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Effects of baffles on flow distribution in an electrostatic precipitator (ESP) of a coal based power plant

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Abstract

Electrostatic Precipitators (ESP) are the most reliable and industrially used control devices to capture fine particles for reducing exhaust emission. Its efficiency is 99% or more. However, capturing submicron particles which are hazardous is still a problem as it involves complex flow phenomena and ESP design limitations. In this study, the effect of baffles on flow distribution inside the ESP is investigated computationally. Baffles are expected to increase the residence time of flue gas which helps to collect more particles into the collector plates, and hence increase the collection efficiency of an ESP. Besides, the placement of a baffle is likely to cause swirling of flue gas and hence sub-micron particles move towards the collector plate due to eccentric and electrostatic force. Therefore, the effects of position, shape and thickness of the baffles on collection efficiency which are also important for ESP design are reported in this study. The fluid flow distribution has been modelled using computational fluid dynamics (CFD) software Fluent and the result and outcome are presented and discussed. The result shows that baffles have significant influence on fluid flow pattern and the efficiency of ESP.

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Keywords: ESP; Flow distribution; residual time; baffles.

1. Introduction

Coal has been a major source of affordable energies for Queensland's electricity generation for decades. In 2010-11, coal based power plant generated around 76 percent of electricity in all over Australia and 62 percent of it was

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supplied just only to Queensland state and remaining power was supplied to other states [1] which is presented in Fig. 1 . Most of the coal power plants and other process industries generally use Electrostatic Precipitators (ESP) because of their effectiveness and reliability in controlling particulate matters. Before going into the environment, flue gas flows through the ESP where dust particles are captured. The ESP can be used as a cleaning device. For separating the dust particles from the flue gas, an electrical force is generally used by the ESP. A rectangular collection chamber which is known as inlet evase and an outlet convergent duct known as outlet evase are the key components of an ESP. For flow distribution, perforated plates are placed inside the inlet and outlet evase. A number of discharge electrodes (DE) and collection electrodes (CE) are positioned inside the collection chamber. Fig. 2 . presents an ESP arrangement and shows the section of a typical wire-plate ESP channel where a set of discharge electrodes is suspended vertically and the gas flows through this channel. By using an electric field, particle separation is achieved. In this paper the influence of baffles on flow pattern is discussed. Flow pattern has a significant impact on particle collection and is also an important parameter for designing and adjusting the operation of an ESP [2].

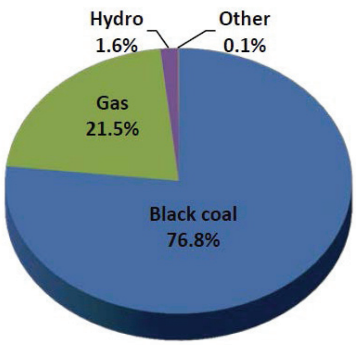

Fig. 1. Queensland grid electricity generations by fuel type, 2010-11 (Source: Electricity gas Australia, 2012)

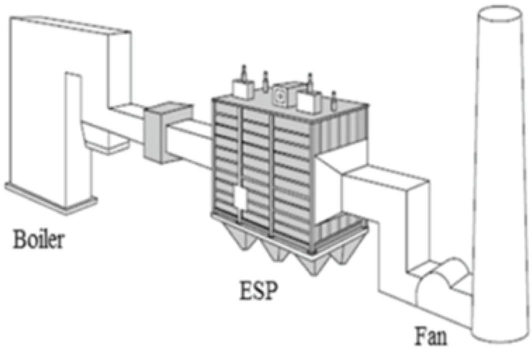

Fig. 2. A typical arrangement of an ESP in the power plant [1]

Particle emissions have become one of the major concerns to power industry because of strict rules and regulations of Environmental Protection Agency (EPA). Particulates contain such materials that can affect our health severely as they may go into the deeper parts of the respiratory tract [3]. Performance optimization of the emission control devices replaces energy recovery and conservation methods. Power stations always desire to control the particulate emissions at a minimum cost in spite of having 99.5% capture capability by the electrostatic