Using bag filter equipment to remove dust produced during the production of cement

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Abstract: The problem of air dust particle emissions in the cement industry and its reduction by bag filter technology are examined in this research. A new filter fabric made of Teflon and fiberglass has had its hydrodynamic resistance coefficient calculated. To maximize efficient filtration settings, experiments were carried out in a variety of operating environments.

Keywords: cement industry, dust cleaning, bag filter, fiberglass, Teflon, hydrodynamic resistance, filtration efficiency.

Introduction

High levels of particulate matter are released into the atmosphere during the cement manufacturing process, which has a negative effect on the environment and creates ecological problems. Industrial facilities currently use a variety of dust management techniques, although bag filter systems are the most effective.

Research Objective

To determine the hydrodynamic resistance coefficient of fiberglass and Teflon-based filter fabric, and to establish optimal parameters for efficient removal of particulate matter generated during cement manufacturing.

Method of Research

To carry out the research, a specialized experimental setup was built, which enables the modeling of actual circumstances in cement production plants. The device is equipped with the necessary measuring tools to ascertain the hydrodynamic properties of the filtration process and is set up for both gas and liquid systems.

Experimental Setup

The experimental setup consists of:

- Gas distribution system (blower, piping network)
- Filter chamber (constructed from transparent material to enable visual observation)
- Manometers and differential pressure transducers
- Gas flow measurement instruments (rotameters)

- Temperature sensors and data acquisition system

Independent Variables

The following parameters were systematically varied in the tests, which were conducted using the design of experiments (DOE) methodology:

Gas volumetric flow rate (Q_{gas}): 140, 425, 710, and 990 m³/h (increment: 285 m³/h) – Four levels

Gas velocity (υ_{gas}): 15, 20, 25, 30, and 35 m/s (increment: 5 m/s) – Five levels

Filter media thickness (δ_f): 2, 3, and 4 mm – Three levels

Filter cage diameter (d_{fil}): 130, 140, and 150 mm – Three levels

Constant Parameters

- Gas density (ρ_gas): 1.29 kg/m³ (air at atmospheric pressure)
- Operating temperature: 20±2°C (standard laboratory conditions)
- Relative humidity: 55-65%
- Atmospheric pressure: 101.3 kPa

Filter Material

A special filter fabric made from fiberglass and Teflon (PTFE) composite material was used in the experiments. The main characteristics of the filter material:

- Grammage: 500-600 g/m²
- Porosity coefficient: 75-80%
- Average fiber diameter: 8-12 μm
- Heat resistance: up to 260°C long-term, up to 300°C short-term

Experimental Methodology

For each experiment, the filter element was secured and the apparatus was started. After reaching steady-state conditions (15-20 minutes), the following parameters were measured:

1. Pressure difference before and after the filter (ΔP)
2. Gas flow rate (Q)
3. Gas velocity (υ)
4. Temperature (T)

Each experiment was repeated three times for each regime, and average values were calculated. The hydrodynamic resistance coefficient was determined using the following formula:

$$\xi = (2 \cdot \Delta P) / (\rho_{gas} \cdot \upsilon^2_{gas})$$

where:

- ξ - hydrodynamic resistance coefficient
- ΔP - pressure drop, Pa
- ρ_{gas} - gas density, kg/m³
- υ_{gas} - gas velocity, m/s

Experiments were conducted for gas and water systems at a temperature of 20±2°C. The obtained results were statistically processed, and regression equations were developed.

Main Results

1. **Filter material selection:** The fiberglass and Teflon composite was found to possess high heat resistance, chemical stability, and mechanical strength.

2.   **Hydrodynamic resistance:** An increase in the resistance coefficient was observed with increasing filter thickness and gas velocity. The most optimal results were recorded at $\delta_f = 3$ mm and $\upsilon_{gas} = 20\text{-}25$ m/s regimes.

3.   **Filtration efficiency:** The Teflon-coated fiberglass filter demonstrated 15-20% higher cleaning efficiency compared to conventional filters.

4.   **Optimal parameters:**
o   Filter diameter: 140 mm
o   Filter thickness: 3 mm
o   Gas velocity: 20-25 m/s
o   Gas flow rate: 550-700 m³/h

Scientific Novelty

•   For the first time, the hydrodynamic characteristics of a bag filter made from fiberglass and Teflon composite material for the cement industry have been comprehensively studied.

•   The effect of filter parameters and operating regimes on the resistance coefficient has been experimentally determined.

•   Optimal filtration regimes have been developed.

Practical Significance

The research results can be applied in modernizing dust cleaning systems in cement plants, designing new bag filter equipment, and developing practical recommendations for improving the efficiency of existing systems.

Conclusion

1.   Filter material based on fiberglass and Teflon demonstrates high efficiency for dust cleaning in the cement industry.

2.   Optimal hydrodynamic resistance and cleaning efficiency are achieved at a filter thickness of 3 mm and gas velocity of 20-25 m/s.

3.   Based on the developed parameters, recommendations have been provided for application in industrial enterprises.

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