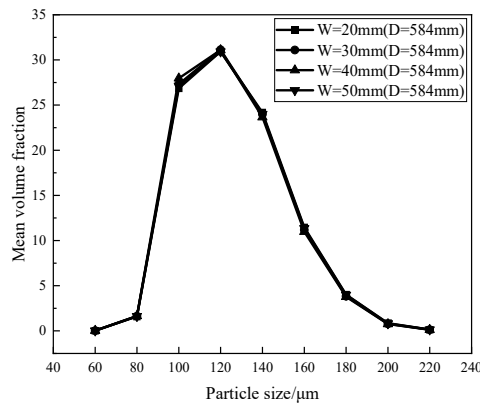


Fig. 11 Particle size distribution under different cover thickness

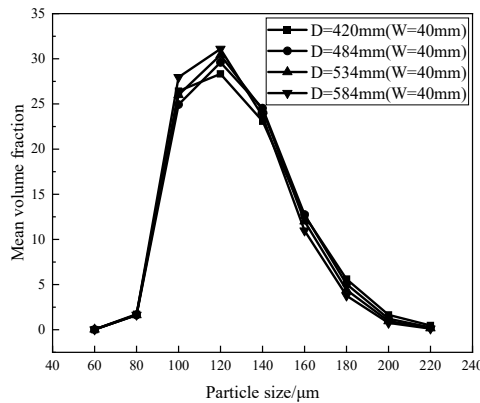


Fig. 12 Particle size distribution under different inner diameters

According to the analysis of Table 3 and Fig. 4, as the inner diameter of the cover plate gradually increases, the axial turbulence capacity in the polymerization kettle increases, more PVC particles are diffused in the polymerization kettle, the PVC particles settling at the bottom of the kettle decrease, and the particles settling at the bottom of the kettle converge and react to produce fewer large-size particles, resulting in a decrease in the proportion of large particles. The turbulence pulsation mainly affects the trajectory of small particles. As the inner diameter of the cover plate increases, the axial turbulence is stronger, and more small particles are diffused in the polymerization kettle and collide and converge. Due to the wider diffusion range and more uniform particle diffusion, many particles converge and react, resulting in an increase in the proportion of medium-sized particles.

6.2 Comparison of Particle Size under Different Stirring Spacing

In the process of rotation, the mixer drives the surrounding flow field to rotate, which will form a stable flow pattern distribution, that is, the action field. Mixing spacing refers to the distance between different agitators h when there are multiple agitators in the mixing tank. When the mixing spacing in the multi-layer mixing tank is too large, the action zones formed by different agitators will be staggered, resulting in low mixing efficiency. When multiple working areas are overlaps, a new flow pattern will be formed, in which particle motion will also be affected, resulting in different polymerization effects. In this simulation, because the particle phase is evenly distributed in 50% of the volume below the polymerization kettle in the initial state, the upper agitator cannot give full play to its stirring effect. In order to explore the polymerization effect of PVC particles under different mixing spacing, the center of the lower layer agitator is used as the base point. The particle size distribution of PVC particles in the kettle was simulated respectively when the stirring interval h was 2550mm, 2600mm, 2650mm, 2700mm, 2750mm, 2800mm. The volume distribution of PVC particles was shown in Fig. 13, and the particle size cloud image was shown in Fig. 14.

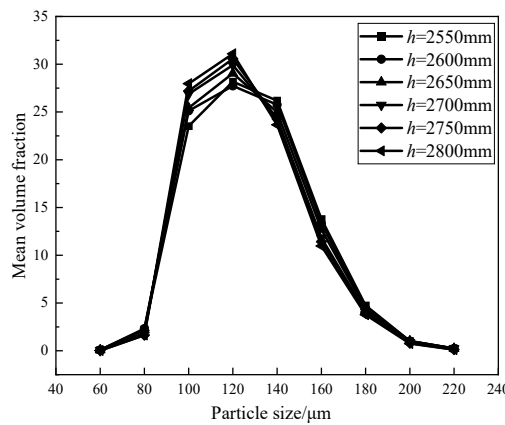


Fig. 13 Particle size distribution under different stirring spacing

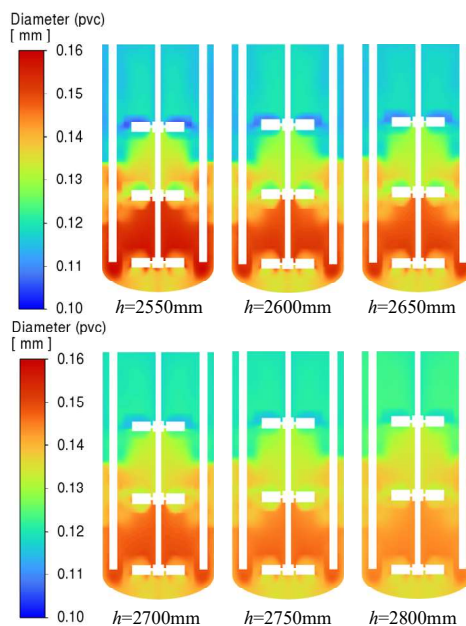


Fig. 14 Particle size distribution cloud image at different stirring spacing

It can be seen in FIG. 13 and FIG. 14 that as the stirring interval h gradually decreases, the proportion of small and medium-sized particles decreases, while the proportion of large particles increases. Since

the initial condition of BN-6 (100 μ m) is set as 1 in this analysis, combined with image analysis, it can be seen that reducing the stirring interval can improve the particle polymerization degree, and the proportion of initial particle size particles decreases when the small particles are almost unchanged. The proportion of large particles increased. This is because when the mixing interval is gradually reduced, the working area formed by the agitator will be overlaps to form a new working area, which is affected by two agitators at the same time, which improves the degree of turbulence of the fluid, has a stronger mixing effect, and enhances the shear effect of the fluid in some areas. Therefore, the decrease of stirring spacing will lead to the increase of the collision frequency of particles in the stirred area, which will promote the polymerization between particles and increase the degree of polymerization of particles. Frequent collision and polymerization between particles will lead to the formation of large-particle size particles, and the proportion of large-particle size particles will increase, while the proportion of medium-particle size particles in the initial state will decrease.

7. Conclusion

Using the double Euler fluid model, the standard k- ϵ turbulence model and the Wen-Yu drag function model, based on the MRF model and the PBM model, combined with the temperature field, gravity field, fluid field and other physical fields, the mixing process of water and PVC particles in the double suction turbine polymerization reactor was simulated. The following conclusions were drawn within the research scope:

- (1) Increasing the inner diameter of the cover plate of the double-suction turbine agitator can effectively improve the negative pressure of the center of the agitator, enhance the axial turbulence ability in the tank, increase the axial motion component of the particles at the center of the agitator, increase the diffusion degree of particles and reduce the local accumulation phenomenon, reduce the dead zone of mixing by up to 22.04%, and improve the mixing efficiency. Changing the thickness of the cover plate has no obvious effect;
- (2) Along the vertical direction of the polymerization kettle, the liquid velocity presents a regular change. The liquid velocity increases at the center height of the agitator, and the liquid velocity at this position is positively correlated with the inner diameter of the cover plate. The liquid velocity reaches its maximum at the height of the upper and lower sides of the agitator, and the maximum velocity does not change with the inner diameter and thickness of the cover plate;
- (3) With the increase of the inner diameter of the cover plate, the proportion of small particle size particles is almost unchanged, the proportion of medium particle size particles increases, and the proportion of large particle size particles decreases; With the decrease of stirring interval, the proportion of small particle size is almost unchanged, the proportion of medium particle size is reduced, the proportion of large particle is increased, and the polymerization conversion rate is increased.

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