PERFORMANCE OF PREKOTAC AS FILTER AIDS IN PILOT PLANT FABRIC FILTRATION SYSTEM

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ABSTRACT

Filter aids is used in air filtration system to fulfil the needs to expand the life span of filter media in fabric filtration system. It has been applied in various ways and precoat filter aids is one of the methods. In this study, the effect of a filter aids performance known as PrekotAC on pressure drop and particle penetration in a filtration system with varying filtration velocity of 1 to 3 m/min was evaluated. The PrekotAC is a combination of Prekot^{TM} and activated carbon mixed in different weight compositions. Result showed that the pressure drop across the fabric media decreases with the addition of Prekot^{TM} in the PrekotAC admixture due to its wide range of non-uniform particle size distribution that gives higher porosity of filter cake during filtration process. The study also showed that the total particle penetration through the fabric media was proportionally related to addition of Prekot^{TM} in the PrekotAC admixture under a constant material loading. The study suggests that the addition of Prekot^{TM} in the formulation of filter aids significantly affect both pressure drop and particle penetration of the fabric filter media.

Keywords— Filter aids, Precoating material, Fabric filtration, Pressure drop, Penetration

1. INTRODUCTION

Fabric filtration has been used as an air pollution control system because of its excellent separation efficiencies even for ultrafine dust particles. [1]. In addition, filtration possesses several advantages such as ease of installation and operation. Flue gas cleaning agents such as activated carbon and lime are normally used along with fabric filtration for air emission control especially in waste incineration processes. 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. This deteriorates its filtration performance with time and simultaneously increasing the maintenance cost having to replace it within a short period of time.

To minimize the problem, the use of so ‘pre-coat’ agent or filtration aids to coat a layer of inert material onto the fabric as a barrier of protection is proposed. PrekotAC is a newly developed filtration aids consisting of a combination of pre-coating material (i.e Prekot^{TM}) 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].

The filter cake that deposited 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 media. Therefore, understanding the parameters effecting the filtration efficiency is important in determining the characteristics of the filter aids where high performance filtration requires low particle penetration without excessive pressure drop builds up across the filter media [3].

This paper presents on the effect of using filtration aids PrekotAC on the particle penetration and pressure drop across a fabric media with material loadings of 0.2 and 0.6 mg/mm² tested under various filtration velocites from 1 to 3 m/min. A detailed results of the study is presented in this paper.

2. MATERIALS AND METHODS

2.1 Activated Carbon and PreKot™

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

Filtration aids was formulated by mixing the adsorbent activated carbon with the pre-coating material PreKot™ in a few proportion of Prekot™ from 10 to 20% by weight. Both activated carbon and PreKot™ were dried in an oven at 105°C for 24 hours before mixing.

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

Activated carbon	PreKot™
Form and colour: powder, black	Form and colour: powder, snowy white
Origin: coal based	Fusion point: 1300-1400°C
pH: 9-11	
Ash content: 8% max	Softening point: 900-1100°C
Surface area: 850 (m^2/g)	Thermal conductivity: Less than 0.0500 (kcal/mh °C at 0°C
Bulk density: 440 (kg/m^3)	Bulk density: 119 (kg/m^3)

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

2.2 Efficiencies of PrekotAC materials as filter aids material

The particle count penetration was monitored using GRIMM Aerosol Portable Laser Aerosol Spectrometer (GRIMM, Model 1.109).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 and material loadings was calculated. The ratio was calculated based on **Equation 1.1** as listed below.

Ratio penetrated particles (R_{pp}) = T_f / T_i …**Equation 1.1**

Where;

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

T_i = total number of penetrated particles for ambient air particles

T_f = total number of penetrated particles after filter aids was added

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 <1.0), it shows that filter aids help to improve the collection efficiency compared to the performance of PTFE fabric filter alone. However, if the R_{pp} is greater than 1.0 (or >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;

1 = equal ratio of the number of penetrated ambient particles compared to the addition of filter aids,

<1 = better filtration efficiency, less particle penetration compared to fabric filter alone

>1 = poor filtration efficiency, higher penetration compared to fabric filter alone

2.3 Pilot Plant Fabric Filter

The pilot plant filtration system is built with 16 bag type filters (200mmD,700mmL), consists of a dust feeder, hopper pulse jet cleaning system and a induced fan as shown in Figure 1. The pilot plant was operated based on the conditions as list in Table 2.

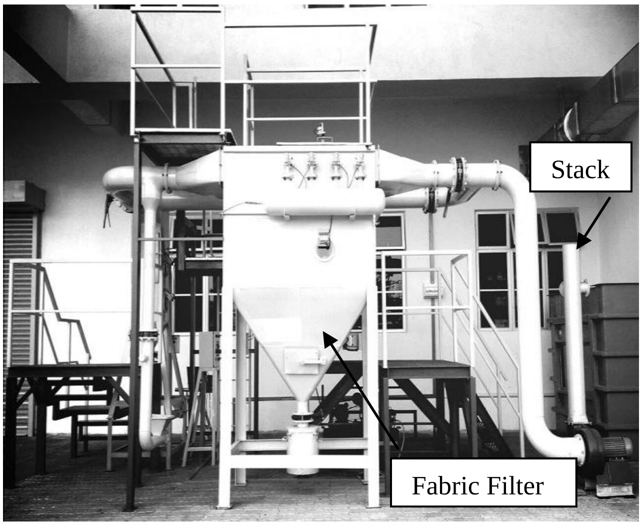

Figure 1: Pilot plant fabric filtration system.

Table 2: Operating variables and conditions of the study

Description	Range	Unit
Dust loading	0.2-0.6	Kg/ m^2
Total Filtration Area	4.5744	m^2
Upper pressure drop limit ΔP_{max}	0-4	inch of H_2O
Filtration velocity, *u*	1-3	m/min

3. RESULT AND DISCUSSION

3.1 Pressure Drop

Figure 2 presents the pressure drop across the fabric media against the filtration velocity which showed a consistent trend with the admixture of filter aids of having lower pressure drop compared to activated carbon alone. As expected, filter aids such as activated carbon which consists of fine particle size distribution lead to a bigger pressure drop across its filter cake as it has broader compressed region compared to a filter aids that has a coarser particle size distribution. It is observed that the addition of PreKot™ in the admixture resulted in a lower pressure drop across the fabric due to increase in the porosity of the filter cake during the filtration process. This is due to porous and fluffy structure of PreKot™ which allows easy passage of air flow across the medium with lower pressure drop. Since pressure drop is one of the most important criteria of a gas cleaning equipment in terms of its operating cost, it appears that a considerably amount of savings could be achieved with the use of filter aids capable of extending the life span of fabric filter in service. Hajar et al., [2] stated that the particulate size distribution plays a substantial role in decreasing the pressure drop with the addition of PreKot™ in the admixture. The latter has a wider range of non-uniform particle size distribution compared to activated carbon that contributes to this effect.

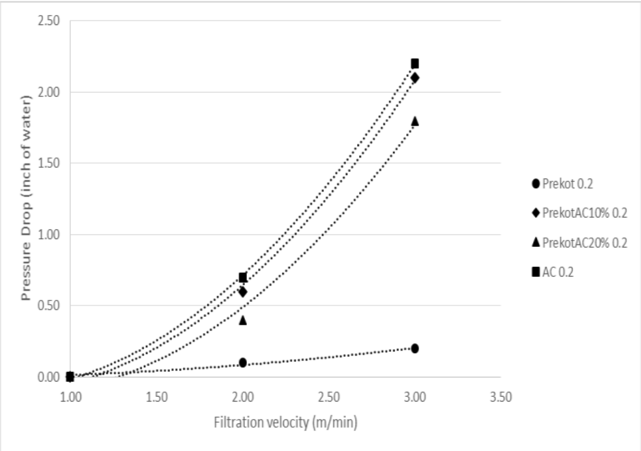

Figure 2: Pressure drop under different filtration velocity at constant loading of 0.2 mg/mm^2.

Other study also reported that filter aids are applied in air filtration system which can reduce the pressure drop across the filter cake as well increase the filtration efficiency [4]. The filter cake that consists of fine particles will form a compacted filter cake of low permeability which makes it difficult for the detachment of filter cake during cleaning process. However, filter cake that form from a filter aids which has coarser particle size can be easily removed from the filter media as compared to filter aids that has finer particles because it have sufficient inertia to break free from the filter media during a cleaning process [5]. Hence, a well balance particle size distribution in a given filter aids will minimize this effect.

3.2 Particle Penetration

3.2.1 Effect of filtration velocities on the efficiencies of PrekotAC as filter aids material

Figure 3 presents the ratio particle penetration through a fabric media with the introduction of filtration aids materials under different filtration velocities from 1 to 3 m/min. Ratio particle penetration (Rpp) is define as number of penetrated particle before divided by the number of particle penetrated after the addition of the filtration aids across the fabric media. Rpp <1.0 indicates that less number of particle penetrated through the fabric media. As expected the Rpp increases with filtration velocity illustrating that more particles are able to penetrate through the media under high filtration velocity. PreKot™ has the lowest number of particles penetrated through the fabric media in all cases while activated carbon presents the highest.

Again, the characteristics of the material in terms of its particle size distribution is the reason for the finding. Activated carbon has more than 80% of particles ≤75 µm compared to PreKot™ only 20% of it is particles ≤75 µm. Thus, it is expected that activated carbon which predominantly consists of fine particles has higher number of penetrated particles compared to PreKot™. However for admixture, PrekotAC 10:90 has the lowest while PrekotAC 20:80 retains the highest total penetrated particles under a constant material loading.

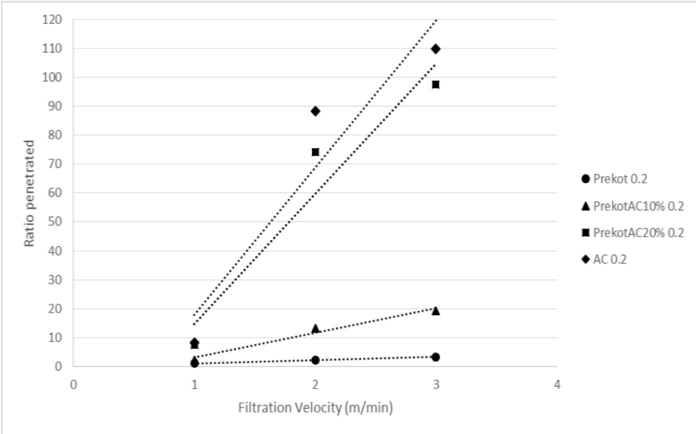

Figure 3: Particle penetration under different filtration velocity at constant loading of 0.2 mg/mm^2.

It was found that, the high porosity and multi cellular shape of the Prekot™ leads to higher particle penetration since fine particles can easily passing through the material under high filtration velocity. Hence, it was observed that the higher the ratio of Prekot™ contained in the PrekotAC is, the bigger the total penetration becomes.

As discuss earlier, the penetration is influenced by the filtration velocity used during the filtration process. The number of particles penetrating through the fabric media increases when the filtration velocity increases from 1 to 3m/min. A higher filtration velocity leads to a bigger driving force causing more particles to pass through the open pores of the fabric media as observed in the study. Similarly, Simon et al. [6] found that particle penetration at a lower filtration velocity is less compared to the particle penetration at higher filtration velocity which force fine particles to easily permeate deep into the pores of the filter media and influence the total number of penetration.

3.2.2 Effect of material loading on the efficiencies of PrekotAC as filter aids material

Besides filtration velocities, material loading is another parameter that could influenced the collection efficiency of a filter aids during filtration process since total penetration is strongly dependent on the material loading of a material. Figures 4 illustrate the effect of material loading on penetration for all filter aids material was tested under different material loadings of 0.2 and 0.6 mg/mm² with filtration velocities from 1 to 3 m/min. Material loading is proportional to filter cake thickness. Cake thickness increases with the particle size as well as the net number of particles deposited. Thus, the higher the material loading is, the thicker the filter cake becomes.

As shown in Figures 4, the ratio of the number of penetrated particles decreases as material loading increases. As the material loading increases from 0.2 to 0.6 mg/mm², the penetrating rate reduces with activated carbon has the highest while PreKot™ retains the lowest in all cases. For PrekotAC filter aids, PrekotAC 20:80 has the highest while PrekotAC 10:90 registered the lowest total number of penetrated particles even at the highest material loading of 0.6 mg/mm². The addition of PreKot™ to activated carbon gave a better collection efficiency compared to the performance of activated carbon alone where PreKot™ helps to block the fine particles from penetrating through the filter media.

The total penetration of each material is following the trend that was reported by previous study which is higher material loading leads to a lower total particle penetration due to its thicker cake thickness that avoid and block particles from penetrating through the filter media. In addition, at higher material loading, more dust layer forms on the surface of the filter medium rather that permeate deep into the medium pores thus reducing the number of particles that penetrating through the filter media. Park et al. [7] stated that at higher material loading, the particles might be deposited in more packed pattern compared to lower material loading because of the increased coincidence event of particle

It was observed that, higher material loading will increase the dust cake thickness that accumulated on the surface of the filter media as cake thickness is closely related to the number of particles. The higher the material loading is, the thicker the filter cake thickness becomes. This can be explained by the fact that at higher dust loading means more of the dust particles arrive at one pore simultaneously, forming a thicker dust cake layer on the filter surface instead of seeping through inside the pore. Therefore, higher material loading will increase the cake thickness resulting in lower penetration compared to lower material loading.

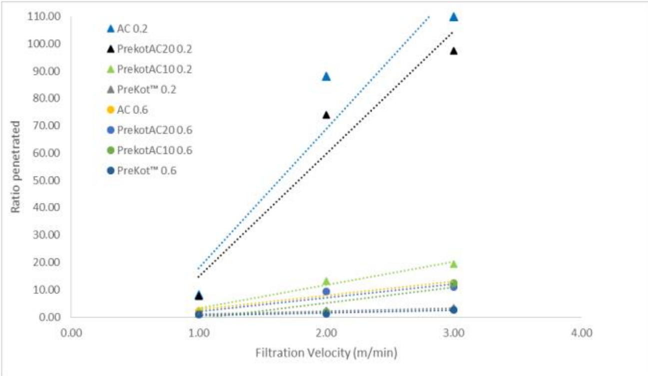

Figure 4: Penetration under different material loading of 0.2 and 0.6 mg/mm^2

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A similar finding was also reported by Lee et al. [8] that at higher material loading, more dust layer forms on the surface of the filter medium rather that permeate deep into the medium pores with filtration time. The enhancement of filter cake thickness caused the number of particles that penetrating through the filter media to reduce. In comparison to higher material loading, at lower material loading, more particles penetrated through the filter media at the initial stage of the filtration process until dust particles begins to accumulate inside the medium pores as filtration process proceeds. Thus, the total penetration at higher material loading is lower compared to lower material loading.

4. CONCLUSSION

The effect of a newly formulated filter aids material on pressure drop and penetration under various filtration velocities had been investigated and reported in this paper. The existence of PreKot™ in the filter aids admixture helps to form more porous filter cake thus reducing the pressure drop even under high air filtration velocity by reducing the compressibility of the cake. Results also showed that raw material activated carbon has the highest while PreKot™ has the least number of particles that able to penetrate through a filter media in all cases.

In term of PrekotAC admixtures, PrekotAC 10:90 has the smallest while PrekotAC 20:80 register the biggest total 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.

5. ACKNOWLEDGEMENT

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