EXPERIMENTAL STUDY ON STRUCTURE AND PERFORMANCE OF DEDUSTING FILTER MATERIAL MODIFIED BY REDUCING GRAPHENE OXIDE SPRAYING

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Abstract. With the continuous improvement of social requirements for air quality, industrial dedusting standards are becoming more and more stringent. Bag dust collector is one of the most commonly used and fastest technological dedusting equipment in industrial dedusting places.The filter bag is the core part of the bag filter, and the post-treatment of the filter bag is a common method to improve the performance of the bag filter.In this paper, air spraying method was used to post-treat four kinds of commonly used bag filter bags: polyimide fiber, polyphenylene sulfide fiber, glass fiber needle felt and flumex high temperature needle felt. The structural parameters and performance parameters of four new composites after post-treatment were compared and analyzed.The results showed that a layer of reduced graphene oxide coating was formed on the surface of the modified filter bag. After comprehensive comparative analysis, the reduction effect of graphene oxide composite with polyphenylene sulfide fiber (PPS) is the best. Under the filtration velocity of 0.8m/s, the filtration efficiency of $PM_{1.0}$, $PM_{2.5}$ and PM_{10} increased by 7.3%, 7.6% and 8.2%, respectively. The fiber porosity decreased from 98.36% to 98.18%. The resistance is basically unchanged, and the influence of resistance does not need to be considered when it is used. This study provides a reference for the post-treatment method of the filter bag of the dust collector.

Keywords. Spraying，reduction of graphene oxide，filter efficiency，filter bag and modification method

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1. Introduction

Atmospheric particulate matter pollution affects air quality, reduces air visibility, and harms people health is one of the most prominent environmental problems[1]. Industrial soot emissions are part of the main sources of fine particulate matters in the atmosphere[2]. The bag filter with the clean high efficiency,is commonly used in industrial places.

The filter bag is the core part of the bag filter, and it plays the main filtering role[3].Graphene has excellent electrical conductivity and mechanical properties, and it has great application prospects in material synthesis[4]. There are still some unreduced oxygen-containing functional groups on reduced graphite oxide, which have better hydrophilicity and better compatibility with materials than graphite[5].It also has similar electrical conductivity and good mechanical properties, and the preparation is economical and simple, which is suitable for industrial promotion. But here is little research on the modification of filter bags using reduced graphite oxide in industry.

Reduced graphite oxide was used to modify the dust-facing surface of the filter bag of the dust collector in this paper.The material properties and dust removal performance were tested and analyzed, at the same time. It also provides reference value for the development of new operative industrial filter bags.

2. Methods

2.1 Synthesis of materials

Four commonly used bag filter bags, including polypropylene fiber (P84), polyphenylene sulfide fiber (PPS), glass fiber needled felt, and Fumex high temperature needled felt were selected by air spraying post-treatment modification and performance testing in this paper.

The blank group and control group of the four experimental materials were shown in **Fig 1**.

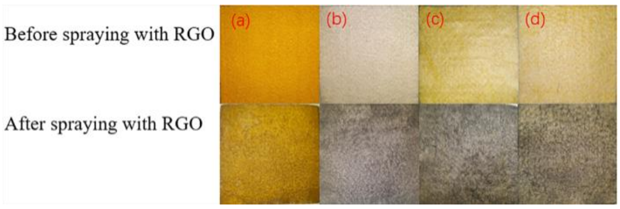

Fig.1. Four experimental materials blank group and control group (a) polyimide fiber; (b) polyphenylene sulfide fiber; (c) glass fiber needled felt; (d) Fumex high temperature needled felt.

2.2 Filter performance test

Particulate matter concentrations were calculated by a GRIMM1.109 portable aerosol spectrometer. Filtration resistance is calculated by HD2114P.0 portable micrometer. The filtration velocity was calculated by an indoor air quality monitor with an accuracy range of 3%. Measure material thickness with a micrometer with an accuracy of 0.01mm. The particle concentration was recorded before and after the experimental bench for ten minutes, and the average value was utilized to analyze the data to reduce experimental errors. The experimental system was showed in **Fig 2**. The construction of the experimental device complies with the Chinese national standard for GB/T 12138-1989. The distribution of measuring points conforms to the Chinese national standard GB 50019-2015.

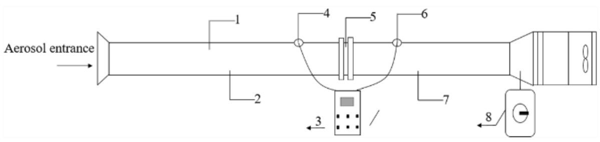

Fig.2. Experiment system
1: Anemometer; 2: Front-end measuring point of particle concentration; 3: Differential pressure gauge; 4: Front-end static pressure measuring point; 5: Measured material; 6: Back-end static pressure measuring point; 7: Back-end measuring point of particle concentration; 8: Frequency converter

Filtration efficiency formula[6]:

$$\eta = \frac{C_1 - C_2}{C_1} \times 100\% \qquad (1)$$

Where η is the filtration efficiency; C_1 is the mass concentration of particulate matter before filtration, μg/m^3; C_2 is the mass of particulate matter after filtration concentration, μg/m^3.

The filtration velocity before and after the filter is the same, and the cross-sectional area is the same; the resistance is expressed by the static pressure difference[7].

$$\triangle P = P_2 - P_1 \qquad (2)$$

Where P_1 is the static pressure before filtration, Pa; P_2 is the static pressure after filtration, Pa.

The fill rate can be calculated by calculating the ratio of the density to the density of the material used to filter the material[8]

$$\alpha = \frac{\rho_1}{\rho_2}$$

Where α is the filling rate, %; ρ_1 is the density of the filter layer of the experimental material, kg/m^3; ρ_2 is the density of the filter layer material,kg/m^3.

3. Discussion and analysis

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3.1 Filtration performance parameters of polyimide fiber (P84) filter material

The outdoor atmospheric dust was used to the dust source in this paper, and the experimental filtration velocities were 0.5m/s and 0.8m/s. **Fig 3** showed the filtration efficiency of the blank group and the control group under the filtration velocity of 0.5m/s and 0.8m/s.

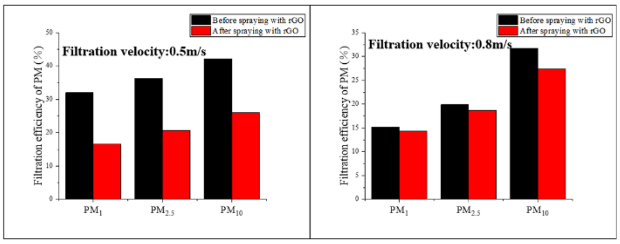

Fig.3. Filtration efficiency of P84 material

As showed in the **Fig3**, the filtration efficiency of P84 filter material is significantly reduced after post-treatment at two wind speeds

This was because a layer of reduced graphite oxide coating was formed on the surfaces of the filter material after post-treatment, similar to mirror treatment. The surfaces of P84 were attached to the surfaces of the filter material, which reduced the interception effect of tiny particles[9]. The particulate matters diffused in the air and is captured after hitting the fluff on the surface of the filter bag. The smaller the particle size, the more noticeable this phenomenon was. After the surfaces of the filter material were smoother after post-treatment, it was industrially conducive to the direct drop of particulate matters, and the dust was collected at the lower end of the dust collector. The emission concentration of pollutants is also decreased.

3.2 Filtration performance parameters of polyphenylene sulfide fiber (PPS) filter material

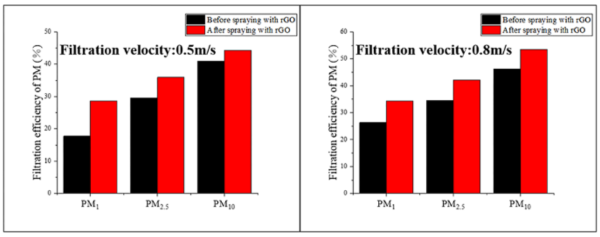

Fig.4. Filtration efficiency of PPS filter material

As showed in the **Fig4**, the filtration efficiency of the PPS filter material had been greatly improved after post-treatment at two filtration velocities.The filtration efficiency of PPS filter material was higher at the filtration velocity was 0.8m/s. The filtration efficiency of the control group for PM_1, $PM_{2.5}$ and PM_{10} was improved by 8.2%, 7.6% and 7.4%, respectively, compared with the blank group. For PM_1, the filtration efficiency was improved to the greatest extent. This was because the porosity of the filter material after post-treatment decreased, and the interception effect on particulate matter increased. Small diameter particles Brownian motion played a leading role in the flow field. It is more likely to capture by the filter material after lower porosity.

3.3 Filtration performance parameters of glass fiber needle felt filter material

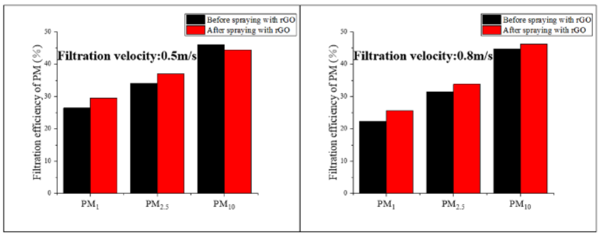

Fig.5. Filtration efficiency of glass fiber material

As showed in the **Fig5**,the filtration efficiency of PM_1 and $PM_{2.5}$ was slightly improved after the post-treatment of the glass fiber filter material. The filtration efficiency of PM_1, $PM_{2.5}$ and PM_{10} under two filtration velocity is improved by 1%-4%.Improvement degree of PM_{10} filtration efficiency under 0.5m/s filtration velocity is negative.This is explained by the fact there is a lot of fluff on the dust-facing surface of the glass fiber filter material, and the fluff is attached to the surface of the filter material after post-treatment modification. After the filter bag is modified after post-treatment, the effect of conflict with fluff and thus being intercepted is reduced.

3.4 Filtration performance parameters of flumex filter material filter material

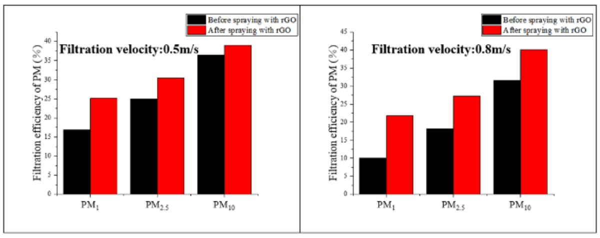

Fig.6. Filtration efficiency of Fumex filter material

As showed in the **Fig6**, the filtration efficiency of PM_1, $PM_{2.5}$ and PM_{10} after the post-treatment of the flumes filter material was improved. For the removal of PM_1, the filtration efficiency of the blank group at a filtration velocity of 0.8m/s decreased the most, reaching 5.9% compared with the filtration velocity of 0.5m/s. This was because the higher the filtration velocity, the shorter the time the airflow stays in the filter material, and the less chance of the dust hitting obstacles, so the filtration efficiency decreased. The porosity of the Fumex filter material is reduced after post-treatment, and the dust is more likely to collide with the fiber and be intercepted when it performs Brownian motion and inertial motion in the flow field. Thereby improving the filtration efficiency.

3.5 The different filtration performance of filter materials

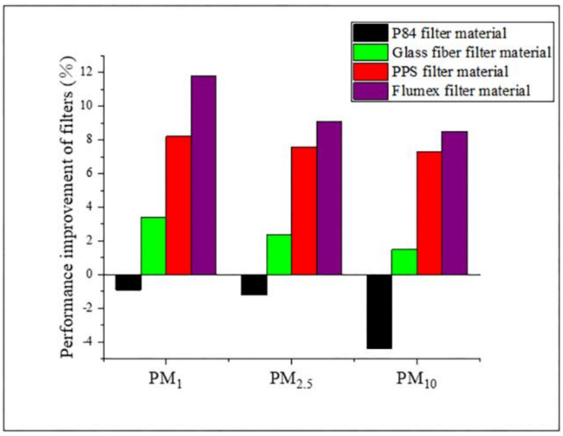

Fig.7. The filtration efficiency of the four filter materials at the filtration velocity of 0.8m/s.

As showed in the **Fig7**, post-treatment modification of P84 filter material did not improved the filtration effect of PM. The other three filter materials had improved the filtration effect of PM after post-treatment modification. All filter materials have the most obvious improvement in the dense particle filtration efficiency of PM_1. The highest form of movement of small-sized particles in the air is diffusion. The porosity of the filter material decreased after post-treatment and modification, and the small particle size particles were easier to be intercepted during the diffusion movement. At the filtration velocity of 0.8m/s, the filtration efficiency of the fumex fiber filter material was improved the most after post-treatment modification. Followed by PPS fiber filter.

3.6 Changes of resistance at different velocities

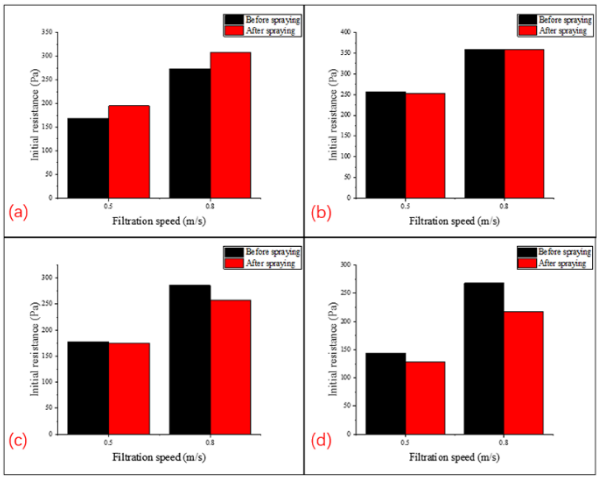

Fig.8. Initial resistance of four materials at different filtration velocities. a is P84 fiber; b is PPS fiber; c is glass fiber; d is flumex fiber.

As showed in the **Figure 8**, the initial resistance of P84 filter material increased after post-treatment modification. This was because the porosity of the fibers decreased after post-treatment, which affected the uniformity of the internal flow field of the filter material, and the resistance increased. The initial resistance of the glass fiber filter material and the Fumex filter material decreased to different degrees at the two velocities after post-treatment. This was explained by the fact that there was a lot of fluff on the dust-facing surface of glass fiber and flumes filter material, and the fluff was attached to the surfaces of the filter material after post-treatment. Fluff could perturb the flow field, making it non-uniform, resulting in increased drag. For the PPS filter material, the initial resistance was almost unchanged at the two filtration velocities after post-treatment. The pressure difference of the four filter materials before and after post-treatment did not change much. The initial resistance also increased as the filtration velocities increased.

4. Conclusion

The synthesis effect of P84 fiber filter material was the best, followed by PPS fiber filter material from synthetic effect. Filtration performances of the four filter materials after post-treatment were fumex high temperature needled felt, PPS fiber, glass fiber needled felt, P84 fiber. Four kinds of filter materials were most suitable for reduction of graphite oxide coating method was PPS fiber filter material after comprehensive analysis.

The relevant parameters in the synthesis process will be optimized in the follow-up, and the post-treatment method of the filter bag of the bag filter will be studied in depth. It provide a reference for the post-treatment method of the filter bag.

references

[1] Maryam M., Enayat A. & K. H. P. et al., ENVIRON RES, Vol.195(2021).

[2]Cheng X., Pu Y. & Gu R., ENERG ENVIRON-UK, Vol.31, No.3(2019).

[3]T.Fei, JIANGNAN UNIVERSITY, 2020.

[4]Farjadian F., Abbaspour S. & Sadatlu M. A. A. et al., CHEMISTRY SELECT, Vol.5, No.33(2020).

[5]B. L., G. T. & J. T. et al., J MATER SCI, Vol.56, No.5(2021).

[6]Deji J., Xin J. & Shaocheng G. et al., POWDER TECHNOL, Vol.388(2021).

[7]Wang Y., Liu J. & Yuan T. et al., WSRJ, Vol.7, No.6(2021).

[8]Wentao H., Yueqiu X. & Feng L. et al., CASE STUD THERM ENG, Vol.26(2021).

[9]Xiao-na L., Wei-wei Z. & Ju-ying W. et al., ECOL ENG, Vol.169(2021).