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Study on the performance of the hydrocyclone for acid hydrolysis residue separation

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Highlights

- The hydrocyclones with different structural configurations by Response Surface Methodology were studied.
- A high sharpness hydrocyclone for acid hydrolysis residue recycling was designed.
- Numerical experiments as well as laboratory tests were performed to evaluate the classification sharpness of hydrocyclone designs.

1. Introduction

The hydrocyclone is an efficient device for the classification and separation of particles and is extensively used for the separation and classification of solid particles in the industries of mineral processing and chemicals. However, these designed by the conventional procedures may have some limitations on the classification sharpness. Otherwise, despite its simple geometry and operation, the detailed flow fluid and the involved mechanism are highly difficult to explain. A great deal of researches has been made to understand the effects of geometric dimensions on the performance. The research showed that a lower underflow rate could be beneficial for the precise separation by increasing in overflow diameter or decreasing in underflow diameter [1]. And Tang et al. [2] determined that the overflow diameter should be in an appropriate range, and a high sharpness of particle classification could be achieved through reducing the percentage of misplaced particles.

To achieve a high sharpness of particle classification by hydrocyclones for acid hydrolysis residue recycling [3], the interactive effects of structural configurations were investigated by central composite circumscribed design (CCD) in this study. The range of single structural configuration for CCD was determined according to the previous study. As a result, the response models between the structural configurations and the classification sharpness were introduced. Accordingly, an optimized hydrocyclone with high sharpness for residue recycling was designed, and good performance of particle classification was achieved in the laboratory tests.

2. Methods

The research was conducted waste residues discharged in the production of TiO_2 by sulfate method as raw materials. In this study, the Reynolds Stress Model has been applied to describe the rotating turbulent flow in the hydrocyclones. The interface between liquid phase and air phase was simulated by the Volume of Fluid Model. The Stochastic Lagrangian Model was used to track the motion behavior of solid phase.

3. Results and discussion

To have a better understanding of classification performance within the hydrocyclone design, the interactive effects of structural configurations on the sharpness were presented through the three dimensional response surface plots. Figure 1 represented the interactive effects of inlet diameter and vortex finder diameter on the classification sharpness.

Four significant structures of hydrocyclone was proposed to CCD model, and the effects of parameters on the sharpness follow the order: the diameter of vortex finder (X2) > the length of cone (X3) > the diameter of inlet (X1) > the diameter of spigot (X4).

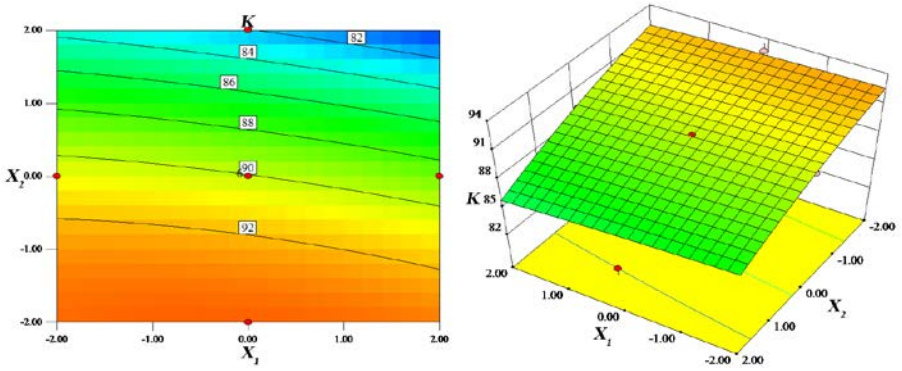
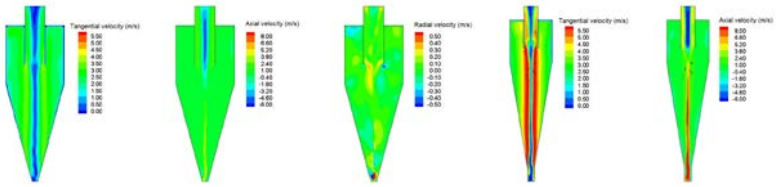


Figure 1. Contour and surface plots for index K in coded values of inlet diameter and vortex finder diameter.

A high efficiency hydrocyclone was designed to separate acid hydrolysis residue. The velocity distributions and classification efficiency in the designed and original hydrocyclone were plotted in Figure 2 and Figure 3.



(a) **(b)**

Figure 2. Description of the fluid flow in the optimized (a) and original (b) hydrocyclone

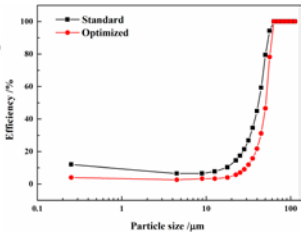


Figure 3. Separation efficiency curves of original and optimized hydrocyclone

4. Conclusions

The Response Surface Methodology is a high efficiency way to deal with multi-parameter process. In this paper, a high efficiency hydrocyclone was designed to separate acid hydrolysis residue. The cut size of particle classification was increased up to 50.9 micron, which indicated a high efficiency of fine particles by the vortex finder. And 96.0 % of the fine particles of impurities were separated by the vortex finder, and 51.0 % of TiO2 was recycled by the spigot. It demonstrated that a high sharpness classification of waste residues could be achieved by the new hydrocyclone.

References

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Keywords
Hydrocyclone, Acid hydrolysis residue, Classification sharpness, Response surface methodology