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PENETRATION OF PARTICLE ACROSS A NEWLY FORMULATED FILTER AIDS MATERIAL

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Abstract. Filter aids is a group of inert materials acting as a ‘barrier’ for protection as well as to allow a uniform air flow passing through a filter cake in a filtration process. In addition, the accumulation of the filter cake deposited on the surface of the filter media helps to increase the performance of filtration. However, some particles do not participate in the formation of the filter cake during cake filtration process. The particles either penetrating through the filter media or clog and block the pores of the filter medium. A high performance filtration requires low dust penetration without excessive pressure drop builds up across the filter media. This paper evaluates on the filtration performance of a newly formulated filter aids material known as PrekotAC which consists of different combination of pre-coating material Prekot™ and activated carbon at material loadings of 0.2 mg/mm² under different air flow rates of 4, 5, and 6 L/min. The PrekotAC was evaluated based on the total particle penetration across its filter cake as a mean of measuring its performance. The study showed that the total particle penetration through the filter media is highly influenced by the air flow rates. It was found that the total particle penetration through PrekotAC10:90 (weight basis of Prekot™:activated carbon) was the lowest while the highest in the case of PrekotAC 40:60 of the four PrekotAC admixtures. In addition, the total particles penetrating through the filter media was the highest for the highest tested air flow rates of 6 L/min.

Keywords Filter aids; Precoating material; Fabric filtration; Penetration

1.0 INTRODUCTION

Fabric filters are increasingly popular as an air pollution control system for the removal particle from gas streams but are sensitive to high temperatures and humidity [1]. It has excellent collection efficiency of 99.9+% for the removal or separation of coarse as well as fine particles through filtration process in many industrial. However, the life span of the fabric filter is usually shorten and influenced by the variations of the flue gas as well as the operating conditions of the process.

A simple technique is to apply so called 'pre-coat' agent or filtration aids to coat a layer of inert material onto the each of the fabric as a barrier for protection as well as to allow a uniform air flow passing through the filter media. PrekotAC is a newly developed filtration aids consisting of a combination of pre-coating material (i.e Prekot™) and activated carbon. Filter aids has been applied in the air filtration system in order to increase the collection efficiency during the filtration process. Filter aids consisting of a group of inert materials used to coat the fabric as a 'barrier' for protection as well as to allow a uniform air flow passing through the filter cake [2].

Al-Otoom [3] reported that filter cake that accumulated on the surface of the filter media acts as a new filter media that helps to increase the filtration efficiency. However, during cake filtration process, some particles do not participate in the formation of the filter cake. The particles either penetrating through the filter media or clog and block the pores of the filter medium. Therefore, understanding the parameters effecting the filtration efficiency is important in determining the best filter aids for filtration process. Lee et al. [4] stated that a good filtration aids should not only able to expand the life span of fabric filter, it should have the least amount of particle penetrated as well as help other particles from penetrating through the filter media. High performance filtration requires low dust penetration without excessive pressure drop builds up across the filter media. Hinds [5] stated that the filter quality is referring to its combination of pressure drop and collection efficiency since these two parameters are closely related to one another.

This paper presents on the penetration of particles of a newly formulated filter aids material known as PrekotAC with material loadings of 0.2 mg/mm² tested under different air flow rates of 4, 5, and 6 L/min. The PrekotAC was evaluated based on the total particle penetration across its filter cake deposited on a filter media as a mean of measuring its performance as a newly formulated filter aids material in filtration process.

2.0 EXPERIMENTAL

2.1 Materials

Activated Carbon and PreKot™

A powder form coal based activated carbon and PreKot™ was used in this study. Table 1 summarized the specifications of the material used in the formulation.

Table 1. Specifications of activated carbon and PreKot™ used in the formulation.

Activated carbon	PreKot™
Form and colour: powder, black Origin: coal based pH: 9-11 Ash content: 8% max Surface area: 850 (m²/g) Bulk density: 440 (kg/m³)	Form and colour: powder, snowy white Fusion point: 1300-1400°C Softening point: 900-1100°C Thermal conductivity: Less than 0.0500 (kcal/mh °C at 0°C Bulk density: 119 (kg/m³)

Note : PreKot™ is a proprietary of AMR Environmental Sdn. Bhd

PrekotAC was formulated by mixing the adsorbent activated carbon with the pre-coating material PreKot™. The formulation was prepared in four different proportion of Prekot™ from 10%-40% by weight. Both activated carbon and PreKot™ were dried in an oven at 105°C for 24 hours before mixing.

The Filtration Test System

The experiment was performed using PTFE teflon and Ryton type filter media subjected under three different air flow rates of 4, 5, and 6 L/min (corresponds to filtration velocity, V_f of 5, 6 and 8 m/min, respectively) with and without the introduction PrekotAC. A material loading of 0.2 mg/mm² was used in each experiment to study the total particle penetration through the filter cake and filter media. Penetration is referring to dust particles that able to pass through the filter media during the filtration processes. The particle count penetration was monitored using GRIMM Aerosol Portable Laser Aerosol Spectrometer (GRIMM, Model 1.109). **Figure 1.1** presents the experimental setup for the filtration test system designed in this study, which consists of a dust feeder, filter media, pressure manometer, rotameter, and a vacuum pump.

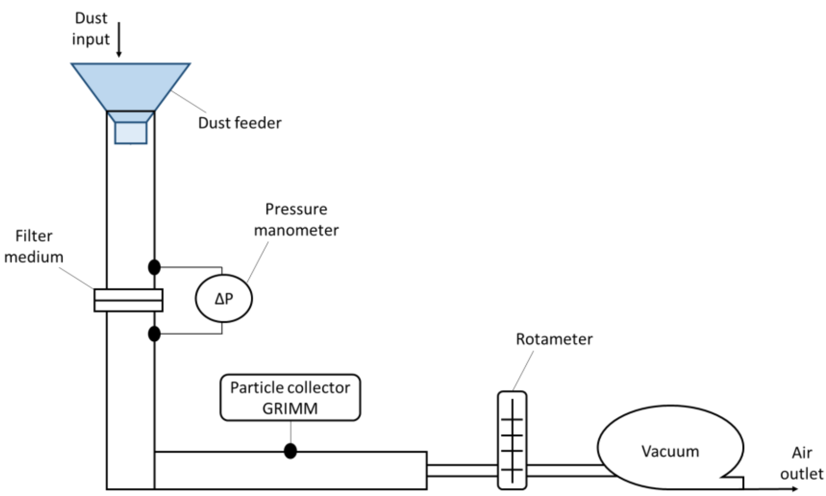

Figure 1.1: Schematic diagram of the filtration test system.

Efficiencies of a newly formulated PrekotAC materials as filter aids material

In order to study the performance of the newly developed PrekotAC, the ratio of the number of penetrated particles with respect to the blank filter under various air flow rates was calculated based on **Equation 1.1** as listed below.

Ratio penetrated particles (R_{pp}) = T_f / T_i …… **Equation 2.1**

Where;

R_{pp} = the ratio of the number of penetrated particles.

T_f = total number of penetrated particles after filter aids was loaded.

T_i = total number of penetrated particles with blank filter or before loading

The performance of each of the formulated material in term of its total penetration was evaluated based on the **Equation 1.1**. If the calculated R_{pp} is less than 1.0 (or R_{pp} <1.0), it shows that filter aids improves the collection efficiency in compared to the performance of PTFE fabric filter alone. However, if the R_{pp} is greater than 1.0 (or R_{pp} >1.0), it shows that with the introduction of filter aids, the total particle penetration is higher compared to the collection efficiency of PTFE fabric filter alone. Hence, it can be summarize that;

R_{pp} =1.0 = initially, without material loading
= the ratio of the number of penetrated particles for fabric filter alone before loading and based on ambient particle.

R_{pp} <1.0 = better filtration efficiency, less particle penetration compared to fabric filter alone

R_{pp} >1.0 = poor filtration efficiency, higher particle penetration compared to fabric filter alone

3.0 RESULTS AND DISCUSSION

Particle size distribution of activated carbon and PreKot™

Figure 3.1 illustrates the particle size distribution of these two original materials, activated carbon and PreKot™. As observed from the figure, activated carbon has slightly more than 80% of particles ≤75 µm compared to PreKot™ that only merely 20% of it is particles ≤75 µm. Thus, it was expected that activated carbon which predominantly consists of smaller particles has higher number of penetrated particles ratio compared to PreKot™. Coarse particles possess higher collection efficiency compare to fine particles since fine particles can easily penetrating through a filter media.

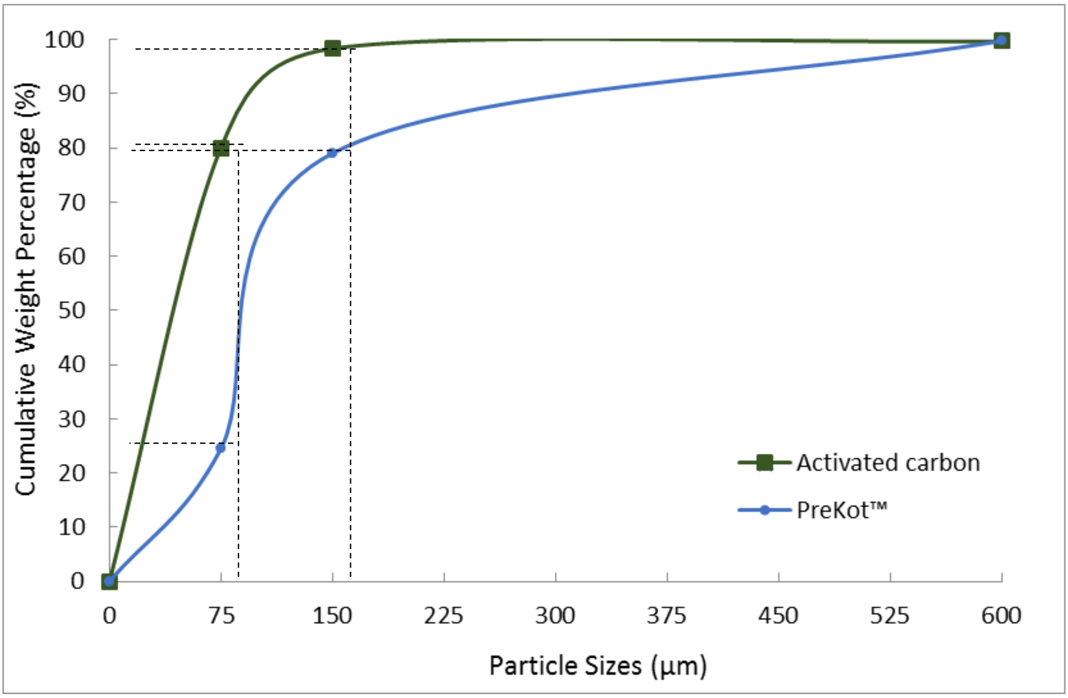

Figure 3.1: Particle size distribution of activated carbon and PreKot™

Effect of flow rates on the efficiencies of PrekotAC as filter aids material

Figures 3.2 presents the ratio of the number of penetrated particles through a PTFE and Ryton filter media, with the introduction of filter aids materials under air flow rates of 4, 5 as well as 6 L/min (also referring to V_f, 5, 6 and 8 m/min, respectively). Both filter media showed a consistent trend where the admixture of PrekotAC having a lower particle penetration compared to activated carbon alone. As observed, PreKot™ has the lowest penetration among all filter aids materials with ryton and teflon filter media. The $R_{pp} = 1$ is a reference marked with dashed line in the figure indicates the ratio of the number of penetrated particles for the filter media alone without the introduction of filter aids. As illustrated in the figure, the activated carbon retains the highest while PreKot™ has the lowest ratio of particles that able to penetrate through the filter media in all cases. It seems that the particle size distribution of the respective material play a major role in this finding. As previously report by Haja et.al [2] activated carbon has slightly more than 80% of particles ≤75 μm compared to PreKot™ that only merely 20% of it is particles ≤75 μm. Thus, it is expected that activated carbon which predominantly consists of smaller particles has higher number of penetrated particles ratio compared to PreKot™ where fine particles can easily penetrating through a filter media.

However, in terms of PrekotAC admixtures, PrekotAC 10:90 has the lowest while PrekotAC 40:60 registered the highest amount particle penetration in all cases. It has been found that, as the ratio of PreKot™ in the PrekotAC admixtures increases, the total particle penetration increases due to higher porosity of admixture which allow fine particle easily penetrating through the filter cake and media.

A similar finding was also reported by Lee et al. [4] and Innocentini et al. [6]. As observed by the authors, the collection efficiency for coarser particles are higher compared to finer particles. Lee *et al.* found that fine particles can easily penetrating through the filter media compared to coarser particles even using two different types of fabric filter. It was reported by Park et al. [7] that the total penetration increases as particle size decreases because of lower impaction effect during filtration process in fresh filter media. Thus, as expected, activated carbon, which mostly consists of fine particles has higher amount of particle penetration compared to the other filter aids material that has coarser particle sizes.

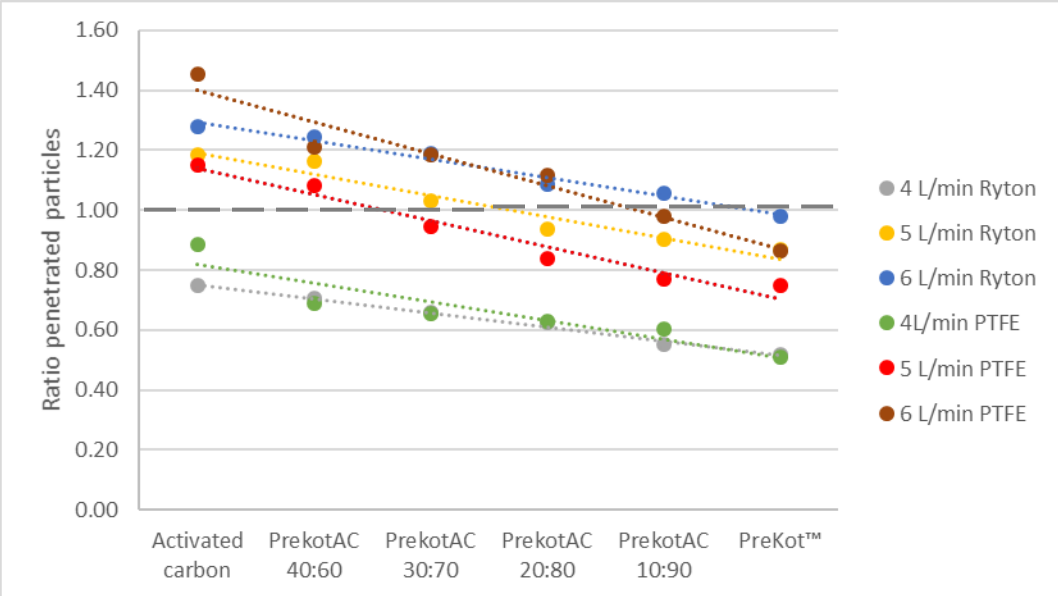

Figure 3.2: The ratio of total penetrated particles of PrekotAC filter aids under various air flow rate with material loading of 0.2 mg/mm² using two types of filter media.

As discuss earlier, the penetration is influenced by the air flow rate used during the filtration process. The number of particles that penetrating through both filter media filter increases when the air flow rate is increasing from 4 to 6 L/min where the penetration through the filter media is the lowest at 4 L/min compared to 6 L/min. A higher air flow rate leads to a bigger driving force causing more particles to pass through the open pores of the filter media as observed in the study. It seems that a high flow rate allowed more particles to pass through the filter media which is due to deep penetration of particles which consequently able to escape the filter media.

Similarly, Simon et al. [8] reported that particle penetration at a lower air flow rate is less compared to the particle penetration at higher flow rate. The authors stated that higher air flow rate forces fine particles to easily permeate deep into the pores of the filter media compare to at low air flow rate which influence the total number of penetration. Walsh [9] also reported that penetration at lower air flow rate is small due to bridges of particles that are formed because of low inertia and long retention time which limit particles from passing through the filter media. This leads to a high collection efficiency of particles.

4.0 CONCLUSIONS

The effect of a newly formulated filter aids material known as PrekotAC penetrating the teflon and ryton under various air flow rates had been investigated and reported in this paper. In all case of filter aids materials, particle penetration through ryton presents a similar trending to teflon under the various air flow rates. In all cases, activated carbon has the highest while PreKot™ has the least number of particles that able to penetrate through a filter media. Based on the observation, total penetration is highly influenced by the particle size distribution of the material. Activated carbon that consists of fine particles has higher penetration because it can easily penetrating through the filter medium compare to PreKot™ that has coarser particle size distribution.

In terms of PrekotAC admixtures, PrekotAC 10:90 has the lowest while PrekotAC 40:60 registered the highest amount particle penetration in all cases. It has been found that, as the ratio of PreKot™ in the PrekotAC admixtures increases, the number of fine particles increases. PrekotAC admixtures perform a better filtration efficiency compare to activated carbon alone because of the effect of diverse in different particle size distributions of non-uniform particle size fractions for the PrekotAC admixtures.

Total particles that penetrating through a filter media is also dependent on the air flow rates. As observed, the total penetration increases as air flow rate increases.

REFERENCES

[1] P.A. Vesilind, S.M. Morgan, L.G. Heine, Introduction to Environmental Engineering, third ed.,USA.Cengage Learning, 2010.

[2] Hajar, S., Nurnadia, A., Rashid, A. and Ammar, M. (2013). Precoating material as filter aids and flue gas treatment for fabric filter. *Article Berita Ensearch.* April-June 2nd quarter. 4-9.

[3] Al-Otoom, A. Y. (2004). Prediction of the collection efficiency, the porosity, and the pressure drop across filter cakes in particulate air filtration. *Atmospheric Environment.* 39: 51-57.

[4] Lee, K. M., Jo. Y. M., Lee, J. H. and Raper, J. A. (2008). Assessment of surface and depth filters by filter quality. *Powder Technology.* 185: 187-194

[5] Hinds, W. C. (1998). *A Wiley-Interscience Publication, 2nd Edition.* 188.

[6] Innocentini, M. D. M., Rodrigues, V. P., Romano, R. C. O., Pileggi, R. G., Silva, G. M. C. and Coury, J. R. (2009). Permeability optimization and performance evaluation of hot aerosols filters made using foam incorporated alumina suspension. 162: 212-221.

[7] Park, B. H., Kim, S. B., Jo, Y. M. and Lee, M. H. (2012). Filtration characteristics of fine particulate matters in PTFE/glass composite bag filter. *Aerosol and Air Quality Research.* 12: 1030-1036.

[8] Simon, X., Bémer, D., Chazelet, S., Thomas, D. and Régnier, R. (2010). Consequence of high transitory airflows generated by segmented pulse-jet cleaning of dust collector filter bags. *Powder Technology.* 201: 37-48.

[9] Walsh, D. C. (1996). Recent advances in the understanding of fibrous filter behaviour under solid particle load. *Filtration & Separation.* 33(6): 501-506.