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# A study of filtration performance in a cross-flow moving granular bed filter: The influence of gas flow uniformity

Chia-Jen Hsu, Shu-San Hsiau *

*Department of Mechanical Engineering, National Central University, Jhongli 32001, Taiwan, ROC*

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ABSTRACT

The cross-flow moving granular bed filter where the dust-laden gas passes horizontally through the granular layer and filter granules moves downwards and is removed at the bottom of the bed. It has the advantages of high filtration efficiency and lower pressure drop.

The uniformity of gas flow is important for achieving a uniform gas distribution and higher usage rate of the filter media in a cross-flow moving granular bed filter. The behaviors related to the uniformity of the gas flow have been studied in previous experiments. The goal of this study is to evaluate the relationships between a uniform gas flow and filtration performance in a moving granular bed. Filtration performance experiments were carried out at room temperature to understand the relationship between gas flow behavior and filtration performance. The performance index such as the pressure drop in the granular bed and filtration surfaces, and filtration efficiency are measured and analyzed. The different baffle geometries are taken into consideration including baffle length and angle of the gas inlet of the moving granular bed filter. The results indicate that a better filtration efficiency of up to 98.55% can be obtained by using a baffle length of 170 mm, and a baffle angle of 50°. The experimental results show that the filtration efficiency is enhanced when the gas flow becomes more uniform in the gas inlet. The experimental results of filtration performance give important information that will be helpful for designing better models of moving granular bed filters in the future such as for the Integrated Gasification Combined Cycle (IGCC) system.



## 1. Introduction

Coal is by far the most abundant fossil-fuel resource worldwide, and is commonly used for the generation of electric power. However, the use of coal for energy generation produces serious environmental pollution and $CO_2$ emission problems. For the above reasons, developing advanced clean coal combustion technology for coal-based electric power generation that is highly efficient but with low $CO_2$ emission has drawn considerable interest in recent years. Dust particulate removal is a key component [1–4] in advanced coal-based power generation systems, such as the Integrated Gasification Combined Cycle (IGCC) and Pressurized Fluidized Bed Combustion (PFBC) systems.

The high temperature syngas contains many dust particulates which should be subjected to a filtration process before entering the gas turbine in order to prevent the erosion of turbine blades and increase the life of the turbine. The techniques for the removal of dust particulates include: cyclones, electrostatic precipitators (ESP), wet scrubbers and fabric or bag filters. However, these techniques are not applicable in a hot gas environment. They are usually employed in gas streams under relatively lower temperature (≤300 °C); moreover, the wet scrubbers and fabric/bag filters exhibit unsteady operation due to the need to clean the filtration surface periodically.

The most promising alternatives seem to be ceramic candle filters and granular bed filters [5,6].

Although the ceramic candle filters generally have a very high cleaning efficiency at high temperature, the filter elements may suffer from microcrack formation due to mechanical fatigue and thermal shock. This behavior will lead to break of candles. It may be necessary to perform the periodically back-pulse cleaning or to shut down the filtration system for replacing the candles. The above problems can be overcome with the moving granular bed filter (MGBF) with its continuous moving of filter media. This method has several advantages for lower variation of pressure drop, high filtration efficiency, long operating lifetime, and low operation cost [7].

There are some important parameters that determine the filtration performance in a moving granular bed filter, including gas superficial filtration velocity, mass flow rate of filter media, particle size, dust cake, bed depth and the properties of the gas and dust particulates [8].

The moving granular bed filter could also be applied in the fast pyrolysis process of biomass for char separation [9–11].

The filtration performance of a moving granular bed filter can be evaluated by examining two outcomes, the filtration efficiency and pressure drop. In terms of the gas flow behavior, it is important to

* Corresponding author. Tel.: +886 3 426 7341; fax: +886 3 425 4501.
*E-mail address:* sshsiau@cc.ncu.edu.tw (S.-S. Hsiau).

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achieve a uniform gas distribution and higher usage rate of the filter media in a moving granular bed filter. The uniformity of gas flow behavior was studied [12] by using a baffle device introduced to the inlet system of a moving granular bed filter operated in fixed-bed mode. Furthermore, other study results [13] show that the uniform gas distribution with both fixed-bed and moving-bed modes could be obtained by adjustment the baffle lengths and angles appropriately.

A series of cold filtration experiments were carried out to find the preliminary results of gas flow behavior in a Moving Granular Bed Filter (MGBF) with baffles. The relationships between gas flow uniformity and filtration performance were also obtained showing that a uniform gas flow could improve the filtration performances. The important parameters in cold filtration tests were baffle length and angle. The filtration performance as indicated by the filtration efficiency and pressure drops in the granular bed and on filtration surfaces were measured and analyzed. Understanding how these parameters are affected by the baffle lengths and angles could help to determine the operational criteria needed to achieve better filtration efficiency as well as improve the filtration capacity of the moving granular bed filter. In addition, the experimental results should be of help in the development of a moving granular bed filter that could be applied to the dust removal system in IGCC and PFBC advanced coal-fired power plants.

## 2. Experimental set-up

### 2.1. Apparatus and material

A schematic representation of the main experimental MGBF apparatus with baffles is shown in Fig. 1(a). The MGBF consisted of the moving bed of the filter system, a gas supply device, a dust supply device, a venturi tube, the baffles (schematically shown in Fig. 1(b)) and a belt conveyor device for the filter medium. The bed of filter system design was adapted from that used by Hsiau et al. [14] with adding the baffles in the inlet system which could improve the uniformity of gas inlet distribution [12,13].

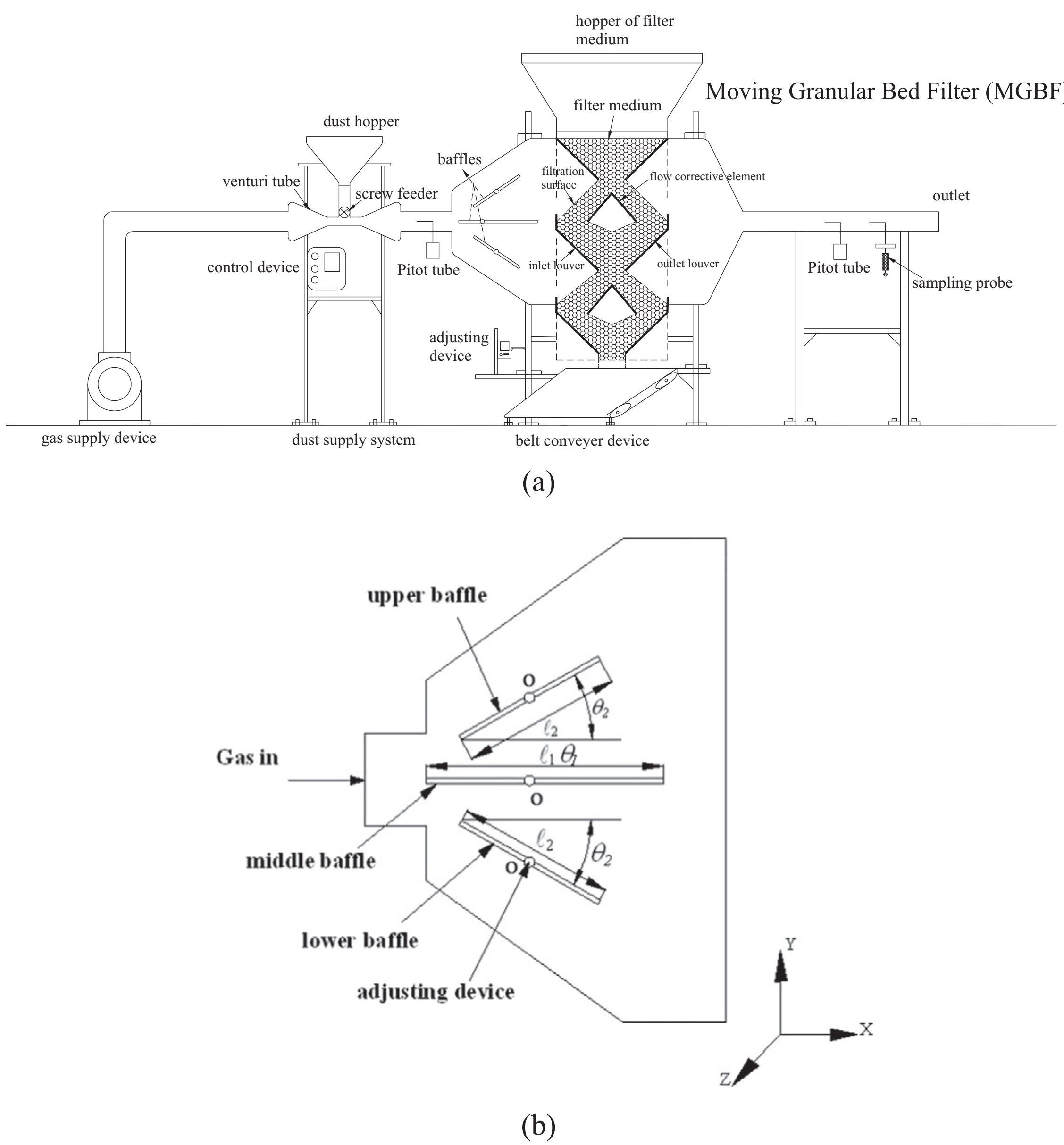


**Fig. 1.** Schematic diagram for the: (a) main experimental apparatus, and (b) baffle definitions of length and angle.