Filter aids influence on pressure drop across a filtration system

S Hajar ¹, M Rashid¹*, A Nurnadia¹, M R Ammar², C M Hasfalina³

¹Air Resources Research Laboratory, Malaysia-Japan International Institute of Technology, 54100 UTM Kuala Lumpur, Malaysia
²AMR Environmental Sdn. Bhd., Taman Sri Pulai Perdana, 81110 Johor Bahru, Malaysia
³Department of Biological and Agricultural Engineering, Universiti Putra Malaysia, 43400 Serdang, Selangor, Malaysia

*E-mail: rashidyusof.kl@utm.my

Abstract. Filter aids is commonly used to reduce pressure drop across air filtration system as it helps to increase the efficiency of filtration of accumulated filter cake. Filtration velocity is one of the main parameters that affect the performance of filter aids material. In this study, a formulated filter aids consisting of PreKot™ and activated carbon mixture (designated as PrekotAC) was tested on PTFE filter media under various filtration velocities of 5, 6, and 8 m/min at a constant material loading of 0.2 mg/mm². Results showed that pressure drop is highly influenced by filtration velocity where higher filtration velocity leads to a higher pressure drop across the filter cake. It was found that PrekotAC performed better in terms of reducing the pressure drop across the filter cake even at the highest filtration velocity. The diversity in different particle size distribution of non-uniform particle size in the formulated PrekotAC mixture presents a higher permeability causes a lower pressure drop across the accumulated filter cake. The finding suggests that PrekotAC is a promising filter aids material that helps reducing the pressure drop across fabric filtration system.

1. Introduction

Fabric filter is defined as any permeable material upon which or within which particles are deposited by the filtration process [1]. It is widely known as one of the excellent air pollution control system with 99% collection efficiency that possesses the ability to capture fine particles and collect a variety of dusts [2]. However, the main issue associated with this application is its short life span due to wear and tear problem in association with the pressure drop which is closely related to cleaning cycle, energy consumptions and operational costs. Thus, the application of filter aids material during filtration process is one of the simplest techniques that can be used to overcome this problem. Filter aids material works as a pre-coating material that coats on the surface of the filter media with a fresh layer of material during filtration process [1, 3].

It was reported that a good filter aids material should has the ability to form a porous filter cake with low surface area and non-uniform particle size distribution [4]. PrekotAC is a newly developed filter aids material that consists of activated carbon and PreKot™. PrekotAC is introduced as a two in one filter aids material, a pre-coating material and an adsorbent. PrekotAC has the capability to form a porous cake with low pressure drop due to its diverse particle size distribution [5, 6].

However, there are a few factors that need to be considered when studying the pressure drop across the filtration system which is the filtration velocity. Studies had been reported on the effects of filtration velocities on pressure drop where it was found that higher filtration velocity leads to higher pressure drop across a filter cake [7-9].
Hence, this study investigates on the influences of a formulated filter aids on pressure drop across a PTFE filter media under various filtration velocities with a constant material loading.

2. Methodology

2.1. Filter Aids Material
The filter aids material or PrekotAC is a combination of 90% activated carbon and 10% PreKot™ were dried in an oven at 110°C for 24 hours before mixing (ASTM D2867-09). Activated carbon is a commonly used filter aids material works as an adsorbent in the industry while PreKot™ is an amorphous hydrated glassy volcanic rock fused aluminium silicate potential used as a pre-coating material. Table 1 presents the specifications of both materials used in the formulation of the filter aids.

|                     | Activated Carbon | PreKot™          |
|---------------------|------------------|------------------|
| Form and color:     | Powder and black | Powder and snowy white |
| Origin: Coal based  | 9-11             | Fusion point: 1300-1400°C |
| pH:                 | 9-11             | Softening point: 900-1100°C |
| Ash content:        | 8%-max           | Thermal conductivity: Less than 0.0500kcal/mh°C at 0°C |
| Surface area:       | 850 m²/g         |                  |

*PreKot™ is proprietary of AMR Environmental Sdn. Bhd.*

2.2. Experimental Procedures
Figure 1 shows the fabricated laboratory scale fabric filtration system that had been designed in order to study and evaluate the performance of filter aids across a PTFE filter media. The unit consists of dust feeder, filter media holder, pressure manometer, particle counter, rotameter as well as vacuum [10]. Pressure manometer (Extech Instrument Model HD755) and Grimm Portable Laser Aerosol Spectrometer (Model 1.109) were installed in the system in order to measure the pressure drop and particle penetration across a filter cake, respectively.

![Figure 1. Laboratory scale fabric filtration system](image)

A PTFE filter media with its basic weight of 800, thickness of 1.3 mm and working temperature of less than 250°C was used in the study. Three different filtration velocities of 5, 6, and 8 m/min were applied under a constant filter aids loading of 0.2 mg/mm² where the pressure drop and particle penetration across the filter media was observed in each run. Table 2 presents the summary of the operating parameters involved in this study.
Table 2. Operating parameters used in the study

| Filter media | PTFE |
|--------------|------|
| Total filtration area | 755 mm² |
| Material loading | 0.2 mg/mm² |
| Filtration Velocity | 5, 6, and 8 m/min |

3. Results and Discussions

3.1. Effects of filtration velocity on pressure drop

Figure 2 presents the effects of filter aids materials, activated carbon, PreKot™ and PrekotAC on PTFE filter media on pressure drop under a constant material loading of 0.2 mg/mm² and three different filtration velocities which showed that the activated carbon and PreKot™ registered the highest and the lowest pressure drop, respectively. On the contrary, PrekotAC showed a consistent pattern of having lower pressure drop compared to activated carbon alone even at the highest filtration velocity of 8 m/min.

![Figure 2](image-url)

Figure 2. Effects of three different filter aids on pressure drop under different filtration velocities.

Previous studies reported that the difference in particle size distribution of the filter aids material influences the pressure drop performance of the material [6, 10]. As in this case, the activated carbon which consists of fine particles (80% of its particles <75 µm) compared to PreKot™ (20% of its particles <75 µm), resulting in a higher pressure drop across its more compact filter cake characteristic [11, 12]. Thus, a combination of activated carbon and PreKot™ presents a diverse particle size distribution material which has the ability to form a more porous filter cake that helps lowering the pressure drop across it.

As in Figure 2, it was observed that pressure drop increases with high filtration velocity due to the compactness of the filter cake that reduces the permeability (airflow) of the filtration [7, 13, 14]. The compacted filter cake creates a higher resistance which corresponds to the pressure drop performance [9, 15, 16].
The influences of activated carbon, PreKot™ and PrekotAC filter aids on pressure drop with mass loading of 0.2 mg/mm² can be explained by Eq. 1, 2, and 3, respectively;

\[
\Delta P_{AC} = 0.61V_f^2 \tag{1}
\]
\[
\Delta P_{P} = 0.58V_f^2 \tag{2}
\]
\[
\Delta P_{PC} = 0.54V_f^2 \tag{3}
\]

Where \( \Delta P_{AC} \), \( \Delta P_{P} \), \( \Delta P_{PC} \) are the pressure drop (in Pa) across the activated carbon, PreKot™, and PrekotAC filter aids, respectively; and \( V_f \) (in m/min) is the filtering velocity. As observed, the slope of Eq. 1 (activated carbon) is higher than the other two filter aids illustrating that the change in the pressure drop using activated carbon as filter aids alone is much more greater compared to the other two materials. Nevertheless, the above equations can be used estimate the pressure drop across the PTFE media with filter aids loading of 0.2 mg/mm². It anticipated that the slope of the curve will be much greater as filter aids loading increases.

Figure 3 presents the effect of filtration velocity on the permeability of accumulated filter aids cake which showed that permeability decreases as filtration velocity increases. It is observed that the permeability of the filter cake is inversely proportional to its pressure drop due to compactness of filter aids as stated in the previous statement. Permeability indicates the relative ease for the fluid to travel through the pore space in the filter media which is closely related to porosity of the accumulated filter cake [17-18]. Hence, a more compacted filter cake is formed under high filtration velocity that gives high pressure drop due to low permeability across the filter cake.

![Figure 3. Effects of filtration velocity on filter aids permeability.](image)

The experimental results indicate that filtration velocity play an important role affecting the pressure drop across filter aids material in a filtration system. The study suggests that PrekotAC is a promising filter aids material as it is not merely two on one filter aids but at the same time it presents better performance in terms of pressure drop across its filter cake compared to activated carbon.

4. Conclusions

A study on the influence of filter aids material on pressure drop under different filtration velocities has been reported. Filtration velocity in a filtration process is one of the parameters that could influence the pressure drop performance where a higher filtration velocity leads to higher pressure drop across a filter cake. However and as observed in this study, the characteristics of filter aids also influence the pressure drop across the media in filtration process. The finding suggests that PrekotAC is a promising two in one filter aids material to be applied in the actual filtration process.
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