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Numerical Investigation into the Distributor Design in Radial Flow Adsorber

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Abstract. Air flow distribution in radial flow adsorber was numerically investigated using computational fluid dynamics (CFD) method, which was proved to be applicable to study the problem of non-uniform distribution in radial flow adsorber. Results showed that the degree of non-uniformity was more serious in desorption process than that is adsorption process. Therefore, it was considered that the non-uniform distribution of flow in a radial flow adsorber was mainly manifested in the desorption process. Optimum design of distributor parameters can improve the flow distribution in adsorber. Meanwhile, three different structures of distributor and the effect of breathing valve were analyzed. Results revealed that truncated cone is more effective than tubular and conical distributors in flow distribution. By inserting the truncated cone in central channel, desorption uniformity was increased by 6.56% and the breakthrough time of CO_2 was extended from 564s to 1138s in the adsorption process. The "dead zone" problem at the top of adsorber during the desorption process was solved by opening breathing valve, which prolonged the working life of adsorber and was proved to have less effect on the uniform of airflow.

AMS subject classifications: 76S05

Key words: CFD method, air separation, radial flow adsorber, adsorption, desorption.

1 Introduction

Industrial gas, oxygen and nitrogen are primarily obtained by air separation now [1, 2]. However, in addition to industrial gases, such as nitrogen, oxygen that required for production, it also contains some impurities, like carbon dioxide and water vapor.

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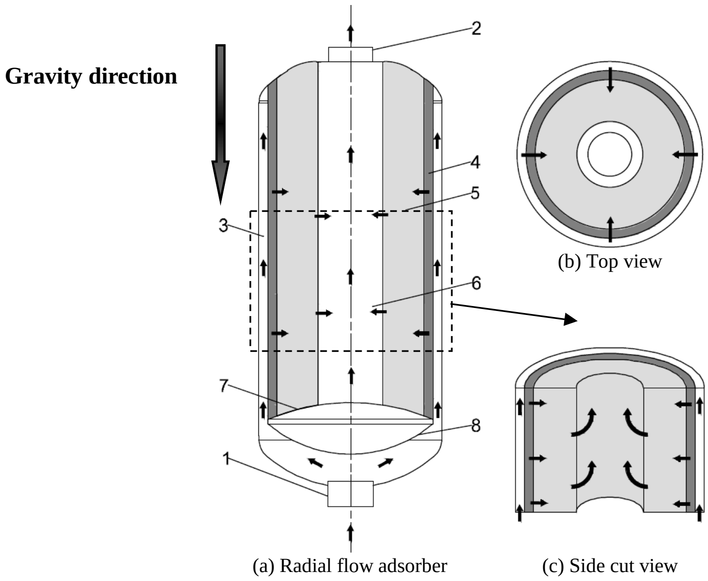

Figure 1: Schematic of the vertical radial flow adsorber and radial flow pattern in adsorption process 1–inlet; 2–outlet; 3–annular channel; 4–alumina layer; 5–molecular sieve layer; 6–central channel; 7–spherical dish head; 8–deflector.

Once these impurities enter the adsorbers, it will precipitate in low temperature heat exchanger, turbines and rectification tower [3]. Therefore, the separation process of air must be pre-purified [4]. As one of the purifiers, vertical radial flow adsorber has many advantages such as small footprint, low bed pressure drop and low regenerative energy consumption [5]. Compared with the traditional vertical axial flow adsorber and horizontal radial flow adsorber, vertical radial flow adsorber is more suitable for the development of large air separation equipment [6,7].

As shown in Fig. 1, vertical radial flow adsorber mainly consists of four parts: annular channel, activated alumina layer, molecular sieve layer and central channel. In adsorption process, processed air enters the annular channel from the inlet by air compressor, and then it passes through the perforated plate into the alumina layer. After the removal of water vapor, dry air reaches the molecular sieve layer to adsorb carbon dioxide, acetylene and other hydrocarbons. Finally, the processed air is collected in the central channel and discharged from the outlet [8]. Desorption process is just reverse, waste nitrogen enters central channel at the top of the adsorber, travels through molecular sieve horizontally and activated alumina, and exits at the bottom of adsorber. In these processes, due to the unique structure of the radial flow adsorber, non-uniform flow distribution usually exists in a vertical radial flow adsorber, which significantly decreases the utilization of adsorbents, reduces the breakthrough time and even causes safety accidents [6].

Considering the similarity of the flow in an adsorber, cylindrical annulus and reactor, we draw on the experience of related research on many cylindrical annulus and RFBR