INTRODUCTION

The shale gas industry has been greatly developing recently in China and as estimated, the production of shale gas will possibly exceed 200 BCM before 2025.\(^1\) And in some areas such as North America, the reserve of shale gas is estimated over at 50 TCF, which means the shale gas industry faces a great opportunity. Many researchers investigated gas consumption and predicted the future tendency of it which proved the importance of shale gas extraction.\(^2\)–\(^5\) However, the large amount of sand carried by shale gas will be a serious problem to the ground-based devices.

The rectifying plate is of great importance in gas pipeline system. In shale gas extraction, the turbulent flow due to the unstable pressure and velocity lead to lower precision in gas measurement. Hence, the rectifying plate is always used to stabilize the fluid\(^6\) in order to improve the measurement accuracy.\(^7\),\(^8\) At the start of shale gas extraction, the large amount of sand particles carried by shale gas is high to 10 tons per day.\(^8\) To ensure the quality of shale gas, sand separators are always used in process of desanding. However, if the separator breaks down, the desanding efficiency of it will be greatly affected, which means more sand particles may possibly enter another devices. In Changning-Weiyuan (Sicuan Province, China) shale gas station, the blockage caused by particle deposition has been common in pipes and devices especially the rectifying plate. Because of the special structure of the rectifying plate, sand particles in
shale gas tend to trapped by the wall of the rectifying plate. Accumulated particles will format deposition if the rectifying plate works longtime without cleaning. Moreover, deposition in the rectifying plate generates blockage and affects the flow field, which lead to greater error in the measurement process of gas flow. This problem has been always happening in Changning-Weiyuan shale gas station and brought many troubles. However, it is hard to take the traditional rectifying plate apart from the pipeline system, in order to solve this problem, a new-type rectifying plate which is easy to dismantle is designed, and comparison of two types rectifying plates is shown in Figure 1.

Unlike the traditional rectifying plate, there is no need to stop the work of transportation system when installing the new-type rectifying plate or dismantling it. Driving device drives the rectifying plate to move up and down between the areas of the valve chest which replaces reduces the risk in human operation.

By using computational fluid dynamics (CFD) method and experiment, the effect of flow field on particles deposition in new-type rectifying system is analyzed in this paper.

Particles deposition in flow field is a complex procedure and is widely studied in recent years. Lorenzo et al\textsuperscript{9} presented newly model of hydrate deposition in gas pipelines and estimated the growth rate and effective shear strength of the hydrate deposit; Forsyth et al\textsuperscript{10} studied the solid particles deposition in turbine engine under high temperature and pressure, and their study indicated that deposition rates under thermophoretic are much higher than isothermal rates; Kharoua et al\textsuperscript{11} used the DPM model to study the deposition of black powder in pipe flow and predicted the particle behavior; Loyseau and Verdin\textsuperscript{12} studied the particle dispersion and deposition in a vertical pipe by using Lagrangian simulations, and the related deposition, impact velocity, and probability density function are investigated in their research; Filali et al\textsuperscript{13} used the CFD method to investigate the effect of flowing condition, particle diameter, and surface roughness on deposition of black powder in gas transmission pipelines. It is found in their study that the particle with diameter smaller than 1 μm is more likely to be transported to the downstream of pipe network; Yasushi and Tomio\textsuperscript{14} studied the effect of particle mass concentration on deposition numerically and indicated that transfer coefficient of particle deposition decreased with the increase of particle mass concentration; Jassim\textsuperscript{15} presented a new method describing the mechanism of the hydrate deposition and found that the
Particle behaviors in the flow field are investigated, and erosion or deposition caused by particle motion is concluded in various researches. However, as an important equipment in gas industry, particle deposition in rectifying plate is rarely focused. In this study, the behavior of particles is analyzed in rectifying plate system by using combination method of FEM model and DPM method. Besides, the experiment method is used in order to verify the simulation model. Through analysis, prediction for deposition rates and deposition distributions under various conditions are presented in this paper. Because the particle deposition of the rectifying plate has not been studied yet, hence the investigation is this paper that contains the experiment and simulation model is useful in describing deposition mechanism and can provide ideas for further studies.

2 | DEPOSITION MECHANISM AND MATHEMATICAL MODEL

2.1 | Deposition mechanism

When sand particles hit the wall of pipe or rectifying plate, they will be rebounded or trapped by the wall and cause erosion or deposition as shown in Figure 2.

Generally, the formation of deposition is more complex. Certain conditions are required or the particles cannot attach to the wall, which will result in deposition. In the rectifying plate system, sand particles carried by the flowing fluid are suffered by various forces and keep a certain motion state. Except buoyancy and gravity, virtual mass force, pressure gradient effects, etc, are also possibly applied on particles.

As Saffman proposed in his theory, when the velocity of the particle is different from that of surrounding fluid and the velocity gradient of fluid is perpendicular to the direction of the particle motion, the velocity difference between two sides of particle generates one kind of lift force with the direction from lower velocity to higher velocity. The mechanism can be described as:

$$F_s = 1.61\rho g \mu_s \left( \mu_s - \mu_p \right) \frac{d\mu_g}{dy}^{1/2}$$

(1)

where $\mu_s$ is velocity of fluid and the $\mu_p$ is the velocity of particle.

And when particles suspended in fluid with temperature gradient, thermophoretic force will affect the particles motion and move it from higher temperature zone to lower temperature zone. Talbot defined the thermophoretic force equation as follows:

$$\vec{F} = -\frac{6\pi d_p \mu^2 C_s (K + C_s Kn)}{\rho (1 + 3C_m Kn)(1 + 2K + 2C_s Kn)} \frac{1}{m_p T} \nabla T$$

(2)
\[ F = C_{vm} \frac{\rho}{\rho_p} \left( \ddot{u}_p \nabla \ddot{u} - \frac{d\ddot{u}_p}{dt} \right) \]  
\[ F = \frac{\rho}{\rho_p} \ddot{u}_p \nabla \ddot{u} \]  

where \( C_{vm} \) is the coefficient of virtual mass force with a default value of 0.5. And due to the work of the pressure gradient in the fluid, an additional force can be written as:

Under some special circumstances, particles in flow field have a certain spinning velocity. And in this condition, Magnus lift force will be generated. If spinning angular velocity of particle is \( \omega \), the force equation can be written as follows:

\[ F_M = \frac{\pi \rho_d \sigma_d (\mu - \mu_p) \omega}{8} \]  

Particles in flow field of rectifying plates system can be mainly acted upon by forces above. Only if the forces on particle are balanced when the particle trapped by the wall, the deposition may have a possibility to be generated in rectifying plate system as Figure 3 shown.

Moreover, the Momentum conservation of particle is also a key factor in process of particle deposition or collision. When a particle moving in fluid and accelerated by forces, the Momentum conservation of it can be written as follows:

\[ \frac{\pi \rho_p d^3}{6} \frac{dW_p}{dt} = \frac{\pi}{6} (\rho_F - \rho_p) g d^3 - \frac{1}{2} \rho_p C_D \frac{\pi}{4} d^2 W_p |W_p| \]  

where \( \rho_F \) is the density of fluid and the \( \rho_p \) is the density of particle. \( W_p \) is the velocity of free dropping.

2.2 | Model of fluid phase

In the simulation, kinetic energy of turbulence \( (k) \) and turbulent dissipation energy \( (\epsilon) \) are used to restrict turbulent fluctuation\(^{26,27}\) and are shown as follows:

\[ U_j \frac{\partial k}{\partial x_j} = \frac{\partial}{\partial x_j} \left( \frac{\nu_t}{\sigma_k} \frac{\partial k}{\partial x_j} \right) + \nu_t \left( \frac{\partial U_i}{\partial x_j} + \frac{\partial U_j}{\partial x_i} \right) \frac{\partial U_i}{\partial x_j} - \frac{\varepsilon}{k} \]

2.3 | Discrete phase model (DPM)

In simulations, the particles are set as discrete phase while fluid is set as continuous phase. Lagrange-Euler method is used to solve the motion equations of multiple-phase. The trajectories equations of particles can be solved by stepwise integration over discrete time steps as follows:

\[ \frac{dx}{dt} = u_p \]  

And coupling with the forces balance equations as follows:

\[ \frac{d\ddot{u}_p}{dt} = F_D(\ddot{u}_p - \ddot{u}) + \frac{g(\rho_p - \rho)}{\rho_p} + \ddot{F} \]

The Equation (7) can be cast into

\[ \frac{du_p}{dt} = \frac{1}{\tau_p} (u - u_p) + \alpha \]  

where \( \alpha \) is a term that concludes accelerations due to all forces except drag force and \( \mu, \alpha, \tau_p \) can be calculated by analyzing. Then, the particle velocity at the new step and the new location can be written as follows:

\[ u_{p}^{n+1} = u_p^n + e^{\frac{\Delta t}{\tau_p}} (u_p^n - u^n) - \alpha \tau_p \left( e^{-\frac{\Delta t}{\tau_p}} - 1 \right) \]  

\[ \chi_{p}^{n+1} = \chi_p^n + \Delta t \left( u_p^n + \alpha \tau_p \right) + \tau_p \left( 1 - e^{-\frac{\Delta t}{\tau_p}} \right) (u_p^n - u^n - \alpha \tau_p) \]
Particles carried by the fluid have a possibility to hit the wall with various impact angles, which can be fitted by piecewise linear function. The following is an impact angle function of sand particle erosion in steel:

\[
f(\alpha) = \begin{cases} 
0 + 22.7\alpha - 38.4\alpha^2, & \alpha < 0.267\text{rad} \\
2.00 + 6.80\alpha - 7.50\alpha^2 + 2.25\alpha^3, & \alpha \geq 0.267\text{rad}
\end{cases} \tag{15}
\]

In Fluent, the equation of accretion rate in DPM model is defined as follows:

\[
E_{\text{accretion}} = \sum_{p=1}^{N_{\text{particle}}} \frac{\dot{m}_p}{A_{\text{face}}}
\tag{16}
\]

where \(\dot{m}_p\) is the mass of the single particle, and \(A_{\text{face}}\) is the area of projection of particle on the wall.

In the simulation, the total number of entering particles is defined by users, and the deposition rate can be written as follows:

\[
\varphi = \frac{n_i - n_e}{n_i}
\tag{17}
\]

where \(n_i\) is the total number of particles, \(n_e\) is the number of particles escaping from outlet.

### 3 | METHODOLOGY

#### 3.1 | Conduction of deposition experiment

The deposition experiment is conducted in Southwest Petroleum University and Figure 4 shows the structure of the system of experiment.

A pressure bottle is connected with the inlet of pipe and used to transport air into the rectifying plate system. A funnel filled with sand is connected at inlet pipe. A sand collecting box at the end of the outlet pipe is used to collect the escaping sand particles. Valve 1 connected with the pressure box is used to control the sand rate, and valve 2 connected with the sand funnel is used to control the rate of sand transport. The hot wire anemometer is used to measure the gas velocity at the inlet of pipe in order to guarantee the accuracy. Moreover, the diameter of sand particles used in deposition experiment is 100 μm.

Cleaning the rectifying plate and pipe before and after each experiment and keeping the rectifying plate system dry. In order to clearly observe the deposition of sand particles, transparent pipe made by Polymethyl Methacrylate is used. Moreover, the inside of the pipe is polished smoothly for the sake of smaller friction resistance between sand and pipe. Along the direction of fluid flowing, there are four drilled holes equidistantly distributed on the top side of each pipe in order to put the probe of hot wire anemometer in.

The flow field of the rectifying plate system under various gas velocity at inlet is measured. Eight measuring points are set at the center of each cross-section where the drilled hole is located and one point set at one rectifying bundle. Moreover, another 2 measuring points are set at the center of both inlet and outlet. The distribution of the measuring points is shown in Figure 5.

The laboratory is a closed zone, and the airspeed at 0.02 m/s is low and can be considered negligible in experiment. Measuring for four times at each measuring point and averaging the data of results. Moreover, it is necessary to block another holes when taking measurement at one measuring point. Because the Reynolds number at inlet controls the flow status in system, hence calculating the Reynolds number by

\[
Re = \frac{\rho vd}{\mu}
\tag{18}
\]
where $Re$ is the Reynolds number, $\rho$ is the density of fluid, $d$ is the Hydraulic diameter, and $\mu$ is the viscosity coefficient. And the data are shown as in Table 1.

As Table 1 indicates, the Reynolds number of each point rises with the increase of the gas velocity at inlet. Besides, there is a rather big increase in Reynolds number from point 5 to point 6 and a sudden reduction in that from point 6 to point 7 under a certain gas velocity at inlet. It is because that the cross-section area of the rectifying plate is much smaller that of pipe and fluid was accelerated while passing through it. Hence, the differential pressure between pipes and the rectifying plate leads to a greatly change in velocity at the surrounding zone of the rectifying plate.

The deposition experiment is also conducted. Sand particles enter in the rectifying plate system from the sand funnel and carried by the gas flow. It worth mentioning that the escaped particles are not suggested weighing because sand particles escaped will diffuse toward environment outside, however, it is impossible to collect all of them because of their small size. Hence, by weighing the sand particles trapped by the rectifying plate system and the total sand particles, the deposition rate can be obtained by Equation (16) and will be more accurate. The results by measurement of particle deposition rate under various Reynolds numbers are shown in Table 2.

It can be found from the result, the deposition rate remained at 100% until the Reynolds number exceeds $14\ 052.59$. This result indicates that in the condition of lower Reynolds number, particles carried by gas flow cannot get to the outlet of the rectifying plate system because they are greatly affected by gravity and tend to deposit. When the Reynolds number exceeds $14\ 052.59$ and continuing to increase, the deposition rate of sand particles in the rectifying plate system is roughly tend to reduce.

### 3.2 Models of rectifying plate system and grid independence verification

The structure of the rectifying plate system is shown in Figure 2. It consists of 22 holes that allow gas fluid to flow through and help stabilize the fluid. Sizes of each component are given after field measurement in Southwest natural gas research institution (Sichuan Province, China).

The model and mesh are generated by ANSYS Workbench, as shown in Figure 6, 578 521 grids are generated, and the inflation method is used to refine grids of near-wall zone in order to make the simulation of flowing closer to practical.

Generally, the grid number may affect the accuracy of simulation. Too many grid points lead to lower efficiency.
of computer but if the grid number is not enough, the accuracy of calculation cannot be guaranteed. Hence, grid independence verification is necessary to be conducted in numerical simulations. In this simulation, sand particles are set as the injection with the flow rate of 0.00347 kg/s, all particle diameters are uniformly defined as 100 μm, and the velocity of gas and particles are set as 3 m/s. The standard k-ε model is applied as the turbulence model for simulation, and the DPM model is used for solving the motion of particles. Turbulence intensity is set to 5%, and hydraulic diameter is set to 80 mm. Inlet is set to velocity boundary while outlet is set to pressure boundary at the pressure of 1 Bar. The enhanced wall treatment is used for better accuracy. In consideration of interaction between particles and eddies in fluid flow, the discrete random walk (DRW) model is applied in simulation.

The grid numbers of 168 502, 376 524, 578 521, 1104 017, 1773 785, and 4095 597 are conducted in the verification and the corresponding results are shown in Table 3 and Figure 7 (gas velocity is set to 3 m/s, flow rate of sand is set to 0.00347 kg/s, and particle diameter is set to 100 μm).

Residual exponents of each term are under $10^{-4}$, and the mass conservation is satisfied in the simulation. It indicates that the grid number of 578 521 can achieve the requirement.

### Table 2: Experiment data of deposition rate in the rectifying plate system

| Reynolds number | 0.00 | 4684.20 | 9368.39 | 14 052.59 | 18 736.79 | 23 420.98 | 28 105.18 | 32 789.37 |
|-----------------|------|---------|---------|-----------|-----------|-----------|-----------|-----------|
| Deposition rate (%) | 100  | 100  | 100  | 100  | 97  | 97.2  | 88  | 75.2  |

The trajectory of sand particle is mainly affected by the fluid properties and characteristics of sand. In this chapter, the effect of fluid on deposition is analyzed; moreover, the parameter of particle is defined in simulation in order to obtain the relationship between them and particle deposition.

### 4 | RESULT AND DISCUSSION

The trajectory of sand particle is mainly affected by the fluid properties and characteristics of sand. In this chapter, the effect of fluid on deposition is analyzed; moreover, the parameter of particle is defined in simulation in order to obtain the relationship between them and particle deposition.

#### 4.1 | Deposition analysis at different Reynolds numbers

Firstly, the flow field of the rectifying plate system is simulated (Gas velocity at inlet is set to 3 m/s, which is equal to Reynolds number of 14 052.59, flow rate of sand is set to 0.00347 kg/s, and particle diameter is set to 100 μm). Black arrows in the figure indicate the direction of fluid flowing, and the red dotted circle highlights the flowing fluid in the rectifying plate system. Different cross-sections distributed along the direction of flowing fluid are generated in order to make it clear to observe the change of flow field in the rectifying plate system. The result is shown in Figure 8.
It can be observed from Figure 8 that stable fluid enters into the pipe and becomes turbulent when passing through the rectifying plate. It is because that the cross-section area of rectifying bundle is smaller than that of pipe lead to the differential pressure, so the velocity of gas increases dramatically. Then, the fluid flows out the rectifying plate and becomes stable gradually. Several simulations under different gas velocities at inlet are conducted and be verified with the data of experiment, the result is shown as in Figure 9.

As can been seen from Figure 9, the curve of experiment data is well coincide with that of simulation data, which prove the accuracy on simulation of flow field. This research is focused on the particle deposition in the rectifying plate system; hence, the effect of flow field on the particle distribution is investigated in order to find out where the deposition may generate. And the result is shown in Figure 10.

Figure 10 shows the particle distribution in the rectifying plate system. White arrow indicates the direction of fluid flowing, and the red dotted circle is used to highlight the particle distribution in rectifying bundles. It can be observed that particle mass concentration in zone of inlet pipe is much higher than that in zone of outlet pipe. The maximum concentration of particle appears in the zone of the rectifying plate and the bright blue area on the bundles is where particle may deposit. In order to investigate the law of particle distribution, four cross-sections are generated equidistantly in each pipe, and one cross-section is generated in the center of the rectifying plate. And the Figure 11 shows the detail.

It can be found that particles distribution shifts along the direction of gravity gradually with the fluid flowing. In the cross-section of the rectifying plate, the particle mass concentration is much higher than that of others cross-section and when particles move out from the rectifying plate, the particle mass concentration dramatically decreased. The mass concentration is 0 kg/m³ at the outlets indicated that there is no particle can escape from the outlet under this condition.

The motion of particle in pipe is greatly affected by the Reynolds number; thus, the particle deposition under various gas velocities from 0 m/s to 13 m/s (Reynolds number varies from 0 to 60 894.55) is analyzed. Keeping the parameters of sand particle unchanged at the diameter of 100 μm and flow rate of 0.00347 kg/s, and the results of simulation are shown as in Figure 12.

Particles are mainly concentrated in the inlet pipe as Figure 12 indicates. Although some particles under the higher Reynolds number can pass through the rectifying plate and

| Grid numbers | Maximum gas velocity (m/s) | Relative error | Max particle mass concentration (kg/m³) | Relative error |
|--------------|---------------------------|----------------|----------------------------------------|----------------|
| 578 521      | 11.57                      | –              | 16.53                                  | –              |
| 1 204 017    | 11.50                      | 0.6%           | 16.27                                  | 1.6%           |
| 1 583 785    | 11.53                      | 0.3%           | 16.38                                  | 0.9%           |
| 2 287 615    | 11.48                      | 0.9%           | 16.29                                  | 1.7%           |
| 3 024 581    | 11.59                      | 0.17%          | 16.33                                  | 1.2%           |
| 4 100 227    | 11.73                      | 0.13%          | 16.84                                  | 1.9%           |
escape from outlet, most of them are prevented by the wall of rectifying plate. The experiment results show the sand deposition and distribution in the rectifying plate system, which can be seen as follow in Figures 13 and 14 (All instruments are positioned horizontally).

It can be found in Figure 13 that when the Reynolds number is controlled at 14 052.59 at inlet, some of sand particles deposited in the inlet pipe though, most of them are mainly deposited in front of the rectifying plate and just only few of them can pass through the rectifying plate. Area 1 and area 2 are where sand particles deposited around the rectifying plate.

The result of deposition under the Reynolds number of 28 105.18 is shown in Figure 14.

The deposition of sand particles changes when Reynolds number at inlet increases to 28 105.18. Particles tend to move toward outlet, and some of them can escape from the outlet. Moreover, the deposition degree is decreased gradually in the outlet pipe along the flow direction.

With Reynolds number at inlet continuing to increase, the deposition of sand particles in both pipes changes slightly. However, the deposition at the wall of the rectifying plate has a obvious change and the results shown as in Figure 15.
It can be clearly observed that the particle deposition in the rectifying bundles increases when Reynolds number varies from 28,105.18 to 37,473.57, because the time that particles arrive at the rectifying plate is less, and some of them can enter the rectifying plate from more positions. However, when Reynolds number increases to 46,841.96, some particles attach to the cross-section of the rectifying plate and the mass of particles in rectifying bundles are almost unchanged by measurement. This result can prove that why the deposition rate changes slightly after Reynolds number is over 37,473.57.

With increase of Reynolds number, particles become far more spread out and some particles can escape from the rectifying system. In software of FLUENT, particles are set as injection and will be tracked in simulation, moreover, the trapped particles and escaping particles will be recorded. The deposition rate is determined by the number of total particles and trapped particles as Equation (16) indicates. By simulation, the results of deposition under various Reynolds number are obtained and are shown as in Figure 16.

It is obtained from simulation that when Reynolds number increases to 18,736.79, a few particles escaped for the first time and the deposition rate starts to decrease. The deposition rate declined suddenly when Reynolds number increases from 18,736.79 to 37,473.57 and then tend to steady as Reynolds number continues to rise. The Boltzmann curve is used to describe the tendency and is well fitted with the result data, and the curve equation can be written as follows:

\[
y = \frac{A_1 - A_2}{1 + e^{11.067 \times 10^6 (x - x_0) / 0.051846}} + A_2
\]

where \(y\) is deposition rate, \(x\) is the Reynolds number, \(A_1 = 100.00342, A_2 = 73.55262, x_0 = 6.0088, \) and \(dx = 0.57466\).

The verification on simulations of field flow and deposition proves the accuracy of the simulation model, so the deposition model can be used to simulate the particle deposition under various conditions.

### 4.2 Deposition analysis at different particle parameters

An investigation of particle deposition under different particle sizes is performed in this section. Controlling the gas velocity at 8 m/s at inlet and varying particle size from 50 μm to 350 μm. Moreover, the others boundary condition remain unchanged.

Along the direction of gas flowing in the rectifying plate, particle mass concentration of each cross-section under various particle sizes is analyzed and Figure 17 shows the result.

It can be observed that with the increase of particle size, the max mass concentration of particle increases. Moreover, the distribution of particles at 50 μm diameter is relatively uniform on each cross-section, but particles tend to fall down when their diameter rises and for this reason, the particle mass concentration at outlet is reduced. Hence, the particle
deposition rate rises with the increase of the particle diameter. Besides, it is found by simulation that the max particle mass concentration appears in rectifying bundles and is increase when particle diameter rises, and this result indicates that the more particles will deposit in the rectifying plate with particle diameter increases.

The relationship between particle diameter and deposition rate can be obtained from Figure 18.

It can be observed that particle deposition rate increases when particles become larger because the motion of particles with larger diameter is greatly affected by the gravity action. Moreover, larger particles are more likely format deposition in the rectifying plate under this velocity; hence, it is useful to control the gas velocity in the rectifying plate system when entered particles are in big size. Lower gas velocity leads to larger particles deposit in

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**FIGURE 11** Particle mass concentration of each cross-section

**FIGURE 12** Particle distributions at different Reynolds number
the front of the rectifying plate and makes cleaning work more convenient.

Besides, the deposition rate will also be affected by the shape of particles that is because the piling method of particles changes with the various particle shape. Hence, particle deposition rate under different particle shape is analyzed. Keeping the gas velocity unchanged at 3 m/s and the particle diameter at 100 μm, moreover, the sand input is still controlled at 0.00347 kg/s. The result which indicates the relationship between shape factor of particles and deposition rate is shown as in Figure 19.

As Figure 19 shows, the deposition rate is increases when particle shape factor rises which means that sharp-edged particle is more effected by the flow compared with the gravity action.

5 | CONCLUSION

New-type rectifying plate system are analyzed in this paper. In the experiment, the Reynolds number of each measuring point is obtained by measurement of gas velocity. Moreover, the particle deposition under the Reynolds number of 14 052.59 is also measured by weighing the mass of trapped particles and total particles. Experiment data are used to verify the accuracy of simulation; besides, the result of simulation is well coincide with the phenomenon of experiment, which proves the applicability of DPM model in describing the particle motion.

It is found from analyzing that particle deposition in the rectifying plate system is greatly effected by the Reynolds
number, particle size and shape factor. Remaining the par-

particle parameters unchanged and increasing the Reynolds

number from 4684.2 to 60,894.55, it is obtained that the

particle deposition in the rectifying plate can be described

by the Boltzmann equation of which curve is well coin-
cide with both the data of experiment and simulation. It

is worth mentioning that when Reynolds number is over
37,473.57, the change of particle deposition rate is not

\[
 y = \frac{A_1 - A_2}{x + A_3} + A_4
\]

FIGURE 15  Particle deposition at the wall of the rectifying plate

FIGURE 16  Deposition rate at different Reynolds number
FIGURE 17  Deposition rate at different particle sizes (A) and particle deposition in the rectifying plate (B)
obvious because the higher Reynolds number lead to particles distribute uniformly, and a certain amount particles tend to be prevented by the rectifying plate. Hence, the amount of particles escaped almost remains unchanged under high Reynolds number.

Moreover, under the Reynolds number of 37,473.57, the deposition rate increases with the increase of the particle diameter. The reason for this result is when particle diameter increases, the trend of particles falling down is more obvious. Hence, smaller particles distribute uniformly while the distribution of larger particles shifts along the direction of gravity. Besides, the effect of shape factor on deposition rate is also analyzed in this research. It is found from investigation that spherical particles are more likely to format the deposition in the rectifying plate system because the sharp-edged particle is more effected by the flow.

This paper presents an analysis in the particle deposition of a new-type rectifying plate and fills up a bland in this area. Though there are still some limitations in the simulation model and experiment method, it provides ideas for relative researchers.

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