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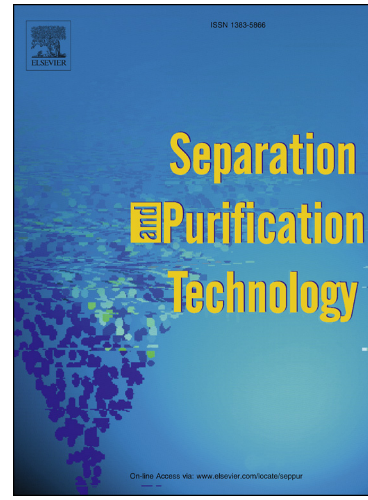

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Geometry optimization of a deswirler for cyclone separator in terms of pressure drop using CFD and artificial neural network

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Four main geometrical parameters of a deswirler (core diameter, number of vanes, height of vanes and leading edge angle) for cyclone separators have been optimized using CFD and artificial neural network. The results indicated that the most significant geometrical parameters of the deswirler are the number of vanes, the vane angle and the vane height. A new optimized deswirler geometry was obtained using the genetic algorithms and its effects on the flow field, pressure losses and cyclone collection efficiency were numerically investigated. The deswirler positively affects the flow field within a cyclone. It dramatically reduces tangential velocities in the vortex finder and only slightly (by 4.5%) decreases maximum tangential velocities in the separation zone. The deswirler also reduces the length of the inner vortex, redistributes uniformly axial velocities at the vortex finder outlet and prevents backward flow. Additionally, the deswirler converts the dynamic energy of the swirling flow into pressure and allows pressure recovery. It reduces pressure losses in the vortex finder by 95.67% that leads to 43.17% reduction in total pressure drop and slightly decreases the separation efficiency for some particle diameters, increasing the cyclone cut size from 1.5 to 1.72 µm.

Keywords: *Cyclone, Deswirler, Geometry optimization, Pressure drop, Surrogate-based optimization*

1. Introduction

Cyclones are simple and inexpensive separation (cleaning) devices without moving parts which can be constructed of any material and operate under severe conditions, such as high temperature and aggressive gases. Therefore, they have been used in practically each industry where there is a need to separate particles from a gas flow, for instance, in wood industry, cement industry, food-processing plants, chemical and petrochemical industries, mineral processing and many others [1].

Despite the fact, that cyclones have simple design, the behaviour of the gas flow is quite complex. The flow pattern in a cyclone can be described by a double vortex. The gas entering the inlet creates a downward spiral flow (it is also referred to as a “main vortex” or “outer vortex”) which continues downward to the bottom of a dust hopper where the flow reverses its axial direction but maintains its direction of rotation. Thus, an upward spiral flow (it is also referred to as a “secondary vortex” or “inner vortex”) is formed travelling to the gas outlet pipe, which is also referred to as a vortex finder.

Since the outgoing gas flow is still swirling, a lot of pressure is lost in the vortex finder. These losses depend on cyclone geometry and can amount to 50% of the total pressure drop in a cyclone [2]. This energy remained in the swirling flow can be recovered or used to increase the collection efficiency (for instance, with a post cyclone [3]). Installation of a deswirler (also referred to as untwisting or rectifying device) in the vortex finder, which straightens the swirling flow and converts the kinetic energy into static pressure, can significantly reduce the pressure losses in the vortex finder and the total pressure drop [4, 5]. Alternatively, modified vortex finders such as perforated and slotted vortex finders with the

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