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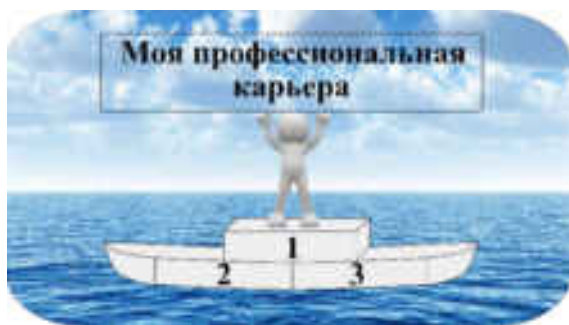


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**Международный научно-образовательный электронный журнал
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Журнал объединяет авторов на территории стран СНГ и помогает обмениваться передовыми научно-образовательными исследованиями.

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Название публикации: «SMALL SCALE CYCLONE SEPERATOR FOR GAS-SOLID SEPARATOR»

Abstract

Cyclone separators are widely used in industrial and laboratory processes for separating solid particles from gas streams. Small-scale cyclone separators are particularly significant for research, pilot studies, and low-capacity operations, providing efficient gas-solid separation with minimal maintenance. This article presents a detailed overview of the design, operation, and performance parameters of small-scale cyclone separators, emphasizing their efficiency, pressure drop characteristics, and application potential in chemical, environmental, and energy engineering. Optimization strategies and scaling considerations are also discussed.

1. Introduction

Gas-solid separation is a fundamental process in chemical engineering, environmental technology, and material processing. Cyclone separators are widely employed due to their simplicity, robustness, and ability to efficiently separate particles without moving parts.

Small-scale cyclone separators are used in:

- Laboratory and pilot-scale experiments
- Dust collection in small industrial processes
- Aerosol and particulate matter sampling
- Combustion research and fluidized bed studies

Designing an effective small-scale cyclone requires an understanding of fluid dynamics, particle behavior, and geometric optimization.

2. Working Principle

Cyclone separators use centrifugal forces generated by a swirling gas flow to separate solid particles from a gas stream. The main components include:

- **Inlet** – tangential entry promotes vortex formation
- **Cylindrical body** – region of forced vortex motion
- **Conical section** – guides particles to the dust collector
- **Vortex finder (outlet pipe)** – allows cleaned gas to exit

When a gas-solid mixture enters tangentially, a vortex forms, and heavier particles are forced toward the walls, eventually sliding down the conical section to the collection hopper, while the gas spirals upward and exits through the vortex finder.

3. Design Considerations

3.1 Geometric Parameters

- Cylinder diameter and height
- Cone angle and height
- Inlet width and height
- Vortex finder diameter

Typical small-scale dimensions:

- Cylinder diameter: 50–200 mm
- Cylinder height: $2\text{--}3 \times$ cylinder diameter
- Cone angle: $10\text{--}20^\circ$
- Inlet width: $0.2\text{--}0.5 \times$ cylinder diameter

3.2 Gas and Particle Considerations

- Particle size: 1–100 μm
- Particle density: 800–2500 kg/m^3
- Gas flow rate: 0.01–0.5 m^3/s

3.3 Material Selection

Common materials:

- Stainless steel

- Aluminum
 - Acrylic or polycarbonate (for visual observation in lab setups)
-

4. Performance Factors

4.1 Separation Efficiency

Efficiency depends on particle size, density, gas velocity, and cyclone geometry.

Fine particles ($<10\ \mu\text{m}$) require careful design to achieve higher separation efficiency.

4.2 Pressure Drop

Pressure drop increases with gas velocity and smaller diameter, improving separation but requiring more energy. A balance is needed between efficiency and energy consumption.

4.3 Particle Re-entrainment

Minimizing re-entrainment requires smooth surfaces, proper vortex finder length, and an appropriate cone angle to prevent particles from rebounding into the gas stream.

5. Optimization and Scaling

Optimization includes:

- Adjusting cylinder-to-cone ratio
- Using CFD simulations to visualize vortex structure
- Arranging multiple small cyclones in parallel to handle larger flows
- Considering Reynolds number and Stokes number for particle motion in

scaling studies

6. Applications

Small-scale cyclones are used in:

- **Environmental Engineering:** Air pollution control, PM_{2.5}/PM₁₀ sampling
- **Chemical Processing:** Particle removal in reactors, fluidized beds
- **Energy Engineering:** Biomass gasification, small-scale combustion

- **Materials Science:** Collection of powders and nanoparticles

Advantages:

- Compact, low-cost design
- No moving parts
- Reliable under variable flow conditions

Limitations:

- Less efficient for ultrafine particles ($<1\ \mu\text{m}$)
 - Requires a blower or vacuum for gas flow
-

7. Conclusion

Small-scale cyclone separators are essential tools for laboratory, pilot, and low-capacity industrial applications. Proper design considering geometry, flow dynamics, and particle properties ensures efficient separation. Optimization through simulation and experimental testing enhances performance. They are valuable in environmental monitoring, chemical research, and educational purposes, offering a low-maintenance, sustainable solution for gas-solid separation.

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