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Effect of Different Parameters of Converging-Diverging Vortex Finders on Cyclone Separator Performance

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Abstract : The present study is done to explore design modifications of the vortex finder, as it has a significant effect on the cyclone separator performance. It is evident that modifications of the vortex finder improve the performance of the cyclone separator significantly. The study conducted strives to improve the overall performance of cyclone separators by utilizing a converging-diverging (CD) vortex finder instead of the traditional uniform diameter vortex finders. The velocity and pressure fields inside a Stairmand cyclone separator with body diameter 0.29m and vortex finder diameter 0.1305m are calculated. The commercial software, Ansys Fluent v14.0 is used to simulate the flow field in a uniform diameter cyclone and six cyclones modified with CD vortex finders. Reynolds stress model is used to simulate the effects of turbulence on the fluid and particulate phases, discrete phase model is used to calculate the particle trajectories. The performance of the modified vortex finders is compared with the traditional vortex finder. The effects of the lengths of the converging and diverging sections, the throat diameter and the end diameters of the convergent divergent section are also studied to achieve enhanced performance. The pressure and velocity fields inside the vortex finder are presented by means of contour plots and velocity vectors and changes in the flow pattern due to variation of the geometrical variables are also analysed. Results indicate that a convergent-divergent vortex finder is capable of decreasing the pressure drop than that achieved through a uniform diameter vortex finder. It is also observed that the end diameters of the CD vortex finder, the throat diameter and the length of the diverging part of the vortex finder have a significant impact on the cyclone separator performance. Increase in the lower diameter of the vortex finder by 66% results in 11.5% decrease in the dimensionless pressure drop (Euler number) with 5.8% decrease in separation efficiency. Whereas 50% decrease in the throat diameter gives 5.9% increase in the Euler number with 10.2% increase in the separation efficiency and increasing the length of the diverging part gives 10.28% increase in the Euler number with 5.74% increase in the separation efficiency. Increasing the upper diameter of the CD vortex finder is seen to produce an adverse effect on the performance as it increases the pressure drop significantly and decreases the separation efficiency. Increase in length of the converging is not seen to affect the performance significantly. From the present study, it is concluded that convergent-divergent vortex finders can be used in place of uniform diameter vortex finders to achieve a better cyclone separator performance.

Keywords : convergent-divergent vortex finder, cyclone separator, discrete phase modeling, Reynolds stress model
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