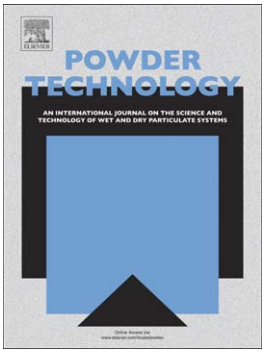

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Performance Study of Backflow Type Dynamic Cyclone Separator for Coalbed Methane

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Abstract Due to the limited production, less permeability and low pressure of coalbed methane (CBM), a new kind of cyclone separator called backflow type dynamic cyclone separator (BDCS) was designed, which includes a dynamic impeller and a center return pipe. It can meet the requirements of the dust and/or liquid separation equipment used for surface gathering process such as high precision, low pressure and anti-flow fluctuation. This paper introduced the structure and working principle of the separator, as well as studying its flow field and separation performance. The research shows that BDCS has less pressure drop compared with the separator without return pipe. The decline rate of pressure drop is about 10% between the separators with or without return pipe. By adding dynamic impeller and return pipe, the efficiency exceeds 95% when the particle size is greater than 5μm. The tangential velocity is decided by the rotating speed of the impeller and almost not influenced by the handling capacity. Therefore, the separator maintains high separation performance when the handling capacity changes from $2\times10^4 m^3$ /d to $3\times10^4 m^3$ /d. It indicates that the device had a good ability of anti-flow fluctuations.

Keywords: Coalbed methane; Dynamic cyclone separator; RSM model; Gas flow field; Numerical simulation;

1. Introduction

Coal-bed methane is a kind of unconventional gas resource that has a symbiosis with coal. It is not only a kind of green energy and chemical raw materials, but also one of the main causes of coal mine accidents. Exploitation and utilization of coal-bed methane resources is of great significance, for it is benefit to China's energy structure adjustment and the decline of coal mining accidents [1, 2].

The raw coalbed methane (CBM) inevitably contains sandstone particles. The existence of these particles reduces the transportation efficiency of CBM and damages the valves and instrumentation devices, etc. It even causes safety accident. Therefore it's necessary to dust the CBM. At present, the domestic field of CBM mining process is mostly designed according to conventional natural gas method, meanwhile separation equipment is used in the process, such as gravity dust separator, filter separator, cyclone separator, etc. Gravity dust separator has the advantages of simple structure, less cost and low energy consumption, but the separation efficiency is low when used to separate fine particles, otherwise the machine will have a large size. So it is generally used as a primary dust removal device [3]. Filter separator has high separation efficiency when separates fine particles, but it has a large pressure drop, and needs periodic cleaning or replacing the filter cloth, etc. Therefore it is usually used as the last stage of separation process which requires high separation efficiency [4, 5]. Cyclone separator is a kind of separation devices utilizing centrifugal force generated by the rotating airflow to separate particles contained in the natural gas. It is characterized by high separation precision, low pressure drop, large handling capacity and stable operation. However, conventional cyclone separator has a certain range of its tangential velocity, resulting in the small centrifugal force that acts on the fine dust, and it is difficult to achieve effective separation [6].

Many researchers have been working on improving the performance of the cyclone separator for years by optimizing the design of its structure and size. Stairmand-efficient cyclone separator is an achievement [7], but it is still difficult to separate fine particles effectively. Radial jet cyclone is a new kind of cyclone that can separate particles close to 1μm [8]. A new designed cyclone has a different separation space consisting of an outer cylinder and a vortex limiter in order to increase the vortex length [9]. But they are both poor in anti-flow fluctuation. Hence, some scholars start trying to join dynamic components in the cyclone separator. Brouwers [10] invented a separator whose core component is a rotary filter, and it can be used to separate the particles larger than 0.1μm. Based on Stairmand-efficient cyclone separator, Chmielniak and Bryczkowski [11, 12] designed a downstream structure cyclone separator in which some rotating blades has been added internally, and the calculation theory, which is about the separation efficiency and the pressure drop of the device, is proposed through theoretical and experimental research. Chen [13] developed a turbine dust separator which used centrifugation force generated by

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