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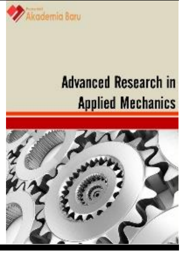

Length and Diameter Ratio Effect on Gas Homogeneity Gradients Flow for Multi-Channel Carbon Filtration System Using Computational Fluid Dynamic Analysis

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ABSTRACT

Hazardous gases are the type of gases in which contributed negative impact to human health and environmental issue. Activated Carbon is the latest adsorption technology that can enhance hazardous gases capturing and applying to the industry applications. Carbon filtration is the device in which can control the concentration to hazardous gas before emitted to the surrounding. In order to increase gas mixing performance, L/D ratio concept was used for flow analyzing with helped of ANSYS Fluent Academic Version 19.2 Software. The optimization was carried out in the system with different inlet lengths to the system and throat diameters. The inlet lengths of 40, 65, 90 and 115 mm while throat diameters of 30, 40, 50, 60 and 70 mm were investigated. The static pressure of each cases was studied. As result, there are 10 cases in which mixed gas is uniformity inside the system. Maximum static pressure among these cases are 2600 Pa with inlet length and throat diameter of 40 mm and 30 mm respectively. As findings, different L/D ratio contributed to gas mixing performance as increasing carbon filtration performance in order to prolong lifespan, and preserve environmental quality.

Keywords:
Hazardous gases; Activated Carbon; Activated Carbon; ANSYS Fluent; Carbon filtration

1. Introduction

While development in industry sector increase, air pollution is the major concern to the human being and environmental surroundings. Different industry activities contributed to many hazardous gases as many processes involved such as oil and gas industry, petrochemical and food industry. Thus, the hazardous gases need to be controlled before emitted to the surrounding [1].

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There are many methods in order to handle to tackle this issue including adsorption, membrane, chemical separation and distillation [2]. Adsorption is commonly used in industry as cost saving, economically and high-quality products. Currently, Activated Carbon is the latest adsorption technology and has been proven by researchers and engineers due to simple design, fast kinetic adsorption and efficiently [3]. The activated carbon is used and apply in carbon filtration application.

Carbon filtration is the device in which hazardous gas and air simultaneously mixed, deliver gas and remove hazardous gases in order to ensure acceptable air quality complying with American Standard of Heating, Refrigerating, Air Conditioning Engineer or ASHRAE standard as shows in Figure 1. In industry, there are different carbon filtration system with different number of filters depends on concentration of hazardous gases involved and pressure drop as these parameters contributed to the system efficiency. The optimum velocity of inlet gases is within 1000 – 2000 ft/min in order to control vapors and minimizing noise [4].

In this study, the analysis was carried out by using ANSYS Fluent Academic Version 19.2 for analysing the flow of the carbon filtration system. The carbon filtration design is developed by various of L/D ratio for analysing the gas mixing performance flows between hazardous gas and air without any filter inside the system. Usually, computational techniques have been widely used in industry application as shorten time, low cost and easy to handle [5].

Fig. 1. Carbon Filtration System [6]

2. Methodology

ANSYS Fluent basically consist of four general methodology which are modelling, meshing development, fluent development and post processing analysis.

2.1 Modelling

The design geometry of carbon filtration was created by using Design Modeller. There are 20 cases was investigated based on different L/D ratio effect as shown in Table 1. Figure 2 shows 2D carbon filtration design.

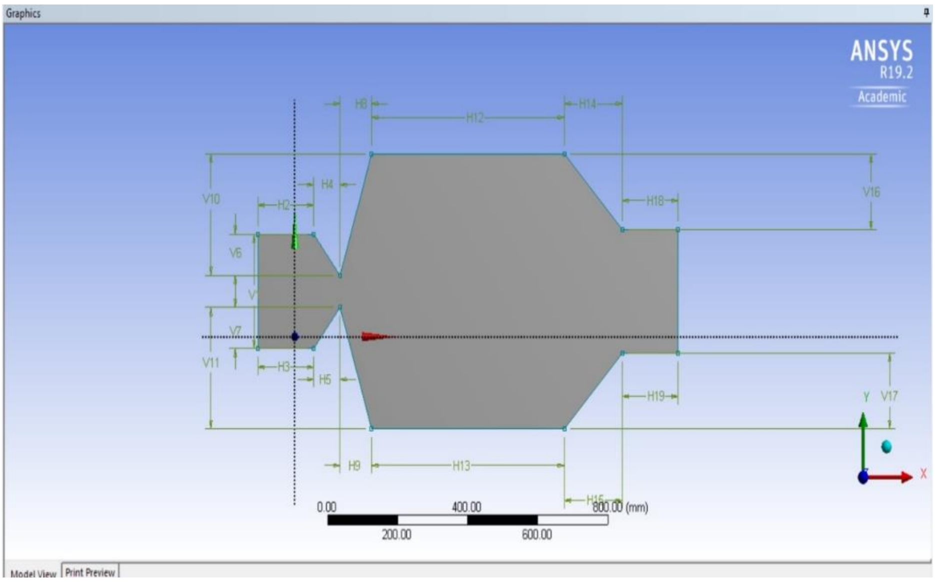

Fig. 2. 2D Carbon Filtration design

Table 1
Different dimension of carbon filtration.

Case	Throat diameter, V_1 (mm)	Inlet Length, H_4 (mm)
1	30	115
2		90
3		65
4		40
5	40	115
6		90
7		65
8		40
9	50	115
10		90
11		65
12		40
13	60	115
14		90
15		65
16		40
17	70	115
18		90
19		65
20		40

2.2 Meshing

After 20 cases modelling done, meshing process was performed by automatic method as commonly used in ANSYS application and can obtain accurate result. Number of divisions was used with mesh type is selected as all quad. The number of divisions of inlet and outlet of the system set as 50 while for walls set as 30. These values are recommended by previous research [7].

2.3 Fluent Development

In Fluent, there are various type of setup including general setting, model selection, boundary condition, material used, cell zone condition, solution method and control, initialization, and monitoring. Number of iterations also important to evaluate the condition of design. All meshed designs are exported to Fluent to analyse flow pattern or profile. Table 2 summarizes the conditions of all Fluent procedure stated above.

Table 2
Fluent Conditions of Carbon Filtration

Procedure	Details
General setting	Type: Pressure based
	Velocity: Absolute
	Time: Steady
	2D Space: Planar
Model Selection	K-epsilon (RNG), energy equation was applied
Boundary Condition	Inlet: Velocity Inlet (v = 7.5 m/s)
	Outlet: Pressure outlet (atmospheric pressure)
Material	Solid: Steel
	Gas: Sulphur Dioxide
Solution Method	Second order upwind system
Initialization	Standard Initialization
	Compute from Inlet
Number of Iterations	500 - 1000

2.4 Post-Processing Analysis

In this study, flow profile of all meshed were investigated by various parameters including static pressure and velocity to generate data. All 20 different dimensions were evaluated based on homogeneity and the highest static pressure as recommended [8]. Graphs of static Pressure versus position along the system was evaluated.

3. Results and Discussions

The aim of this research is to identify fluid flow of Sulphur Dioxide gas inside system for different inlet length parts and throat diameters by effect of static pressure profile. To obtain this, numerical simulation was performed and verified each case. The benefit of this study is to determine the best fluid flow in order to increase the efficiency of gas mixing performance. Based on 20 conditions that 7 conditions were homogeneity at divergent point in which inlet pressure is suddenly decrease and emerging rotational flow [8]. Figure 3 illustrates the total pressure distribution of all homogeneity conditions and the highest net pressure of 2600 Pascal with throat diameter and Inlet length of 30 mm and 40 mm, respectively as considered from suddenly diameter at the divergent to the system.

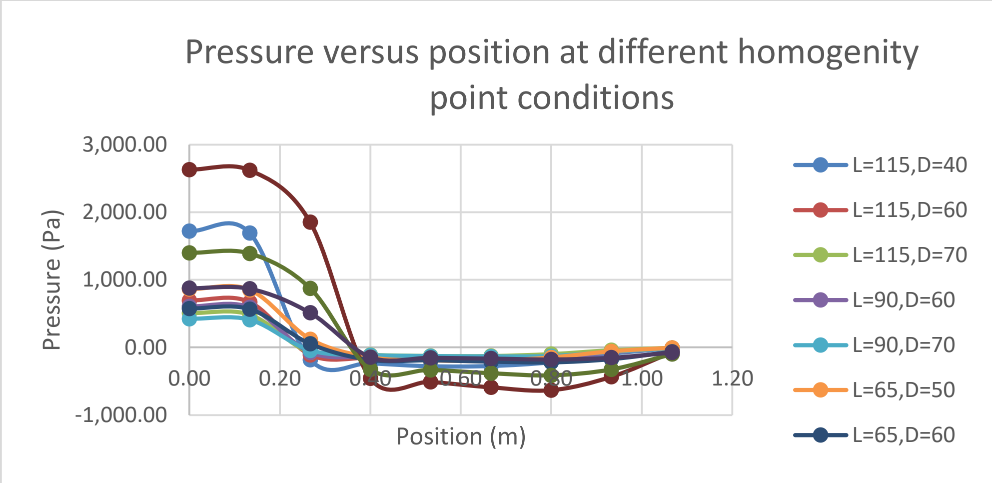

Fig. 3. Pressure distribution versus distribution at different homogeneity conditions

4. Conclusion

The effect of different throat diameters and inlet lengths at carbon filtration design system in the form of pressure has been illustrated by using ANSYS Fluent Academic Version 19.2. The meshing of carbon filtration design with number of divisions at inlet, outlet and walls are different based on the previous study. The boundary conditions of the design are complying with ASHRAE standard. Pressure is main parameters that contributed to carbon filtration performance and related to the gas concentration. Based on the result, it shown that 10 different cases illustrate saturated and smallest diameter and inlet length shows highest net total pressure. As findings, different L/D ratio contributed to gas mixing performance as increasing carbon filtration performance in order to prolong lifespan, and preserve environmental quality.

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