

ABSTRAK

Penelitian ini dilatarbelakangi oleh permasalahan operasional pada unit *single cyclone separator* tipe *tangential inlet* di industri pupuk, yakni terjadinya fenomena stagnasi dan penumpukan material debu pupuk berukuran 20 mikron pada dinding kerucut akibat kelemahan momentum penurunan tekanan (*pressure drop*) *existing* sebesar 39,8 mmH₂O. Penelitian ini bertujuan untuk menemukan konfigurasi modifikasi geometri yang mampu mengeliminasi penumpukan debu sekaligus menaikkan dan menjaga *pressure drop* pada rentang spesifikasi aman operasional manufaktur (100–150 mmH₂O). Metode perancangan menggunakan pendekatan analitis komparatif teoretis dan simulasi komputasional. Evaluasi analitis awal mengekskansi 48 variasi rasio geometri menggunakan Metode Leith-Mehta untuk efisiensi separasi dan Metode Stairmand untuk besaran hambatan energi. Desain finalis tervalidasi kemudian disimulasikan menggunakan perangkat lunak *Computational Fluid Dynamics* (CFD) dengan pengaturan model turbulensi *Reynolds Stress Model* (RSM) dan pelacakan partikel *Discrete Phase Model* (DPM) berasumsi *one-way coupling*. Hasil penyaringan teoretis menetapkan rancangan *Lapple General Purpose* sebagai modifikasi geometri terpilih, yang secara matematis sukses mencapai keseimbangan performa dengan efisiensi 86,41% dan capaian *pressure drop* sebesar 135,29 mmH₂O yang mendarat secara presisi pada batas spesifikasi pabrik. Komparasi hasil simulasi CFD membuktikan secara faktual terjadinya penguatan kecepatan tangensial dan aksial secara signifikan, yang divalidasi oleh penurunan *particle residence time* pada pelacakan trajektori DPM, sehingga mengonfirmasi bahwa gaya dorong aliran yang baru telah berhasil menyapu seluruh debu menuju *dust outlet* dan mengeliminasi fenomena stagnasi secara absolut.

Kata Kunci: *Computational Fluid Dynamics*, Efisiensi Separasi, Modifikasi Geometri, Penurunan Tekanan, *Single Cyclone Separator*.

ABSTRACT

This research is motivated by operational issues in a tangential-inlet single cyclone separator unit within the fertilizer industry, specifically the stagnation and accumulation of 20-micron fertilizer dust particles on the conical wall. This phenomenon is attributed to the weak momentum caused by the existing pressure drop of 39,8 mmH₂O. This study aims to find a geometric modification configuration capable of eliminating dust accumulation while simultaneously increasing and maintaining the pressure drop within the safe operational specification range of the plant (100–150 mmH₂O). The design method employs a theoretical comparative analytical approach and computational simulation. The initial analytical evaluation expanded upon 48 geometric ratio variations using the Leith-Mehta Method to determine separation efficiency and the Stairmand Method for pressure drop evaluation. The validated finalist design was then simulated using Computational Fluid Dynamics (CFD) software, utilizing the Reynolds Stress Model (RSM) for turbulence and the Discrete Phase Model (DPM) for particle tracking under a one-way coupling assumption. The theoretical screening established the Lapple General Purpose design as the selected geometric modification, which mathematically achieved an optimal performance trade-off with an efficiency of 86.41% and a pressure drop of 135.29 mmH₂O, landing precisely within the safe factory limits. The comparison of the CFD simulation results factually demonstrated a significant strengthening of tangential and axial velocities. This was validated by a reduction in particle residence time through DPM trajectory tracking, confirming that the new flow momentum successfully swept all dust particles toward the dust outlet, thereby completely eliminating the stagnation phenomenon.

Keywords: *Computational Fluid Dynamics, Geometric Modification, Pressure Drop, Separation Efficiency, Single Cyclone Separator.*